Association of Schools of Construction of Southern Africa

The 16th Built Environment Conference

*Construction in 5D: Deconstruction, Digitalization, Disruption, Disaster & Development: A Second Look*

26 - 27 September 2022, Lanseria, South Africa

Conference Proceedings
PREFACE

The Association of Schools of Construction of Southern Africa (ASOCSA) Built Environment conference series in its 17th year of existence continues to be one of the major cutting-edge built environment conferences on the African continent. Since its inception in 2006, the blind peer reviewed conference proceedings have been referred to by both private and public sector policy and decision makers. The series produces a post-conference edition of the Journal of Construction, which is on the list of journals approved by the South African Department of Higher Education and Training (DHET) for subsidy. The conference series continues to be endorsed by the International Council for Research and Innovation in Building and Construction (CIB), one of the largest global built environment research organizations and recognized by the Australian Institute of Building (AIB). The conference provides an interactive international forum and networking opportunities among researchers, academics, administrators and practitioners, representing institutions of higher learning, government agencies, contracting organisations, consulting enterprises, financial institutions, and other construction-related organisations.

The past two conferences had been severely impacted by the effects of the COVID-19 pandemic, and the academic world across the globe either cancelling conferences or converting them to virtual events. However, true to its vision and commitment to continue being a premier African built environment conference, ASOCSA and the organizers persevered under difficult and challenging circumstances to present the previous version in the long-standing Built Environment series as a virtual conference.

It is with great excitement and relief that life has returned to some level of normalcy, and following the removal of travel and other restrictions, the 16th Built Environment Conference is again for the first time since 2021 an in-person event. Delivering a world-class conference is not novel for ASOCSA. The conference proceedings will be published by ASOCSA within a reasonable time after the conference once all audits and verifications have been completed. The authors of a selection of the best ten to twelve conference papers will be invited to rework their papers into book chapters that will be published in a Scopus, Compendex and Web of Science indexed edited book post-conference and titled, Construction in 5D: Deconstruction, Digitalization, Disruption, Disaster, Development: A Second Look.

OBJECTIVES

The 16th Built Environment Conference as the second contribution to the three-part focus on Construction in 5D: Deconstruction, Digitalization, Disruption, Disaster & Development: A Second Look has a range of interesting and cutting-edge peer-reviewed research papers addressing topical issues that affect the built environment not only in South Africa but in the regions beyond. Notwithstanding the ever-increasing challenging global economic environment with shrinking sponsorship budgets, the conference continued in the tradition of previous conferences in the series and provided an international forum with clear industry development and sustainability focus. This focus provided the opportunity for researchers and practitioners from developed and developing nations to deliberate topical current issues that impact the Built Environment.

The broad objectives of the conference were:

- To provide a forum for multi-disciplinary interaction between academics and industry practitioners.
- To disseminate innovative and cutting-edge practices that respond to the conference theme three-part series and outcomes, namely Construction in 5D: Deconstruction, Digitalization, Disruption, Disaster & Development: A Second Look.
- To provide a world class leading internationally recognized, accredited and SCOPUS-indexed conference for the built environment; and
- To contribute to the existing built environment body of knowledge (BEBOK) and practice.

The conference organizers brought together in a single forum, a group of researchers and academics from the wide range of built environment disciplines that include engineers, architects, quantity surveyors, construction, and project managers. ‘Delegates’ and participants were drawn not only from South African institutions of higher education, government agencies, and other construction-related organizations but also from across the African continent and the United Kingdom.
There is little doubt that the construction industry has experienced exponential change and development in recent years. The 16th Built Environment Conference will examine five of these cutting-edge concepts to determine their state of the art in the construction sector both in practice and academic research. This conference which is the second in a three-part series therefore seeks responses to questions related to current conversations, debates, and empirical research on:

- **Deconstruction** – the dismantling or ‘unbuilding’ of buildings to maximise reusing and preserving the demolished fragments and involves taking a building apart piece by piece, essentially reversing the order of its construction.

- **Digitalization** – the conversion and transformation of construction business processes to use digital technologies and embrace the ability of digital technology to collect data, establish trends and make better business decisions.

- **Disruption** – displacement of well-established construction technologies, techniques, or products to disruptively affect the normal operation or function of the construction industry while potentially creating a new industry or market. Artificial intelligence, virtual/augmented reality, internet of things, blockchain technology, and e-commerce are some of the disruptive technologies that are significantly influencing the future of the construction industry.

- **Disaster** – an occurrence that disrupts the normal conditions of existence and operation causing a level of suffering and challenge that exceeds the capacity of adjustment of the affected community and the construction industry.

- **Development** – in the context of construction refers to an industry that possesses the vision, leadership and capacity to bring about a positive transformation of itself within a condensed period of time.

The conference includes papers that address, inter alia,

- Current trends and developments
- Policies
- Legislation and regulations
- Practices
- Case studies.

The internationally peer reviewed, and edited conference proceedings that contains the full papers is aimed at contributing significantly to the body of knowledge relative to the science and practice of construction not only in South Africa but everywhere where the products of construction are produced even in these new challenging times of fear and uncertainty.

**Prof Theo C. Haupt**  
**Conference Academic Chair (2022)**  
**Durban, South Africa**  
**September 21, 2022**
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ACKNOWLEDGEMENTS

The organizing committee of the 16th Built Environment conference, held in Lanseria, South Africa, is grateful to the Council of the Association of Schools of Construction of Southern Africa and member universities and individuals for supporting this conference through their valued contributions. Special thanks are also extended to our conference partners for supporting the conference. Without the support received, this conference and the further development and growth of the Association of Schools of Construction of Southern Africa (ASOCSA) with respect to its mission in the region would not be possible. Additionally, this support demonstrates the commitment to the further development of the body of knowledge relative to the science and practice of construction. This commitment is deeply valued and acknowledged. Additionally, this support demonstrates the commitment to the further development of the body of knowledge relative to the science and practice of construction. This commitment is deeply valued and acknowledged.

Further thanks are extended to Dr. Progress Chigangacha (Nelson Mandela University) and Dr. Mariam Akinlolu (Mangosuthu University of Technology) who worked tirelessly especially in the co-ordination of paper reviews. The organizing committee also wishes to acknowledge the selfless contributions of the Scientific and Technical Committee and panel of reviewers who ensured that each paper was rigorously refereed for inclusion in the conference proceedings and possible selection for inclusion in the published SCOPUS-indexed post-conference publication of the highest standard that satisfies the criteria for subsidy by the South African Department of Higher Education and Training (DHET).

The excellent support of our webmaster, Tamar Ellis in setting up and supporting the conference website and technical support during the conference itself is appreciated. The sterling contributions of Ferial Lombardo in the co-ordination and organization of the conference are acknowledged.

ORGANISING COMMITTEE

Prof Theodore Haupt, Nelson Mandela University, Conference Academic Chair
Dr. Progress Chigangacha, Nelson Mandela University, Conference Academic Co-Chair
Mrs. Ferial Lombardo, Conference Secretariat

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Prof. John Obas Ebohon, London South Bank University, UK
Dr. S Zulu, Leeds University, UK
Dr. N Chileshe, University of South Australia, Australia
To maintain and ensure the highest quality in the conference proceedings and comply with the requirements for subsidy of the South African Department of Higher Education and Training (DHET), a rigorous two-stage system of peer review by no less than two acknowledged experts in the field was followed. In terms of this process, each abstract received was twice blind reviewed in terms of:

- Relevance to overall conference theme and objectives;
- Relevance to selected sub-theme;
- Originality of material;
- Academic rigour;
• Contribution to knowledge; and
• Research methodology.

Authors whose abstracts were accepted after a blind peer review process was completed were provided with anonymous reviewers' comments and requested to submit their full papers noting and addressing these comments. Evidence was required relative to the actions taken by authors regarding the comments received. These resubmitted papers were twice blind reviewed again in terms of:

• Relevance to overall conference theme and objectives;
• Relevance to selected sub-theme;
• Originality of material;
• Academic rigour;
• Contribution to knowledge;
• Research methodology and robustness of analysis of findings;
• Empirical research findings; and
• Critical current literature review.

Authors whose papers were accepted after the second review were provided with additional anonymous reviewers' comments and requested to submit their revised full papers. These final papers were only included in both the conference presentation schedule and the conference proceedings after evidence was provided that all comments were appropriately responded to, having been multiple peer-reviewed for publication. At no stage was any member of the Scientific and Technical Committee or the editor of the proceedings involved in the review process relative to their own authored or co-authored papers. The role of the editors was to ensure that the final papers incorporated the reviewers’ comments and arrange the papers into the final sequence based on the conference presentation schedule as captured on the conference proceedings and Table of Contents. Of the 65 abstracts originally received, only 41 papers were finally presented at the conference and inclusion in the conference proceedings, representing an acceptance rate of 63%. To be eligible for inclusion these papers had to receive one of three recommendations from at least two reviewers, namely:

• Accepted for publication or
• Provisional acceptance provided minor changes / corrections are made or
• To re-submit for publication provided author/s reconsider/s the areas of concern

TAX BENEFIT

ASOCSA is a registered Public Benefit Organization as defined in Section 30 of the Income Tax Act and a registered Section 21 Company as defined in the Companies Act. Therefore, all donations made to ASOCSA will be fully deductible for income tax purposes and a section 18A certificate, for proof of deductibility will be issued to the donor upon receipt of the donation. The deductible donation is limited to 10% of the donors’ taxable income before providing for Section 18A and Section 18 deductions.
September 2022
To whom it may concern,

Dear Author,

RELATIVE CONTRIBUTION OF ACADEMIC INSTITUTIONS TO THE 16TH BUILT ENVIRONMENT CONFERENCE 2022

On behalf of ASOCSA 2022, we confirm that the papers accepted for publication in the 16th Built Environment conference proceedings met the 60-40% conference policy.

A total of 41 (single or co-authored) peer-reviewed papers from 17 national and international universities were presented at the conference.

The total author affiliation breakdown for each of the papers are shown on Table 1.

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The final accepted papers are published in the conference proceedings with **ISBN number: 978-0-6397-2285-6**

Kind regards,

Prof Theo C. Haupt
Conference Chair (2022)
History

ASOCSA is not the first attempt to form a body that addresses, inter alia, matters of construction education and training. In the days of the Building Industries Federation South Africa and the National Development Fund there were regular annual meetings of the Heads of Departments that offered construction-related programs. Recognizing the two-tiered higher education sector in South Africa, there were separate meetings for universities and the former technikons. In the more recent past, the Chartered Institute of Building - Africa initially convened annual educators’ forums that did not quite fulfill the same function as the previous forums. However, during 2005 the very first meeting of University Heads of Departments drawn from all higher education institutions in South Africa met for the very first time since the re-landscaping of the sector in the same venue to discuss matters affecting construction, and particularly construction education in the country. This meeting was repeated in 2006 where the need was expressed for the establishment of a formal forum / association of universities to engage in discussion / debate / collaboration / promotion of matters of mutual interest and so ASOCSA was born.

Broad Aims

ASOCSA aims to be the professional association for the development and advancement of construction education in Southern Africa, where the sharing of ideas and knowledge inspires, guides and promotes excellence in curriculums, teaching, research and service. To achieve this aim ASOCSA is partnering with the construction industry to find ways to effectively represent the interests of both construction academic and industry practitioners. ASOCSA will offer a variety of programs and services designed to help its members serve their customers more effectively and succeed in an increasingly challenging environment of construction information management and technology. To this end ASOCSA provides a forum for the debate and discussion of issues of mutual interest to all industry stakeholders. For example, one of the tasks of ASOCSA will be supporting the development of curriculums that address the needs of the construction sector in the Southern African region. ASOCSA convenes an annual conference that is one of only two construction-related conferences previously accredited by the Department of Higher Education and Training (DHET) where construction academics and practitioners can interact relative to practical experience and the findings of relevant research. This conference series is endorsed and underwritten by the International Council for Research and Innovation in Building and Construction (CIB) as well as several major industry stakeholders.

The Journal of Construction which is accredited by the Department of Higher Education presently published electronically four times per year is the official journal of ASOCSA and in the past more than 5,000 complimentary copies were distributed to all industry stakeholders in the Southern African region. The production and distribution of practice notes and technical papers is a further endeavor to grow the partnership between academia and industry.

With respect to the Southern African region, ASOCSA is committed to the following:

Vision

To drive innovative construction related higher education

Mission Statement

To promote, facilitate, develop, and monitor the relevance and quality of construction related curricula, research, and graduates in conjunction with higher education institutions, industry and government.

Strategic objectives

The objectives of the Association are:

- to promote and facilitate the development of curricula for construction related programmes
- to assist with the accreditation of construction related programmes
- to hold an annual conference that acts as a forum for multi-disciplinary interaction between academics and practitioners
• to publish an accredited research-based journal and contribute to the built environment body of knowledge (BEBOK)
• to disseminate information dealing with construction education and related matters
• to develop and maintain closer links with industry and government
• to represent the collective views of its members
• to liaise with other organisations and persons to promote the interests of its members
• to promote and support relevant postgraduate research
• to provide bursaries to postgraduate students in accordance with set criteria

ASOCSA continues to seek opportunities to promote both academic and industry employment opportunities. Finally, ASOCSA intends to play a significant and supportive role in the accreditation of construction-related academic programs.

Heads Forum meetings

ASOCSA believes that meetings of the Heads of School and Departments of Construction in Southern Africa is a vital component of its functions and holds both formal and informal discussions with Heads during each conference. The annual Construction Education Summit series commenced in 2021 (CES21) is planned from 2023 to become a formal platform for engagement with all construction higher education stakeholders.

International Affiliation

ASOCSA has commenced discussions about closer collaboration with similar institutions such as the Associated Schools of Construction (ASC) in the United States, the Royal Institute of Chartered Surveyors (RICS), the Chartered Institute of Building (IOB), Australian Institute of Building (AIB) and Council of the Heads of the Built Environment (CHOBE) in the United Kingdom. ASOCSA has entered a Memorandum of Understanding with the International Council for Research and Innovation in Building and Construction (CIB).

In summary, benefits of membership of ASOCSA which are self-evident include participation in meetings of the Heads and the CES series throughout the region, access to the Journal of Construction with reduced paper processing fees, reduced rates at all ASOCSA, MBA and CIB events, involvement at regional level with industry-academia forums, interaction and networking opportunities relative to, for example, collaborative research, curriculum development, external moderation of courses, and external examination.

ASSOCIATION OF SCHOOLS OF CONSTRUCTION OF SOUTHERN AFRICA

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Associate Editor: Mr Ferdinand Fester, Durban University of Technology

For more information on ASOCSA and its activities visit www.asocsa.org
Dear Author

PEER REVIEW PROCESS CONFIRMATION: 16TH BUILT ENVIRONMENT CONFERENCE: LANSERIA, SOUTH AFRICA 2022

This serves to confirm that the following blind peer review process was strictly followed relative to this conference.

To ensure the highest quality in the conference proceedings and comply with the requirements for subsidy of the South African Department of Higher Education and Training (DHET), a rigorous two-stage system of peer review by no less than two acknowledged experts in the field has been followed. In terms of this process, each abstract received was twice blind reviewed in terms of:

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Sincerely,

Dr. Progress Chigangacha (Conference Co-Chair)
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An exploration into the perceptions of social sustainability in the built environment amongst project managers

Tascha Bremer¹ & Rumbidzwai S. Mhinga²
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ABSTRACT AND KEYWORDS

Purpose of this paper
Sustainability is a word that has gained prominence and popularity over the past few decades. The term “sustainability” comprises environmental, economic and social sustainability. Environmental sustainability has been the main aspect that has been focused on, followed by economic sustainability, however social sustainability has received little attention at all especially within the built environment. The aim of this research is to understand why the built environment treats social sustainability as the least important pillar, despite having improved on environmental and economic sustainability.

Design/methodology/approach
This research follows a concurrent embedded mixed-method approach within a pragmatic paradigm. A mixed-method approach was used for this research and semi-structured interviews were carried out. Project managers in South Africa were interviewed on social sustainability and were requested to answer questions about social sustainability within the built environment. This study also conducted a secondary data analysis of similar research by Ohene, Nani and Tetteh (2019).

Findings
The key findings are that social sustainability is treated as the least important pillar of sustainability due to the lack of a universal definition and understanding, the competitive nature of the built environment, the fact that it cannot easily be numerically or monetarily valued or measured, the socio-economic and sociocultural climate, and because there are no industry assessment bodies or tools for it.

Research limitations/implications
The study concludes that the concept of social sustainability is currently very broad, vague and subjective within the industry. This lack of clarity of what exactly social sustainability means and encompasses in the context of the built environment is a huge barrier in its implementation in the industry. It is recommended that more research be done on the subject matter, thereby resulting in the development of a definition, guideline or standard practices being established in the industry for there to be a universally understood meaning of what social sustainability means and looks like in the built environment. Furthermore, the establishment of an industry body which can advocate for social sustainability and can make assessment tools is also recommended.

What is original/value of paper
Social problems within and due to the built environment have been neglected and left unattended to. This paper attempts to understand why social sustainability is treated as the least important pillar within the built environment.

Keywords: Project managers, social sustainability, Construction projects, Property development, Sustainability
INTRODUCTION

In 2015 the United Nations set up the 2030 Agenda for Sustainable Development in which aims and measures to balance economic progress, environmental protection, and the minimisation of social inequalities and disparities were brought forth (Filho et al, 2019: 179). These measures are in agreement with the general and most popular understanding of sustainability, which comes from the Brundtland Report of 1987; which considered sustainability as a triad consisting of three main pillars; namely environmental, economic and social sustainability (Shirazi and Keivani, 2017: 1526). There have been great strides globally in reducing the negative impact that the built environment has on the environment, with measures ranging from national policies to international treaties; all with the intention to increase environmental sustainability. Next in terms of popularity is economic sustainability and the business case for economic sustainability has also been proven, with most industries having shown a reduction in the cost of production and operating prices when it comes to sustainable technologies in their respective fields.

Lastly there is social sustainability, which, briefly outlined, is about aspects that affect society as a result of the built environment. This last pillar is the focal sustainability pillar in this paper. In theory all three pillars hold equal importance and should be balanced as they all have a part to play in making sure that future generations can also live with adequate resources. In literature they are all just as important, however, in reality, social sustainability has been the least researched and examined of the triad; receiving the least attention in the built environment (Ghahramanpour, Lamit and Sedaghatnia, 2013: 186; Rogers, Gardener and Carlson, 2013: 3474; Shirazi and Keivani, 2017: 1526). It has also received the least amount of resources in terms of research and application. Social sustainability is hardly discussed in the context of the built environment, and as a result, many people don’t actually know what exactly it is.

There is an ongoing debate regarding how to define social sustainability; and to date, there is no single globally accepted definition of it. Abed (2020: 85) describes social sustainability as a multidisciplinary concept which emphasises the importance of the interactions between humans and place, as these are the components that make up a neighbourhood. Another perspective is that by Shirazi and Keivani (2007: 1532) who state that social sustainability is a physical and non-physical aggregation. This means that although dealing with issues within the built environment means focusing mainly on the physical factors of social sustainability, non-physical factors of social sustainability must also be considered as both of these are inherently interrelated. This is similar to Vallance, Perkins and Dixon (2011: 343-344) who suggest a “threefold schema” or framework of social sustainability, consisting of development sustainability, bridge sustainability and maintenance sustainability. Another proposed conceptual framework is that by Eizenberg and Jabareen (2017: 11) whereby social sustainability consists of four complementary concepts, each with a distinct purpose within the social sustainability framework. The four concepts are safety, sustainable urban forms, equity and eco-prosumption. Although no one standard, universally accepted definition of social sustainability can be found from the readings, there are recurring themes.

There is a combination of traditional social sustainability themes such as equity, housing and environmental health, and new intangible and less measurable themes such as well-being, identity, sense of place and culture (Colantonio et al., 2009: 4). The most notable clarification is that social sustainability comprises tangible or physical factors as well as intangible or non-physical factors. This helps to organise the theory and compartmentalise this very broad subject a little more. Not only is social sustainability lacking in theoretical data and information regarding its definition, it is also lacking in practical data on how to incorporate it in developments and operationalising it in built environment projects. Case studies where social sustainability has intentionally been a priority are few. Of the few studies that have been done on social sustainability, the majority have been based on developed and affluent countries, and so there is a gap in research on social sustainability studies in developing and less-developed countries (Ghahramanpour, Lamit and Sedaghatnia, 2013:187). Although theory states that all three pillars should be met and that they are equally as important, practice does not reflect this. There is therefore a disconnect between what sustainability in its entirety is in theory, and what built environment professionals actually practise in reality. The main aim of this study was to understand why social sustainability is treated as the least important pillar of the three pillars of sustainability. This study examined the perceptions that project managers have of social sustainability in terms of its definition, why it is treated the way it is treated, and its importance in comparison to the other two pillars.
2. RESEARCH METHODS

A concurrent embedded mixed-method approach was chosen for this research because a combination of qualitative and quantitative approaches was needed. This form of mixed-method approach has one data collection phase, during which both qualitative and quantitative data are simultaneously collected, and one set of data plays the primary role and guides the project, whilst the other set of data is embedded in the predominant one and is secondary (Creswell, 2009: 197). A qualitative approach was needed due to the fact that the topic of this research is one which required a literature review and also dialogue and in-depth conversation by means of interviews with the research respondents. However, some of the questions in the research were about the respondents’ demographic characteristics such as age and number of years of experience, and the categorisation of the numerical data provided required a quantitative approach.

Thus, the qualitative approach was the primary method and the quantitative approach was embedded in it, and these two approaches were integrated during data collection. The sampling method which was selected was convenience sampling whereby the research participants whom the researcher had access to and were willing to participate in the study were interviewed. Homogenous sampling was used, and the homogenous characteristics chosen in this research were that all research participants were construction project managers with a minimum of two years of project management experience in the construction industry and at least one tertiary education qualification in the built environment.

This research used both primary and secondary data collection tools; by means of semi-structured interviews, a literature review, as well as a secondary data analysis of a previous study by Ohene, Nani and Tetteh (2019). For the primary data, nine semi-structured interviews were conducted in order for data to be collected. Due to the pandemic, this research did not carry out any in-person interviews, but rather they were all virtually conducted through video calls on Zoom.

The study used research by Ohene, Nani and Tetteh (2019) to conduct a secondary data analysis. In 2019, the authors wrote a paper titled “Critical Barriers to Social Sustainability: the Quantity Surveyors’ Perspective” which was published in the Journal of Architectural Environment & Structural Engineering Research. Data for this study was obtained by first carrying out a literature review, and then conducting a survey. A comprehensive literature review which was carried out revealed that there were 19 barriers to social sustainability. A structured questionnaire based on this information was designed for the survey and was answered by 110 quantity surveyors who were all registered with the Ghana Institution of Surveyors.

A sample of quantity surveyors was obtained from a target population of 424 quantity surveyors registered and in good standing with the Ghana Institution of Surveyors as of 2018. The sample size was obtained using Kish 1965 formula and was determined to be 120. There were 130 questionnaires sent out to quantity surveyors, and 110 were answered, giving a response rate of 91.6%. The data collected from the answers to the questionnaires was then analysed using factor analysis. The respondents were requested to rank each of the barriers to social sustainability in terms of criticality from 1 to 5, using the Likert scale (1 being non-critical and 5 being very critical). This data was collected in 2018 and is therefore less than 5 years old, thus making it relevant and not outdated for this current study.

2.1 Data analysis

The data from the interviews was transcribed and the transcripts were first coded using structural coding and this research coded the data based on the topics discussed in the interviews. After the data was organised according to topics of discussion, further analysis of this data was conducted by means of thematic analysis. This method of analysis involves searching for patterns in data and determining how those patterns of meanings can be further organised into themes (Sundler et al., 2019: 735). In addition, this study conducted a secondary data analysis of a previous study. In this research, the study by Ohene, Nani and Tetteh (2019) was analysed in an effort to get data and information to answer the research questions, especially the main one. The secondary data analysis was conducted to supplement this current research. Thus, this combination aimed to produce a final study which was data-rich.
3. RESULTS

3.1 Why social sustainability is treated as the least important of the three pillars

The main codes and themes identified from the responses to the question of why social sustainability is treated as the least important of the three pillars are shown in table 3.1. These themes were analysed in conjunction with the results of the study by Ohene, Nani and Tetteh (2019). The interviewees in this study found that social sustainability is treated as the least important pillar because of its lack of a universal definition, the competitive nature of the built environment, the social-economic and socio-cultural climate, the lack of any industry assessment bodies or tools that focus on it, and the fact that it cannot easily be numerically or monetarily measured or valued. Similarly, the study by Ohene, Nani and Tetteh (2019) found that there was a lack of implementation of social sustainability in the Ghanaian construction industry due to eleven main variables of barriers which were grouped into four categories known as components, namely socio-cultural, political and technical, knowledge awareness and financial barriers.

<table>
<thead>
<tr>
<th>Structural code (Topic)</th>
<th>Codes</th>
<th>Themes</th>
</tr>
</thead>
</table>
| Why social sustainability is treated as the least important pillar | • Lack of a clear definition and understanding of it  
• Industry and individuals not sure how to implement it  
• Subjective understanding of it | The lack of a universal definition and understanding of what social sustainability means in the context of the built environment |
| | • The pressure to complete projects quickly  
• Industry’s desire and drive to make profit  
• Social wellbeing of workers compromised in an effort to achieve organisational goals | Competitive nature of the built environment |
| | • Numerical value cannot easily be assigned so difficult to measure  
• Its results do not show up immediately  
• Lack of experience on how to incorporate and measure it in projects | Social sustainability cannot easily be numerically or monetarily measured or valued |
| | No industry body or council to advocate for it | There are no industry assessment bodies or tools for social sustainability |

3.2 Knowledge and implementation of social sustainability

3.2.1 Individual knowledge of social sustainability

The project managers were asked what they understand social sustainability to mean in the context of the built environment and how they define it. As can be seen from the table 3.2.1, the project managers interpreted social sustainability to consist of a number of indicators or themes, both physical and non-physical. These were identified as employee wellness and wellbeing, providing communities with social infrastructure, upskilling and uplifting communities where projects are taking place, respecting the culture, traditions and not displacing people in areas where projects take place, and enhancing the way of life for the local residents. All of these interpretations were also found by Ohene, Nani and Tetteh (2019) in their literature review, resulting in them stating that there are various definitions of social sustainability, and these are largely dependent on the stakeholder’s perspective.
<table>
<thead>
<tr>
<th>Structural code (Topic)</th>
<th>Codes</th>
<th>Themes</th>
</tr>
</thead>
</table>
| Individual knowledge of social sustainability | • Fair labour practices (observing workers' rights)  
• Taking care of employee health and safety  
• Good work-life balance  
• Adequate living conditions  
• Payment of good salary and wages  
• Adequate time off from work  
• Working fair hours- not overworking employees  
• Focusing on the "staff happiness factor" | Employee wellness and wellbeing |
| | • Access to amenities and services  
• Satisfaction of human needs  
• Improved social equity  
• Improved social welfare  
• Improved social justice  
• Improved equality of condition  
• Improved distribution of resources | Provision of social infrastructure |
| | • Employing, educating and upskilling local people  
• Providing business opportunities for and conducting business with local businesses  
• Providing financial assistance  
• Generating income within the community | Upskilling and uplifting communities where projects take place |
| | • Not making the community's social status and social standing worse  
• Not displacing local residents  
• Respecting the culture of residents | Respecting the culture and traditions of people in an area and not displacing them when projects take place |
| | • Projects that benefit the local community as a whole | Enhancing the way of life for the local residents |

3.2.2 Industry knowledge of social sustainability

When asked whether they thought that there currently is a consistent and unified view and definition of social sustainability within the built environment, all of the interviewees said that they did not think so. This was identified to be due to the vagueness of the concept, the lack of clarity and confusion on how to implement it, the fact that different individual interpretations of social sustainability lead to different organisational approaches. This agreed with Ohene, Nani and Tetteh (2019) stated that the construction industry’s notion of social sustainability varies and is based on the individual perspectives of the various stakeholders. This is shown in table 3.2.2.
Table 3.2.2: Codes and themes regarding industry knowledge of social sustainability

<table>
<thead>
<tr>
<th>Structural code (Topic)</th>
<th>Codes</th>
<th>Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry knowledge of social sustainability</td>
<td>• Broad and vague concept</td>
<td>Broad and vague concept which is not generally understood</td>
</tr>
<tr>
<td></td>
<td>• Lack of clarity of what exactly social sustainability is</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Not well defined in the context of the built environment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Aspects of social sustainability already being mandated by law to be implemented, although not being called social sustainability</td>
<td>Lack of clarity and confusion on how to implement it</td>
</tr>
<tr>
<td></td>
<td>• Different interpretations because people have different individual experiences</td>
<td>Different individual interpretations of social sustainability lead to different organisational approaches</td>
</tr>
<tr>
<td></td>
<td>• Subjective understanding of social sustainability results in different organisational approaches</td>
<td></td>
</tr>
</tbody>
</table>

3.2.3 Industry implementation of social sustainability

The interviewees were all asked if they had ever been involved in projects where social sustainability had been prioritised. Firstly, it was acknowledged by an interviewee that the answer to this question depends on how one defines social sustainability in the built environment. In addition, it was also pointed out by another interviewee that the answer to the question also depends on whether social sustainability is perceived as individual elements or as a collective term. As a result, 33% of the interviewees in this study believed that they had been in projects where social sustainability has been prioritised, whilst 67% did not believe that they had been in socially sustainable projects before. For those who believed that they had been involved in socially sustainable projects, none of those projects had sought any form of social sustainability certification.

3.3 Ranking the importance of the three pillars of sustainability

3.3.1 Individual ranking of the importance of the three pillars of sustainability

The interviewees were asked if they personally thought that environmental, economic and social sustainability are all equally as important. Most of the interviewees, 78% of them, thought that all of the pillars were equally as important because they are all connected and can help each other. However, the other 22% thought that social sustainability should be considered to be more important than the other two pillars due to the socio-economic context of South Africa since it is a developing nation.

3.3.2 Industry ranking of the three pillars of sustainability

All of the interviewees who were asked if they thought that the industry views all of the pillars as being equally as important did not think that the industry does. Ohene, Nani and Tetteh (2019) also posited that the focus in literature and in industry practice has not been equally distributed, but rather, environmental and economic sustainability have both had more emphasis than social sustainability, leaving social sustainability to be seen and treated as the least important pillar.

3.4 Growth of social sustainability in the built environment

The majority of the interviewees, 67%, thought that the same practices that led to the growth of environmental and economic sustainability could be used to grow social sustainability in the built environment. They attributed the growth of environmental and economic sustainability to practices such as marketing, public relations and education through university curriculums. However, 33% of the interviewees did not think that the same practices could be used for social sustainability to grow.
4. Discussion

Why social sustainability treated as the least important of the three pillars of sustainability. This study found that one of the main reasons which came up repeatedly during this research is the lack of a definition and understanding of what social sustainability means in the built environment. Currently, it is a very broad, vague and largely subjective concept (Almahmoud and Doloi, 2016: 35; Eizenberg and Jabareen, 2017: 2). This is a big obstacle in the industry because the lack of definition has resulted in the lack of implementation of social sustainability on a large scale, because people do not know what exactly it is or how to implement it. Those that do attempt to implement it do so based on their own subjective interpretations of it, which differ amongst individuals and organisations (Davidson, 2010 cited in Ghahramanpouri, Lamit and Sedaghatnia, 2013: 189).

Another reason why social sustainability has been treated as the least important pillar of sustainability is because of the competitive nature of the built environment. It is a profit-driven industry which is driven by tight profit margins and deadlines. These margins are influenced by a variety of factors, and at times contractors lower their margins in an effort to get more work (Bilal and Oyedele, 2020: 2), thus overlooking social aspects on projects. In addition, the fact that it is difficult to place numerical or monetary value, and to measure social sustainability also add to why it is treated as the least important pillar of sustainability. Most organisations deal with measurable items, be it numerical or monetary measurements, and this is difficult to do with social sustainability. This agrees with work done by Almahmoud and Doloi, (2016: 37) as well as Boström (2012: 6) who state that social sustainability’s difficulty to evaluate and incorporate into projects as one of the reasons why it is not often included in projects. It is difficult to quantify and objectively measure it as there are no tools to do so. Furthermore, the lack of industry assessment bodies or tools which focus on social sustainability was found to be one of the reasons why social sustainability is treated as the least important pillar of sustainability. It is currently largely voluntary to implement social sustainability in projects. There is no council or system in place to monitor and safeguard it, and to make sure that it is being implemented, and that it is being implemented correctly. As a result, it is not taken seriously or prioritised in the built environment, and as such, there is a common call for local participation and empowerment in social sustainability’s accreditation and certification (Boström, 2012: 11) in order for it to be prioritised. In addition, the socio-economic and socio-cultural climate is also a reason why social sustainability is not prioritised. Socio-economic problems such as a lack of financial and human capacity, lack of awareness, lack of community spirit, gender gap and political influence can affect the willingness and capacity that people have to guarantee a deliberative participatory process (Zuhair and Kurian, 2016: 137). One such socio-cultural problem due to previous political influence is that of the apartheid legacy which was highlighted by Interviewee D. In their response, Interviewee D posited that the mindset that racial segregation caused influenced and continues to influence how social sustainability and social issues are viewed. Although apartheid ended over two decades ago, the economic, social, and cultural effects of apartheid are still evident in South Africa today (Fogel, 2019: online; Adama, 2021: online).

Thus, social sustainability is treated as the least important pillar of sustainability because of its lack of a universal definition and understanding, the competitive nature of the built environment, the fact that social sustainability cannot easily be numerically or monetarily valued or measured, the socio-economic and socio-cultural climate, and because there are no industry assessment bodies or tools for it.

What project managers understand social sustainability to mean in the context of the built environment. Some project managers view social sustainability as employers taking care of their employees and prioritising their wellbeing. This can be through fair labour practices, paying employees well, having employees with a good work-life balance, not overworking employees, providing sufficient leave days for employees, focusing on the overall wellbeing of employees, the health and safety of employees on site, and taking into consideration the staff happiness factor. This is for all employees of the built environment, whether blue collar or white collar. This agrees with Boström (2012: 7) who state that workers’ rights are a part of social sustainability. Gan et al. (2017: 429) also agree with this perspective as they emphasise the importance of adequate compensation as well as prioritising health and safety of workers throughout the process.

Other project managers interpret social sustainability to mean providing communities with social infrastructure to improve their quality of life. These findings agree with Ayodele and Ogunlola (2016: 140) who in their research found that socially sustainable communities are those that provide their residents with local infrastructure, services and social amenities. The provision of social infrastructure
is more than just about the infrastructure itself, but rather what that infrastructure does and provides. The provision of infrastructure leads to the provision of access to items such as housing, water, medication, food (Vallance, Perkins and Dixon, 2011: 343-344) and also increases social equity, equality of condition, quality of life and the distribution of resources within society (Dempsey et al., 2011: 292-297; Eizenberg and Jabareen, 2017: 11; Shirazi and Keivani, 2017: 1537). Social infrastructure also provides some social justice and social welfare (Boström, 2012: 7) which lead to the satisfaction of the human needs (Ghahramanpour, Lamit, and Sedaghatnia, 2013: 188).

To other professionals, social sustainability means upskilling and uplifting communities where projects are taking place. This can be in the form of employing, educating and upskilling local people, providing business opportunities for and conducting business with local businesses, providing financial assistance, and generating income within the community. The skills and business gained from this help the community during the project, and also long after the project is complete. This interpretation of social sustainability was the most prevalent one in this study. Therefore employment, education, skills development, empowerment, and participation are factors of social sustainability that are outlined by Vallance, Perkins and Dixon (2011: 343-344) as well as by (Colantonio et al., 2009: 4).

Furthermore, some project managers find that social sustainability can also mean respecting the culture, traditions and not displacing people in areas where projects take place, thereby agreeing with Zuo, Jin and Flynn (2012: 59) as well as Vallance, Perkins and Dixon (2011: 345) who highlight the importance of respecting the culture and way of life of the current community and not uprooting that which is. It means enhancing the way of life for the local residents and having projects that benefit the local community as a whole- and not just the developer or end users of the development (Sierra-Varela, Yepes and Pellicer, 2018: 2).

How project managers view social sustainability’s importance as a pillar of sustainability in comparison to environmental and economic sustainability the study found that individually, most project managers personally think social sustainability is equally as important as environmental sustainability and economic sustainability. They found that these three pillars have a knock-on effect with each other as they all need to coexist in projects in order for true sustainability to be achieved. This is in agreement with work done by Zuo, Jin and Flynn (2012: 52). The study also found that a few project managers consider social sustainability to be more important than the other two pillars in the South African context due to the socio-economic situation in the country. This is in agreement with (Almahmoud and Doloi, 2016: 36) who discuss the need for developing countries to primarily place focus on the socio-economic issues as opposed to environmental issues in the development of modern projects.

However, this sentiment that the project managers have in their personal capacity is not reflected in the industry as a whole. The collective built environment’s actions and approach to social sustainability do not reflect the individual project managers’ perceptions of it as the industry generally focuses on environmental sustainability and economic sustainability at the expense of social sustainability and there is a trade-off (Parra, 2013: 149).

Can the practices that have led to the growth in environmental and economic sustainability in the built environment also be used to grow social sustainability? Based on the majority responses in this study, it is believed that the practices that led to the growth of environmental sustainability and economic sustainability can be used to grow social sustainability as well. It is highly recommended to include the education of social sustainability within the education system as students must first be educated and trained on social sustainability so that they can be equipped to implement and address it in future projects once they are working professionals (Valdes-Vasquez and Klotz, 2011: 189). Another way identified to grow social sustainability in the industry is to improve marketing around it. Organisations incorporating social sustainability into projects and marketing those projects as socially sustainable projects could help to increase consumer confidence in the organisation as many consumers have been found to feel better when they purchase products from organisations that are seen to be socially responsible (Toussaint, Cabanela and González-Alvarado, 2021: 2). These were the main ways that environmental sustainability and economic sustainability grew in popularity and implementation in the built environment, and as such, can be used to increase social sustainability as well.
5. CONCLUSION

Social sustainability is a sustainability pillar which is currently very vague, lacks clarity and is therefore open to interpretation on what exactly it means in the built environment. There are numerous ways which it can be understood and thus many organisations steer clear of it because they don’t quite know how or what the right way to implement it is. Other organisations who attempt to incorporate it into their projects do so based on their own subjective interpretations of it since there is no objective framework for it. This pillar is viewed as an equal to environmental and economic sustainability by most project managers in their personal capacities, however they do not think that the industry as a whole views social sustainability to be equally as important as the other two pillars. In fact, the collective industry treats it as the least important pillar. This study found that this treatment of social sustainability can be attributed to its lack of a universal definition and understanding, the competitive nature of the built environment, the fact that it cannot easily be numerically or monetarily valued or measured, the socio-economic and socio-cultural climate, and because there are no industry assessment bodies or tools for it. This therefore shows that although in theory all pillars hold equal importance, the reality of what happens in the industry does not reflect the theory.

6. RECOMMENDATIONS

More research needs to be done on the subject matter of social sustainability within the built environment in order for this topic to become more mainstream in academia and in the industry. There needs to be a definition, framework, guideline or standard practices established in the industry in order for there to be a universally understood meaning of what social sustainability means and looks like in the built environment. The establishment of an industry body which can advocate for social sustainability and can make assessment tools should be considered. Furthermore, social sustainability should be taught in more detail in the education curricula.

7. REFERENCES


Impact of Covid-19 on construction businesses and their associated business survival practices in Zambia

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ABSTRACT AND KEYWORDS

Purpose of this paper
The purpose of this study was to investigate the impact of the Covid-19 pandemic on construction business in Zambia and the business survival practices adopted by the companies in responding to the effects of the pandemic on business.

Design/methodology/approach
The study uses an ex-post facto design which is descriptive in nature. The study sample was conveniently drawn from construction professionals and contractors operating in the Zambian construction industry. The data was analysed using the relative importance index (RII) after an exploratory factor analysis (EFA) was performed to assess the factor structure of the study variable. Scale reliability was assessed using Cronbach alpha, item-total correlations, composite reliability and average variance extracted.

Findings
The results show that the Covid-19 pandemic led to project distress, a poor business environment, and financial distress for companies in the Zambian construction industry. In order to cope the effects of the pandemic, construction businesses resorted to reducing their operational costs, reduction of profit margins on bids, business development, strategic business management, exercising financial discipline, waste minimisation and financial prudence. Government assistance was the least used survival strategy.

Research limitations/implications
The study was exploratory in nature and so used scales which are not widely validated. Some of the study scales exhibited poor reliability. Also, the study used a small sample of 30 respondents. Therefore, the results need to be interpreted with caution and further studies are required to valid the findings from this study.

Keywords: Covid-19 impact, business survival practices, Zambian construction industry.
1.1 Introduction

The Covid-19 pandemic had a devastating impact on businesses globally. For example, the International Monetary Fund (IMF) projected annual global GDP growth to drop to 3% in 2020, while the Zambian economy was projected to contract by 2.6% in 2020 from the earlier projection of 3.6%. According to the business survey, report of the United Nations Development programme (2021), Covid-19 caused a number of challenges to enterprises, with the most significant challenges being loss of customers rated at 77.3% of the total responding enterprises. Other reported challenges include supply chain cuts at 37.7%, high commodity prices/material prices reported at 36.0% and problems with late payments at 32.3% among others which were also re-echoed by Bsisu (2020). These challenges affected operating revenue for enterprises (Bank of Zambia, 2021).

In order to deal with the impact of the pandemic on businesses, firm's adopted business survival practices. Survival practices are the fundamental links between corporate governance and firm performance (Adam and Alarifi, 2021). Survival practices are important to many parties in the community for they benefit from the enterprise's survival aside from its managers. These parties include workers, consumers, and suppliers (Jiang et al., 2021). Another importance is that exploring and documenting these strategies that successful small business owners use to succeed beyond 5 years within an unstable economic could potentially contribute to a reduced failure rate (Adam and Alarifi, 2021).

There is not much written about the survival skills of the business firms in Zambia during economic recession even when it is known that the small and medium firms from different industries including the construction sector share a huge chunk of Zambia’s Gross Domestic Products (GDP) and need to survive (Chappell, 2015). Much focus by a number of scholars is on the impacts of Covid-19, how much the businesses were affected and what areas were affected (Adam and Alarifi, 2021). In Zambia, there was little focus on studying how and what survival practices were adopted by the businesses to make it out through the economic recession caused by the Covid-19 pandemic. There is, therefore, a significant need to explore and expand the survival skills of the business firms in Zambia during the Covid-19 economic recession in preparation for the future unforeseen economic shocks.

This study therefore assessed the impact of the Covid-19 pandemic on construction businesses in Zambia and the business survival practices adopted by the companies in responding to the effects of the pandemic on business. An assessment of the impact of the pandemic on construction businesses and the survival practices adopted could inform measures aimed at dealing with any economic recessions which threaten the survival of companies in the future.

This paper is structure as follows. The following section discusses the impact of the Covid-19 pandemic on businesses and the survival strategies adopted to adapt to the impact of the pandemic. This is followed by the methods sections which explains the research design and approach used for the study. The results are then presented and discussed after which the conclusion is presented.

1.2 Covid-19 impact and survival strategies

1.2.1 Covid-19 impacts on business

The Covid-19 pandemic has had a devastating impact on businesses across the globe. Studies have shown that the Covid-19 outbreak reduced corporate revenues, which ultimately led to lower performance, implying that investment and income reduced (Bartik et al., 2020; Veselovská, 2020; Raoufi and Fayek, 2021). The pandemic has had a negative impact on the production, operation, and sales of these industries, which is eventually reflected in the negative return rate (Zamani et al., 2021). This obviously led to economic recess since the economic activities were no longer strong to support the economy.

Covid-19 impact restrictions imposed by the authorities reduced mobility causing many industries to shut down their business and resulted in job loss and the essential supplies like food and medical supplies that led to a socio-economic impact on each individual (Kapoor, 2020). The total lockdown caused by Covid-19 had severely curtailed economic activities such as project financing, labour, supply chain of materials and business management. There was a sharp decline in savings and investment; decline in the stock market activities, as some investors had pulled out their funds from the stock market.
due to high risks and uncertainties (Bartik et al., 2020). Covid-19 pandemic was unpredictable in terms of when it could be contained in order for businesses to become viable again.

The general consequences of economic recession were high interest rates, increased inflation, reduced consumer confidence, and reduced real wages (Davis et al., 1988; Ndulo et al., 2010; Mohsin et al., 2021; Paul et al., 2021). High interest rates limited the liquidity or the amount of money available to invest. Borrowing for investment become expensive due high interest rate and this lead to low investment in the economy.

The Covid-19 pandemic also had a damaging effect on supply chains. The Covid-19 pandemic is not the first disaster that abruptly damaged the supply chain. According to Veselovská (2020), Xu et al. (2020), Amoah and Simpeh (2021), Elali (2021), Sarkis (2021) and von Gaudecker et al. (2021) several other natural catastrophes such as the 2011 mega-earthquake in Japan, the 2003 severe respiratory syndrome (SARs) outbreak in China, and the 2004 tsunami in Indonesia had also led to shortages of various materials and products. However, based on scope and magnitude, the impacts of Covid-19 are different from all these previous events (Xu et al., 2020). During the pandemic, the situation drastically deteriorated by firstly shortage of construction material supply, which then affected the construction industry. Whereas Nicola et al. (2020) reported that the restrictions imposed by the authorities had reduced the mobility of people, causing many industries to shut down their businesses. Material delays that stalled overall project progress and triggered major schedule disruptions were experienced due to the social distancing and quarantining requirements that resulted in a smaller workforce within supply chain organizations. The delays were particularly evident when the supply chain included materials or raw materials from other countries (Fernandes, 2020). The Covid-19 crisis shocked supply chains. Amoah and Simpeh (2021) observed demand and supply ripples; chaos and resonance effects propagated across global networks.

1.2.2 Covid-19 impacts on construction business

The construction industry was equally devastated by the pandemic. It was observed by Nguyen et al. (2021) that the most impacting factors caused by Covid-19 pandemic economic recession on the construction businesses were the suspension of projects, labour impact and job loss, time overrun, cost overrun, and financial impact. Most of the firms operating in the construction industry faced such challenges during the Covid-19 pandemic economic recession. For instance, the Zambian government suspended the construction of projects, which were below 80% completion and only proceeded with the projects, which were 80% complete and above (Ministry of Commerce, 2020; Bank of Zambia, 2021).

Prominently, three factors came about during the review of the literature that caused financial problems during Covid-19 are late payment, project cost increase, and reduced projects (Amoah and Simpeh, 2021). These factors include late payment. Project payments are usually paid in phases. For government projects, payment will be made after the company claims the completed project’s work phase. According to Bartik et al. (2020) and Alsharef et al. (2021) the payment of claims made was delayed due to disrupted government operations during Covid-19 economic recession. Another factor was increased project costs, a few factors identified had increased the project cost, including the higher price of materials. The higher material price is caused by the changes in foreign exchange rates and the increased demand for supplies (Amoah and Simpeh, 2021; Paul et al., 2021). Thirdly, low cash flow, the pandemic curtailment measures inevitably led to the substantial deterioration of firm financing environment and substantial declines in firm financing capacities, which further exacerbated the risk of capital chain disruption (Jiang et al., 2021). Zamani et al. (2021) observed that many firms had insufficient cash inflows to cover their daily expenses, with some going into bankruptcy and liquidation, which then led to a general decline in the scale of firm investment.

Covid-19 caused loss of jobs around the world due to various factors. Some people were retrenched from their workplaces because their organizations were no longer having contracts, some organisation could not pay the workers and other factors. For example, approximately 620,000 people had been displaced from work as of April 28, 2020, in the UK (Byrne et al., 2020). These job losses came in waves, which coincided with increasing levels of government restrictions and public health guidelines. Following the spread of the virus, many countries started implementing several measures to reduce movement of people, and that has mainly obstructed the construction industry because it requires on-site work and every project member must be available to work, check, and monitor all the work activities
The construction industry, like many other industries, had been affected by the Covid-19 pandemic in many different aspects of its operations. A shortage of specialized labour and key-personnel on construction projects due to the spread of Covid-19 and the dynamic changes of the construction work environment are just some examples of the challenges that the industry faced (Byrne et al., 2020; von Gaudecker et al., 2021).

Lee et al. (2020) and Lemieux et al. (2020) argued that labour shortage was not a significant effect of business as the construction organizations implemented various procedures to mitigate the effects of the pandemic on their operations. Measures such as health screening of workers, providing additional personal protective equipment (PPE) to workers, disinfecting shared tools and equipment, upgrading site facilities, implementing physical distancing (or social distancing) procedures, and implementing remote working were used to keep workers in their workplaces and continue with business. For instance, Lemieux et al. (2020) stressed that the virtual environment was integrated into the construction activities as a “new normal” and there was more flexibility of working due to adaptation of these technological tools.

1.2.3 Survival practices adopted by companies

In order to cope with the pandemic, companies adopted different survival practices to avoid bankruptcy. Survival practices are rational actions of firms carried out to overcome negative operating environmental influences, and create firm performance (Aghimien et al., 2018). Lansley (1987) remarked that the survival practices of firms are the actions, which allow firms to weather economic storms. Generally, the survival practices were either financial, cost control, or contracting related in nature.

For financial related measures, the majority of the companies set aside contingency funds from their companies’ reserves. Some companies reserved at least three to six months of fixed operational costs (e.g., employees’ salaries and office expenses) to mitigate the lagged impact of the recession on the business operation (Devi et al., 2020; Elali, 2021). Strategies of some contractors opted for alternative loan services to finance their debts and to increase their working capital. This practice is in agreement with Giones et al. (2020) findings that borrowing money from banks to finance debts and increase working capital is common during a recession. The remaining companies, on the other hand, operate within their working capital and adopt the “wait-and-see” mode because they do not want to overstrain their debt obligation (Davis et al., 1988). The third most common financial-related practice is related to construction machineries and office equipment (Mbah et al., 2018).

According to Davis et al. (1988), Adegbenbo et al. (2020) and Jayalath and Gamage (2021), companies adopt the three following cost control/reduction measures. The measures include stricter site management to reduce material wastage, stricter financial management on the company’s cash flow and stricter procurement procedures. Firms recognised the need to assume a more active role in managing their project sites and the company’s cash flow and procurement procedures during the prolonged recession (Gemar et al., 2019; Zamani et al., 2021). Some of the practices adopted by the companies interviewed to curb material wastages include imposing wastage rates for construction materials on site, delegating responsibility of material inventory management to respective site managers, adopting the just-in-time delivery concept, implementing a profit-sharing scheme by rewarding employees for materials they save and implementing materials recycling programmes.

Construction companies took measures of bidding for more projects that are within their firms’ resources and capabilities and setting size limitation on projects undertaken at which the failure of one project would not endanger their firms’ operations (Alsharef et al., 2021). The other strategy among the companies is to enter into forward contracts with their suppliers and subcontractors (e.g., concrete and reinforcement bars suppliers) to protect the firm against cost escalation during the economic recession period (Mwiinga et al., 2020). With fewer projects available during the economic recession, the fierce competition in the construction market is obvious; hence, companies strategize by bidding for projects with tiny or zero profit margins. Their objective is to win some projects that enable them to maintain cash flow and to keep their employees. This practice agrees with the findings of Salamon et al. (2009) and Mathias et al. (2017) that the bid pricing strategy of submitting a lower bid price with tiny or zero profit margins is common during recession periods.
2. RESEARCH METHODS

2.1 Research design

The study used a descriptive cross-sectional quantitative survey to assess the impact of the Covid-19 pandemic on construction businesses in Zambia and the business survival practices adopted by the companies in responding to the effects of the pandemic on business. This method was preferred because the study is exploratory in nature and so a descriptive approach was appropriate.

2.2 Sample and data collection

Owing to the difficulty of compiling a sampling frame for probability sampling, non-probability sampling was used. Convenience sampling was the preferred sampling approach because it provided a feasible means of sampling considering the limitations of time and cost allocated for the study. The study participants were therefore selected based on their availability to respond to the questionnaire. The researcher identified the participants by visiting construction and consultancy firms based on ease of access to their premises.

2.3 Instrument design

The survey instrument items were adopted from literature phrased to suit the local context. Table 4 and 5 show the items that were included in the questionnaire. The statements reflect the Covid-19 pandemic effect on businesses and the survival practices adopted based on the literature review. Respondents were asked to rate the extent to which they agreed with each of the statements using a five-point Likert scale (1 = disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree). The five-point Likert scale was adopted because of its ability to provide results that are unambiguous and easy to interpret (Ekanayake & Ofori, 2004).

2.4 Procedures

A literature review was conducted to identify Covid-19 pandemic effects on businesses and the survival practices which were adopted by companies in dealing with the effect of the pandemic. The identified factors were made into phrases which respondents could respond to on a five-point Likert scale. There were a total of eight items measuring the Covid-19 effect on the construction businesses and 22 items measuring the adopted survival practices. The questionnaire was administered to construction professionals (quantity surveyors, construction managers, architects, contractors, and construction suppliers) in the construction industry in Zambia based on convenience sampling. A total of 58 completed questionnaires were retained.

2.5 Results and discussion

The data was first subjected to exploratory factor analysis (EFA) in order to establish the factors into which the Covid-19 impacts, and the survival practices adopted clustered into. The relative importance index (RII) was then used to establish the relative importance of the items in each cluster. Descriptive and reliability statistics were also computed for the items in each cluster. Results of the EFA, descriptive, and reliability statistics are shown in Table 3. Scales reliability was assessed using the Cronbach’s alpha, item-correlations, composite reliability (CR), and average variance extracted (AVE).

Prior to these analyses, the Kaiser-Meyer-Olkin measure of sampling adequacy and the Bartlett’s Test of Sphericity were computed to assess the suitability of the data for the EFA. According to Hair et al. (2010), data is suitable for EFA if the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is above 0.70 and the Bartlett’s Test of Sphericity (BTS) is significant (p < .05) and all communalities are above 0.30. The results of the KMO and the Bartlett’s test are shown in tables 1 and 2. The KMO for both constructs were below the recommended threshold of 0.70 but the Bartlett’s test met the acceptance criteria (p < .05). This means that the sample is not completely sufficient for the EFA and so the results have a limitation and should be interpreted with caution.
The results of the EFA, descriptive, and reliability statistics are shown in Table 3. The EFA results show that Covid-19 effect on construction businesses factored into three factors namely, financial distress (FD), project distress (PD), and a poor business environment (PBE). The adopted business survival practices factored into eight factors namely, business development (BD), exercise financial discipline (EFD), strategic business development (SBD), financial prudence (FP), reduce operating costs (ROC), waste minimisation (WM), profit reduction (PR), and government assistance (GA). The reliability statistics for the factors for Covid-19 effect on business show that FD exhibits a poor Cronbach’s alpha but acceptable composite reliability (CR) and average variance extracted (AVE) while PD was poor on all three reliability statistics. PBE on the other hand exhibited very good reliability scores. For the adopted business survival practices, BD exhibited good Cronbach’s alpha but poor CR and AVE while EFD and SBD exhibited poor Cronbach’s alpha but good CR and AVE. FP was poor on all three reliability statistics. ROC, WM, and PR exhibited poor Cronbach’s alpha but acceptable CR and AVE. GA exhibited very good reliability scores on all measures. The scales therefore exhibit very mixed reliability results with some scales lacking reliability. The results therefore have limitations in terms of scales reliability and should be interpreted with caution.

### Table 3: EFA, descriptive and reliability statistics

<table>
<thead>
<tr>
<th>Research Constructs</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Cronbach’s Alpha</th>
<th>Item-correlations Factor Loadings</th>
<th>CR</th>
<th>AVE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial distress (FD)</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1 FD1</td>
<td>3.433</td>
<td>0.728</td>
<td>0.146</td>
<td>0.079</td>
<td>0.709</td>
<td>0.67</td>
</tr>
<tr>
<td>2 FD2</td>
<td>2.600</td>
<td>0.724</td>
<td></td>
<td>0.079</td>
<td>0.705</td>
<td></td>
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<tr>
<td><strong>Project distress (PD)</strong></td>
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</tr>
<tr>
<td>1 PD1</td>
<td>4.033</td>
<td>0.899</td>
<td>0.422</td>
<td>0.199</td>
<td>0.743</td>
<td>0.61</td>
</tr>
<tr>
<td>2 PD2</td>
<td>4.000</td>
<td>0.685</td>
<td></td>
<td>0.423</td>
<td>0.658</td>
<td></td>
</tr>
<tr>
<td>3 PD3</td>
<td>3.233</td>
<td>1.135</td>
<td></td>
<td>0.263</td>
<td>0.630</td>
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<tr>
<td><strong>Poor business environment (PBE)</strong></td>
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</tr>
<tr>
<td>1 PBE1</td>
<td>4.367</td>
<td>0.490</td>
<td>0.731</td>
<td>0.676</td>
<td>0.824</td>
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<td>2 PBE2</td>
<td>4.000</td>
<td>0.685</td>
<td></td>
<td>0.477</td>
<td>0.619</td>
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<tr>
<td>3 PBE3</td>
<td>1.667</td>
<td>0.959</td>
<td></td>
<td>0.672</td>
<td>0.917</td>
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<tr>
<td><strong>Adopted business survival practices</strong></td>
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<tr>
<td><strong>Business development (BD)</strong></td>
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<td>1 BD1</td>
<td>4.167</td>
<td>0.592</td>
<td>0.704</td>
<td>0.514</td>
<td>0.705</td>
<td>0.61</td>
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<tr>
<td>2 BD2</td>
<td>3.300</td>
<td>1.055</td>
<td></td>
<td>0.694</td>
<td>0.806</td>
<td></td>
</tr>
<tr>
<td>3 BD3</td>
<td>3.233</td>
<td>0.971</td>
<td></td>
<td>0.334</td>
<td>0.545</td>
<td></td>
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<tr>
<td>4 BD4</td>
<td>4.167</td>
<td>0.986</td>
<td></td>
<td>0.507</td>
<td>0.634</td>
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<td><strong>Exercise financial discipline (EFD)</strong></td>
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<td>4.461</td>
<td>0.776</td>
<td>0.593</td>
<td>0.427</td>
<td>0.716</td>
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<td>0.427</td>
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<td><strong>Strategic business management (SBM)</strong></td>
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<td>1 SBM1</td>
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<td>0.609</td>
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<td>2 SBM2</td>
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<td>0.695</td>
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<td>0.564</td>
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<td>3 SBM3</td>
<td>3.233</td>
<td>7.224</td>
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<td>0.547</td>
<td>0.794</td>
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<td><strong>Financial prudence (FP)</strong></td>
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<tr>
<td>1 FP1</td>
<td>1.333</td>
<td>0.547</td>
<td>0.593</td>
<td>0.391</td>
<td>0.746</td>
<td>0.50</td>
</tr>
<tr>
<td>Research Constructs</td>
<td>Mean</td>
<td>Std. Dev</td>
<td>Cronbach’s Alpha</td>
<td>Item-correlations</td>
<td>Factor Loadings</td>
<td>CR</td>
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<tr>
<td>Covid-19 effect on construction businesses</td>
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<td></td>
</tr>
<tr>
<td>2 FP2</td>
<td>2.400</td>
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<td>3 FP3</td>
<td>3.033</td>
<td>0.999</td>
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<tr>
<td>4 FP4</td>
<td>3.233</td>
<td>0.568</td>
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<td>Reduce operation cost (ROC)</td>
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<td>1 ROC1</td>
<td>4.200</td>
<td>0.551</td>
<td>0.535</td>
<td>0.404</td>
<td>0.841</td>
<td>0.84</td>
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<td>2 ROC2</td>
<td>3.067</td>
<td>0.868</td>
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<td>0.404</td>
<td>0.774</td>
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<td>Waste minimisation (WM)</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 WM1</td>
<td>2.967</td>
<td>1.351</td>
<td>0.593</td>
<td>0.344</td>
<td>0.566</td>
<td>0.73</td>
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<tr>
<td>2 WM2</td>
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<td>0.907</td>
<td></td>
<td>0.604</td>
<td>0.832</td>
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<td>3 WM3</td>
<td>3.500</td>
<td>0.938</td>
<td></td>
<td>0.332</td>
<td>0.806</td>
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<td>Profit reduction (PR)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1 PR1</td>
<td>4.300</td>
<td>0.651</td>
<td>0.471</td>
<td>0.320</td>
<td>0.609</td>
<td>0.76</td>
</tr>
<tr>
<td>2 PR2</td>
<td>2.867</td>
<td>0.860</td>
<td></td>
<td>0.320</td>
<td>0.886</td>
<td></td>
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<tr>
<td>Government assistance (GA)</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>1 GA1</td>
<td>1.900</td>
<td>0.845</td>
<td>0.748</td>
<td>0.623</td>
<td>-0.781</td>
<td>0.83</td>
</tr>
<tr>
<td>2 GA2</td>
<td>1.533</td>
<td>0.629</td>
<td></td>
<td>0.623</td>
<td>-0.820</td>
<td></td>
</tr>
</tbody>
</table>

After assessing the reliability of the scales, the relative importance index (RII) was used to assess the most important items within each factor. The RII was calculated using the formula:

\[ RII = \sum \frac{W_A N}{N} \]  

where W is the weight assigned to each questionnaire item by the respondent on a scale of one to five. “A” is the highest weight in the scale (i.e., 5 in our case) and N is the total number of the sample (Holt, 2014). The relative importance indexes were calculated for each variable and the overall rankings were established for each variable as well as within each cluster derived from EFA. The RII scores were sorted in descending order from the highest to the lowest. The five important levels were deduced from the RII scores and interpreted as low (L) (0.0_RII _ 0.2), medium-low (M-L) (0.2_RII _ 0.4), medium (M) (0.4_RII _ 0.6), high-medium (H-M) (0.6_RII _ 0.8) and high (H) (0.8_RII _ 1) (Ahmed et al., 2020).

Table 4 shows the ranking of the Covid-19 effects on construction businesses in Zambia. Based on average rankings for each of the clusters, project distress was the highest ranked effect on construction businesses followed by a poor business environment and lastly financial distress. This means that the biggest effect on construction businesses was at the project level.

The individual items with the highest importance level were disruption to the projects which led to delayed project completion and followed by increased project costs. The pandemic also led to limited funding of projects which subsequently led to low cash flows for the construction businesses. This is line with findings that project financing was curtailed by the pandemic (Kapoor, 2020; Bartik et al., 2020) and that some projects were suspended (Nguyen et al., 2021). The individual items which were ranked as least important are losing of skilled workers, failure to pay employees, and shortage of building materials. The low ranking of shortage of materials is in contrast to studies which found that there were shortages of materials while that for losing skilled workers resonates with findings which suggested that labour shortages were not a significant effect of the pandemic (Lee et al., 2020; Lemieux et al., 2020).
Table 4: Covid-19 effect on construction businesses

<table>
<thead>
<tr>
<th>Financial distress (FD)</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Covid-19 pandemic led to the scaling down/partial closure of your business</td>
<td>0.687</td>
<td>1</td>
<td>H-M</td>
</tr>
<tr>
<td>2 One of the Covid-19 pandemic impacts was failure to pay the employees.</td>
<td>0.520</td>
<td>2</td>
<td>M</td>
</tr>
<tr>
<td><strong>Average RII</strong></td>
<td><strong>0.604</strong></td>
<td><strong>1</strong></td>
<td><strong>H-M</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Project Distress (PD)</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Covid-19 outbreak led to increased project cost</td>
<td>0.807</td>
<td>2</td>
<td>H</td>
</tr>
<tr>
<td>2 Disruption of projects due to Covid-19 outbreak led to delayed payments on projects</td>
<td>0.913</td>
<td>1</td>
<td>H</td>
</tr>
<tr>
<td>3 There was shortage of construction materials during Covid-19 lockdowns.</td>
<td>0.647</td>
<td>3</td>
<td>H-M</td>
</tr>
<tr>
<td><strong>Average RII</strong></td>
<td><strong>0.789</strong></td>
<td><strong>H-M</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Poor business environment (PBE)</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 There was limited funding for projects during Covid-19 pandemic outbreak</td>
<td>0.873</td>
<td>1</td>
<td>H</td>
</tr>
<tr>
<td>2 Because of Covid-19 impacts, the firm had low cash flow for its expenses.</td>
<td>0.800</td>
<td>2</td>
<td>H</td>
</tr>
<tr>
<td>3 The firm lost skilled employees due to Covid-19 pandemic.</td>
<td>0.333</td>
<td>3</td>
<td>M-L</td>
</tr>
<tr>
<td><strong>Average RII</strong></td>
<td><strong>0.671</strong></td>
<td><strong>H-M</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 5 shows the ranking of the adopted business survival practices by construction businesses in responding to the Covid-19 pandemic in Zambia. Based on the average ranking of the clusters in descending order was as follows; reducing operating costs (ROC), profit reduction (PR), business development (BD), strategic business management (SBM) all of which had an average RII above 0.60 and meaning that they were high medium to high in relative importance. Those that fell below 0.60 RII were exercising financial discipline (EFD), waste minimisation (WM), and financial prudence (FP). Government assistance (GA) was the lowest ranked factor.

The individual items ranked as the highest adopted business survival practices were monitoring of cash flows and operating through technology. This is in tandem with findings that some companies resorted to strict cost control on construction sites (Jayalath and Gamage, 2021). Others were digital working from home, and bidding for more projects. These measures resonate with findings that there was a wide scale transition to virtual working (Lemieux et al., 2020) and that low bids are common during periods of recession (Salamon et al., 2009; Mathias et al., 2017). These four items were ranked above 0.80 RII which means that they were very highly ranked. The lowest ranked items were getting government assistance, getting a loan, and selling equipment. This is in contrast to studies which reported that companies acquired loans to meet their cash deficits (Giones et al., 2020).
Table 5: Adopted business survival practices

<table>
<thead>
<tr>
<th>Business development (BD)</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 The company had to bid for more projects to secure its job market during Covid-19 pandemic.</td>
<td>0.833</td>
<td>1</td>
<td>H</td>
</tr>
<tr>
<td>2 The company put aside contingency sums during Covid-19 pandemic outbreak for its expenses for a minimum of 6 months.</td>
<td>0.660</td>
<td>2</td>
<td>H-M</td>
</tr>
<tr>
<td>3 The company sold the equipment and machines to make it through an economic recession caused by Covid-19 pandemic.</td>
<td>0.367</td>
<td>4</td>
<td>M-L</td>
</tr>
<tr>
<td>4 The firm signed security agreements with financial institutions</td>
<td>0.647</td>
<td>3</td>
<td>H-M</td>
</tr>
<tr>
<td>Average RII</td>
<td>0.625</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exercising financial discipline (EFD)</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 The company acquired a loan to boost the capital during Covid-19 pandemic and secure its existence in the business.</td>
<td>0.307</td>
<td>2</td>
<td>M-L</td>
</tr>
<tr>
<td>2 The firm established project milestone monitoring system to monitor cash flow at each milestone of a project.</td>
<td>0.860</td>
<td>1</td>
<td>H</td>
</tr>
<tr>
<td>Average RII</td>
<td>0.584</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Strategic business management (SBM)</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 The firm postponed debt servicing by agreeing with the creditors to allow the business to thrive.</td>
<td>0.647</td>
<td>1</td>
<td>H-M</td>
</tr>
<tr>
<td>2 One of the survival initiatives that your company took to survive during Covid-19 pandemic was diversifying into other businesses.</td>
<td>0.587</td>
<td>3</td>
<td>M</td>
</tr>
<tr>
<td>3 The company signed a series of contracts in advance with the suppliers to remain competitive during Covid-19 pandemic.</td>
<td>0.600</td>
<td>2</td>
<td>M</td>
</tr>
<tr>
<td>Average RII</td>
<td>0.611</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Financial prudence (FP)</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 The company acquired government assistance to boost the capital and remain competitive during Covid-19 pandemic.</td>
<td>0.267</td>
<td>4</td>
<td>M-L</td>
</tr>
<tr>
<td>2 The company slashed the employees’ salaries during Covid-19 pandemic to minimise its expenses and channel resources into capital boost.</td>
<td>0.480</td>
<td>3</td>
<td>M</td>
</tr>
<tr>
<td>3 The firm made financial investments in other sectors e.g. Real estates, bonds, forex, etc.</td>
<td>0.607</td>
<td>2</td>
<td>H-M</td>
</tr>
<tr>
<td>4 The firm implemented a day’s sales outstanding (DSO) matrix system to measure efficiency of a firm in converting receivables into cash.</td>
<td>0.647</td>
<td>1</td>
<td>H-M</td>
</tr>
<tr>
<td>Average RII</td>
<td>0.500</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reduce operation cost (ROC)</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Your company changed the way of running your business to digital work culture during Covid-19 pandemic. E.g., making use of electronic/digital strategies, working from home, etc.</td>
<td>0.840</td>
<td>1</td>
<td>H</td>
</tr>
<tr>
<td>2 The firm implemented a 3 to 6 months fixed operational cost for its expenses.</td>
<td>0.613</td>
<td>2</td>
<td>H-M</td>
</tr>
<tr>
<td>Average RII</td>
<td>0.727</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Waste minimisation (WM)</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 The company implemented a strict waste management policy on site to minimise material wastage during Covid-19 pandemic.</td>
<td>0.593</td>
<td>1</td>
<td>M</td>
</tr>
<tr>
<td>2 The company implemented a profit-sharing scheme for employees when they save materials on site during Covid-19 pandemic.</td>
<td>0.587</td>
<td>2</td>
<td>M</td>
</tr>
<tr>
<td>3 The firm went into ‘wait and see’ mode to observe the situation before any adjustments to business operations.</td>
<td>0.500</td>
<td>3</td>
<td>M</td>
</tr>
<tr>
<td>Average RII</td>
<td>0.560</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Profit reduction (RP)</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 The firm developed new ways of operation through technology, e.g., working from home.</td>
<td>0.860</td>
<td>1</td>
<td>H</td>
</tr>
<tr>
<td>2 The firm developed a strategy of bidding for projects with zero to tiny profits to secure its existence in business.</td>
<td>0.573</td>
<td>2</td>
<td>M</td>
</tr>
<tr>
<td>Average RII</td>
<td>0.717</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Government assistance (GA) |   |   |   |
1 The government offered financial assistance to the Zambian businesses during the Covid-19 pandemic. GA1 0.380 1 ML
2 Your company had access to the financial assistance for businesses provided by the government. GA2 0.307 2 ML

Average RII 0.344 ML

3. Conclusion

This study assessed the impact of the Covid-19 pandemic on construction businesses in Zambia and the business survival practices adopted by the companies in responding to the effects of the pandemic on business. The results show that project distress was the highest ranked effect on construction businesses followed by a poor business environment and lastly financial distress for the companies. Specifically, disruption to the projects led to delayed project completion and increased project costs. The pandemic also led to limited funding of projects which subsequently led to low cash flows for the construction businesses. In response to the effects of the pandemic, construction business adopted several survival mechanisms including reducing operating costs, profit reduction, business development, and strategic business management. The most frequently adopted strategies were strict monitoring of cash flows and operating through technology. Contrary to findings from other studies, construction businesses in Zambia did not rely much on government support or loans. The study contributes to the discourse on measures which can be adopted to deal with economic recession by construction businesses.

These findings need to be interpreted with caution as they have some limitations. Firstly, some of the study scales had poor reliability and so further studies are required to validate these findings. Secondly, the study was exploratory in nature and relied on a small sample size. Future studies could assess the SCM practices with a much larger sample size in order to validate these findings.

4. References


Identifying Key Barriers Impeding Circular Built Environment Transition in Africa: An Exploratory Factor Analysis

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ABSTRACT

Purpose of this paper
This paper seeks to identify the key barriers hindering circular built environment (CBE) transition in Africa.

Design/methodology/approach
An exploratory factor analysis (EFA) was performed to reveal the factor structure underlying what the construction stakeholders and circular economy (CE) experts consider as the key impediments towards CBE transition. Assumptions of sample adequacy (KMO = 0.885) and sphericity (Bartlett’s test of sphericity =p<0.001) were fulfilled. The principal axis factoring extraction method coupled with the varimax rotation was employed. The number of key barriers were extracted using both the eigenvalues above 1 and visual inspection of the Scree plot.

Findings
The results of a pilot study (which included 14 countries) show that the key barriers include: implementation and regulations, client demand, supply chain, environmental, technological, and knowledge and information. Moreover, the CE initiatives are still immature in Africa, as evidenced by the prevalence of implementation related barriers.

Research limitations/implications
Data was obtained from a pilot study that consisted of 14 African countries, out of a total of 54 involved in the survey. Therefore, the barriers identified should be treated as indicative and not prescriptive.

What is original/value of paper
The paper highlights the key barriers impeding the Circular Built Environment transition in Africa. The outcomes of this paper can be used by policymakers, academics and industry practitioners to facilitate a CBE transition within Africa.

Keywords: Barriers, Circular Built Environment, Circular Economy, Africa, Exploratory Factor Analysis
1. INTRODUCTION

The construction sector is one of the leading consumers of natural resources. Besides resource consumption, the sector also infamously generates considerable amount of waste. Globally, the construction sector consumes between 40-50% of raw materials (Seyis, 2020), emits 25% carbon dioxide (Mahpour, 2018) and material wastage during construction accounts for 10-15%, whereas 54% of the demolition waste is dumped in landfills (Eberhardt et al., 2021). However, according to the Africa Waste Management Outlook, in Africa, an astonishing 90% of the waste is dumped in landfills (United Nations Environment Programme, 2018). Arguably, it appears that the most prevalent waste generation practices are encountered during both the construction and demolition (C&D) phases. To that end, circular economy (CE) solutions such as design for deconstruction/disassembly, design out of waste, low carbon materials, adaptive reuse, shared ownership, product as a service among others are contemporary topics in the sector (Gibberd, 2020; Cimen, 2021; Kirchherr et al., 2017). One may appropriately argue that CE practices should concentrate more on the design stage for possible adoption of innovative designs and material choices instead of trying to address the waste generated during C&D phases. Nevertheless, considering that the sector is currently dominated by linear practices of extract—use—dispose, closing the loop to enable the extracted materials to retain their usefulness as long as possible could be a more feasible option.

Moreover, the construction sector is one of the most conservative sectors when it comes to adopting new concepts and technologies (Gomaa et al., 2022). Primarily, that potentially sets the tone for inexhaustible endemic barriers that deter transforming the built environment towards a circular built environment. CE is a relatively new concept that is attributed to Pearce and Turner (Pearce & Turner, 1990). Contextually, a circular built environment (CBE) can be defined as a developmental system that is designed and built-in accordance to the three circular economy objectives enunciated by the Ellen MacArthur Foundation (2013) namely reducing waste and pollution, elongating the useful life of existing material stocks and adopting regenerative systems (i.e., materials that can easily be decomposed after use). Basically, the CBE can be considered an end-product of responsible resource consumption and production in the construction sector. On the other hand, a barrier can be viewed as any impediment, obstruction, obstacle or hindrance either systemic or otherwise that limits potential implementation of a desired practice. Consequently, in the construction sector, barriers are stumbling blocks that hinder the application of industry-wide best practices. Several scholars have explored diverse barriers that restrict the construction industry contributing to a circular built environment. These barriers can be categorised mainly into institutional, market, financial, regulatory, technological, socio-economic, and environmental barriers (Giorgi et al., 2022; Mahpour, 2018; Bilal et al., 2020; Oluleye et al., 2022; Yu et al., 2022).

Nonetheless, to date, to the knowledge of the researchers these barriers have not been explored exclusively to the African construction industry. This presents a significant gap considering that the African context is unique and to some extent barriers that are affecting the Global North might not apply or vice versa. To fill this gap, this study seeks to investigate the dominant barriers that hinder a transition towards CBE in the existing literature and to validate them among African construction stakeholders and CE experts. A factor analysis was applied to elicit the contextual barriers that are perceived to significantly hinder the African circular built environment.

2. LITERATURE REVIEW

Lately, circularity in the built environment has become a “hot topic”. It has resulted in an exponential growth of studies in the area. Ranked among the highly touted facets of this concept by both the academics and policymakers alike, is the theme of CBE barriers. These barriers determine the extent to which the concept could potentially transform the built environment. Resultantly, scholars have explored barriers of CBE across the globe at great lengths (Mishra et al., 2022; Yuan, 2017; Bilal et al., 2020; Giorgi et al., 2022; Liu et al., 2021). Nonetheless, although some of the barriers are seemingly cross-cutting, it appears there are situations whereby some barriers are unique to the level of development. The primary barrier that seems prevalent is the lack of CE policies (Yu et al., 2022). However, Smol et al. (2015) and Akinade et al. (2020) argue that even in some countries where policies are available, the governments seem reluctant to either implement or enforce them. Policy inconsistency and reluctance in particularly endemic in Africa. Yu et al. (2022) add that lack of
interdisciplinary stakeholder engagement significantly hinders policy implementation. Apart from the policies, it seems lack of circularity education and awareness is problematic in fostering CBE. Liu et al. (2021) agree with this supposition. Nonetheless, it suffices to say that it would be potentially interesting to identify barriers as observed in different regions of the world.

A study conducted the European Union (EU) by Smol et al. (2015) identified disjointed value chains, limited CE business models, consumer perception of waste as a resource as the thorny issues. Additionally, Kirchherr et al. (2018) explored barriers in Belgium, Germany, the Netherlands, Portugal, Sweden and the United Kingdom (UK). The authors categorised the prevalent barriers into four groups, cultural, regulatory, market and technological.

Arguably, it appears that although these developed countries are considered technologically advanced, the construction sector still faces technological barriers. By and large, Africa is usually associated with being a technological laggard, yet Kirchherr et al. (2018) prove that even the construction sector in the developed countries face the similar challenge. To buttress the technology barrier, Ratnasabapathy et al. (2021) lamented the of technology for effective waste trade, lack of waste data reporting system in Australia. Inadequate secondary materials markets pose a threat to the circularity drive in the construction industry (Charef et al., 2021).

Giorgi et al. (2022) explored the construction sector in Belgium, Netherlands, UK, Denmark, and Italy and concluded that the key barriers include design for deconstruction or disassembly practices dominated by the private companies, market competition, and lack lifecycle management systems to assess the environmental impact of circularity. Charef et al. (2021) postulate that high cost of hazardous waste treatments, and storage of reclaimed materials poses as an obstacle. After reclaiming materials, the company would store the material for use in the next project of which at times it might not be guaranteed that the materials will be required. It can be deduced that failure to measure the benefits of circularity hinders CBE transition.

In China, Huang et al. (2018) identified the lack of building design standards and codes for reducing waste, low cost for disposal, limited reuse of construction waste, limited waste management, lack of standards for construction waste reuse, immature recycling technology, and immature recycling market. The barriers related to CE immaturity are thought-provoking considering that China was one of the early adopters of CE. Mahpour (2018) identified agency and ownership issues in C&D waste management, lack of integration of sustainable C&D waste management, and uncertain future when one transitions towards circular economy as the priority barriers in Iran. It is evident that protectionism of the current status quo fuels the failure to adapt limits the construction sector. It is human nature to maintain their comfort zone particularly if the perceived benefits seem unmotivating. Huang et al. (2018) augmented this observation through identifying company hesitancy and lack of government incentives as other critical obstacles. When companies are hesitant, this will naturally transfer to the clients they serve as well. Charef et al. (2021) add that lack of client demand hinders CE transition. That being said, it appears that majority of construction sector practitioners would rather maintain conventional methods rather than adopt new ideas presented by the CE.

In the context of developing countries, Bilal et al. (2020) identified 12 prevalent barriers, chief among them is a lack of environmental regulations and laws is driving the rest of the barriers to the circular economy, the lack of public awareness and support from public institutions. Specifically in Africa, UNEP (2018) observed weak legislation and enforcement, unsupportive policy. In India, Mishra et al. (2022) developed a scale instrument using EFA and CFA among small to medium enterprises hindering CE practices. The study outlined 95 barriers categorised into seven groups including culture, knowledge and skills, government and regulations, market demand and finance. Additionally, Gibberd (2020) and Rademaekers et al. (2020) identified several barriers applicable to Africa namely lack of capital costs, lack of operational costs, lack of awareness among designers, limited regulations and standards on construction waste and pollution, lack renovation skills, and failure to support local material suppliers. In the same vein, Akinade et al. (2020) identified 26 as that hinder the use design of deconstruction (DfD) as a CE approach. From the study, authors categorised the 26 barriers into five groups, mainly related to a lack of regulations, devoid information during designing, limited market for recovered materials, difficulties in crafting DfD business case and insufficient DfD tools. Irrespective of the
geographical location, it appears that CBE faces significant barriers (Menegaki & Damigos, 2018; Chen et al., 2022; Bertozzi, 2022; Charef et al., 2021). Therefore, premised on the identified barriers across the globe, the authors summarised these into 29 statements for exploration in the African context (Refer to Table 2.1).

Table 2.1. A summarised list of barriers impeding circular built environment

<table>
<thead>
<tr>
<th>Label</th>
<th>Barriers</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>Lack of benchmarking process for CE.</td>
<td>Huang et al. (2018), Yuan (2017)</td>
</tr>
<tr>
<td>Q2</td>
<td>Lack of circular construction-based education and awareness.</td>
<td>Liu et al. (2021), Yu et al. (2022), Bilal et al. (2020)</td>
</tr>
<tr>
<td>Q3</td>
<td>Lack of standards on the quality of secondary products.</td>
<td>Charef et al. (2021), Gibberd (2020)</td>
</tr>
<tr>
<td>Q6</td>
<td>Virgin materials are cheaper than secondary materials.</td>
<td>Gibberd (2020), Rademaekers et al., (2020)</td>
</tr>
<tr>
<td>Q7</td>
<td>Lack of effective CE-based knowledge management systems in the construction industry.</td>
<td>Giorgi et al. (2022)</td>
</tr>
<tr>
<td>Q8</td>
<td>Lack of penalties on illegal dumping.</td>
<td>UNEP (2018), Eberhardt et al. (2021)</td>
</tr>
<tr>
<td>Q10</td>
<td>Lack of government certification for reuse and recycling.</td>
<td>Liu et al. (2021), Mishra et al. (2022)</td>
</tr>
<tr>
<td>Q11</td>
<td>Unavailability of construction waste data for prediction in a CE environment.</td>
<td>Ratnasabapathy et al. (2021)</td>
</tr>
<tr>
<td>Q12</td>
<td>Current building codes only favor virgin materials.</td>
<td>Gibberd (2020), Bilal et al. (2020)</td>
</tr>
<tr>
<td>Q13</td>
<td>Lack of clearly defined CE indicators for construction waste.</td>
<td>Menegaki and Damigos (2018)</td>
</tr>
<tr>
<td>Q14</td>
<td>The infancy of circularity technologies.</td>
<td>Huang et al. (2018), Kirchherr et al. (2018)</td>
</tr>
<tr>
<td>Q15</td>
<td>Unavailability of effective web-based waste exchange systems and databases for the quality of secondary products.</td>
<td>Ratnasabapathy et al. (2021)</td>
</tr>
<tr>
<td>Q16</td>
<td>Unavailability of disassembly implementation.</td>
<td>Akinade et al. (2020), Giorgi et al. (2022)</td>
</tr>
<tr>
<td>Q17</td>
<td>Waste management legislation and government regulatory measures for CE are not binding or not enforced.</td>
<td>UNEP (2018), Yu et al. (2022)</td>
</tr>
<tr>
<td>Q18</td>
<td>Fragmented nature of the construction industry.</td>
<td>Chen et al. (2022), Bertozzi (2022)</td>
</tr>
<tr>
<td>Q19</td>
<td>Unavailability of the local and global markets for adopting secondary products for building construction.</td>
<td>Giorgi et al. (2022), Mahpour (2018)</td>
</tr>
<tr>
<td>Q20</td>
<td>Difficulty in identifying the physical and chemical properties of construction and demolition waste and their suitability for circularity.</td>
<td>Charef et al. (2021)</td>
</tr>
<tr>
<td>Q21</td>
<td>Lack of understanding of the potential of CE principles and 3R (recycling, reuse, recovery) initiatives in construction waste management.</td>
<td>Liu et al. (2021), Gibberd (2020)</td>
</tr>
<tr>
<td>Q22</td>
<td>Lack of monitoring and tracing mechanisms of waste flow in a closed loop.</td>
<td>Giorgi et al. (2022)</td>
</tr>
<tr>
<td>Q23</td>
<td>High cost of implementing circular economy.</td>
<td>Charef et al. (2021), Gibberd (2020)</td>
</tr>
<tr>
<td>Q24</td>
<td>Public perception of CE products being inferior to virgin products.</td>
<td>Smol et al. (2015), Menegaki and Damigos (2018)</td>
</tr>
<tr>
<td>Q25</td>
<td>Unclear financial benefits.</td>
<td>Chen et al. (2022), Mishra et al. (2022)</td>
</tr>
</tbody>
</table>
3. METHODS

To identify the key barriers that impede the CBE transition in Africa, the researchers adopted an Exploratory Factor Analysis (EFA) using IBM SPSS version 28. An EFA is a quantitative technique used mostly to explore the structure underlying a set of observed variables used to assess a latent variable (Alhija, 2010). Additionally, Pett et al. (2003) claimed that researchers employ EFA when they are unsure how many factors are necessary to explain the interrelationships among a set of characteristics, indicators, 6 or items. Contextually, to identify the essential barriers impeding the African countries, the researchers used simple random sampling to administer a closed-ended online survey questionnaire comprising of 29 barriers gleaned from literature (Dillman et al., 2014).

A 5-point Likert scale was adopted in the survey, with the options Strongly Disagree, Disagree, Unsure, Agree, and Strongly Agree (Kyriazos & talikas, 2018). For this pilot study, a total sample of 100 was scientifically drawn from the African construction industry stakeholders and the CE experts. There is ongoing debate on the sample size considered good in EFA. Howard, (2016) is of the opinion that the sample should be greater than 200 while, Pallant (2016) recommends at least 250. Nonetheless, for a pilot study, the researchers considered a sample of 100 coupled with computing a Kaiser—Meyer—Olkin (KMO) Measure of Sampling Adequacy appropriate procedures to determine the sample size.

The sample represented the governments, academia, construction industry and non-governmental organisations. An online link was generated through Google Forms© and distributed via emails. To widen the sample reach, the authors also randomly shared the link to relevant groups and individuals via LinkedIn and Facebook. For the inclusion criteria, the authors ensured that those who had both knowledge and experience about the African construction industry participated through clearly enunciating that in the Request for Consent Pop-Up Page. The Google Forms© link was deactivated on July 28, 2022. The data was collected, cleaned and coded using Excel 2016 before being exported to SPSS.

To conduct a factor analysis, the authors adopted the recommendations proffered by Howard (2016): (1) The KMO Measure of Sampling Adequacy and Bartlett’s test of sphericity to inspect suitability of the data. Pallant (2016) further adds that the KMO is reliable in determining sample size. The rule of thumb is that an adequate sample size should have a KMO score that is greater than 0.60 and the Bartlett’s test of sphericity must be statistically significant (p<0.05). The authors deactivated the Google Forms© link after 82 responses and computed the KMO and Bartlett’s test of sphericity. (2) The Principal Component Analysis (PCA) was conducted to ascertain the type of rotation to adopt. Thereafter, the Principal Axis Factoring (PAF) was computed as suggested by Howard (2016). (3) The Kaiser’s criterion eigenvalue above 1 and the scree plot were also generated. (4) The varimax rotation option was chosen after realising that the items were uncorrelated (as indicated in stage 2). (5) Finally, the factor loadings below 0.40 were suppressed to attain a visually clear rotated component matrix. In literature, the decision about factor loading cut-off point is debatable, either selecting 0.30 or 0.40. For instance, Pallant (2016) recommends the use of 0.30 whereas, both Hinkin (1995) and Howard (2016) prefer 0.40 instead.

4. RESULTS

4.1 Sample demographics information

The total sample of 82 respondents took part in the study. These respondents represented 14 African states namely: Ghana, The Gambia, Nigeria, Ivory Coast (Western Africa), Kenya, Tanzania (Eastern Africa), Botswana, South Africa, Namibia, Malawi, Zimbabwe, Zambia (Southern Africa), Morocco

<table>
<thead>
<tr>
<th>Question</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q26</td>
<td>Client hesitancy to adopt circular economy principles.</td>
<td>Huang et al. (2018)</td>
</tr>
<tr>
<td>Q27</td>
<td>Protectionism of existing business models.</td>
<td>Charef et al. (2021)</td>
</tr>
<tr>
<td>Q28</td>
<td>Government reluctance to support circularity.</td>
<td>Smol et al. (2015); Akinade et al. (2020)</td>
</tr>
<tr>
<td>Q29</td>
<td>Construction practitioners are technologically averse.</td>
<td>Gomaa et al.(2022), Oluleye et al. (2022), Yu et al. (2022)</td>
</tr>
</tbody>
</table>
(North Africa), and Cameroon (Central Africa). In addition, approximately 4.9% of the respondents were resident in the United States of America, China, Switzerland and The Netherlands. Different professions are pursuing CE, although it appears that Quantity Surveyors and Architects contributed a significant proportion of nearly 35.4% and 13.4% respectively. A total of 70% of the respondents represented researcher/academia, consultancy and contracting. It seems these are the main groups that are in the forefront of advancing circularity in Africa. The majority of the respondents had attained a Master’s degree (52.4%) and had work experience not exceeding five years. Cumulatively, approximately 84% of the respondents noted that they had an average to above average knowledge of CE practices in the construction industry while only 3.7% deemed themselves as experts. The low level of experts was expected considering that CE in Africa is relatively new. Nonetheless, an average understanding of the CE practices was considered important in this study so that the respondents could perhaps correctly rank the identified barriers.

4.2 Factor analysis

A total of 29 CBE barriers were subjected to principal axis factoring (PAF) using IBM SPSS version 28. Before performing the PAF, the data was inspected for suitability and the type of rotation to adopt using the PCA. The component correlation matrix showed most scores less than 0.30 which means that the factors were uncorrelated (Pallant, 2016). As a result, an orthogonal rotation-varimax was adopted. The KMO value was 0.885, exceeding the recommended 0.60 and the Bartlett’s test of sphericity was statistically significant (p<0.001) which supported the factorability of the correlation matrix. The PAF revealed the presence of six components with eigenvalues greater than 1 which was also confirmed through visual inspection of the scree plot (see Table 4.1). On the other hand, Table 4.2 shows the factor loadings of the rotated factor matrix.

<table>
<thead>
<tr>
<th>Construct</th>
<th>No. of Items</th>
<th>Eigenvalue</th>
<th>Variance Explained (%)</th>
<th>Factor Loadings (Range)</th>
<th>Cronbach’s Alpha (α)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementation and Regulatory Barriers (IRB)</td>
<td>7</td>
<td>13.287</td>
<td>45.82</td>
<td>0.593–0.789</td>
<td>0.917</td>
</tr>
<tr>
<td>Client-Demand Barriers (CDB)</td>
<td>9</td>
<td>2.169</td>
<td>7.48</td>
<td>0.401–0.704</td>
<td>0.915</td>
</tr>
<tr>
<td>Supply chain Barriers (SCB)</td>
<td>5</td>
<td>1.642</td>
<td>5.66</td>
<td>0.488–0.871</td>
<td>0.870</td>
</tr>
<tr>
<td>Environmental Barriers (EB)</td>
<td>4</td>
<td>1.368</td>
<td>4.72</td>
<td>0.559–0.627</td>
<td>0.828</td>
</tr>
<tr>
<td>Technological Barriers (TB)</td>
<td>2</td>
<td>1.159</td>
<td>3.99</td>
<td>0.570–0.876</td>
<td>0.802</td>
</tr>
<tr>
<td>Knowledge and Information Barriers (KB)</td>
<td>2</td>
<td>1.081</td>
<td>3.73</td>
<td>0.472–0.790</td>
<td>0.602</td>
</tr>
</tbody>
</table>
5. DISCUSSION

Table 4.1 and 4.2 illustrate the outputs of the factor analysis procedure. Pallant, (2016) and Howard, (2016) both argue that factor analysis does not show the reliability and internal consistency of the each factor scale. To address this limitation, the Cronbach Alpha was computed (Cronbach & Meehl, 1955). Out of the six factors, only five had good coefficient scores ranging between 0.802–0.917. The sixth barrier scale was questionable with a score of 0.602. Pallant (2016) observed that generally, when using a construct with less than 10 items, the Cronbach Alpha is usually low.

5.1 Implementation and regulatory barriers (IRB)

The construction industry is one of the most regulated industries. In Africa, the case is not different. In other words, most processes and procedures are guided by set standards, codes and practices. Nonetheless, it appears that in Africa at the moment the industry is devoid of CE implementation and regulatory frameworks. Lack of regulations was also observed across six European countries by Kirchherr and colleagues (2018). In Africa, the top three barriers impeding CBE transition were: unavailability of disassembly implementation, current building codes that favor virgin materials and unavailability of effective web-based waste exchange systems and databases for the quality of secondary products. Gibberd (2020) also adds that in Africa the current building codes inspire practices that are not circularity in nature. This situation corroborates similar challenges encountered in other continents (Huang et al., 2018; Charef et al., 2021). It also clarifies the reason behind the prevalent use
of linear practices in the construction industry. Again, as indicated in literature, the construction industry in Africa is fragmented (Chen et al., 2022; Bertozzi, 2022). To that end, the construction industry in Africa ought to revamp its regulations so that they incorporate the new CE-based practices.

5.2 Client demand barriers (CDB)

The construction industry is predominantly a client-led sector. This means that the clients demand for projects determine the construction activities. In most countries, particularly in Africa, the government remains the major client (Rademaekers et al., 2020). Consequently, the views of the clients about CE practices are critical in transitioning towards circularity. However, the study reveals that generally the public perception about circularity remains low which undoubtedly hinders CBE transition. Unlike, the European setup where it was observed that the private sector and clients are propelling the CBE transition, the case appears opposite in Africa, Again, it was realized that the clients have unclear understanding of the concept hindering their appetite for CE inspired projects (Smol et al., 2015; Kirchherr et al., 2018). Moreover, it is widely perceived that CE implementation attracts significantly high costs (Chen et al., 2022). Unless the benefits outweigh the financial implications either real or perceived, CBE transition will not be realized in Africa. Again, having noted that the major client in Africa is the government perhaps explains the failure to fully migrate towards circularity. To foster rapid transition towards circularity, the governments could potentially partner with non-governmental (NGOs) proponents that are advancing circularity practices across the globe. The clients and their level of understanding of the CE practices and benefits underpin the likely CE drive in the construction industry.

5.3 Supply chain barriers (SCB)

Apart from being highly regulated at national level, the construction sector also relies on industry best practices. Therefore, guidelines, benchmarking and standardization are common in the industry. However, with regards to CE in the African context, it appears that there is lack of widely adopted CE best practices within the supply chain (Huang et al., 2018; Charef et al., 2021; Gibberd, 2020). To that end, the construction industries across the continent seem to adopt different practices across the supply chain (Rademaekers et al., 2020). The most prevalent barriers in this category include, a lack of guidelines and manuals for construction and demolition waste sorting and collection in a CE environment, lack of CE business models for the construction industry and lack of standards on the quality of secondary products. Failure for the supply chain to jointly adopt the CE practices hinder any potential transition. These results concur with the observations made by Mishra et al. (2022) in India. Additionally, Akinade et al. (2020) observed that linearity business models were a threat to circularity transition. Arguably, unlike the Global North, the African continent is endowed with abundant natural resources and use of secondary materials across the supply chain might not be deemed viable (Rademaekers et al., 2020). Benchmarking in the African continent remains very low because CE practices are still emerging.

5.4 Environmental barriers (EB)

The construction sector contributes immense negative environmental impacts. As a result, CE has been largely touted as one of the practices to promote environmental sustainability (Cimen, 2021). The study reveals that there are low environmental impact reduction initiatives to drive Africa towards CBE. For instance, barriers such as unavailability of construction waste data for prediction in a CE environment, lack of construction waste refiners and recovery facilities and lack of penalties on illegal dumping (Charef et al., 2021). Not surprisingly, the disposal of C&D waste in the illegal dumpsite is still a common practice across Africa. These dumpsites are largely mostly free and yet their environmental impact is of enormous proportions. In Africa, cost reduction is a significant enabler any practice. Levies and penalties associated with restricting illegal dumping seems to be selectively applied and ceases to serve as a deterrent (UNEP, 2018). Therefore, the lack of environmental impact reduction initiatives proves to be a critical barrier in the construction industry.

5.5 Technological barriers (TB)

The level of technological advancement has a bearing on CE adoption in the construction sector. Primarily, the availability of data and its management through technological systems determines the extent to which the C&D waste can be adequately disposed (Giorgi et al., 2022). However, Africa has for a long time has been perceived as a technological laggard. Arguably, the continent faces other
pressing socio-economic challenges such as unemployment. Therefore, the adoption of technology such as 3D concrete printing and robotics that may endanger employment creation cannot be prioritized (Smol et al., 2015; Akinade et al., 2020). As a result, notwithstanding the efficiency brought about by technology, it appears that the governments across Africa remain reluctant to support CE. Perhaps, since the political will of these governments is supposedly derived from the public, any policy direction that would likely endanger the creation of jobs could culminate impact their re-election aspirations. Bearing in mind that the African construction industry is mostly technologically averse, CE practices such as data management, material passports, tracking renovation status and so on are unlikely to be attained.

5.6 Knowledge and information barriers (KIB)

Finally, it is important to note that this construct scored a questionable Cronbach Alpha of 0.60 and therefore the authors caution the application of its items. Notwithstanding that, the two items that loaded under this factor are, difficulty in identifying the physical and chemical properties of construction and demolition waste and their suitability for circularity and virgin materials are cheaper than secondary materials. It seems that inadequate information about secondary materials (used products) is lacking in the construction industry in Africa (Gibberd, 2020; Rademaekers et al., 2020). Again, since Africa is largely characterized by readily available natural resources, the proposition to use secondary materials might be unpopular which hinders CBE transition. The prospects of fully migrating toward CBE in Africa is likely to result from incessant education and information dissemination about the benefits associated with adopting CE practices.

6. CONCLUSION AND RECOMMENDATIONS

In Africa, CE practices in the construction industry remain immature. A factor analysis was employed to validate 29 barriers that hinder CBE transition in Africa. EFA is a useful technique to investigate the underlying structure of items using the factor loadings. The key barriers were extracted using PAF coupled with varimax rotation and these comprised of, limited CE implementation and regulatory frameworks, low client demand for circular construction, lack of industry-wide CE best practices, limited environmental impact reduction initiatives, inadequate technological advancements and insufficient information about secondary materials. However, the sixth barrier had a questionable Cronbach Alpha (\(\alpha = 0.602\)) which implies a cautious approach when administering that scale. It is recommended that local governments, as the major client should demand circular construction and also consider partnerships with the NGOs that are CE forerunners globally. Although, the KMO (0.885) and Bartlett’s test of sphericity (p<0.001) confirmed the sample adequacy it should be noted that the rule of thumb considers 82 as a low sample size. Therefore, it is recommended that future studies focus on the same topic but adopt a minimum of 200 responses. Furthermore, the model can also be validated using CFA as well. Since this study was limited to the 14 African states, while 4.9% were non-resident in Africa, a comparable study can be explored in at least 50% of the 54 states to evaluate if there are any new and unique barriers that emerge. Nonetheless, this pilot study makes a significant contribution that can be used by policymakers, academics and industry practitioners facilitating a CBE transition within Africa.

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7. REFERENCES


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Mishra, R., Kumar, R., & Govindan, K. 2022, Barriers to the adoption of circular economy practices in Micro, Small and Medium Enterprises : Instrument development , measurement and validation. Journal of Cleaner Production, 351, 131389.


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Construction Project Finance for Success: SME Perspective

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ABSTRACT

Purpose
Small and medium enterprises (SMEs) successful execution of construction projects hinges on several factors. When clients’ financing is delayed, SMEs face uncertainty in securing construction project funding. Project finance is key to successful project execution among SME contractors. Therefore, this study aimed to investigate construction project financing strategies for successful project completion from a SMEs perspective.

Design/methodology
A qualitative research approach was used based on interviews with 28 SME contractors, and consultants working with the SMEs in Gauteng province. Content analysis with the assistance of an Excel spreadsheet was used to analyse the data.

Findings
The findings indicate that construction SMEs heavily rely on various sources to finance the projects successfully. These financing strategies include Self-funded, Client upfront payment, Friends & Family, Government assistance, and Bank loan. Overall, there was a general agreement among SME contractors that bank financing is the least used source of funding. The prominent finances are sourced from personal income and immediate family and friends.

Research limitations/implications
The interviewees were managers of SME contractors working in the construction industry in Gauteng province, South Africa.

Practical implications
For SMEs to successfully finance their project, they should have self-acquired financial muscles or financial support from close acquaintances but not rely on bank loans and other sources of project finance.

Original/value
The knowledge advanced in this study will inform owners of small and medium-sized contractors of strategies necessary for sourcing finances for successful project delivery.

KEYWORDS: Access, Challenges, Construction SMEs, Project Finance Strategies, South Africa.
1. INTRODUCTION

Small and Medium Enterprises (SMEs) play an essential role in global and national economies (Fiseha and Oyelana, 2015; Kasseah and Thoplan, 2012; Muriithi, 2017; Sarvari, Chan, Alaeos, Olawumi and Aldaud, 2021). SMEs contribute to economic growth, job creation and economic and social cohesion. SMEs are considered the backbone of economic growth in all countries because they account for 80% of global economic growth (Aiyetan, Smallwood and Shakanu, 2022; Taiwo and Falolu, 2016). SMEs contribute over 55% of GDP and over 65% of employment in high-income countries. In low-income countries, formal SMEs contribute over 95% of total employment and above 40% of GDP in emerging economies (World Bank, 2022). In South Africa, SMEs represent more than 98% of businesses, employ between 50% and 60% of the country’s workforce across all sectors and are responsible for a quarter of job growth in the private sector (International Finance Corporation-IFC, 2021). However, these numbers are significantly higher when informal SMEs are included (Naradda Gamage, Ekanayake, Abeyrathne, Prasanna, Jayasundara and Rajapakshe, 2020; World Bank, 2022). The statistics suggest that economic and SME development are interrelated (Bosma, Sanders and Stam, 2018).

The construction sector is a significant component of any economy as it contributes significantly to global GDP and provides employment; hence it is a fundamental factor in the quality of the ‘people’s lives and the ability of the government to achieve many of its policy aims (Vaitkevicius, 2014). The construction industry comprises a complex supply chain network consisting of hundreds of SMEs who tend to deliver major construction projects (Thwala, Mustapha and Aigbavboa, 2018). SMEs have offered lessons to large organisations in surviving within a volatile environment and provided a focus for economic and management enquiry (Muriithi, 2017). By 2030, 600 million jobs will be needed to absorb the growing global workforce, which makes SME development a high priority for many governments around the world (World Bank, 2022). However, access to finance is a crucial constraint to SME growth (Adomako, Danso and Ofori Damoah, 2016; Cowling, Liu and Zhang, 2018). It is the second most cited obstacle facing SMEs in growing their businesses in emerging markets and developing countries (Beck and Demirguc-Kunt, 2006; Muriithi, 2017; Lee, 2014).

Construction SMEs face numerous impediments to sustainable growth and development (Aiyetan et al., 2012). These impediments included: operational factors, financial constraints; limited marketing and human resources management expertise; limited strategic planning; and ineffective information technology (IT) implementation (Cowling et al., 2018). This has been attributed to the SMEs’ inability to be adept at marketing, financial control and often the lack of motivation to accelerate the firm’s innovative capacity (Stokes, 2000; Storey, 1994). Financing options for SMEs are an essential tool for the growth of SMEs and accessing the right kind of financing according to the firm’s needs (Abbasi, Wang and Danish-Abbasi, 2017). The financing of construction projects by SMEs has been highlighted as a central point in the improvement, development and completion of construction projects (Abdul Saleh and Worthington, 2013). Though SMEs are known to be the backbone of the economy and play a vital role in the country’s growth and development (Abdul-Saleh and Worthington, 2013). SMEs face hindrances while accessing financing from financial institutions for the success of their construction projects (Dombrowski, Crespo and Zahn, 2010; Rymaszewska, 2014; Sarvari, Chan Alaeos, Olawumi and Aldaud, 2021). This study examines SME project financing strategies for the successful completion of construction projects from the SMEs’ perspective by enhancing their knowledge about the project financing strategies they can employ for the successful completion of construction projects. The study was conducted only on SMEs Gauteng province-based appointed for public and private sector construction projects. Though SMEs are known to be the backbone of the economy and play a vital role in the country’s growth and development (Abdul-Saleh and Worthington, 2013; Aigbavboa, Oke and Kakanyo, 2016). SMEs face hindrances while accessing financing from financial institutions for the success of their construction projects (Rymaszewska, 2014; Sarvari, Chan Alaeos, Olawumi and Aldaud, 2021). This study examines SME project financing strategies for the successful completion of construction projects from the SMEs’ perspective by enhancing their knowledge about the project financing strategies they can employ for the successful completion of construction projects. The study was conducted only on SMEs Gauteng province-based appointed for public and private sector construction projects.
2. LITERATURE REVIEW

2.1 Challenges for accessing finance for business

Various research has been conducted regarding SMEs’ challenges to access finances leading to project delays and failure (Adugna, 2015; Akogbe, Feng and Zhou, 2013; Eniola, 2018; Kholif, Hosny and Sanad, 2013; Owolabi et al., 2014; Patil, Gupta, Desai, & Sajane, 2013). SMEs’ challenges in accessing finance have been attributed to SMEs’ inability to produce good business plans according to financial institutions; inadequate collateral on the part of the entrepreneur; lack of credit history; poor market research, and the absence of a viable business idea; and the lack of access to vibrant markets. (Fatoki, 2014; GEM, 2014). In addition, financial institutions are accustomed to lending to established construction firms as dealing with SMEs is considered risky and amidst the uncertainty of the viability of the loan repayment (Didier, Huneeus, Larrain and Schmukler, 2021; GEM, 2014). Access to banking services favours SMEs with acceptable credit histories and sufficient collateral (Duarte, Gama and Esperança, 2017). For start-ups, micro-enterprises, entrepreneurs from previously disadvantaged communities or groups with limited collateral or weak credit histories face challenges accessing construction project finance from banks (Hanedar, Broccardo and Bazzana, 2014).

Lack of finances by construction SMEs has been cited as a significant factor affecting SMEs’ operations in prior research (De Prijcker, Collewaert and Vaacker, 2019; Manigart and Sapienza, 2017). In a study to establish causes of construction project delays in eThekwini of KZN, top of the list of causes were contractor's cash flow problems, delay in progress payments by the client, and contractors’ inability to finance the project (Adugna, 2015). Other studies have published SMEs' causes of construction project failures (Owolabi et al., 2014). These include a lack of contractor’s financial capabilities (Adugna, 2015); high escalation prices of material due to inflation, and lack of funds to finance the construction project to completion (Akogbe et al., 2013); high cost of procuring skilled labour for the job; changes by the professional team and poor site supervision by the contractor (Adugna, 2015; Gupta, Desai and Sajane, 2013); lack of good communication between parties involved and inadequate information from the professional team (Kholif et al., 2013); changes made to construction drawings during construction and the slow pace in decision making for the project (Owolabi et al., 2014; Patil et al., 2013).

Several studies have identified financial and cashflow mismanagement as factors for delaying the successful completion of construction projects (Gunduz, Niesemin and Ozdemir, 2013; Khamooshi and Golafshani, 2014; Shehu, Endut and Akintoye, 2014; Ramanathan, Potty and Arazi, 2012). In their study, Shehu et al. (2014) examined the causes of construction project completion. They concluded that cashflow mismanagement accounted for the successful completion of construction projects. Their findings indicated that the delays were due to mismanagement of cash flows for SME contractors with multiple projects being executed simultaneously. This is because the SME contractors tend to utilise payments received for one project on another project, thereby creating a ripple effect of slow progress on whose payment was received (Zayed and Liu, 2014). The slow progress is caused by a lack of cash flow which then causes the delay due to a shortage of materials, failure to pay workers' wages and failure to honour suppliers of materials and related services (Aigbavboa et al., 2016; Hamza, Mutala and Antwi, 2015).

Labour-related factors have been identified as causes negatively affecting the successful completion of construction projects among SMEs (Ali, Awad and Abdul salam, 2020; Danso, 2014; Othman and Mydin, 2014; Ye, Jin, Xia and Skitmore, 2014). Gunduz et al. (2014) studied the causes of delays in construction projects. They identified 9 variables related to construction project delays. According to their findings, poor labour productivity resulting from employing unskilled cheap local labour was cited as some of the essential causes for delayed and successful completion of construction projects. This was also attributed to the financial loss incurred by the SME contractors (Memon, Rahman and Hasan, 2014; Shrivas and Singla, 2022).

2.2 Business finance strategies

Strategies for construction project financing by SMEs are something SMEs should address by ensuring self-introspection. This is done by ensuring proper-financial record keeping, good management practices and their attitude towards risk, influencing their financial decisions (Brick and Visser, 2015;
Rao et al., 2021). SMEs firms should ensure internal capabilities, including financial, planning, marketing and technical management abilities, to manage their finances and be competitive in the marketplace (Eniola and Ektenag, 2014; Falahat, Ramayah, Soto-Acosta and Lee, 2020). These are considered critical factors for SM’s development, survival, and competitiveness (Brick and Visser, 2015). Long-standing customer relations and solid reputations, and the awareness of alternative financing arrangements are some of the strategies SMEs employ to secure funding for their projects (Bertoldi, Economidou, Palermo, Boza-Kiss and Todeschi, 2021).

Fundamental sources of financing are debt and equity (Eniola, 2018; Kira and He, 2012). Debt is borrowed funds to be paid in the future specified period with interest (Deryse de Goeji and Kappert, 2012). In equity, investment is made to get a share/ownership part in the firm whose profits are essential because of its benefits (Jensen, 2019; Martinez-Sola, Garcia-Teruel and Martinez-Solano, 2014). SMEs can be funded internally and externally (Rao, Kumar, Chavan and Lim, 2021). Internally generated funds include investment profits, sales of assets, extended payment terms, reduction in working capital and accounts receivable (Eniola, 2018). In contrast, external sources are firm owners, companies and relatives, banks and financial institutes (Vaitkevicius, 2014).

SMEs are inclined towards internal funding sources and short-term debt over external funding (Uyar and Guzelyurt, 2015). This is consistent with other researcher’s findings that SMEs resort to internal financing that is a business person’s own (Gregory, Rutherford, Oswald and Gardner, 2005; Kester and Robins, 2011; Meehan’s and Lucey, 2011). Primarily because of the easy access and non-restrict nature of internal funding and external sources of funding (Eniola, 2018). Further, the accessibility of financing by SMEs has been hindered by a lack of information on product types, availability and qualification criteria (Gartner, Frid and Alexander, 2012). SMEs may not attempt to borrow a loan from a financial institution such as a bank because they believe they will be rejected (Garwe and Fatoki, 2012). This has contributed to their inclination toward internal sources of finances, which in most cases, are insufficient for them to sustain business operations (Rao et al., 2021). One of the strategic decisions SMEs makes when sourcing financing is to select cheap funding sources and maximise the benefits, allow them to transfer risk, and maintain control of their business (Gartner et al., 2012).

The incentive for the present study is that there is a paucity of empirical work on construction project finance strategies for SME construction firms. Prior research is mainly found in advanced nations and does not apply to developing countries (Eniola, 2018). Little research in emerging economies was centred on the sources of financing that centred around family and social networks (Agrawal, Catlini and Goldfarb, 2015; Burton, Khavul, Siegel and Wright, 2015). Therefore, this study focused on developing nations in South Africa by looking at financing strategies employed by construction SMEs.

3. METHODOLOGY

The qualitative approach was used for this study to collect data. According to Bryman et al. (2014), qualitative data allows for evaluating the data according to the rules prescribed and can be reviewed for any errors or measured for validity and reliability. Semi-structured interviews based on primary data were administered among purposively selected SME contractors and Consultants (Pandey and Pandey, 2015; Williman, 2011). Selected SME contractors are registered in the CIDB contractor database and operate from Gauteng province (Adams, Khan and Raeside, 2014). While the selected Consultants are working with SMEs in the Gauteng province. Gauteng province was chosen because it has high levels of construction SME growth in South Africa (Stas SA, 2015).

An interview allows for the researcher and respondent to interact and have an exchange of ideas and information. Using an interview, the two can connect more, creating a free flow of ideas and bringing the researcher and respondent to the same level (Pandey and Pandey, 2015). The interviews were conducted telephonically with the participants. Telephone interviews appear to increase the perceived sense of anonymity and are suitable for collecting data on sensitive topics. Further, telephone interviews are cost and time effective and allow the researcher to have wide geographic access to the participant and reach participants on a wide minimising expense.
The number of SMEs approached was 35 potential respondents randomly selected from an online platform for construction practitioners to network. Of the 35 approaches, however, 28 responded to the interview, yielding an 80% response. The interview questions were divided into two sections. Section A identified the profile of the respondents. Section B identified SMEs’ strategies for financing their construction projects. The interview lasted for 20 – 25 minutes for each of the participants.

Content analysis was used to analyse the data collected. The content was selected based on the research questions, which were analysed. Units and categories of analysis were defined, and a set of coding rules was developed. The test was coded according to the set rules. This allowed the analysis of the results, and conclusions were drawn.

4. RESULTS

<table>
<thead>
<tr>
<th>Work experience</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>– - 9 years</td>
<td>9</td>
<td>32%</td>
</tr>
<tr>
<td>1- - 19 years</td>
<td>16</td>
<td>57%</td>
</tr>
<tr>
<td>2- - 30 years</td>
<td>2</td>
<td>7%</td>
</tr>
<tr>
<td>Over 30 years</td>
<td>1</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Areas of work</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Company</td>
<td>14</td>
<td>50%</td>
</tr>
<tr>
<td>Consultancy working with SMEs</td>
<td>13</td>
<td>46%</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nature of Company</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sole proprietorship</td>
<td>10</td>
<td>36%</td>
</tr>
<tr>
<td>Limited liability</td>
<td>18</td>
<td>64%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The data collection phase generated responses from 28 participants, as shown in Table 1. All the SMEs were registered with the CIDB database and operating in Gauteng province. Regarding age, 32% of respondents had 1-9 years of work experience, while only 4% had over 30 years of experience. About 57% and 7% had 10-19 years and 10-21 years of work experience, respectively. The participants are at the management level. Most firms were limited companies at 64%, while sole traders were 36%. The SMEs are involved in three main construction activities: new construction at 50%, consultancy at 46%, and general building and demolitions & renovation at 4%.

4.2 Project financing strategies

The different answers regarding the sources of funding received from the respondents are shown in Table 2.

<table>
<thead>
<tr>
<th>Funding Sources</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-funded</td>
<td>9</td>
<td>32%</td>
</tr>
<tr>
<td>Client upfront payment</td>
<td>8</td>
<td>29%</td>
</tr>
<tr>
<td>Friends &amp; families</td>
<td>6</td>
<td>21%</td>
</tr>
<tr>
<td>Government assistance</td>
<td>3</td>
<td>11%</td>
</tr>
<tr>
<td>Bank loan</td>
<td>2</td>
<td>7%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
The responses received from the 28 respondents were captured as follows. Thirty-two (32%) respondents indicated that the SMME should fund the project themselves, and 21% indicated that the SMME should look for no interest-bearing loans from business associates, friends and family. The greatest advantage to such a non-interest-bearing loan from friends and family is that most of the time, SMMEs only make small profit margins, and that profit margin will be eroded by any interest charge for capital to execute the project. Another advantage of this kind of loan is accessibility. There are generally less stringent requirements for obtaining a loan of this nature than obtaining a loan from an official financial institution. Seven percent (7%) of respondents noted that a bank loan might be used to fund a project. The bank loan could be an overdraft facility, credit card facility or a short-term loan. The disadvantages of these are the high-interest rates linked to these short-term loans offered by banks, and also banks have very stringent approval criteria, which many SMMEs may not meet. Eleven percent (11%) of respondents noted government assistance through loans and grants should be considered for SMME project funding. The disadvantage of such government assistance is the turnaround time for approving such assistance. The funding may be approved long after the time when the project should be completed. There is no sense of urgency in government assistance. The advantage is the assistance which may be a grant or a low interest-bearing loan, can advantage emerging SMMEs to succeed in their projects. Twenty-nine (29%) respondents recommend that the client funds SMME projects in for form of upfront payment or deposit made to the SMME for the SMME to start the project.

5. DISCUSSION AND IMPLICATIONS

5.1 Sources of project financing

The results show that few construction SMEs in Gauteng adopt various project funding strategies to manage their projects effectively. The funding sources used are discussed below.

5.1.1 Self-funded

The study has revealed that most construction SME’s primary source of project finance is ‘owner’s’ funds. SMEs employ owners’ savings and retained earnings as financing techniques (Fatoki, 2014). When SMEs seek capital or extra funds to finance their operations, the foremost option is to invest by themselves (Abbasi et al., 2017). Owners’ equity is cited as the widely used source of financing among construction SMEs. Two main reasons for this behaviour are that equity money is less risky for financing a business than debt money. If the business fails, entrepreneurs and owners would only lose their investments. Secondly, in case of failure, using debt financing could lead to the loss of the owner’s assets. Therefore, SME owners prefer to finance their projects with low-risk money than with high-risk debt (Eniola, 2018).

5.1.2 Client upfront payment

Findings have shown that most SMEs rely on client upfront payment as one of their strategic alternative funding sources for their projects. Upfront payments enable SME firms to smoothly execute the works, ensuring timely completion (Abdulsaleh, A.M & Worthington, 2013). This enables SMEs to meet their supplier financial obligations, pay workers on time and avoid stoppages which can affect the progress of work. Furthermore, timely upfront payments to construction SMEs improve the overall performance of SMEs contractors towards their growth (Thwala et al., 2018).

5.1.3 Family and friends

Informal external sources comprise monetary help from family and companions. Findings show that borrowings from close relatives and friends mostly supplement construction SM’s primary source of financing. The findings have shown that SMEs find it easy to access informal financing as it does not have strict requirements and takes a shorter processing period (Uyar and Guzelyurt, 2015). This kind of financing is considered a source of trust capital. Financing from friends and family is a very good alternative as the investors’ sole purpose is not monetary, and they are ready to accept lower or no interest in their investments. Furthermore, finance from family and friends has a few downsides. Though risk remains within the social circle of the owner, it can affect the relationship in a negative way (Perason, 2016).
5.1.4 Government assistance

Findings indicate that government assistance is a strategic source of funding for construction among construction SMEs. Government funding enables SME operations to be carried out timely (Thwala et al., 2018). Further governments, through policy and regulations and tax incentives, particularly regarding raw material cost, positively affect SMEs as a source of financing (Adugna, 2015; Patil et al., 2013).

5.1.5 Bank loan

Formal outer sources are represented by financial intermediaries such as banks and securities markets. The study has revealed that few SMEs access formal financing largely because it is costly and has bureaucratic processes to be accessed. These findings suggest that the unfriendly products and services formal financial institutions have in place to support are unsuitable for SMEs such as those in the construction sector. This may hinder construction SMEs from progressing and developing due to financing challenges. The results have also indicated that the SMEs’ experience with financial institutions suggests a weak relationship, which causes the SMEs to have a negative attitude towards approaching formal financial institutions (Duarte et al., 2017). Furthermore, results indicate that sound financial management and practices are critical strategic characteristics SMEs should possess to access bank project financing. Regarding information, the results suggest an opportunity for financial institutions to engage and educate SMEs regarding their products and how to access them easily.

6. CONCLUSION

Construction SMEs should be aware and be braced with alternative financing alternatives. They should also use asset parsimony and advocate the utility of networking in organising resources if they cannot be obtained from financial capital. Construction SMEs should develop financial discipline by having adequate financial information, proper financial records, secure collateral, and good management practices. It is recommended that construction SMEs should undergo financial literacy. Further, construction SMEs should employ sound financial management practices, enabling them to have internal financial requirements for seeking debt financing from formal financial institutions. As the results suggest, financial institutions can leverage the business opportunities created by the willingness of construction SMEs to seek financial options for their projects at a reasonable cost. This will ensure the sustainability of the SMEs, their projects and their essential role in contributing to the country’s social-economic development.

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Model for Effective Public Procurement for Small, Medium and Micro Enterprises in South African Construction Industry

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ABSTRACT & KEYWORDS

Purpose of the Study
Although several reforms made to the South African public procurement system and application of supply chain management as a strategic policy strategic instrument, the South African public procurement system has still been strongly criticised for not encouraging the participation of small and medium enterprises. Hence, this study aimed to develop an effective public procurement model to encourage the participation of small, medium and micro enterprises in public procurement process. The effective public procurement model was measured by adopting five pillars of South African public system: openness, value for money, accountability, transparency and competitiveness.

Design/Methodology/Approach
The quantitative research method was employed to generate knowledge of the subject matter. The target population is approximately 400, including employees, managers, directors, business owners, procurement experts and professionals from Public Works Sector, Construction Industry Development Board, Business Chamber, Business Council, Procurement Institute, Built Environment Council and Progressive Professionals Forum. To determine the sample size, the 95% confidence level was chosen, with the margin of error at 5%. The stratified sampling method was used to select a sample size of 250 respondents. A questionnaire was used to collect data from 229 respondents. The data was analysed using the Statistical Package for the Social Sciences and Analysis of Moment Structure.

Findings
The findings revealed that openness, value for money, accountability and transparency made the strongest contribution to effective public procurement model, except competitiveness.

Research Limitations/Implications
The scope of the study was limited to the public procurement system in the South African context

Practical Implications
The study enhances efficiency in the South African public procurement system.

This study is unique as it contributes to expanding the body of knowledge on the public procurement system in South Africa.

Keywords: Accountability, Openness, Public Procurement, Small and Medium Enterprises, Value for money
1 INTRODUCTION

Gherghina, Botezatu, Hosszu and Simionescu (2020) argue that small, medium and micro enterprises (SMMEs) are the primary driver of economic development globally, especially in emerging nations. In the European Union (EU), evidence shows that nearly 99% of all businesses have created approximately 85% of new jobs (Ndiaye, Razak, Nagayev & Ng, 2018). Statistics indicated that in 2015 there were more than 23 million SMMEs providing 90 million jobs, generating a higher added value of €3.9 billion (European Union, 2019). Saah (2021) observes that South African SMMEs have positively impacted economic development through job creation, contribution to gross domestic product (GDP), and poverty eradication. Moise, Khoase and Ndayizigamiye (2020) also concur that South African SMMEs drive the country’s economy and serve as springboards to industrialisation. Furthermore, evidence suggests that South African SMMEs provide much-needed support for the economy, contributing to the country’s GDP with an approximate generation of 34–38.8% (Kalidas, Magwentshu & Rajagopaul, 2020; Small Enterprise Development Agency (SEDA), 2020; International Finance Corporation (IFC), 2018).

Despite the significant contribution of construction SMMEs to the economy, these SMMEs are faced with numerous challenges ranging from access to finance, legislation barriers, managerial skills, procurement management, to quality management and good governance (Jili, Masuku & Selepe, 2016; Ngcobo & Sukdeo, 2015; Fatoki, 2014; Windapo & Cattell, 2013). However, the study focuses on public procurement challenges faced by SMMEs. It has been observed that South African SMMEs are confronted by daunting procurement challenges which are significant and have impacted negatively on the country’s development while limiting its ability to drive the national economy as expected (Pillay & Mafini, 2017; Dauda & Nyarko, 2014; Gbandi & Amissah, 2014; Letchmiah, 2013). Within the context of South Africa, public procurement occurs in line with the Broad-Based Black Economic Empowerment (B-BBEE) Act 53 of 2003. The World Bank (2020) observes that public procurement is a necessary strategic development tool for promoting good governance and embedding the most effective and efficient use of public resources, which ultimately results in improved service delivery. Due to the ever-increasing focus on sustainable development, the role and direction of public procurement have shifted from a predominantly technical and administrative process to a series of processes built around efficiency, transparency, and accountability in using public resources.

From 1995, the South African public procurement reform initiative focused on addressing two primary objectives: promoting good governance and introducing a preferential system to address socio-economic concerns. The reform was underpinned by several legal frameworks, including the Public Financial Management Act (PFMA) 1 of 1999 and the Preferential Procurement Policy Framework Act (PPPFA) 5 of 2000. According to the National Treasury (2014), public procurement is underpinned by five pillars: value for money (the best available outcome when all applicable costs and benefits over the procurement cycle have been considered), open and effective competition (open and fair procurement system), ethics and fair dealing (ethical standards based on mutual respect, and trust), accountability and reporting (the degree to which public official and government entities are accountable for their plans, actions, and outcomes), and equity (fair and equal access to public procurement).

Of recent times, there has been a paradigm shift in the South African public procurement system. Fourie and Malan (2020) argue that unlike in the past, the South African public procurement system is required to ensure timely, effective, and efficient delivery. Within the context of this study, effective public procurement comprises three elements, including innovative, green, and sustainable public procurement. Although there exist several studies on the potential of public procurement to promote innovation (Manninen, Mainela, Ulkuniemi, Karhu & Rytilahti, 2015; Knutsson & Thomasson, 2014; Rolfstam, Phillips & Bakker, 2011; Uyarra & Flanagan, 2010). However, it has been found that the innovative ways of implementing the public procurement (IPP) process remain under-researched (Knutsson & Thomasson, 2014). Tshikhudo, Aigbavboa and Thwala (2016) claim that, although many governments have enacted environmental laws to cope with growing ecological problems, little attention has been given to green public procurement (GPP) as a policy tool. It has also been found that despite the importance of public sector procurement, there is limited research on how sustainable public procurement (SPP) can be achieved through public procurement, especially in SMMEs (Knutsson & Thomasson, 2014). Manyathi, Burger and Moritme (2021) point out that there is little empirical evidence.
and conceptual model on the effective public procurement model, particularly for small, medium and micro enterprises. Therefore, this study aimed to develop an effective public procurement to encouraging the participation of SMMEs within the South African construction industry.

2 LITERATURE REVIEW

2.1 Public Procurement and Effective Public Procurement

Public procurement has been defined as public spending for works, goods, and services (Nijboer, Senden & Telgen, 2017). National Treasury (2014) identifies five pillars that underpin public procurement: value for money, open, effective competition, ethics and fair, accountability and reporting and equity. According to Nkwe, Singh and Karodia (2015), Section 27(1) of the Constitution of the Republic of South Africa stipulates that when a state organ in the national, provincial, and local sphere of government contracts for goods and services, it must be done per principles such as fairness, equity, transparency, competitiveness, and cost-effectiveness. Fourie and Malan (2020) claim that these fundamental principles of good governance and public procurement are the starting point for a legislative framework concerning public procurement in the South African context. Moreover, Public Financial Management Act 1 of 1999 rests on the above five Constitutional pillars, describing the features of an effective procurement system as “fair, equitable, transparent, competitive and cost-effective”.

2.2 Legislative Frameworks that Underpin South African Public Procurement System

Prior to the transition, public procurement in South Africa was geared towards large and established building and civil contractors (Ambe & Badenhorst-Weiss, 2012). During this era, emerging contractors found it difficult to participate in government procurement procedures. However, post-1994, the public procurement process was granted constitutional status to address past discriminatory policies and practices (Bolton, 2006). According to Selomo and Govender (2016), South African public procurement reforms are underpinned by the promulgation of legal frameworks such as the Constitution of South Africa Act 108 of 1996, the Public Financial Management Act (PFMA) 1 of 1999, the Municipal Finance Management Act (MFMA) 56 of 2003 and the Broad-Based Black Economic Empowerment Act (BBEE) 53 of 2003, the Preferential Procurement Policy Framework Act (PPPFA) 5 of 2000, and the Supply Chain Management (SCM). However, it has been argued that, while there is a vast array of regulations, in court rulings, policy documents, circulars, and practice notes to regulate public procurement processes, there remains broad scope for procurers to design their systems and practices in line with the principle of ‘good governance’ (Bolton, 2016; Pillay & Mafini, 2017).

According to Nkwe, Singh and Karodia (2015), Section 27(1) of the South African Constitution stipulates that when a state organ in the national, provincial, and local sphere of government contracts for goods and services, it must be done per principles such as fairness, equity, transparency, competitiveness, and cost-effectiveness. Fourie and Malan (2020) claim that these fundamental principles of good governance and public procurement are the starting point for a legislative framework concerning public procurement in the South African context. Section 27(1) does not prevent or limit an organ of the state from implementing procurement policies for allocating contracts to specific categories of people.

The Public Financial Management Act 1 of 1999, as amended, requires public officials to conduct their procurements within the regulatory framework of the Constitution and the Preferential Procurement Policy Framework Act (UNIDO, 2017; Letchmiah, 2012). Section 2 of the Act outlines the objectives, including transparency, accountability, and prudent management of funds, expenditure, assets, and liabilities. Watermeyer (2011) states that the PFMA allows the National Treasury to make legislation that applies to all applicable institutions under the Act to conduct their procurement in a fair, equitable, transparent, and competitive manner. Moreover, Section 38 of the Act requires accounting officers to report unauthorised, irregular, and wasteful transactions to the National Treasury. In the interests of efficient and effective financial management and of leveraging government procurement expenditure to attain socio-economic benefits, Section 38(1)[a] [iii] of the PFMA and Treasury Regulation 16A 9.1(c) were promulgated. This allowed for institutionalising through the establishment of procurement departments, and the provision for public entities to have their databases of registered suppliers given preference in the procurement process.
The Municipal Finance Management Act 55 of 2003 (MFMA) replaced an antiquated local government finance system that concentrates mainly on compliance with rules and procedures. MFMA was promulgated to help mitigate the deficiencies in budgeting, accounting, and reporting, and to provide a technique which improved efficiency in the utilisation of public funds. The approach to implementing MFMA reforms is two-phased. Firstly, the capacity of municipalities must be accommodated. Thus, municipalities with limited capacity are given sufficient time to comply with certain aspects of the Act. In contrast, those municipalities with high capacity are required to implement the provisions of the Act more rapidly. Secondly, the implementation programme prioritises issues relating to financial management, irrespective of the municipal capacity. Mazibuko and Fourie (2013) claim that the MFMA prescribes secure, sound, and proper management of the fiscal affairs of municipalities. This is accomplished through the establishment of norms and standards and other requirements for promoting transparency and accountability per budgetary and financial affairs of municipalities. Moreover, the MFMA ensures sound management of municipal revenues, expenditure, assets, and liabilities. Besides this, it provides prudent management and handling of financial issues within municipalities.

The Preferential Procurement Policy Framework Act 5 of 2000 is a procurement policy that aims to achieve secondary objectives simultaneously with the procurement’s primary goal. The PPPFA gives effect to Section 217 of the Constitution by providing a framework for implementing procurement policy under Section 27(2) of the Constitution. Section 27(1) of the Constitution contains the primary objectives, which require that the public procurement system be “fair, equitable, transparent, competitive and cost-effective” (Nkwe, Singh and Karodia, 2015). The secondary objectives are to provide for the categorisation of preference in the award of contracts, and to provide the protection and advancement of people from disadvantaged backgrounds. Ambe and Badenhorst-Weiss (2012) postulate that the Act promotes historically disadvantaged individuals (HDIs) through the allocation of preference points in tendering concerning goods and services.

The Broad-Based Black Economic Empowerment Act 53 of 2003 provides a legal framework for promoting Broad-Based Black Economic Empowerment (B-BBEE). The B-BBEE is a government policy that aims to advance economic transformation and improve Black people’s participation in socio-economic and political activities (DTI, 2007). The B-BBEE is similar to affirmative action policies implemented by countries such as the United States of America (USA), and the United Kingdom (UK). The B-BBEE promotes economic empowerment of all Blacks, including women, youth, people with disabilities, and rural dwellers. As Raga and Taylor (2010) point out, the B-BBEEA expands the framework provided in the PPPFA by giving a tenderer’s B-BBEE contributor level status weight in a tender pitch, thus accelerating indirect empowerment through preferential procurement (Letchmiah, 2012; Raga & Taylor, 2010). Furthermore, the B-BBEE with which all organs of state, including state-owned enterprises, must comply in procurement decision-making also includes a set of qualification criteria for the issuance of licenses, the sale of state assets, and the forming of public-private partnerships.

The Procurement and Supply Chain Management policy is the responsibility of the SCM Office in the National Treasury, the Provincial Treasuries, and the Minister of Finance. Government expenditure and, by implication, public procurement, is overseen by the National Treasury, particularly the Office of the Chief Procurement Officer established in 2014; and while provinces have the procedural autonomy to implement their policies, they must do so guided by treasury regulations (Bolton, 2016; Vabaza, 2015; Turley and Perera, 2014). Section 112(ii) of PFMA requires each municipality to implement its SCM policy; and specifies the five pillars as the founding principles (Turley & Perera, 2014).

Section 112(ii) of Public Financial Management Act 1 of 1999 makes the requirement that Supply Chain Management systems assess bids on “value for money,” and this could imply sustainable public procurement, as well as innovation procurement when considered across the entire life cycle of the product, the purchase price being only one of the cost elements in the supply chain and throughout the life cycle (Turley and Perera, 2014). From the perspective of the Best Value (BV), public procurement creates more opportunities for maximising public value and stakeholder participation. The BV is consistent with the Public Value (PV) model, which assumes that procurement practices are like a post-Toyota approach, where in addition to the price, the supply chain is actively managed to produce value. These assumptions underpin the importance of value for money, forming a central pillar in public
procurement. It is suggested that public procurement must meet the value for the money spent by the procuring entity (National Treasury, 2014; Horn & Raga, 2012). The principle of the best value for money refers to the “best available outcome when all applicable costs and benefits over the procurement cycle have been considered” (Molver & Noeth, 2017). To meet this requirement of public procurement, the government and procurement entities must ensure that resources are utilised as per the intended purposes. However, Fourie and Malan (2020) contend that using price as a single indicator in public procurement is often unreliable. Hence, government entities cannot automatically justify the best value for money based on accepting the lowest price offer.

2.3 Pillars and Principles of Effective Public Procurement

Corruption in public procurement represents the greatest restrictive factor facing SMMEs in South Africa. To this end, it is suggested that the public procurement practices be open to public scrutiny. This principle of the public procurement process is not unique to South Africa. For instance, in Brazil, public procurement regulations provide that the government procurement processes be open to everyone. China also operates a procurement system that includes open tendering. According to Fourie and Malan (2020), the principle of open and effective competition requires transparent policies, guidelines, procedures, and practices, access to all parties so that they can compete openly and fairly.

As mentioned above, Section 217 of South Africa’s Constitution stipulates that the procurement system must be competitive. Research shows that competitive bidding leads to competition among suppliers, guaranteeing lower awarding prices due to the lowest-cost bidders’ selection (Baldi, Bottasso, Conti & Piccardo, 2016). According to Fourie and Malan (2020), the principle of open and effective competition requires transparent policies, guidelines, procedures, and practices, access to all parties so that they can compete openly and fairly.

Accountability is another important pillar of public procurement, in which individuals and entities are responsible for their actions and decisions (Fourie and Malan, 2020). Sibanda, Zindi and Maramura (2020) state that the principle of accountability requires the supply chain management (SCM) official to account for, justify and accept the responsibility of their actions. However, Auditor-General [South Africa] (AGSA), 2019) reports that accountability in municipal financial management and performance in the South African municipalities has deteriorated.

Transparency requires all stakeholders to act within ethical standards based on mutual respect and trust (Fourie & Malan, 2020). In the context of public procurement, transparency is defined as decisions that relate to enforcement in a manner that follows procedures. A transparent procurement process helps to ensure good economic governance. Moreover, a study suggests that a transparent procurement process provides a more efficient allocation of resources through competition, quality procurement, and cost savings (Oyegoke, 2012). Transparency in construction procurement is necessary in the quest to ensure excellence in the construction business. Hyacinth and Yibis (2017) suggest that public authorities demonstrate professionalism in public procurement. Efforts to promote transparency in public procurement should eliminate favouritism, especially at the evaluation stage.

Using the findings from existing research, a proposed conceptual model for effective public procurement showing the relationship between dependent and independent variables is depicted in Figure 1.
Based on the conceptual model, the following hypotheses are proposed:

*H1: Value for Money has a direct influence on effective public procurement*

*H2: Openness has a direct influence on effective public procurement*

*H3: Accountability has a direct influence on effective public procurement*

*H4: Competitiveness has a direct influence on effective public procurement*

*H5: Transparency has a direct influence on effective public procurement*

### 3. RESEARCH METHODOLOGY

A descriptive research design was employed to help describe the factors that influence effective public procurement. Quantitative research method was utilised to generate knowledge and create understanding about the factors that influence effective public procurement. The target population of the study was approximately 400, including employees, managers, directors, and government officials in the participating organisations such as Public Works Sector, Construction Industry Development Board, Business Chamber, Business Council, Procurement Institute, Built Environment Council and Progressive Professionals Forum. In this study, to determine the sample size, the 95% confidence level was chosen, with the margin of error at 5%. Given the target population, a stratified sampling technique was used to select the sample size of 250 for the study. Structured questionnaire was distributed to the 250 respondents. Before the full-scale investigation, a pilot study was conducted to determine the reliability and validity of the questionnaire. Of the 250 questionnaires distributed to the respondents, only 229 have completed and returned their questionnaires. Statistical Package for the Social Sciences (SPSS) and Analysis of Moment Structure (AMOS) were used to analyse the data. The full research protocol was obtained from the researcher’s institution. The ethical considerations addressed in this study included informed consent, privacy and confidentiality, anonymity, bias, and plagiarism.

### 4 FINDINGS AND DISCUSSION

#### 4.1 Exploratory Factor Analysis

Exploratory factor analysis (EFA) was used to test the reliability and validity of the variables in the conceptual model. The factorability and multicollinearity assumptions were tested by examining the correlation matrix. To assess the factorability of the data, Pearson correlations were calculated to determine the intercorrelations for each variable. All variables had at least one correlation coefficient greater than 0.30 and appear suitable for factor analysis.

Four items of the openness scale were analysed. The corrected item-total correlation values were above 0.3, indicating that the items measured the construct adequately. To determine the strength of the item intercorrelations, the Kaiser-Meyer-Olkin (KMO) for openness was 0.885, and Bartlett’s test of Sphericity with p<0.000. Cronbach’s alpha score of 0.951 was obtained for the scale, indicating adequate internal reliability. The findings indicate that the factor loadings for all four items were above the cut-off value of 0.30. For the commonalities, all the factors were less than 0.999, meaning that all the items were acceptable and could be perceived as key factors determining effective public procurement. Moreover, one factor with the eigenvalue of 2.612 accounted for 65.310% of the variance. The total variance explained is above the recommended cut-off value of 50% (Kline, 2015; Motulsky,
2015). Also, eight items of the accountability scale were analysed. The KMO for accountability was 0.914, and Bartlett’s test of Sphericity with p<0.000 was obtained. The Cronbach’s alpha score of 0.944 was obtained for the scale, indicating adequate internal reliability. The factor loadings for all eight items were above 0.30. Besides, one factor with the eigenvalue of 4.600 accounted for 57.502% of the variance. 8

Furthermore, six items of the transparency scale were analysed. The KMO for transparency was 0.892, and Bartlett’s test of sphericity was obtained with a significance of p<0.000. In addition, the Cronbach’s alpha score of 0.894 was obtained for the transparency scale. The loadings for all six items were above the cut-off value of 0.30. One factor with eigenvalue of 3.817 accounted for 3% of the variance. Moreover, four items of the competitiveness scale were analysed. The KMO for competitiveness was 0.744, and the Bartlett’s test of sphericity was obtained with a significance of p<0.000. The Cronbach’s alpha of 0.755 was obtained for the competitiveness scale, indicating adequate internal reliability. The factor loadings for all the four items were above the cut-off value of 0.30. The results showed an eigenvalue of 2.220, which accounted for 55% of the variance. Besides, ten items of the value for money scale were analysed. All the items had values above 0.3, indicating that the items measured the construct adequately. The KMO for value for money was 0.928 and a Bartlett’s test of Sphericity with p<0.000 was obtained. This indicated that the KMO value is above the cut-off value of 0.60. The reliability score of 0.864 was obtained for the scale, indicating adequate internal reliability. The results further showed that the eigenvalue value for the one item was 5.245, which accounted for 52.452% of the variance.

4.2 Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) was used to determine whether the variables adequately describe the data. Figure 2 shows the initial hypothesized measurement model. The Root Mean Square Error of Approximation (RMSEA), Standardised Root Mean Square Residual (SRMR), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), Normed Fit Index (NFI), Relative Fit Index (RFI), Parsimony Adjusted Normed Fit Index (PNFI), and Parsimony Adjusted Comparative Fit Index (PCFI) were the fit indices considered in this study.

4.3 Measurement Model Fitness

Table 1 indicates that the validity of the measurement model produced a chi-square value of 1162.8 and 579 degrees of freedom. The p-value was less than 0.005 (p=0.00). Table 2 shows CMIN/df =2.008 and based on the cut-off criteria was indicative of good fit. The RMSEA (0.066) and SRMR (0.045) scores showed poor fit. The CFI (0.888), RFI (0.784), the TLI (0.879) and NFI (0.817) further suggested a perfect fit of the model. The indices for PNFI (0.737) and PCFI (0.819) were above 0.50, indicating an acceptable fit. A model re-specification was further conducted to enhance the fit indices of the measurement model.
### Table 1: Goodness of fit indices for measurement model

<table>
<thead>
<tr>
<th>Model Fit Index</th>
<th>Threshold</th>
<th>Model Fit</th>
<th>Model-specification</th>
<th>Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Squared test</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMIN/df</td>
<td>df ≤2</td>
<td>2.008</td>
<td>Acceptable Fit</td>
<td>1.892</td>
</tr>
<tr>
<td></td>
<td>df ≤ 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMSEA</td>
<td>Values ≤0.05</td>
<td>0.066</td>
<td>Acceptable Fit</td>
<td>0.063</td>
</tr>
<tr>
<td></td>
<td>Values ≤0.06-0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRMR</td>
<td>Values ≤0.05</td>
<td>0.045</td>
<td>Good Fit</td>
<td>0.023</td>
</tr>
<tr>
<td></td>
<td>Values &gt;0.05 ≤0.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLI</td>
<td>Values ≥0.95</td>
<td>0.879</td>
<td>Poor Fit</td>
<td>0.993</td>
</tr>
<tr>
<td></td>
<td>Value is 0.90-0.95</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>Value is 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NFI</td>
<td>Value ≥ 0.95</td>
<td>0.802</td>
<td>Poor Fit</td>
<td>0.815</td>
</tr>
<tr>
<td></td>
<td>Value is 0.90</td>
<td></td>
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<tr>
<td></td>
<td>- 0.95</td>
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<td></td>
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</tr>
<tr>
<td>RFI</td>
<td>Value ≥ 0.95</td>
<td>0.784</td>
<td>Poor Fit</td>
<td>0.917</td>
</tr>
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<td></td>
<td>Value is 0.90</td>
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<tr>
<td></td>
<td>- 0.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFI</td>
<td>Value ≥ 0.95</td>
<td>0.888</td>
<td>Poor Fit</td>
<td>0.902</td>
</tr>
<tr>
<td></td>
<td>Value is 0.90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 0.95</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PNFI</td>
<td>Value &gt; 0.90</td>
<td>0.737</td>
<td>Acceptable Fit</td>
<td>0.743</td>
</tr>
<tr>
<td></td>
<td>Value &gt; 0.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCFI</td>
<td>Value &gt; 0.90</td>
<td>0.817</td>
<td>Acceptable Fit</td>
<td>0.823</td>
</tr>
<tr>
<td></td>
<td>Value &gt; 0.50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 4.4 Structural Model Fitness

Path modelling is the second stage of SEM, which involves linking the latent variables. The goodness-of-fit indices determine the reliability of a research model and its adequacy to test hypothesised relationships among constructs in a study. The structural model showed acceptable absolute fit. The chi-square value was 1162.8 and had 579 degrees of freedom. The associated p-value was less than 0.005 (p=0.00).
Table 2: Structural model fit indices

<table>
<thead>
<tr>
<th>Model Fit Index</th>
<th>Threshold</th>
<th>Model</th>
<th>Fit</th>
<th>Model-specification</th>
<th>Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Squared test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMIN/df</td>
<td>df ≤ 2</td>
<td>2.008</td>
<td>Acceptable Fit</td>
<td>1.909</td>
<td>Good Fit</td>
</tr>
<tr>
<td></td>
<td>df ≤ 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMSEA</td>
<td>Values ≤ 0.05</td>
<td>0.066</td>
<td>Acceptable Fit</td>
<td>0.063</td>
<td>Acceptable Fit</td>
</tr>
<tr>
<td></td>
<td>Values ≤ 0.06-0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRMR</td>
<td>Values ≤ 0.05</td>
<td>0.045</td>
<td>Good Fit</td>
<td>0.027</td>
<td>Good Fit</td>
</tr>
<tr>
<td></td>
<td>Values &gt; 0.05 -≤ 0.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLI</td>
<td>Values ≥ 0.95</td>
<td>0.879</td>
<td>Poor Fit</td>
<td>0.891</td>
<td>Poor Fit</td>
</tr>
<tr>
<td></td>
<td>Value is 0.90-0.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NFI</td>
<td>Value ≥ 0.95</td>
<td>0.817</td>
<td>Poor Fit</td>
<td>0.813</td>
<td>Poor Fit</td>
</tr>
<tr>
<td></td>
<td>Value is 0.90 - 0.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RFI</td>
<td>Value ≥ 0.95</td>
<td>0.784</td>
<td>Poor Fit</td>
<td>0.995</td>
<td>Good Fit</td>
</tr>
<tr>
<td></td>
<td>Value is 0.90 - 0.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CFI</td>
<td>Value ≥ 0.95</td>
<td>0.819</td>
<td>Poor Fit</td>
<td>0.900</td>
<td>Acceptable Fit</td>
</tr>
<tr>
<td></td>
<td>Value is 0.90 - 0.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PNFI</td>
<td>Value &gt; 0.90</td>
<td>0.737</td>
<td>Acceptable Fit</td>
<td>0.743</td>
<td>Acceptable Fit</td>
</tr>
<tr>
<td></td>
<td>Value &gt; 0.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCFI</td>
<td>Value &gt; 0.90</td>
<td>0.819</td>
<td>Acceptable Fit</td>
<td>0.823</td>
<td>Acceptable Fit</td>
</tr>
<tr>
<td></td>
<td>Value &gt; 0.50</td>
<td></td>
<td></td>
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</tbody>
</table>

A model re-specification was conducted to enhance fit indices of the measurement model. The highest residual correlation was identified, and error terms within the factor were correlated. Table 2 indicates that the assessment of the validity of the refined structural model produced a chi-square value of 1099.5. The p-value was less than 0.005 (p=0.00). The CMIN/df = 1.909 and based on the cut-off criteria was indicative of good fit. Table 3 shows that the CMIN/df = 2.008 and based on the cut-off criteria was indicative of good fit. The value of RMSEA = 0.063 and SRMR (0.027) showed poor fit. The CFI (0.900), RFI (0.995) further suggested a good fit for the structural model. The indices for PNFI (0.734) and PCFI (0.823) were above 0.50, indicating an acceptable fit.
The relationships among the variables within the structural model were determined. The results of the standardised regression relationships from the structural model are depicted in Table 3. The parameter estimate is significant at p≤0.05. The results of the influence of the exogenous variables on endogenous are further discussed.

Table 3: Structural model statistics

<table>
<thead>
<tr>
<th>Proposed Hypothesis</th>
<th>Regression Estimate</th>
<th>P</th>
<th>Rejected/Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPP ← OPN</td>
<td>1.449</td>
<td>0.003</td>
<td>Supported</td>
</tr>
<tr>
<td>EPP ← ACCN</td>
<td>1.248</td>
<td>0.043</td>
<td>Supported</td>
</tr>
<tr>
<td>EPP ← TRPN</td>
<td>1.636</td>
<td>0.039</td>
<td>Supported</td>
</tr>
<tr>
<td>EPP ← COMPT</td>
<td>-0.345</td>
<td>0.421</td>
<td>Rejected</td>
</tr>
<tr>
<td>EPP ← VFM</td>
<td>0.726</td>
<td>0.037</td>
<td>Supported</td>
</tr>
</tbody>
</table>

Inspection of the R2 and p-value for the openness construct revealed a direct influence of openness on effective public procurement. The direct influence of openness on effective public procurement is statistically significant as the p-value (p=0.003) is less than the cut-off value of 0.50. Therefore, the hypothesis cannot be rejected. According to Fourie and Malan (2020), the principle of open and effective competition requires transparent policies, guidelines, procedures, and practices, access to all parties so that they can compete openly and fairly. Accountability was hypothesized to have a direct influence on effective public procurement. R2 was 0.1248, and the p-value was 0.043, indicating statistical significance as the p-value was less than 0.50. Therefore, the hypothesis cannot be rejected. A study confirmed that for a procurement process to be effective, accountability must be ensured (Sibanda et al., 2020). Inspection of the R2 and p-value for the transparency construct revealed a direct influence of transparency on effective public procurement. The direct influence of transparency on effective public procurement is statistically significant as the p-value (p=0.039) is less than the cut-off value of 0.50.
Therefore, the hypothesis cannot be rejected. According to Horna and Raga (2012), the principle of transparency is very crucial in the public procurement process.

Although competitiveness was hypothesized to have a direct influence on effective public procurement, there was no empirical findings to support the hypothesis, as no statistical significance was found (R2=-0.345, p=0.421). Therefore, the hypothesis is rejected. Although findings from past studies have suggested competitiveness as an essential feature of an effective procurement system (Baldi et al., 2016; Horn & Raga, 2012; Tadley's, 2012). These findings contradict the anticipated outcome of competitiveness as a determinant of effective public procurement. Value for money was hypothesized to have a direct influence on effective public procurement. The p-value was 0.037, indicating statistical significance as the p-value was less than 0.50. Therefore, the hypothesis cannot be rejected. Findings from the study confirm that to obtain a quality procurement system, it is important for value for the money and that the quality of the goods/services/works must meet the entity’s criteria and cost constraints (National Treasury, 2015; Horn & Raga, 2012).

5. CONCLUSION AND FURTHER RESEARCH

Effective public procurement is a potential catalyst for innovative solutions to pressing societal challenges. Therefore, this study aimed to develop an effective public procurement model for SMMEs within the South African construction industry. The variables that measured effective public procurement in this study included value for money, openness, accountability, transparency and competitiveness. The findings showed that the direct influence of openness, accountability, transparency and value for money on effective public procurement were statistically significant as the p-value was less than the cut-off value. The findings are consistent with previous scholarly research, which states that accountability, transparency and value for money are the key determinants of effective public procurement. Although competitiveness was hypothesized to have a direct influence on effective public procurement, there was no empirical findings to support the hypothesis, as no statistical significance was found. The model only focused on effective public procurement without explaining how it was arrived at. The model could not explain how the pillars of public procurement impact effective public procurement. That is, the model only includes public procurement pillars and prances such as value for money, transparency, accountability, openness, and competitiveness. Therefore, future research should validate the model to determine exactly how effective public procurement was arrived at.
6 References


An investigation and comparison of the mental health of the construction industry workforce prior to and during the pandemic in UK

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ABSTRACT AND KEYWORDS

Purpose of this paper
This research investigated and compared the mental health of those working within the construction industry prior to and during the COVID-19 pandemic. There had been research exploring this topic prior to the pandemic. However, there had been limited exploration into how the pandemic period affected mental health, despite the speculation that the pandemic caused the mental health of those working in the construction industry in the UK to decline.

Design/methodology/approach
The research was carried out using a mixed methodology, including primary, secondary, qualitative, and quantitative data. Due to the complex nature of the topic, but also the need to explore past and current events, the research question required a mixed methodology.

Findings
There were high rates of poor mental health and suicides within the construction industry in the UK. This had been well documented for some years, the pandemic was expected to exacerbate these issues due to restrictions and changed stressors. However, this research showed that the mental health of construction workers did not necessarily worsen, in addition to there being a lower level of suicides in 2020 compared to 2019. However, the rates had been still alarmingly high, and the construction industry had reached crisis point. Further research needed to be carried out in the years following the pandemic.

Original value
The mental health of construction workers in the UK had been consistently poor over at least the last decade. Additionally, there were high rates of suicides within the construction industry. However, the speculation that statistics would show declining mental health in the industry during the pandemic, was proved to be incorrect by the primary and secondary research. The research provided data and discussions on the mental health of construction employees prior and amid the global pandemic in UK. It shaded light on the post-pandemic era on how to improve the mental wellbeing of employees for all stakeholders in the construction industry.

Keywords: Mental health; Construction workforce; Pandemic; Suicide; Wellbeing
1. INTRODUCTION

Historically, construction has always been a dangerous profession. In 1974, the year in which The Health and Safety at Work Act was introduced, 166 construction workers died carrying out their jobs. Those 166 deaths accounted for 25% of all work-related deaths that year. In 1981, there were almost 8 deaths for every 1000 workers. 116 workers died in total on various sites in that year (Safety Fabrications, 2019). Despite construction industry related deaths still accounting for over 25% of the UK’s work-related deaths each year, it has worked hard to ensure there is greater safety on site.

However, the mental health of those working in the construction industry has remained consistently poor for at least the last decade (ONS, 2021). Professor Charles Egbu, the President of the Chartered Institute of Builders (CIOB) stated in the Foreword of Rees-Evans (2020) that ‘despite significant improvements in the safety of the construction workforce in recent years, mental health has become a silent crisis’. It could be argued that this is a result of an absence of any legal legislations which require employers to have mental health policies in place for their employees, unlike the physical health and safety of employees for which there is legislation such as The Health and Safety at Work Act in 1974.

With the mental health of construction workers already at crisis point, it was speculated that the global pandemic would exacerbate the mental health issues of those already suffering and cause further cases. BWI (2020) was concerned that Covid-19 would challenge the safe working environment of construction workforce. Indeed, the effects of COVID-19 were felt by millions globally, but those working in construction were thought to be particularly vulnerable, with further job and finance instability and pressures as a result. Up until early 2022, it had been too early to determine the actual effects that the pandemic had on UK construction workers.

Following the suggestion of Lingard et al. (2021) of what has been learned from the global pandemic, this research aims to understand the implications that the COVID-19 pandemic has had on the mental health of those working in the construction industry in the UK, why COVID-19 has caused the implications, and what can be done to manage and support the mental health of employees in the built environment as a result. Research objectives included: 1) analysing the statistics of the mental health of construction workers pre-pandemic and during the pandemic; 2) exploring the reasons that those working within the construction industry are more likely to suffer from poor mental health than most other professions, both pre and during the pandemic; 3) exploring the difference in stresses imposed on employees pre and during the pandemic; and 4) investigating the support that construction industry employees receive regarding their mental health.

2. LITERATURE REVIEW

Those working in construction can be at high risk of suffering poor mental health (Sherratt et al., 2019; Lingard and Turner, 2015). There are many studies, surveys and data which document the consistently poor mental health, and high suicide rates of those working within the construction industry in the UK, but since the outbreak of the coronavirus, and the introduction of lockdowns, there has been a lot of speculation as to whether these statistics will continue to worsen because of pandemic related stressors.

This review analyses publications exploring mental health and the construction industry, such as Understanding Mental Health in the Built Environment (Rees-Evans, 2020), Suicide by Occupation, England and Wales, 2011 to 2020 Registrations (ONS, 2021), Occupational Stress in the Construction Industry (Campbell, 2006), Suicide by Occupation, England: 2011 to 2015 (ONS, 2017), and Deaths from Suicide that Occurred in England and Wales: April to July 2020 (ONS, 2021).

This review is split into 3 sections: poor mental health and high suicide rates within construction in the UK, stresses imposed on construction workers in the UK, and help available from employers to those working within construction in the UK.
2.1 Poor Mental Health and High Suicide Rates within Construction in the UK

Despite lower rates of health and safety related deaths on sites in recent years (Safety Fabrications, 2019), the rate of suicides carried out by those working in the construction industry have stayed consistent over the last decade (ONS, 2021).

This dataset is limited, however. This research paper is focusing on the UK, but the ONS (2021) data only includes England and Wales statistics, therefore only including statistics from 2 of 4 of the countries which make up the UK. In addition, the number of deaths by suicide registered in a year, doesn’t necessarily reflect the actual number of deaths by suicide in the year, as inquests into deaths by suicide can take months and result in delay of registration (ONS, 2021). Furthermore, the data released in the ONS (2021) publication is raw data. An analysis of the numbers of deaths by suicide by occupation, hasn’t been carried out by the ONS since 2017, and only included statistics between 2011 and 2015 (ONS, 2017). As a result, the raw data will need to be collated, and the Standard Occupational Classification (SOC) codes applied to extract the relevant statistics. The ONS doesn’t provide a standard list of job codes which are included within the construction industry category, so these will need to be identified for this research paper. The SOC codes identified by the ONS (2017) may vary from those identified for the purposes of analysing the Suicide by Occupation (ONS, 2021) data. Therefore, the ONS analysis of Suicide by Occupation (2017) will be dismissed from this study, and only the raw data released by the ONS in 2021 will be used to analyse the number of deaths by suicide in the construction industry.

A piece of research undertaken by Rees-Evans carried out in 2019, just before the first case of Coronavirus was diagnosed, titled Understanding Mental Health in the Built Environment (2020) explores in detail the general mental state of those working within the construction industry. The results show that 26% of workers had suicidal thoughts, and as many as 87% of workers suffered anxiety in the year preceding the survey because of their job, as well as 70% suffering from depression.

Reese-Evans (2020) report, Understanding Mental Health in the Built Environment, explores many issues, not limiting itself to feelings of anxiety, depression, and negative/suicidal thoughts. It asks about feelings of stress, irritability, and fatigue, as well as low self-confidence, feelings of being overwhelmed, and poor concentration. 95% of workers felt irritable, and 90% felt overwhelmed, as well as 98% having suffered from fatigue in the preceding year.

These statistics reveal that those working in the industry are highly vulnerable to mental health issues which could potentially lead to negative thoughts. The survey itself, however, was carried out globally, and only 80% of respondents were from the UK. Of these 80%, it is also not certain which regions. The data from the ONS (2021) only represents statistics from England and Wales, whereas Rees-Evans (2020) could represent respondents from Northern Ireland and Scotland also. Despite these limitations, there were 80% UK respondents from a pool of over 2,000 people.

2.2 Stresses Imposed on Construction Workers in the UK

The construction industry has several stressors which come together in a unique combination. Campbell (2006) studied stressors within the construction industry and split them into different categories: job role factors, job demand factors, organisational factors, physical factors, and other factors. Of job role factors, conflicting demands, inadequate managerial support, and lack of career progression were the highest 3 factors affecting stress. Of job demand factors, too much work, pressure and ambitious deadlines were the top 3 factors affecting stress. Of organisational factors, lack of feedback, poor communication and inadequate staffing were the top 3 factors affecting stress. Of physical factors, lack of privacy, inadequate temperature control and problems with office accommodation were the top 3 factors affecting stress. In addition, the public misconception of the construction industry was a large contributor to workplace stress.

This research was carried out 14 years ago, if the same survey was carried out today it may show different results. This may affect the validity of the source. It is also unclear where the respondents were from, although we know there were 847. However, Campbell (2006) found that 14 years ago, 68% of respondents had suffered from stress, anxiety, or depression because of working in the construction
industry. 12 years after Campbell (2006), Reese-Evans (2020) found that 97% of respondents had suffered from stress, anxiety, or depression, which is an increase of 29%. ENR (2020) revealed that nearly 40% of U.S. forms had been forced to lay off employees caused by Covid-19 pandemic.

2.3 Help Available from Employers to those Working within Construction in the UK

Rees-Evans (2020) explored not only the statistics of those who were facing mental health issues in the UK just prior to the global pandemic, but also whether their companies offered support for mental health, and the kind of support that was on offer. The survey found that 49% of respondents were certain that their company did not offer any kind of policy which supported the mental health of their employees.

What is most concerning, is that only months later, the UK would be locked down by the Prime Minister, and that those who were already suffering from mental health issues, may be subjected to further stressors and isolation. Some would also potentially lose loved ones to the coronavirus, which could exacerbate their mental state. All of this was happening, and less than 50% would receive mental health support.

3. METHODOLOGY

3.1 Primary and Secondary Data

Primary data, or raw data, is defined in the Cambridge Dictionary as 'Information that you collect yourself, rather than get from somewhere else'. Primary data can be collected in various ways, such as circulating questionnaires, or conducting interviews. Primary data collection allows the person(s) conducting the research to tailor the questions asked, tailor the target audience reached out to, and tailor the topics of conversation, which allows them to gather specific data needed to investigate their research question.

Secondary data, however, is defined by the Cambridge Dictionary as 'Data that is publicly available', such as through reports, research papers, journals, and raw statistics collected by others such as the ONS. Primary data collection is the only way to collect data which is new. In addition, as mentioned, it allows the author of research to collect specific data which is required to discuss their chosen topic. The downside of primary data collection is that it can take a lot of time to gather, but also to analyse. In addition, if an author is to rely solely on primary data, they would need many respondents, which can be difficult. Secondary data is much easier to collect, due to it being readily available and having already been analysed. However, there can be limitations out of the control of the author, such as geography, age, gender, occupation etc, depending on what their topic of research is.

3.2 Chosen methods

The research adopted a mixed methodology. Secondary data collection was mostly quantitative research, although secondary qualitative research was utilised where available. The limitations of secondary data were that there was no control over control groups and variables. In the case of this research paper which was concentrating on the mental health of UK construction workers, geographical limitations might affect the validity of the research. In addition, it often would not be known whether the mental health of the respondent was a result of their profession, or external factors such as personal bereavement.

Primary data collection was used in the form of a questionnaire. A questionnaire was chosen over an interview as mental health is a sensitive topic. Many people with existing or previous mental health issues might be uncomfortable sharing it. Utilising an anonymous response questionnaire would help respondents to feel more comfortable in opening up about their experiences. The study was conducted in London, U.K. The survey included professionally verified Linked-In personnel in the construction industry. Survey questions were designed specifically to identify the profile differences (as regards mental health) in a relatively short period of time into the lockdown (approximately 12 months). The study assumed that this would be a reasonable period for professionals to be able to assess the stresses, strains, or any other effects that they had experienced both during the lockdown and previous thereto.
The questionnaire consisted of quantitative questions with multiple choice answers to allow fast and accurate analysis of the quantitative data. There was a message at the beginning of the questionnaire warning that suicide would be mentioned, to allow participants to close it down before the questions started should they feel they were unable to proceed.

4. DATA ANALYSIS AND DISCUSSION

4.1 The mental health of construction workers pre-pandemic

A questionnaire was issued by the author via the professional social media platform LinkedIn, requesting that those working in the construction industry in the UK anonymously answer questions regarding their mental health before and during the COVID-19 pandemic. There was a trigger warning on the post to alert respondents to the content and mentioning of suicide before they opened it, as well as the confirmation that the respondents would stay anonymous. To further protect identity, the questionnaire did not ask for even the job role of the respondent. There were 40 responses to the questionnaire between December 2021 and February 2022.

The responses from the questionnaire showed that prior to the pandemic, 100% had suffered from stress at some point because of working in construction, 92% had suffered from anxiety, 77% had suffered depression and 38% had suffered from suicidal thoughts. These statistics are alarmingly high, regardless of how often the individuals had suffered from any of the above. A survey carried out by Rees-Evans in October 2019, just before the COVID-19 pandemic, and published in 2020, found that of 2,081 respondents, 87% experienced anxiety, 70% experienced depression, 25% had suicidal thoughts and 97% experienced stress of some kind. Shockingly, 44% of the respondents said that their company did not have mental health policies in place, and only 38% offered helplines to support the mental health of their employees (Rees-Evans, 2020). It is important to note here that the survey was offered worldwide, and only 80% of the respondents came from the UK. This presents a limitation to this report in terms of geographical statistics. However, it still highlights the high levels of mental health issues experienced by employees of the built environment, as well as the lack of support offered overall.

Randstad (2017) carried out a survey which collected 3400 responses. About 34% had experienced mental ill health in the previous year. The statistics shown through primary and secondary research into the mental health of construction workers pre-pandemic, largely reflect each other. All studies found extremely high levels of stress, depression, and anxiety. Rees-Evans’ 2019 study found that 25% suffered from suicidal thoughts, and the primary research revealed that 38% of respondents had suffered suicidal thoughts. The primary research showed a higher percentage by 13%. A potential explanation for this is that only 80% of the respondents of the survey were from the UK, in addition to a much lower number of respondents in the primary research questionnaire. Alderson (2017) found that 42% of over 2000 respondents in a survey carried out by Construction News, suffer from mental health issues in their workplace. This reveals that construction workers, statistically, are more than twice as likely to suffer from mental health issues compared to the national average (Mind, 2017).

The statistics needed to be collated to combine the England and Wales data sets, in addition to defining the Standard Occupational Classification (SOC) job codes which determine which occupations would fall under the construction industry category. For this study, job codes were sorted using their SOC Unit Group, to allow a more detailed analysis of the suicide rates in various occupations. 29 SOC Unit Groups were identified.

The ONS (2021) data reveals that in 2019, there were 3,094 suicides across England and Wales in total. Of these, 18.21% worked within the construction industry in some capacity. In 2019, the single largest SOC Unit Group was Care workers and home workers, at 3.88% of the overall number of suicides. Elementary construction occupations were the third largest at 3.23% of the total number of suicides.

SOC Unit Group, Elementary construction occupations, presented the largest overall percentage of suicides in 2017, 2012 and 2011. In most other years, those working in at least 1, if not 2 occupations under the construction industry category, were the 2nd and 3rd most likely to commit suicide across the total number in each year.
The data shows that (using suicide rates as a key indicator) the mental health of those working in the construction industry has stayed consistent since 2011, with the highest suicide rates being in 2012 at 19.21% overall, and the lowest in 2014 at 16.83%. Although, 2014’s statistics were an anomaly, as since 2011, it was the only year in which the rates dropped below 17% overall. The average percentage of suicide rates within the construction industry against the overall number in England and Wales between 2011 and 2019 is 18.05%. The high rates of stress, anxiety, depression, and suicidal thoughts amongst those working in construction found in the questionnaire, reflect the findings in both the CIOB (2020) survey report and the ONS (2021) suicide rates.

4.2 The mental health of construction workers during the pandemic

Early speculation suggested suicide rates in the UK would increase during the initial stages of the pandemic, however, the ONS (2020) found that in fact, suicide rates across the UK between April and July 2020 were lower in comparison to the same period in the preceding years, being comparative only to the 2016 statistics. Between April 2020 and July 2020, 1,603 suicides were recorded (ONS, 2020). According to the ONS (2020), this was “the most complete period because of the late registration of deaths”.

The raw data later released by the ONS (2021) showed that in the year, the total number of suicides across England and Wales reached 2,899, 195 fewer than in 2019. The complete statistics for 2020 followed the same trend as between April 2020 and July 2020 (ONS,2020), contradicting the speculation that the rates would increase.

Of the 2,899 suicide related fatalities, 18.21% were of those working in the construction industry. Despite there being fewer deaths overall, there were only 0.25% less within construction industry roles. Similar trends were found in the primary data research as displayed in Figure 1.

![Figure 1. Comparison of stress levels of respondents before and amid the pandemic](image)

The key findings here are that 75% of respondents claimed to be often with stress, but this rate was reduced to 33% during Covid. Instead, more respondents stated being sometimes with stress, i.e., 40% during Covid compared to 18% before that. Prior to the pandemic 100% of respondents suffered from stress of some level. There was also a 7% increase of those who only suffered from stress on a rare occasion. Differing from stress, depression is another description of mental health as displayed in Figure 2.

![Figure 2. Comparison of depression levels of respondents before and amid the pandemic](image)
Prior to the global pandemic, only 23% of respondents said they had never suffered from feelings of depression, rising to 48% during the lockdown. A lower percentage of respondents suffered from depression during lockdown compared to before. The third measurement in terms of suicidal thoughts is presented in Figure 3.

![Figure 3. Comparison of suicidal thoughts from respondents before and amid the pandemic](image)

The data shown here indicates that overall, the number of respondents who thought about suicide during the lockdown was less than prior to the lockdown. From the previous questionnaire responses analysed, it can be ascertained that overall, the mental health of the respondents somehow improved during the pandemic. As previously mentioned, it could be argued that this was due to respondents being able to spend more time with family, being able to spend more time on their hobbies, take up new hobbies, or perhaps they were able to sleep more with a less frequent or easier commute to work. Lack of sleep can exacerbate poor mental health (Cherry, 2020).

However, more respondents thought about suicide “often” than previously. This could be because the lockdown increased depressions as corresponding to Figure 2 or meant that the respondents were spending more time on their own if they already lived alone. Between 3rd April and 3rd May 2020, the ONS (2020) carried out a survey around Coronavirus and Loneliness in Great Britain. They found that 7.4 million people reported that their wellbeing was negatively impacted because of the lockdown imposed and referred to them as “lockdown lonely”. However, in this study, respondents were asking only to their working life. The pandemic heightened job insecurity for many, especially for those who were self-employed and were struggling to secure the required income through The Furlough Scheme.

4.3 Exploring the mental health for employees working within the construction industry

An interview conducted by Everymind (2020) revealed that construction workers were subject to a plethora of stressors, and hence it was unsurprising that high rates of poor mental health were consistently reported. Stressors include shift work, job insecurity, working away from home for long periods of time, low pay, high job demands, late payments, separation from family, competitive environments, long working hours, physically demanding work, and the pressure of maintaining the “tough guy” image (Everymind, 2020; Salmon (2019); UK Construction Media, 2018). In addition, 89% of the construction workforce are male and men are less likely to report mental health issues, and therefore aren’t getting the help they need (Lorek, 2020).

Furthermore, the Rees-Evans (2020) study revealed further insight into the causes of poor mental health for construction workers. 96% suffered from fatigue, 86% had a lack of self-confidence and 91% felt overwhelmed, in addition to the high levels of stress, anxiety, depression and suicidal thoughts as previously broken down. In the same study, 92% felt there was poor communication, 92% felt that they had to adhere to unrealistic deadlines, 79% suffered stresses because of poor temperature control, 67% suffered from a lack of adequate toilet facilities, 93% felt they had too much work to do and 94% felt stresses due to time pressures.

Reese-Evans (2020) also focused on separating issues into responses from manual labourers, middle management, and senior management. Across all three, there were high levels of stress because of bullying. 86% of manual labourers, 63% of middle management, and 52% of senior management
reported stress as a result of bullying. 83% of senior management reported stress as a result of pressure to respond to e-mails and phone calls outside of working hours. Across all three levels, there were high levels of stresses as a result of inadequate staffing, poor communication and poor planning. In addition, 84% of manual labourers suffered from stress because of isolated working.

These stressors were all present before the Coronavirus pandemic. During the pandemic, many of the stressors were heightened, particularly for those in construction with low skill jobs. Many of these workers are self-employed, and the uncertainty of relying on furlough pay, as well as not knowing when work levels would return to ‘normal’ left many in further doubt of job security (Everymind, 2020). Further financial strain was also placed on those who were earning the sole income of the family, or the breadwinner of the family (Everymind, 2020). For those already suffering from fatigue, there were now added pressures of blurring lines between work and home. Without clear boundaries, many started to work outside of their working hours more often, and spend less time recuperating (Everymind, 2020).

A study carried out by the Association for Project Management, as cited in Cotton (2021), revealed that 40% of Project Manager respondents said their work-life balance suffered, 40% said their home life and personal relationships were impacted, and 39% said there were unrealistic expectations placed on them by stakeholders, all as a result of the COVID-19 pandemic.

4.4 Exploring the difference in stresses imposed on employees pre and during the pandemic

To explore the difference in stresses imposed on employees pre and during the pandemic. As discussed previously, stressors include shift work, job insecurity, working away from home for long periods of time, low pay, high job demands, late payments, separation from family, competitive environments, long working hours, physically demanding work, and the pressure of maintaining the “tough guy” image (Everymind, 2020; Salmon, 2019; UK Construction Media, 2018). Individually, these stressors are not unique, any of these can apply to other professions, however within construction, these stressor usually come together at the same time, and for extended periods of time.

Many stresses experienced by those working in construction during the pandemic, were also experienced prior to the COVID-19 outbreak, however they were heightened as a result. These were stresses such as financial worries and lack of job security. However, a stress suffered during the pandemic which would not have been present prior to it, was that of labour shortages due to staff isolating with the Coronavirus. As cited by Cotton (2021), a study showed that 39% said there were unrealistic expectations placed on them because of the pandemic, in addition to 40% revealing their work-life balance and personal life were affected because of restrictions.

In the UK, the sickness absence rate fell to 1.8% in 2020, the lowest recorded level since records began in 1995. This is most likely because so many people were furloughed, they wouldn’t have needed to report sickness absence. However, for those who were still able to work, 14% of all absences were because of Coronavirus between April 2020 and April 2021 (ONS, 2021). For construction, this would have caused labour shortages, putting stress onto supervisors and contractors who were working to deadlines.

Furthermore, there were cost implications as a result of mass lateral flow testing (LFT) and introducing provisions to be COVID-19 compliant on site and in offices including procuring additional Personal Protective Equipment (PPE) and having to have workers 2 metres apart in offices and on site. The Royal Institute of Chartered Surveyors (RICS) (2020) carried out a survey which found that 69% of respondents were experiencing a reduced cashflow. Research cited in O’Connor (2020) revealed that COVID-19 caused productivity losses reaching 35%. The same research analysed 45 projects delivered during the pandemic and found that 7% of the productivity losses could be attributed to labour shortages and social distancing.

4.5 Investigating the mental support that construction industry employees receive

The smaller the company, the less likely they are to offer help to their employee surrounding their mental health and wellbeing (Rees-Evans, 2020). Only 32% of respondents who worked in companies with 10-49 employees reported that that were mental health policies in place, and that dropped to 22% in companies with fewer than 9 employees. In the same report, results showed that 21% of respondents
working in companies with between 50 and 249 employees said there were no policies in place, and 10% reported no policies in companies with more than 250 employees. Of those whose companies did offer policies, only 38% offered helplines, 38% offered flexible working, 7% offered a ‘switch off [phones and e-mails]’ policy outside of working hours and only 31% received training on mental health and systems (Rees-Evans, 2020). In this study as shown in Figure 4, 7.5% of respondents stated there was no mental health policy in place at their company, and 15% of respondents were unsure, however, data was not collected on the size of the company the respondents were working for, nor were specific details about the policies in place.

![Figure 4. Responses whose employers had a mental health policy in place](image)

5. CONCLUSION AND RECOMMENDATION

This study looked to explore the mental health of those working in construction before and during the COVID-19 pandemic. Sources showed that prior to the pandemic, suicide rates have remained constant in construction, with on average, a significant proportion of work-related suicides being committed by those working in the construction industry each year in the UK. Prior to the pandemic, according to primary data research, 100% of the respondents had suffered from work-related stress at some point. With consistently high levels of anxiety and depression across surveys and research, the mental health of construction workers in the UK should be prioritised, especially by those who employ them. There was no sharp increase in suicide rates as was predicted. In addition, the general mental health of those working in construction improved, with a decrease of 13% suffering from stress as revealed by primary data research. This suggests that despite some new stressors, such as whole teams being absent due to sickness at the same time, and existing stressors being exacerbated by the pandemic, such as financial and job security, the COVID-19 pandemic did not necessarily result in worsened mental health of those working within construction in the UK. One of the factors contributing to improvement of mental health could be furlough scheme introduced during the pandemic, which had a positive effect on no significant rise in mental health during the pandemic. The effects of this scheme on the wellbeing or mental health might be investigated in future work. Nevertheless, poor mental health was still high, and this should not be ignored.

The study discussed the reasons why those working within the construction sector were so vulnerable to suffering from poor mental health. Research found that there were many contributing factors, which came together in a way which heightens the risk of suffering from poor mental health. This was explored across existing studies through secondary data search. Men were less likely to seek support and speak out when their mental health was suffering, and therefore would most likely continue to worsen with time. The study also looked to explore whether the stressors changed during the pandemic. There was a lack of research in this area. From the limited research that was available, it was found that some reported that existing stresses were simply exacerbated. Finally, this study explored the support that construction industry employees received regarding their mental health.
The primary research was limited to a small sample size with only 40 valid responses. It is recommended to conduct a larger-scale survey to compare against the primary data collection carried out by this research. The future survey could also include questions surrounding stressors, and the difference between stressors both prior to and during the pandemic. Since the UK has begun easing out of lockdown restrictions, and many have returned to their offices, it may be that the stresses imposed on UK construction workers change again after the pandemic. In a few years, it is recommended that research is undertaken to explore this, and whether the ‘new normal’ stressors affect mental health more or less than they did prior to the pandemic. Finally, the implications of a lack of mental health policies within companies needs to be considered. It needs to be considered whether legislation could improve the mental health of not just those who work within the construction industry, but across the whole of the UK.

This research contributes to understanding the mental health of those working within the construction industry within the UK during the Coronavirus pandemic. Prior to this research there has been very little data reported on during the pandemic, and it contradicts early speculation that the pandemic would worsen the mental health of those working in the construction industry.

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The growth and performance of construction firms in South Africa: does leadership style make a difference?

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ABSTRACT AND KEYWORDS

Purpose of this paper
The purpose of this paper is to examine whether there is a significant relationship between leadership styles and organisational growth and performance of construction firms in South Africa. The rationale for this paper originates from the notable failure of prominent construction firms in South Africa. This decline in the performance of construction firms brings about the need to investigate the relationship between leadership styles and the growth and performance of construction firms.

Design/methodology/approach
The study employed mixed-method research approach involving the use of a case study and survey research design. Structured interviews were used to elicit primary qualitative data while an online questionnaire was used in generating quantitative data over five years for construction companies listed in Grade2-9 on the Construction Industry Development Board (cidb) Register of Contractor (RoC). The data collected was analysed using descriptive and inferential statistics. The descriptive analysis was based on the responses of 31 contractors in the Western Cape. Pearson correlation analysis was conducted to examine the effect of leadership styles on the company’s growth and performance. Interviews were analysed using thematic analysis.

Findings
The study found that the relationship between six leadership styles and organisational performance were significant at the 5% level of confidence, while three were significant at the 1% level. The relationship between leadership styles and organisational growth and performance was found to be positive but moderately weak.

What is original/value of paper
The outcomes of the research are useful to current construction company leaders and practitioners entering the industry as they will be aware of the correct and most effective leadership style that benefits construction companies. This will bring about overall firm growth, improved company performance and reduced failures of contractors in the South African construction.

Keywords: Construction Industry, Democratic Leadership, Growth, Laizzez-Faire Leadership, Organisational Performance, South Africa, Transformational Leadership
1. INTRODUCTION

Leadership as a concept has been redefined several times following the progressive shifts of leadership models (Çelik et al., 2016), suggesting an evolutionary definition that varies with the environment (Antonakis and Day, 2017). Several definitions of leadership give rise to behavioural traits that can be grouped into leadership styles. These leadership styles are categorised as autocratic/authoritarian, democratic-participative, paternalist, transactional, charismatic, transformational, laissez-faire and strategic leadership (Liphadzi et al., 2015; Çelik et al., 2016). Leadership in the construction industry has been undervalued with the emphasis being on project delivery and performance (Toor and Ogunlana, 2006).

The economic downturn has led to construction firm failure, which is characterised by the decrease in sizeable high capital ventures such as critical infrastructure projects. As such, contracting firms are facing insolvency in a market full of uncertainties (Ozorhon et al., 2008). PwC (2016) asserts that South African firms in the Grade 9 position on the Construction Industry Development Board (CIDB) Register of Contractors, namely Murray and Roberts, Aveng and Group Five were unable to generate high construction revenues compared to previous years.

Scholars acknowledge lack of leadership and poor leadership as the principal reasons why construction firms are failing (Girma, 2018). Odendaal (2018) acknowledges that due to a lack of leadership attributes, firms struggle to prosper in the competitive construction environment and find it challenging to adapt to complex changes such as an economic crisis or an exponential rise in technology. Charges of collusion and anti-competitive behaviour corroborated an instance of poor leadership in South African construction companies during stadium projects for the 2010 FIFA World Cup (Meyer, n.d). The practice of leadership in most of the cases cited is poor, and Korman (2018) found that the leaders are not exerting the effective skills or processes to promote or increase the success factor required to achieve the company goals. While Girma (2018) notes that the existing models of leadership cannot sustain the enterprise past the economic difficulties in the construction environment. Moreover, limited research has investigated the leadership styles used in construction organisations.

Hence, this study investigates the leadership styles used by construction company executives and whether it impacts organisational performance. This is done through identifying leadership styles used in construction firms, determining the performance and growth pattern of construction firms, finding out the impact of leadership styles on construction company performance (financial success and internal productivity) and establishing the impact of leadership styles on the growth pattern of construction companies.

The objectives mentioned above was achieved by initially conducting a review of literature relevant to the topic. With a firm understanding of the proper research, a mixed-method research approach was used in obtaining empirical data that answer the research objectives. A combination of case studies and cross-sectional surveys of construction companies was employed in collecting the necessary data. Additionally, secondary data was obtained from the construction companies and used in the research.

2. LITERATURE REVIEW

Horta and Camanho (2014) affirm that constructions firm is in survival mode since firms are not able to cope with the continually evolving environment. Scholars have stated several reasons behind this failure; however, the main reason acknowledged is a lack of leadership within the organisation (Gallager, 2018).

2.1 Concept of Leadership

It is asserted that leaders play a crucial role in shaping collective norms, helping teams to cope with their environment, and coordinating collective action (Guzzo and Dickson, 1996). Leadership is seen as an authoritative source of management development and provides a sustained competitive advantage for the improvement of organisational performance. This is because intangible assets such as leadership styles, culture, skill and competence, and motivation are seen progressively more as a critical source of strength in firms that can combine people and processes along with financial objectives to achieve holistic organisational performance in construction firms (Horta et al., 2009). Subsequently, the effect of leadership on organisational performance is perceived as the fundamental driving forces.
for the improvement of an organisation (Obiwuru et al., 2011). The assets and characteristics of leadership have given rise to leadership styles as established by scholars such as Toor and Ofori (2006); Toor and Ogunlana (2008); and Ofori (2009). As previously mentioned, some of the most prominent leadership styles are categorised as autocratic/authoritarian, democratic, transactional, transformational and laissez-faire leadership (Liphadzi et al., 2015; Çelik et al., 2016).

Transformational leadership invokes feelings of trust, admiration, loyalty and respect from followers towards the leader, and the followers are encouraged to perform better than at the initial expectation (Çelik et al., 2016). Transactional leadership displays two types of behaviour: constructive and corrective behaviour (Aarons, 2006). Constructive behaviour involves a reward system, whereas corrective behaviour entails corrective actions (Bryant, 2003). The democratic leadership style exhibits an attitude to motivate subordinates, encourages them to be more creative, ensures that the discussion is open to all the followers and guarantees the followers are involved and committed to projects (Gastil, 1994). While Autocratic also known as authoritarian leadership has qualities of this leader's decision-making process is not consultative, legitimate power and pressure are used as a motivational means, mistrust to the followers is quite usual, delegation and empowerment is less (Keskes, 2014; Padilla et al., 2007).

2.2 Leadership in Construction

It has been conceded that leadership is specific to the environment, and the construction industry has requirements that are unlike any other sector (Liphadzi et al., 2015; Girma, 2018). Price (2003); and Oyewobi et al. (2016) infers that a positive personality and proving an inspiration to others are critical values for leadership in the construction industry.

According to Price (2003), Liphadzi et al. (2015), Kerndnern and Thanibenjasith (2017), the leadership styles that are the most indicative of these characteristics are transformational and democratic leadership. However, the research that exists in relation to leadership and organisational growth and performance in the construction industry is not specific to the South African construction industry. Several authors have identified the state of leadership in construction, notably CIOB (2008); however, this applied to industries in other countries. Toor and Ofori (2008) declare that the implementation of successful leadership is critical to construction industries in developing countries. There are distinct challenges to the construction industries in developing countries, as affirmed by Windapo and Cattell (2013), namely skills shortages, technological development and impoverishment. The research conducted by Liphadzi et al. (2015) is in South Africa; hence, it is suitably applicable. Yet, the focus of the study is leadership styles in relation to project success. However, as highlighted previously, project performance is not the same as construction firm performance.

2.3 Organization Growth and Performance

Organisational performance is defined as the ability of a company to succeed by attaining their goals and mission (Yukl and Becker, 2006). The evaluation thereof is characterised as achieving high profit, improving product quality, surviving in a weak economy and using relevant strategies for action (Koontz and Donnell, 1993). The common traits that arise from all the literature are the ability for the organisation to achieve their goals and the workforce accomplishing their tasks satisfactorily.

The growth rate is established when the company generates positive cash flow, creates value by continuing to expand above-average earnings and, also contributes to the implementation of new technologies (Yukl and Becker, 2006). Additionally, the characteristic of an organisation's successful growth is their allocation of profits back into the business for expansion (Obiwuru et al., 2011). This study will use financial success indicators such as turnover and internal productivity indicators like growth on the CIDB RoC, technological impact etc. of financial growth and performance

2.4 Conceptual Framework

Several studies substantiate the existence of a relationship between the leadership and the performance and growth of an organisation. There has been notable research by Price (2003) about the connection between leadership and the organisation, leading to the conclusion that the workforce performs better when they have a relationship with the leader. Andersen and Tope (2002) further emphasise that there exists a dynamic relationship between leadership styles and the company’s
growth as the leadership styles and qualities exhibited by leaders have essential performance implications.

Research performed on the topic established that there exists an important link between transactional leadership and organisational performance. However, scholars such as Ofori and Toor (2012), acknowledged that it is little or no connection on factor bases and observations obtained from research indicate that there is no significant link. Girma (2018) highlights that the organisational environment is continually shifting and leaders with considerable vision and adaptability are paramount for organisational growth and performance. Shokane et al. (2004) confirm that the South African construction industry needs transformational leadership dimension to grow and improve performance. However, this is not the only applicable leadership style suitable for the construction industry. Instead, scholars such as Albloshi and Nawar (2015) assert that a dynamic form of leadership is best for the construction industry. This consists of characteristics that can be extracted from different leadership styles to constitute a leadership style that is best for a given firm (CIOB, 2008).

A study carried out by Jing and Avery (2008) illustrates that current state of research concerning the relationship between leadership and organisational performance does not lead to a firm conclusion as the results are difficult to interpret. Leadership is subjective to the organisation and depends on several factors as well as the organisational environment to be correctly perceived (Oyewobi et al., 2016). Similarly, Obiwuru et al. (2011) affirm that the effect of leadership on organisational growth and performance is conditional to the climate in which the organisation exists and the interactions with internal and external parts.

**Hypothesis**

The following hypothesis is stated to guide the direction of the study:

H1: Leadership styles impact the performance and growth of construction companies in South Africa.

Ho: Leadership styles do not impact the performance and growth of construction companies in South Africa

3. **RESEARCH METHODOLOGY**

For the research approach, the mixed method was conducted, and a concurrent mixed-method research design was implemented using both a survey and case study. The main assumption of this type of approach is that both sets of data deliver different kinds of information and yield the same results when combined (Schoonenboom and Johnson, 2017). Additionally, the sampling techniques used for this research is the random sampling for the surveys and purposive sampling for the case study. Random sampling is performed as the targeted population results in the same performance and the unit being selected is not modified by the selection of other units from the same population (Schoonenboom and Johnson, 2017).
Similarly, a non-random sampling is done by choosing a list of names or details of the respondents with a particular characteristic. This sampling technique was beneficial for this area of study as the focus is on the senior executive – leaders such as CEOs and Directors of contracting firms listed in Grades 2 to 9 on the CIDB Register of Contractors. Therefore, it is ensured that the interviews are focussed on participants who possess the characteristics and experience to answer the study questions.

Furthermore, personal interviews and emails were used as methods of data collection. The interview protocol is composed of questions presented in the same order to ensure accuracy and consistency throughout the data collection, including an in-depth understanding of the interviewee. An online questionnaire was also administered to gather data on the leadership styles and performance of the construction company. The structured questionnaires were sent via email using the SurveyMonkey platform to CEOs and Directors of contracting firms listed in Grade 2 to Grade 9 across the CIDB Register of Contractors in the Western Cape, South Africa.

This data collection technique is as the most efficient when it comes to accessing the maximum number of contractors as well as a quick way of procuring results across this cohort of respondents in the Western Cape. The first part of the protocol addresses the primary objective of the identification of leadership styles. The second part of the interview protocol investigates company growth and performance. The survey questions were compiled after a thorough literature review. The first section was broken down into two parts: statements and scenarios. The second section compromises of nine questions relating to the company’s growth and performance. Both descriptive method of data analysis which allows the collection, organisation including presentation of data and inferential method of data analysis were employed to analyse the data.

Thirty-one out of a sample size of 197 firms, responded to the survey, representing a response rate of 16%. The descriptive analysis was based on the information obtained from the thirty-one respondents. The data procured using a five-point Likert scale from the participants were analysed using mean score with three being the significant threshold. The Pearson correlation method of data analysis was used to investigate the effect of leadership styles on the company’s growth and performance. The software used in the analysis is the Statistical Package for the Social Sciences (SPSS). Interviews were analysed using thematic analysis.

Cronbach’s alpha was performed to measure the reliability of the findings obtained from the research questionnaire and was found to be 0.74, which suggests that the results are reliable. Before the data collection for the research, and ethics clearance was obtained from the University of Cape Town. The questionnaire was also piloted by three experts to enhance the validity of the results. The limitations encountered while conducting this research includes the difficulty to access financial data from private construction companies. Also, studies like this are generally undertaken on CEOs and Directors of companies and therefore reaching the senior or top leaders, was difficult due to their busy schedules. The reliability of data depends highly on how the participants answered the questions during the interviews and online survey. Additional, time was the most significant constraint as not all the respondents contacted, were able to answer the surveys.
4. FINDINGS AND DISCUSSION

The study found that the most prevalent leadership style is transformational; however, there are facets of other leadership styles that merge with transformational leadership to create an integrated leadership style. There is evidence to support the fact that there is a dynamic approach to leadership in the South African construction industry to achieve organisational growth and performance as the industry is unique. Also, leaders are found to produce more results as they adapt to the circumstances, they find themselves in. It can be inferred from the case study results that the leadership in an organisation has to be adaptable to the environment, and leaders have realised this and changed accordingly over their experience in the industry as is evident from an interviewee stating: “...as you evolve as a leader, sometimes you also need to realize that to resolve conflict, sometimes maybe you need to let the circumstances calm down a bit. And then maybe the next day deal with it...”. However, the data from the surveys are not indicative of the type of leadership style that is best suited for organisational growth and performance because of the low levels of correlation between the variables.

Liphadzi et al. (2015) revealed that the transformational leadership style has the most impact on organisational performance due to the organisational culture and environment that the style invokes for the greater functioning of the workforce. Out of the 153 correlation coefficients between leadership styles and organisational performance analysed and shown in Table 1, only six were significant at the 5% level of confidence, and three were significant at the 1% level. This significance is not enough to conduct a regression analysis to deduce the most appropriate leadership style that achieves the highest organisational growth and performance in the South African construction industry. Literature suggests that the most common leadership style used in the South African construction industry is transformational (Albloshi and Nawar, 2015; Liphadzi et al., 2015). Hence the characteristics listed in Table 1 lean towards the more positive styles of transformational, transactional and democratic leadership in the Western Cape.

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5. CONCLUSION AND FURTHER RESEARCH

This study investigated the impact of leadership styles on the growth and performance of construction firms in Western Cape, South Africa. The research has been designed to identify the leadership styles used in construction firms as well as determining the performance and growth pattern of Construction firms. The study further finds out whether leadership styles impact company performance (financial success and internal productivity), including the growth pattern of construction companies. The findings revealed that most of the construction companies in the Western Cape are growing at a slow rate, whereas the performance of others seemed to have remained the same over the past five years. Overall, the significant findings obtained from the correlation test revealed that there is a relationship between leadership styles and company growth and performance. It also showed that transformational and democratic leadership styles have the most impact on organisational growth and performance. Transformational and democratic leaders can provide a corresponding change in the organisation by adopting transformational and democratic styles to survive the on-going economic crisis in South Africa. Thus, the result of the study proves that the leaders should adopt a dynamic approach in this regard.
and display positive leadership styles that are democratic and transformational within the organisation as it is difficult to survive on just one leadership style especially in this complex industry. Furthermore, this study recommends that to increase organisational performance in the construction industry, a dynamic approach to leadership needs to be implemented.

6. ACKNOWLEDGEMENT

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7. REFERENCES


Assessing the Mental Well-being of the Construction Workforce in South Africa using the World Health Organisation (WHO-5) Wellness Index Measure

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ABSTRACT AND KEYWORDS

Purpose
The purpose of this study is to assess the psychological wellbeing of the construction workforce in South Africa using the validated WHO-5 Wellbeing Index Measure.

Design/methodology/approach
In this cross-sectional study, data were collected from contractors working in the Kwa-Zulu Natal province in South Africa. The sample were conveniently selected based on proximity and familiarity to the researcher. A quantitative research approach was used, and data were analysed using IBM SPSS v25. Furthermore, descriptive statistics was used to analyse data and further interpreted using the prescribed WHO-5 scoring system.

Findings
The findings of the study revealed the mean responses ranging from 3.31 for ‘I have felt cheerful and in good spirit’; 3.00 for ‘I have felt active and vigorous’ and ‘I have felt calm and relaxed’; 2.63 for ‘I woke up feeling fresh and rested’ and the lowest ranking of 2.37 for ‘My daily life has been filled with things that interest me’. The overall WHO-5 score was calculated as 57.24 which is slightly above the cut-off score determined as =/<50.00. Cronbach’s Alpha was further used to measure the internal consistency and reliability was accepted as good at 0.893 across all the scales used, and further analysis of the results was conducted.

Research limitations/implications
The study is only limited to assessing the psychological wellbeing on a conveniently sampled population using self-report questionnaire. Therefore, may suffer from limitations associated with self-reporting such as response bias, social desirability, introspective ability, understanding and limitations with rating scales.

Value of paper
It is hoped for that the findings of this study will reveal the state of mental wellbeing among the construction workforces. Several limitations are acknowledged. This is a snap survey and forms part of an ongoing empirical research.

Keywords: Construction Industry, Construction Workforce, Mental Well-being, Mental Health, WHO-5
1. INTRODUCTION

The issue of mental health problems and poor well-being have recently grown in importance in the workplace (Farmer and Stevenson, 2017). Assessing the well-being of employees is beneficial to both the companies and individuals (ibid). This information obtained from surveys can be used to establish well-being leads and strategies, aimed at the areas of workers well-being and engagement where help is needed the most. Furthermore, feedback enables individuals to take positive steps to improve their health and well-being, subsequently driving up workers’ well-being as a whole.

The WHO (1948) defines health as a state of complete physical, social and mental well-being, and though not the absence of disease. And further well-being is a positive state experienced by an individual. Well-being is influenced by both physical and mental health (Dolan et al., 2008; Shields and Price, 2005) where mental health is considered a state of mental well-being that enables individuals to cope with life’s demands (WHO, 1948). Well-being is a constituent of health and well-being that underpins an individual’s abilities to make decisions, form relationships and shape their environment (ibid). Therefore, poor mental health results in poor mental wellbeing.

In construction as with other workplaces, mental ill-health and well-being problems are rife (ILO, 2014; CIOB, 2006; Cassell, 2017). Traditionally, health and safety issues in the construction industry tended to focus on safety and the mitigation of physical injuries as opposed to focusing on mental health and well-being (Lovelock, 2019). The construction industry needs to consider mental health problems seriously (BSG, 2017). Mental health and well-being issues are attributed to the demands as a result of the nature of the industry. These demands emanate from several stressors such as unrealistic expectations, physically demanding work, poor working conditions, lack of communication, complicated interrelationships among different stakeholders, multiple stakeholders, lack of support, difficult tasks, deadlines and working overtime in some instances (Aires et al., 2016). Most workers in construction commute long distances to work and some travel far away from their homes to work which could result in loneliness and be a significant factor contributing to stress, depression and anxiety (Christodoulou, 2021). Construction projects are seasonal, and this leads to job insecurity which in itself is another major stressor (ibid). Over and above dangerous working conditions and strict deadlines, workers must adhere to safe working procedures which can be extremely difficult when working under pressure. As a result, workers worry about their wellbeing and become increasingly stressed and the stress usually a precursor to common mental disorders such as depression, anxiety, boredom, frustration, other negative emotions and in some extreme cases suicide (ibid).

Stress and unhealthy working conditions are also known to manifest as psychosomatic symptoms such as headaches, low energy, insomnia, back pain or chest pain (Christodoulou, 2021; Aires et al., 2016). Furthermore, increased job demands can lead to unintentional blindness as too much focus on complex tasks often leads to low levels of concentration (ibid). It is evident that as mental and physical fatigue mount during prolonged work activities, workers are most likely to conduct unsafe behaviours (Hosseini et al., 2010). Mental ill-health has detrimental impacts on health and safety and therefore, workers in the construction industry need to be aware that mental health issues are just as important to them as their physical wellbeing (BNG, 2017; Wang et al. 2017; Bryson and Duncan, 2018; Beswick et al., 2007; Boschman et al., 2013).

A comprehensive examination of both the psychosocial work environment and the prevalence of mental ill-health in construction will enable a deeper understanding of the magnitude and scope of psychosocial risk factors as well as mental health issues experienced in construction (BNG, 2017; Wang et al. 2017; Bryson and Duncan, 2018; Boschman et al., 2013). Consequently, this comprehensive understanding can substantially contribute towards selecting the relevant interventions for the workers, more so, because workers spend most of their time in the workplace environment (ibid). Therefore, it is necessary to assess the mental well-being of the workforce in order to understand their impacts on mental health and to subsequently reduce injuries, prevent disabilities, and increase productivity (Boschman et al. 2013).

In order to assess the well-being of the workforce, it is necessary to use a validated measure such as the World Health Organisation-Five Well-Being Index (WHO-5). The WHO-5 is among the most widely used questionnaires assessing subjective psychological well-being since its first publication in 1998.
Also, some stress-related studies have been conducted using the WHO-5 to measure distress or poor well-being (Topp et al., 2015). The rating scales used to assess well-being are designed to be disease anonymous (generic) because such scales provide information relating to the overall effect of a clinical intervention (Ware, 1994; Topp et al., 2015). Furthermore, a generic scale enables a comparison with mean values from the general population or with mean values from other clinical populations regardless of the disease entity or condition under examination (ibid). Therefore, the WHO-5 is a generic scale for the assessing of general well-being.

The current study assesses the general wellbeing of the construction workforce in South Africa using the WHO-5 scale. To date, no studies in SA have been conducted using the WHO-5 or other validated measures to assess the mental well-being of the construction workforce. Possessing knowledge and understanding about specific mental well-being challenges may assist in the recognition of symptoms, management and subsequently the prevention of mental health issues by promoting help-seeking behaviour among workers. It remains unclear what proportion of the general construction workforce in South Africa is facing challenges with mental well-being which could subsequently lead to detrimental mental health risk factors. Therefore, the absence of these knowledge makes it difficult for the industry to address mental health issues, develop interventions and for workers to seek the necessary help.

2. METHODOLOGY

In this cross-sectional study, data were collected from contractors working in the Kwa-Zulu Natal province in South Africa. The sample were conveniently selected based on proximity and familiarity to the researcher. This form of sampling maximised the response rate as the study was conducted over a short period. Some respondents were referrals recommended by other participants – a variant of snowballing sampling technique. A total of 40 questionnaires were emailed and the study achieved a response rate of 80%. The questionnaire included the demographics and WHO-5 Wellness Index Measure. The WHO-5 measure for general wellbeing was chosen due to its simplicity to interpret and understand and also, because it is a validated measure used across all disciplines to measure subjective wellbeing of the general population. This study employed a quantitative research approach and data were analysed using IBM SPSS v25.

Furthermore, descriptive statistics was used to analyse data and further interpreted using the prescribed WHO-5 scoring system. The WHO-5 comprises of five items "I have felt cheerful and in good spirits.", (2) "I have felt calm and relaxed.". (3) "I have felt active and vigorous.", (4) "I woke up feeling fresh and rested.", (5) "My daily life has been filled with things that interest me." The respondents were instructed to read “Please indicate for each of the five statements which is the closest to how you have been feeling over the last two weeks”. Furthermore, Cronbach’s Alpha was conducted to determine the internal consistency of the responses. This exploratory study forms part of ongoing empirical research. Ethical clearance to conduct the study was approve by the General Human Research Ethics Committee (GHREC) (Ethical Clearance Number: UFS-HSD2021/2006/22) at the University of the Free State. Informed consent was granted from the respondents before conducting the study and all research protocols were followed according to the requirement of GHREC.

3. RESULTS

This section presents the analysis of the data collected and discusses the findings. Data were analysed using IBM Statistical Package for Social Sciences (SPSS) version 25. Tables were used to present data and key findings.

3.1 Profile of the Respondents

The respondents of the study were the construction workforce working for contractors comprising of artisans, construction professionals and construction labourers. Table 1 shows the profile of the respondents:
Table 1: Profile of the Respondents

<table>
<thead>
<tr>
<th>Age and number of years of experience</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of Employee</td>
<td>33</td>
<td>25</td>
<td>52</td>
</tr>
<tr>
<td>Years of Experience</td>
<td>10</td>
<td>2</td>
<td>32</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender of Respondents</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>20</td>
<td>62.5</td>
</tr>
<tr>
<td>Female</td>
<td>12</td>
<td>37.5</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Highest formal qualification</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary or high school</td>
<td>4</td>
<td>12.5</td>
</tr>
<tr>
<td>Technical or Vocational College</td>
<td>4</td>
<td>12.5</td>
</tr>
<tr>
<td>University Degree</td>
<td>24</td>
<td>75.0</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Position in Organisation</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Manager</td>
<td>4</td>
<td>12.5</td>
</tr>
<tr>
<td>Health and Safety Officer/Manager</td>
<td>2</td>
<td>6.3</td>
</tr>
<tr>
<td>Quantity Surveying</td>
<td>9</td>
<td>28.1</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>6</td>
<td>18.8</td>
</tr>
<tr>
<td>Foreman/Supervisor</td>
<td>2</td>
<td>6.3</td>
</tr>
<tr>
<td>Artisan</td>
<td>3</td>
<td>9.4</td>
</tr>
<tr>
<td>Construction Workers/Labourer</td>
<td>4</td>
<td>12.5</td>
</tr>
<tr>
<td>Other (Specify)</td>
<td>2</td>
<td>6.3</td>
</tr>
<tr>
<td>Total</td>
<td>32</td>
<td>100.0</td>
</tr>
</tbody>
</table>

The results in Table 1 indicated that the median age of the respondents was 33 years ranging from 25 years minimum to 52 years’ maximum. The median years of experience were 10 years ranging from a minimum of 2 years to a maximum of 32 years. The majority of the respondents were male at 62.5%. Most respondents had obtained a University Degree (75%) followed by both technical/vocational schools (12.5) and secondary/high school qualifications (12.5%). Furthermore, the majority of the respondents were Quantity Surveyors (28.1%); followed by Civil Engineers (18.8%); both Construction Workers Construction Managers (12.5%); Artisans (9.4%) and Health and Safety Officers-Managers and others (6.3%). Overall, most respondents were construction professionals (65.7%) followed by Construction Labours (18.8%) and Artisans (15.7).

3.2 Reliability

Cronbach’s Alpha reliability test was used to determine the reliability and internal consistency for each construct, as indicated in Table 3. The Cronbach’s Alpha coefficients between 0.70 ≤ α ≥ 0.80 are
‘acceptable’ while between 0.80 ≤ α ≥ 0.90 are considered ‘good’ and coefficients 0.9 ≤ α are ‘excellent’. Therefore, Frequency Percent Construction Manager 4 12.5 Health and Safety Officer/Manager 2 6.3 Quantity Surveying 9 28.1 Civil Engineering 6 18.8 Foreman/Supervisor 2 6.3 Artisan 3 9.4 Construction Workers/Labourer 4 12.5 Other (Specify) 2 6.3 Total 32 100.0 based on the results in Table 2, reliability was accepted as good at 0.893 across all the scales used, and further analysis of the results was conducted.

### Table 2: Reliability Test

<table>
<thead>
<tr>
<th>Cronbach’s Alpha</th>
<th>Based on N of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>.893</td>
<td>5</td>
</tr>
</tbody>
</table>

#### 3.3 WHO-5 Wellness Index Measure

The respondents were asked to rank their level of agreement in relation to the past two weeks based on a 6-point Likert scale according to the WHO-5 wellness scale where 5 = All of the time; 4 = Most of the time; 3 = More than half of the time; 2 = Less than half of the time; 1 = Some of the time; 0 = At no time. Table 3 shows their responses

<table>
<thead>
<tr>
<th>Table 3: WHO-5 Wellness Index</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have felt cheerful in good spirit</td>
<td>3.31</td>
<td>1.18</td>
<td>1</td>
</tr>
<tr>
<td>I have felt active and vigorous</td>
<td>3.00</td>
<td>1.30</td>
<td>2</td>
</tr>
<tr>
<td>I have felt calm and relaxed</td>
<td>3.00</td>
<td>1.16</td>
<td>3</td>
</tr>
<tr>
<td>I woke up feeling fresh and rested</td>
<td>2.63</td>
<td>1.16</td>
<td>4</td>
</tr>
<tr>
<td>My daily life has been filled with things that interest me</td>
<td>2.37</td>
<td>1.41</td>
<td>5</td>
</tr>
<tr>
<td>TOTAL (multiply by 4)</td>
<td>57.24</td>
<td>24.84</td>
<td></td>
</tr>
</tbody>
</table>

From the Table 3, the mean responses ranged from 3.31 for ‘I have felt cheerful in good spirit’; 3.00 for ‘I have felt active and vigorous’ and ‘I have felt calm and relaxed’; 2.63 for ‘I woke up feeling fresh and rested’ and the lowest ranking of 2.37 for ‘My daily life has been filled with things that interest me’. However, in order to understand the meaning the result, the WHO-5 measures wellbeing by calculating the raw score which is calculated by totalling the figures of the five answers (in this case the five means) where the raw scores range from 0 to 25, 0 representing worst possible and 25 representing best possible quality of life. The raw score is multiplied by 4 in order to obtain a percentage score ranging from 0 to 100 whereby, 0 represents worst possible, whereas a score of 100 represents best possible quality of life. For the result in Table 3, the total was determined by adding 3.31 + 3.00 + 3.00 + 2.63 + 2.37 which equated to 14.31. Furthermore, 14.31 x 4 = 57.24. Therefore, the WHO-5 score = 57.24. The score is slightly above the cut off score which is determined as ≤50 and which is indicative of poor wellbeing.

#### 4. DISCUSSION AND CONCLUSION

The current study assessed the wellbeing of the construction workforce in South Africa using the psychometric properties of the WHO-5 Wellness Index Measure. The general wellbeing score for the
workforce was slightly above average at 57.24. Although the scale has been used across different disciplines such as Geriatrics, Psychiatry, Endocrinology, Depression, Psychometry etc., (Guomundsdottir et al., 2014; Allgaier et al., 2013; Awata et al., 2006; Liwowsky et al., 2009; Henkel et al., 2003) they may not be used to draw comparisons in the current study. Furthermore, there are currently no studies conducted using WHO-5 measure in SA on the general population. Therefore, this study provides in hindsight the wellbeing of the workforce. It is imperative to address the mental wellbeing of the construction workforce which has one of the highest suicide incidents. It is hoped that the findings of the study together with further developments could assist in the improvement of the workers’ wellbeing and subsequently assist clinicians to diagnosis and psycho-therapeutical processes of the construction workers.

Furthermore, it is noteworthy to acknowledge the limitations of the current study. It is necessary to conduct further research employing a larger sample size. Also, the type of sampling used in the study faces challenges associated with self-report questionnaires such as response bias, social desirability, introspective ability, understanding and limitations with rating scales. Future research should use Confirmatory Factor Analysis to test the one-dimensionality of the WHO-5. Additionally, the use of other scales such as the Patient Health Questionnaire-9 (PHQ-9) paired with the WHO-5 may reveal symptoms of depression among the population. And also, future research could assess the wellbeing among different groups in the workforce such as artisans, CPPs and labourers. The current study only focused on assessing the wellbeing of the workforce. Therefore, future research could specifically assess common mental disorders using different scales.

5. ACKNOWLEDGEMENTS

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6. REFERENCES


Psychosocial hazards in work environments and effective approaches for managing them. Wellington, New Zealand: WorkSafe New Zealand.


Preamble to the constitution of the world health organization as adopted by the international health conference. New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948

Emerging Black Businesses Participation in the South African Public Sector Property Management Portfolio

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ABSTRACT & KEYWORDS

Purpose
Owning property does not only provide shelter but is also a potential source of income. However, there are limited Emerging Black Business property owners in South Africa participating in the Public Sector Property Management Portfolio. Therefore, this study aims to examine the participation of emerging black business owners in the public sector property portfolio with a view to improving property management practice.

Design/methodology
The study employed a qualitative research design using semi-structured interviews with 18 registered property owners and government officials in the Free State province. Data was analysed using a mixed method of thematic and content analyses.

Findings
Findings indicate ineffective legislative frameworks and low participation of emerging black-owned businesses in public sector property management portfolios. This was found primarily due to poor implementation, a lack of public and private sector co-operation, and a lack of information sharing on best practices.

Research limitations/implications
The research study was limited to emerging black business owners in the Free State province, South Africa.

Practical implications
There is a need to develop property incubator programmes for mentoring and educating emerging black business property owners. Investment and participation in property development incubators and information sharing will enhance emerging black business owners’ participation in the public property management portfolio.

Original/value
The findings will inform Emerging Black Business owners and the government on strategies necessary for enhanced participation in the South African Public Sector Property Management Portfolio.

Keywords: Emerging Black Businesses, Property-owners, Public Sector, Property Management Portfolio
1. INTRODUCTION

Property management (PM) is the overseeing of commercial, residential or industrial properties (Field and Rogers, 2021; Sanderson and Read, 2020; Tan, Shen and Langston, 2014). This means managing property owned by someone else (Tan et al., 2014). As Mukori (2013) indicates, government fixed property must help achieve its service delivery objectives. Therefore, there is a need for the government to manage state properties in a manner that can benefit the country. The public and private sectors are both concerned about the management of properties property management (Vermiglio, 2011). In South Africa, the National Department of Public Works (NDPW) at "the national and provincial level is mandated to be the main custodian of the state-owned immovable property, which includes specialised functional accommodation, land parcels, office accommodation and residential accommodation" (Boshoff & Chidi, 2013:3234). For some time, researchers have been trying to analyse how the property industry can be utilised to transform the economy of different countries. Economic transformation is defined by Balchin, Booth and Willem te Velde (2019) as a process where various countries are breeding and holding on to high and long-term economic growth. Economic growth is boosted by investment, which results in capital goods creation (Cleaver, 2011).

Inequality in the distribution of income, as well as skewed opportunities and poverty, characterise South Africa (Black, Calitz and Steenekamp, 2012:124). As a result of this scenario, the government was driven to develop programmes aimed at changing the economic structure’s environment, targeting empowering marginalised black communities (Van Nieuwenhuysen, 2018). Driven by the abovementioned, the South African government developed various legislation to attempt to empower Emerging Black Businesses (EBBs) in the property sector. These include the Government Immovable Asset Management Act (GIAMA) 2007, Reconstruction and Development Programme (RDP) of 1993, Broad-Based Black Economic Empowerment Act 53 of 2003 (BBBEE), and the Property Sector Transformation Charter (2010). These legislative frameworks were implemented for economic development and property sector transformation to support small businesses (Krüger, 2014). However, the legal frameworks are not free from criticism as some feel the government is not implementing relevant policies. This view is supported by several authors who claim that South Africa’s most significant threat is the government and policy failures to transform the structure of its economy (Akonsomi, Kola, Ndlovu and Motloung, 2016; Gumede, 2013; Shai, Molefinyana and Quinit, 2019).

The South African government property management portfolio stood at 2500 in 2014, signalling the need for government to maximise the impact of the public sector property management framework as a tool for development becomes essential. This also indicated the need for government to utilise important sectors of the economy, such as the property sector, to fight high levels of unemployment. This study aims to examine strategies for emerging black businesses to enhance their participation in the public sector property management portfolio in South Africa. The study was limited to emerging black businesses in the Free State province.

2. LITERATURE REVIEW

2.1 Public sector property management for business

Asset management in the public or private sectors aim to accomplish a practical and balanced distribution of the portfolio of properties to yield the most reimbursements at the least cost (Garmendia and Kapur, 2013). However, traditionally, property management deals with daily operations and maintaining separate property units. In contrast, asset management is a process of making decisions and deciding on the implementation of the actual acquisition of property, its use, and disposition (Kaganova, Rutledge and Dragana-Markovic, 2012). Muczyński (2015:5) claims that the Public Sector Property Management Portfolio (PSPM) policy "focuses on supplying the right quantity of property to public goods and services, supporting local economic development and obtaining revenues from alternative sources". However, there is a gap in the current public sector property management framework concerning economic transformation, hence the need for balance in the management of immovable property where public entities must fulfil their service delivery mandate and objectives (Alexander, 2013; Mdinda, 2014).
A study by Marona and van den Beemt-Tjeerdsma (2018) found that the opportunity cost of not managing public real estate strategically is high and has implications for local budgets and services. Nowadays, public and private organisations pay particular attention to sustainability in real estate and management (Marona, 2016). Public Real Estate Asset Management (PREM) as a real estate (or property) management consists of making all decisions and taking all activities necessary to maintain the real estate in proper condition in compliance with its purpose, as well as making justifiable investments in real estate” (Muczynski, 2015:5). Asset management in public or private sector aims to accomplish a practical and sensible distribution of the portfolio of properties so that it will yield the most reimbursements at the least cost (Garmendia and Kapur, 2013). Traditionally, property management deals with daily operations and maintaining separate property units. In contrast, asset management is a process of making decisions and deciding on the implementation of the actual acquisition of property, its use, and disposition (Kaganova, Rutledge and Dragana-Markovic, 2012).

There is a need for property management in any organisation, including the public sector, because assets are crucial to all organisations as they contribute to their success (Maletswa and Boshoff, 2015). Maletswa et al. (2015) further hinted that large sum of money are devoted to such assets, which calls for their more efficient and effective management, thereby adding value to the public sector real estate assets.

2.2 Economic transformation supporting emerging businesses

Historically, economic growth works better to ensure that societies are improved in terms of their lives, especially those at the bottom of the pyramid (Jayne, Chamberlin & Benfica, 2018). Transforming the economy means that countries must sustain high-quality and long-term economic growth (Balchin, Booth and Willem te Velde, 2019). The shift in the economy in both public and the private sectors can be achieved through the evolution of all industries and the need for a shift from a low productivity sector to high productivity (Ellis, McMillan and Silver, 2017). For businesses to thrive, there is a need to have land to erect properties that can support the business (Mbutuma, 2019). The lack of basic needs, such as shelter and the provision of properties, mainly for housing, is a significant challenge (Jayne et al., 2018). Property acquisition in most African countries, especially for middle-income and poverty-stricken communities, was mainly aimed at housing construction, not office space for businesses (Jähäna, 2015).

The South African economy is divided into two economies: the developed economy on one hand and the developing economy on the other (Mbeki, 2004). In terms of the directive and facilitative interventions in the economy explained by Wang (2018), the South African government plays different roles and participates in picking what industry can support economic growth. This aims to narrow the gap between the developed and developing economies to improve overall performance. However, the annual report from the Free State Department of Public Works and Infrastructure report for 2014/15 reflects that only 26% of contracts for accommodation in the province were secured for black landlords (Republic of South Africa, 2016). This position has not changed much since (Republic of South Africa, 2021).

To ensure that black people are included in renting or owning properties, the South African government developed different policies such as the Property sector charter of 2007, the Broad-Based Black Economic Empowerment (BBBEE) Act passed in 2003, Preferential Procurement Policy Framework (PPPFPA) Act of 2000, Public Finance Management (PFMA) Act of 1999, Government Immovable Assets Management (GIAMA) Act 19 of 2007 and Treasury Regulations. These aim at making an impact on the property sector’s transformation. However, South Africa’s commercial property sector lags in terms of black people owning property and having adequate representation as of 2018. The weak economy dragged the property sector under pressure when no black-owned funds were listed on the Johannesburg Stock Exchange (J.S.E.) (Ramasodi, 2013).

The South African government developed the Property Sector Transformation Charter around 2010 as a guiding tool for transforming the property industry (Department of Public Works, 2017). With the transformation charter, all state-owned entities, municipalities, and provincial and national departments must indicate targets on their annual performance plans. The national department of public works was mandated to implement the above policies as the custodian of the transformation charter (DPW, 2010).
Through these efforts, the government aimed to register its seriousness about black emerging businesses' participation in the sector not only as employees but also as property owners (DPW, 2017). The government recognised how the property sector could contribute to growing the country's economy and the importance of land ownership since no property can exist in the isolation of land. The 20120/2021 annual report and annual performance plan of the Department of Public Works and Infrastructure in the Free State province reflect that the provincial government targeted that by 2024, it should achieve 70% of black landlords to be contracted by the Department for office accommodation (Republic of South Africa, 2021). According to the report, in 2017/18, the department contracted 23% of black landlords for office accommodation. These statistics reflect slow progress from the government's side in ensuring that the share and participation of black emerging businesses in the property sector as Landlords grow.

3. METHODOLOGY

The study adopted a qualitative research approach. Data was collected through semi-structured interviews comprising both open-ended and closed-ended questions. The qualitative approach enables the researcher to collect in-depth information about the study phenomenon (Coulthard, 2016). The present study intends to understand the strategies for improved public sector property management portfolio participation. Purposive sampling was employed to select emerging black business owners in the province. Due to ethical reasons, the identity of the participating implementing agent and respondents are not disclosed in this study in keeping with confidentiality and anonymity.

The registered property owners and government officials who participated in the study were chosen through purposive sampling, a non-probability sampling method. Purposive sampling enables researchers to select respondents based on their professional competence, knowledge of the phenomenon understudy, and their availability willingly give the information. The number of emerging black business owners interviewed was 18.

A mixed method of thematic and content analyses were used to analyse the date with the aid of an excel sheet to analyse the data. Themes where identified as they emerged from the data. After coding, content analysis was applied. Both methods emphasise the meanings and are appropriate where context is important rather than generalisation, as the case was in this study (Creswell, 2015). The findings are presented in the next section.

4. RESULTS

4.1 Theme 1: Inclusivity and representation Emerging black businesses in the public property sector

The first theme of inclusivity and representativeness of emerging black business emerged as indicated in figure 1.

![Inclusivity & representation](image)

*Figure 1. Inclusivity and representation of South African demographic in the public sector property management portfolio opportunities*
The findings from the study on participation are shown in Fig. 1. From the data, the extent to which the inclusivity and representation of South Africans in the public property sector emerged as a theme. The highest response suggested that the representation of the South African demographics in the public sector property did not reflect inclusivity. This was followed up by the aspect of uncertainty where respondents were unsure about the extent to which representation and inclusivity are achieved. However, about one fifth showed that the South African demographics are slightly represented and thus slightly inclusive in the public sector property.

**4.2 Theme 2: Challenges faced by Emerging Black businesses in the South African property sector**

Challenges faced by historically disadvantaged people in becoming property owners is the second theme which emerged from the interviews as indicated in Fig 2.

![Figure 2. Challenges faced historically disadvantaged people in becoming property owners](image)

In Figure 4.2, five key challenges faced by historically disadvantaged people and emerging businesses in becoming property owners were identified. The most challenge was that lack of knowledge hinders historically disadvantaged people from owning properties. This is despite the South African government developing the Broad-Based Black Economic Empowerment Act (BBBEE) 2003 (Musabayana and Mutambara, 2022). Further, it also emerged that lack of funding was a critical challenge affecting historically disadvantaged businesses negatively when it comes to owning property. Thus, lack of funding emerged as the second most barrier to property ownership encountered by emerging businesses. It was found that difficulty in accessing information and the lack of mentors in the property sector for historically disadvantaged people and businesses hindered property ownership and meaningful participation in the property sector.

**4.3 Theme 3: Effectiveness of the current Legislative frameworks**

The third theme which emerged from the study was built around the effectiveness of the current legislative frameworks for increased participation in the property sector. The findings are depicted in figure 3.
Examining the interview data closely, it was found that the current legislative frameworks are poorly implemented and not effective in achieving their intended objectives of increasing the participation of emerging black businesses in the property sector as owners. In second place, there was uncertainty about the effectiveness of the current legislative frameworks. This is because some of the interviewees indicated that there seems to be mixed results of positive and negative consequences and impact thereof in practice. A few interviewees were of the view that the current legislative frameworks were moderate in terms of their effectiveness in creating an enabling environment for the participation of emerging black business property owners in the public sector property management portfolio.

5. DISCUSSION AND IMPLICATIONS

5.1 Theme 1: Inclusivity and Representation of Emerging Black Businesses

The findings revealed that the inclusivity and representation of emerging black business property owners was very minimal. These findings suggest that the South African government does not currently create an enabling environment to make it easier for historically disadvantaged groups to participate in the mainstream economy (Mlkori, 2013). The findings highlight the challenging task that the Department of Public Works and Infrastructure have to overcome to achieve the target of 70% of black landlords to be contracted for office accommodation by 2024 (Republic of South Africa, 2021). The Multi-Criteria Analysis (M.C.A.) model is used as a classification method for municipal property management to find a convenient place for municipal assets (Constantin, Goschin, Statev, Ralev & Ileanu, 2011b). The findings that most respondents felt that there was poor inclusivity and under-representation of all, especially black people in the South African demographics in the public sector property, which implies that the M.C.A. model can be used to establish targets and criteria for inclusivity when characterising properties to ensure inclusivity. Inclusiveness is propagated as a win-win scenario for developing the sector and uplifting the disadvantaged emerging black businesses. Inclusivity requires good sound institutional structures to be in place for effective implementation, thereby ensuring that the benefits are passed on to the intended beneficiaries (Chamberlain and Anseeuw, 2017).

5.2 Theme 2: Challenges faced by historically disadvantaged people in becoming property owners

Under theme two, the findings revealed five key challenges faced by emerging black businesses in participating in the public sector property portfolios. The most dominant challenge faced was found to be the lack of information. Emerging black businesses need improved access to the updated or latest information through the internet or career days at school to know more about the property sector (Okoye, 2017). This will give the Emerging black businesses (EBBs) the required information for making decisions and hopefully enhance participation in the public sector property portfolio market. The study
revealed that funding is another critical factor which affects the participation of EBBs in the public sector property portfolio. According to Mbutuma (2019), funding is an obstacle to disadvantaged people in terms of owning properties, requiring complex B-BBEE structures to be implemented. Start-up property businesses require funding to finance their property acquisition, renovations and marketing. Further, they require funding for their operations in order to sustain their businesses (Ratshitanga, 2017). The findings relating to the challenges of the difficulty to access information, lack of knowledge, and funding are consistent with the literature as previous studies have highlighted such (Mbutuma, 2019; Witbooi and Ukpere, 2011; Okoye, 2017). To fully realise the full potential and enhanced participation of the emerging black business property owners in the public sector property management portfolio, the challenges faced by the EBBs need to be addressed effectively (Littewood and Holt, 2018).

5.3 Theme 3: Effectiveness of the Current legislative frameworks

Findings suggest that the current government legislative frameworks for enhancing emerging black business owners’ participation in the public sector property portfolio are ineffective. Legislative frameworks create a deliberate environment to encourage equal participation in the property sector. According to the literature, the "top-down imposed" approach in legislative implementation through decentralisation is an effective way to enhance the participation of EBBs in the property sector (Yusof, 2013). Instead, legislation should include and adequately implement sound management information systems, strategies and strong management structures (Shardy et al., 2011). Furthermore, the government is required to improve and transform the property sector in delivering infrastructure to meet social, economic and physical objectives (Abdullah et al., 2012).

6. CONCLUSIONS

There is low participation of emerging black businesses in the public property management portfolio with low representation in the property sector. This is mainly because of the lack of effectiveness of the current legislative frameworks. Emerging black business property owners play an essential role in developing the South African property sector. Therefore, it is crucial that the government examines and improves the implementation of legislative frameworks to make them more effective in achieving their intended objectives. Inclusivity would broaden the ‘EBBs’ participation in the sector and enable their meaningful and enhanced contribution to the property sector. It is recommended that measures and targeted support be put in to improve knowledge acquisition and sharing and access information that will enable them to access opportunities and know-how of the property sector. Furthermore, the EBBs should employ effective strategies to ensure a sound financial base to help them manage their business operations to overcome financial-related challenges in their pursuit of participating in the public sector management portfolio. Lastly, EBBs need to foster co-operation with public entities to learn and share best practices regarding property sector management.

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The potential of Industry 4.0 to enhance project delivery in the Zimbabwean construction industry

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ABSTRACT & KEYWORDS

Purpose of this paper
The aim of this research was to investigate the potential of Industry 4.0 technologies to improve project delivery in the construction industry in Zimbabwe.

Design/methodology/approach
The data was collected through the distribution of structured questionnaires to general contractors, architects, and engineering firms in Bulawayo, Zimbabwe. The data was analysed using MS Excel to generate descriptive statistics in the form of frequencies and mean scores (MSs).

Findings
The results show that there is limited use of Industry 4.0 technologies. Nonetheless, Industry 4.0 is perceived to have the potential to enhance timely delivery of projects through enhanced visualisation of projects before construction, improved connectivity of project team, improved building design, provision of accurate data, and improved planning and decision making. Nonetheless, the lack of funds, lack of resources, lack of knowledge, and the lack of skilled labour are the major barriers constraining the use of the technologies.

Research limitations/implications
The study is based on a small sample, which may affect the generalisation of the findings to other regions.

Practical implications
The perceived importance of Industry 4.0 on project delivery calls upon the creation of an enabling framework to support the adoption of these technologies to improve performance. The integration of Industry 4.0 into the built environment curriculum is important to impart knowledge and skills to the graduates.

What is original/value of paper?
The study makes an important contribution to an emerging body of knowledge in Zimbabwe.

Keywords: Barriers, Construction, Industry 4.0 technologies, Project time delivery
1. INTRODUCTION

Technology has been changing over the years from the First Industrial Revolution to the Fourth Industrial Revolution (FIR) also known as Industry 4.0. In the construction industry, Industry 4.0 seeks to promote the integration of information by the use of the Internet of Things (IoT) at different stages and by introducing the use of new devices such as drones, laser scanners, 3D printers in anticipation of being able to manage construction at the design stage, and construction and delivery of sustainable and smart buildings (Osunsanmi et al., 2018). According to Schwab (2017), Industry 4.0 has the ability to fully integrate people and digital machines, with the assistance of the Internet and information technology (IT).

According to Chigara et al. (2013), the construction industry in Zimbabwe experiences poor productivity, low profitability, schedule, and cost overruns. In view of the persistent problem of poor project performance, the construction industry can leverage Industry 4.0 technologies and concepts to improve construction project delivery. This is supported by empirical evidence which shows that Industry 4.0 technologies offer great opportunities for improving construction project performance through the elimination of challenges such as project delays (Maskuriy et al., 2019). This is corroborated by recent developments in Wuhan Province, China where the use of Industry 4.0 technologies facilitated the construction of a hospital for COVID-19 (Coronavirus) patients in 10 days (Ankel, 2020). This shows how construction projects can be undertaken in a short space of time, reducing cost, and producing a satisfactory product.

Although the construction industry is considered to be a latecomer to the efficiency offered by the adoption of IT (Osunsanmi et al., 2018), lessons can be drawn from sectors such as manufacturing and banking with regards to how adopting Industry 4.0 technologies has helped to increase productivity, accuracy, and efficiency, and improve customer satisfaction (Osunsanmi et al., 2018). Time overruns have become the norm in the construction industry in Zimbabwe resulting in increased project costs, poor productivity, and substantial risk to clients. Accordingly, this study investigated the benefits of Industry 4.0 technologies to enhance project time delivery, and barriers to the introduction of Industry 4.0.

2. THE REVIEW OF THE RELATED LITERATURE

This section presents the theoretical background of the study relative to specific subject areas.

2.1 Construction project delays

A delay in construction can be referred to as a proposed time, postponed because of circumstances that are related to construction stakeholders such as the client, consultant, and contractor (Muizzi et al., 2020). Xongo (2018) classifies delays into two major classes, which are excusable and non-excusable. Excusable delays are delays which are out of the control of the contractor and the fault element will not be of the contractor (Muizzi et al., 2020). These delays can be a result of outbreaks such as the coronavirus (COVID-19), change of the scope of work by clients, floods, acts of God, mistakes and errors in specifications, material delivery delays, and death (Xongo, 2018). Time extensions can be granted relative to excusable, also known as unavoidable delays (Muizzi et al., 2020).

Previous studies identified various factors that cause delays on construction projects. These causes can be classified as client-related, contractor-related, and labour- and equipment-related factors. According to Doloi et al. (2012), late payment to the contractor contributes to project delays. This observation is corroborated by Masood et al. (2015) who report that late payment of contractors contributed to construction project delays in Pakistan. The client-related construction delays affect the delivery of the project as it may not be delivered on time, negatively affecting the project time delivery. Despite the shortcomings from clients, contractors as the principal organisation responsible for the actual execution of the works, contribute to project delays. This arises from inadequate planning and scheduling, lack of experience, delays in mobilising the site, poor site management and supervision, conflict with subcontractors, subcontractor or contractor-related rework, lack of familiarisation with new software, and inadequate risk management and analysis (Doloi et al., 2012; Khair et al., 2016; Muizzi et al., 2020; Muhwezi et al., 2014).
Studies that investigated the impact of labour- and equipment-related factors contributing to construction project delays concluded that poor labour supply and productivity, labour disputes and strikes, shortage of skilled operators, lack of effective health and safety (H&S) inspection, non-availability of required equipment, and delays in terms of equipment delivery have a significant effect on timely project delivery (Doloi et al., 2012; Khair et al., 2016; Muizz et al., 2020). Furthermore, low motivation and morale of labour, unqualified and inexperienced labour, improper equipment, non-adoption of modern technology, and frequent equipment breakdowns were identified in the Ugandan construction industry (Muhwezi et al., 2014).

In addition to the client-, contractor-, labour-, and equipment-related factors, construction project delays are also influenced by external factors such as weather conditions, financial market instability, local authority restrictions relative to the site location, local authority delays in terms of providing building permits and changes to the government regulations and laws, resulting in poor project delivery time (Khair et al., 2016). In Sudan, Khair et al. (2016) report that severe weather conditions, which include plummeting temperatures affect the labour force working on projects thereby contributing to delays. In Zimbabwe, Chigara and Moyo (2012) established that the instability of the financial and economic environment affected the implementation of key projects such as the library at the National University of Science and Technology Library.

Project delays affect overall project performance. They have an adverse effect on project budget, workers' H&S, and quality. This calls for innovative interventions to ensure successful project delivery. The introduction of Industry 4.0 is considered an effective strategy to influence the completion of construction projects on time, and within budget (Osunsanmi et al., 2018). This study will focus on assessing the potential of Industry 4.0 technologies to improve project delivery time.

2.2 The role of Industry 4.0 in improving project delivery

Industry 4.0 is part of the technological and industrial revolution that evolved from the steam engines of the First Industrial Revolution, mass production systems of the Second Industrial Revolution, and the Third Revolution which started in the early 1970s, where electronics and IT systems began (Raj et al., 2020). To be competitive globally, businesses adopted automation and programmed machines into their production processes in the manufacturing industry (Raj et al., 2020). Deloitte (2017) states that the Industry 4.0 concept has its background in the German government as a high-tech strategy to promote computerisation in the German manufacturing industry.

Industry 4.0 technologies can be used to enhance construction project delivery time (Maskuriy et al., 2019). On-site automated and robotic systems are used directly on the construction site to create buildings and structures (Delgado et al., 2019). In Australia, a FBR Ltd. bricklaying machine called
HadrianX employs an intelligent control system, aided by CAD to calculate materials and movements needed for bricklaying (Matthews, 2019). In Singapore, the use of BIM-to-field mobile applications during the construction phase, through tablets and smartphones, enhances the sharing of information on site and improves communication and collaboration (Hwang et al., 2020). BIM is also used to automatically analyse as-built reality captures in the 3D scans to detect work differences. The digital twin works in parallel with construction activities and early alerts are given before an incident happens, thereby reducing the costs of the project, as the working team would have rectified issues proactively (Pring, 2020).

In the United Kingdom, the use of the design for manufacturing and assembly (DfMA) approach by Bryden Wood company has been shown to make construction faster and efficient, reducing the market risk of the investors due to the delays if DfMA was not implemented (Wood, 2020). The DfMA with the help of Revit and BIM brought speed and flexibility of the completion of the construction of the London Crossrail, by breaking the design details into smaller details (Wood, 2020).

Mann (2020) alludes that BIM and digital technology have the potential to transform the sustainability of the built environment. Installing sensors into new buildings, which can track energy performance and pattern behaviour of the occupants can help to reduce carbon footprints and improve the sustainability of the building (Mann, 2020). The effect of this is to reduce energy consumption, which subsequently reduces the cost of projects.

3. RESEARCH METHOD

This study was informed by the positivist worldview and quantitative research approach which entailed the distribution of thirty (30) structured questionnaires to construction professionals working for contractors, property consultants, engineers, and architects in Bulawayo. Quantitative research involves numerically measuring variables by using acceptable measures such as questionnaires and rating scales (Leedy and Ormrod, 2016). The sample frame consisted of 29 contractors registered with the Construction Industry Federation of Zimbabwe (CIFOZ), 4 architects registered with the Institute of Architects of Zimbabwe (IAZ) and 4 consulting engineers registered by the Zimbabwe Association of Consulting Engineers (ZACE). Purposive sampling was used to select the construction professionals who participated in the survey. The questionnaire consisted of 13 short and precise close-ended questions and 1 open-ended question with an estimated completion time of 10 to 15 minutes. The questionnaires were distributed via e-mails (10 No.), and the drop-off and pick-up methods (20 No.). Prior to distributing the questionnaire, it was pilot tested on three construction professionals to assess the clarity of questions and the identified errors were rectified (Leedy and Ormrod, 2016). The data was analysed utilising Microsoft Excel to produce descriptive statistics, such as the calculation of frequencies, percentages, and a measure of central tendency in the form of a mean score (MS).

4. RESEARCH FINDINGS

4.1 Demographic profile of the respondents

A total of 20 questionnaires, representing a 66.7% response rate, were completed, and analysed. The completed questionnaires were received from architects (10.0%), property consultants (15.0%), and general contractors (75.0%). The occupations of the respondents included project managers (45.0%), senior engineers (20.0%), quantity surveyors (15%), general managers (10.0%) and architects (10.0%). The respondents’ work experience spanned from 1 year to more than 30 years and most of the respondents had 11 to 15 years (30.0%) of experience. The qualifications of the respondents include a Diploma (20.0%), Bachelor’s degree (55.0%), a Master’s degree (15.0%), and B-Tech degree (10.0%). The demographic analysis indicates that the respondents had relevant experience and knowledge to provide valid and reliable assessments of the issues raised in the questionnaires. However, given the small sample size, the results can be considered indicative.

4.2 The use of Industry 4.0 technologies in the construction industry

The respondents were asked to indicate the Industry 4.0 technologies used in the construction industry in Zimbabwe.
Figure 2 indicates that respondents perceive that Industry 4.0 technologies / concepts are used to varying degrees in the construction industry in Zimbabwe. The majority of the respondents affirm that Industry 4.0 technologies such as AutoCAD (85%), and Smartphones (75%) are used in the construction industry. Notably, more than half of the respondents believe that Google Earth (65%), BIM (60%), 3D printing (55%), and pre-fabrication (55%) are used in construction in Zimbabwe. However, more than half of the respondents perceive that drones (60%), robots (70%), head-mounted display devices (90%) and exoskeletons (100%) are not used in the construction industry. Although the results reveal the adoption of Industry 4.0 technologies to a degree, they confirm the conclusion of Osunsamni et al. (2018) that the construction industry is a latecomer in terms of the adoption of IT.

4.3 Impact of Industry 4.0 technologies on project delivery

Table 1 shows the respondents’ assessment of the impact of Industry 4.0 technologies on project delivery in terms of percentage responses to a scale of 1 (not at all) to 5 (major), and a MS ranging between 1.00 and 5.00, with the midpoint score being 3.00.

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Response (%)</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhances timely delivery of projects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visualization of project before the construction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved connectivity of the professional team</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improve building designing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More accurate project data</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Share up to date construction information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improve planning and decision making</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improve monitoring and supervision on site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase knowledge sharing and collaborative working.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improve navigation of construction sites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation of topographic information of the environment around a construction site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase contractor’s competence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce idle time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce scope of work</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Response (%)</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhances timely delivery of projects</td>
<td>0.0 0.0 15.0 5.0 25.0 55.0</td>
<td>4.20</td>
<td>1</td>
</tr>
<tr>
<td>Visualization of project before the construction</td>
<td>10.0 0.0 0.0 5.0 25.0 60.0</td>
<td>4.15</td>
<td>2</td>
</tr>
<tr>
<td>Improved connectivity of the professional team</td>
<td>0.0 5.0 0.0 20.0 30.0 45.0</td>
<td>4.10</td>
<td>3</td>
</tr>
<tr>
<td>Improve building designing</td>
<td>0.0 0.0 10.0 15.0 45.0 30.0</td>
<td>3.95</td>
<td>4</td>
</tr>
<tr>
<td>More accurate project data</td>
<td>0.0 5.0 5.0 20.0 30.0 40.0</td>
<td>3.95</td>
<td>5</td>
</tr>
<tr>
<td>Share up to date construction information</td>
<td>5.0 0.0 0.0 15.0 55.0 25.0</td>
<td>3.90</td>
<td>6</td>
</tr>
<tr>
<td>Improve planning and decision making</td>
<td>0.0 0.0 20.0 15.0 25.0 40.0</td>
<td>3.85</td>
<td>7</td>
</tr>
<tr>
<td>Improve monitoring and supervision on site</td>
<td>0.0 0.0 15.0 30.0 25.0 30.0</td>
<td>3.70</td>
<td>8</td>
</tr>
<tr>
<td>Increase knowledge sharing and collaborative working.</td>
<td>0.0 0.0 30.0 20.0 15.0 35.0</td>
<td>3.55</td>
<td>9</td>
</tr>
<tr>
<td>Improve navigation of construction sites</td>
<td>5.0 0.0 0.0 55.0 20.0 20.0</td>
<td>3.45</td>
<td>10</td>
</tr>
<tr>
<td>Generation of topographic information of the environment around a construction site</td>
<td>15.0 5.0 5.0 15.0 20.0 40.0</td>
<td>3.40</td>
<td>11</td>
</tr>
<tr>
<td>Increase contractor’s competence</td>
<td>5.0 5.0 25.0 20.0 30.0 15.0</td>
<td>3.10</td>
<td>12</td>
</tr>
<tr>
<td>Reduce idle time</td>
<td>0.0 0.0 10.0 40.0 25.0 25.0</td>
<td>2.95</td>
<td>13</td>
</tr>
<tr>
<td>Reduce scope of work</td>
<td>15.0 20.0 0.0 10.0 30.0 25.0</td>
<td>2.95</td>
<td>14</td>
</tr>
</tbody>
</table>

Given that 12/14 (85.7%) of the MSs > 3.00, it suggests that Industry 4.0 technologies contribute to a major (positive) as opposed to a minor extent to the realisation of these benefits.
The MSs for the benefits ranked 1st to 10th are > 3.40 ≤ 4.20, which indicates that respondents deem that Industry 4.0 technologies contribute between a moderate to a near major / near major extent to the realisation of these benefits. The results show that the leading benefits of adopting Industry 4.0 technologies are the improved timely completion of projects. This will be facilitated by the visualisation of the project before construction (MS = 4.15), improved connectivity of the professional team (MS = 4.10), improved design (MS = 3.95), more accurate project data (MS = 3.95), and share of up-to-date construction information (MS = 3.90).

The benefits ranked 12th to 14th have MSs > 2.60 ≤ 3.40 suggesting that respondents deem that adoption of Industry 4.0 technologies contribute to the realisation of 'increased contractor's competence, reduced idle time, and reduced scope of work' between a minor to a moderate / moderate extent. The respondent's perceptions are supported by Delgado et al. (2019) who state that robots are used for simple tasks such as painting walls and laying bricks to ensure rapid completion of the project.

### 4.3 Barriers to the use of Industry 4.0 technologies in the construction industry in Zimbabwe

Table 2 shows the respondents’ assessment of the barriers to the adoption of Industry 4.0 technologies in terms of percentage responses to a scale of 1 (not at all) to 5 (major), and a MS ranging between 1.00 and 5.00, the midpoint score being 3.00. The results show that the MSs for 7 / 8 (87.5%) barriers are ≥ 3.00, which indicates that they are deemed to be a major as opposed to a minor barrier.

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Response (%)</th>
<th>MS</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of funds</td>
<td>U 1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lack of funds</td>
<td>0.0 0.0 10.0 0.0 45.0 45.0</td>
<td>4.25</td>
<td>1</td>
</tr>
<tr>
<td>Lack of resources</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0</td>
<td>3.90</td>
<td>2</td>
</tr>
<tr>
<td>Lack of knowledge</td>
<td>10.0 10.0 5.0 15.0 25.0 35.0</td>
<td>3.40</td>
<td>3</td>
</tr>
<tr>
<td>Lack of skilled labour</td>
<td>5.0 5.0 25.0 0.0 0.0 0.0</td>
<td>3.35</td>
<td>4</td>
</tr>
<tr>
<td>Lack of understanding of the strategic importance of Industry 4.0</td>
<td>10.0 20.0 0.0 15.0 25.0 30.0</td>
<td>3.15</td>
<td>5</td>
</tr>
<tr>
<td>Resistance to change</td>
<td>5.0 20.0 5.0 30.0 15.0 25.0</td>
<td>3.05</td>
<td>6</td>
</tr>
<tr>
<td>Lack of clear regulatory standards and codes</td>
<td>10.0 5.0 20.0 25.0 20.0 20.0</td>
<td>3.00</td>
<td>7</td>
</tr>
<tr>
<td>Lack of standards</td>
<td>5.0 30.0 15.0 25.0 15.0 10.0</td>
<td>2.45</td>
<td>8</td>
</tr>
</tbody>
</table>

Lack of funds has a MS > 4.20 ≤ 5.00, which indicates that the respondents deem this barrier to constrain the adoption and use of Industry 4.0 technologies in the construction sector between a near major to a major / major extent. Lack of resources, and lack of knowledge have MSs > 3.40 ≤ 4.20, which indicates that the respondents deem these barriers to constrain the adoption and use of Industry 4.0 technologies in the construction sector between a moderate to near major / near major extent. The results are consistent with those of Chigara and Smallwood (2021) that high investment cost and lack of knowledge are the leading barriers affecting the adoption of Industry 4.0 technologies in Zimbabwe.

Lack of skilled labour, lack of understanding of the strategic importance of Industry 4.0 technologies, resistance to change, and lack of a clear regulation of standards and codes have MSs > 2.60 ≤ 3.40, which indicates that the respondents deem these barriers to constrain the adoption and use of Industry 4.0 technologies in the construction sector between a near minor to moderate / moderate extent relative to the adoption and use of Industry 4.0 technologies in the Zimbabwean construction. The results reinforce the findings of a past study which reported that lack of skilled labour affects the introduction of Industry 4.0 in construction (Horvath and Szabo, 2019).

### 5. CONCLUSIONS AND RECOMMENDATIONS

The aim of the study was to investigate the potential benefits of introducing Industry 4.0 technologies and concepts in the Zimbabwean construction industry to enhance the timely delivery of projects. The results show that AutoCAD, Google Earth, and Smartphones were the technologies perceived to be more prevalent in the construction industry, the responses ranging from 65.0% to 85.0%. Nonetheless, a significant number of technologies are considered as not being used. The study established that applying Industry 4.0 technologies to construction can enhance delivery time for construction projects (MS = 4.20). This will be facilitated through the visualisation of projects before construction (MS = 4.15),
improved connectivity of the project team (MS = 4.10), improving building design (MS = 3.95), provision of accurate project data (MS = 3.95) and improved planning (MS = 3.85). The results reveal that lack of funds, lack of resources, lack of knowledge, lack of skilled labour, and lack of understanding of the strategic importance of Industry 4.0 are the main barriers limiting the adoption of Industry 4.0 technologies in the construction industry in Zimbabwe.

The results highlight the importance of having interventions that promote the adoption of Industry 4.0 technologies in the construction sector. The labour-related barriers to the adoption of Industry 4.0 amplify the need for tertiary-built environment education institutions to integrate Industry 4.0 technologies into their curricula. On the other hand, the cost implications of the adoption of Industry 4.0 highlights the need for the government and other industry players to evolve policies that promote economic benefit from the adoption of these technologies.

This study focused on the benefits of Industry 4.0 technologies to enhance project time delivery but did not focus on how contractors can access the Industry 4.0 technologies. Further studies can focus on how contractors can up-skill in terms of Industry 4.0 to apply Industry 4.0 technologies to enhance project performance in the Zimbabwean construction industry.

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Leadership style and its influence on job satisfaction of South African quantity surveyors

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ABSTRACT AND KEYWORDS

Purpose
Insight into the most appropriate leadership style in quantity surveying firms could play a significant role in employee job satisfaction. Therefore, this research aims to establish if there is a relationship between the leadership styles used in quantity surveying firms and the level of job satisfaction experienced by employees.

Design/methodology/approach
The research used a positivist research philosophy, deductive reasoning, and a mono-method (quantitative) survey approach. Candidate and registered quantity surveying members of the Association of South African Quantity Surveyors (ASAQS) were approached to complete the online questionnaire.

Findings
The results revealed that 64.5% of all the variance in job satisfaction in South African quantity surveyors could be explained by the leadership style that the leaders implement in the organisation. The prevailing leadership style used is transformational leadership, which is positively correlated to employee job satisfaction.

Practical implications
Transformational leadership should be implemented in the quantity surveying industry in South Africa to increase the job satisfaction of the quantity surveyors

What is original/value of paper
The study findings are valuable to many role players in the quantity surveying industry in South Africa. When transformational leadership is implemented in the quantity surveying industry, the job satisfaction of quantity surveyors is increased.

Keywords: Job satisfaction; Leadership styles, Transformational leadership
1. INTRODUCTION

Employees do not quit working for firms; they quit working for their bosses (McCrae, 2020). The leaders in any organisation need to be aware of their effect on their employees. Human capital is a firm's most significant competitive advantage, and employees are therefore seen as intangible assets contributing to a firm's continued success and development (Loganathan, 2013). Competitors can duplicate products, ideas, or processes, but they cannot duplicate the human capital of another firm (Gillaspie, Nobe & Valdes-Vasquez, 2016). The reality of business today is that good staff are hard to find and even harder to replace (Van Eck, 2016). Staff who are challenged and rewarded financially, intellectually, and emotionally are more productive and less prone to leave a firm (Van Eck, 2016). Employee satisfaction has, therefore, become one of the primary objectives of firms in recent years, with job satisfaction deemed a prerequisite for competitive levels of firm success and quality (Garca-Bernal et al., 2005).

Efforts at defining "satisfaction" acknowledge that it is “the "final state of a psychological process” (Garca-Bernal et al., 2005: 280). Job satisfaction can be described as a multi-dimensional idea incorporating a set of unfavourable or favourable feelings about employees’ perception of their jobs. More simply, it equates to a person's attitude towards their work (Bowen & Cattell, 2008; Walker, 2011). Hee and Ling (2011) regard job satisfaction as an index of staff turnover in that workers will not be likely to resign if they are fulfilled and satisfied with their work.

One of the main factors influencing employee job satisfaction is the quality of leadership in an organisation (Belias & Koustelios, 2014). Good leaders will help to encourage, motivate and stimulate their employees to achieve significant performance results (Gill, Flaschner & Shachar, 2006). The way employers treat their employees is a crucial determinant of long-term business success (Campbell, 2007). The leaders or managers in any firm are vital to the performance of employees, and a positive relationship between them is crucial (Nidadhavolu, 2018). Without proper leadership, an organisation will not realise its goals and mission. Poor leadership leads to poor financial results, low employee morale, high employee turnover, and low goal achievement (Lim, Loo & Pey, 2017). Hence the leadership styles adopted in an organisation significantly influence its success, the job satisfaction of its employees and the retention of highly skilled employees (Botha, Vrba & Smit, 2021). It is the leader’s responsibility to manage, moderate, form and change the employees’ feelings, mindset, behaviour, performance and thoughts (Khumalo, 2015).

Research has been conducted on job satisfaction (Bowen & Cattell, 2008; van Eck, 2016) and leadership (Liphadzi, Aigbavboa & Thwala, 2015) independently in the quantity surveying profession. However, no research exists on the influence of leadership styles on the job satisfaction of South African quantity surveyors. Therefore, this research aims to establish if there is a relationship between the leadership styles used and the level of job satisfaction experienced by quantity surveying employees. Insight into the most appropriate leadership style in quantity surveying could play a significant role in employee retention and job satisfaction.

The introduction is followed by a brief review of job satisfaction and leadership style literature. The methodology section indicates that the research used a positivist research philosophy, deductive reasoning, survey approach, mono-method (quantitative), and a cross-sectional time horizon. Subsequently, the results and discussion section focus on a multiple regression to predict if leadership styles influence employee job satisfaction. The concluding remarks finally indicate that if a transformational leadership style is implemented, employees will experience job satisfaction.

2. LITERATURE REVIEW

2.1 Defining job satisfaction

No specific definition will explain the term 'job satisfaction' (Van Eck, 2016) because job satisfaction comprises of human factors that differ from person to person (Boschmans, 2009). However, it is generally accepted as a multi-faceted concept that includes employee feelings about various extrinsic and intrinsic job components (Chaudhry, 2007).
2.2 Importance of job satisfaction

The importance of job satisfaction becomes clear when one observes the relationship between levels of job dissatisfaction, grievance expression, absenteeism, tardiness, high turnover and low morale (Chaudhry, 2007). Employees dissatisfied with their jobs are often absent or late and have low morale. Employees with low morale at work will not be as productive as employees with high morale. Leaders often point to employees’ morale as one of the critical factors for success (Bakotić, 2016). Napoleon Bonaparte once said: “The effectiveness of the army depends on its size, training, experience and morale, and morale is worth more than all the other factors together” (Bakotić, 2016:119). Thus, firms wishing to offer clients high-quality services need to minimise the voluntary job turnover of experienced employees, both by decreasing their desire to leave and increasing their job satisfaction (Hee & Ling, 2011).

The quality of life of employees is significantly impacted by job satisfaction (Jansen, 2015). This finding should interest leaders of all firms since satisfied employees will be prepared to exert considerably more effort (Jansen, 2015). Employees with high levels of job satisfaction usually love their job and are productive (Bakotić, 2016). There is a sense of justice in their work environment, and they feel that their job provides them with positive qualities such as good pay and security, variety, pleasant co-workers, autonomy and challenge (Bakotić, 2016). Happy employees will even dedicate their private time to work activities, be enthusiastic and creative, find a way to overcome any hurdle in the execution of their work, and support their superiors and colleagues (Bakotić, 2016).

Bakotić (2016) discovered a statistically significant positive correlation between financial indicators of organisational performance and job satisfaction, proving that workers who are satisfied at work, work better and that the company benefits from it financially. According to Loganathan (2013), employees who experience job satisfaction show higher levels of commitment to their jobs and organisations, leading to increased efficiency and lower staff turnover, which results in success for the organisation.

2.3 Job satisfaction in the quantity surveying industry

The three major job satisfaction studies conducted on quantity surveyors in South Africa were done by Bowen and Cattell (2008), Bowen et al. (2008) Van Eck (2016). Bowen and Cattell (2008) found that 88% of their respondents enjoyed their job and that 42% experienced high levels of job satisfaction.

This 88% of the respondents indicated that they loved their job. In another study done by Bowen et al. (2008), only 39% of quantity surveyors who are employees and not employers in their organisations reported either liking their jobs very much or loving it. They also found that few quantity surveyors experience high job satisfaction. However, 81 to 88% of the quantity surveyors included in the study by Bowen et al. (2008) were found to have experienced job fulfilment concerning their career expectations. Lastly, Van Eck (2016) conducted a study to determine the job satisfaction of Generation Y quantity surveyors. Generation Y are people who were born between 1980 and 1990. The study found that most Generation Y quantity surveyors are experiencing job satisfaction.

2.4 Leadership styles

Leadership is a complex concept and can be defined in various ways. Burns (1978) defined leadership as an act of leaders that motivates followers to act for specific goals that represent the values, motivations, expectations and aspirations, wants and needs of both leaders and followers. Leadership is about the relationship between followers and those who aim to lead (Kouzes & Posner, 2002). A leadership style combines the leader’s self-related information, personality traits and underlying motives (Toor & Ofori, 2006). The literature identifies the three most common leadership styles employed in the current climate: transformational leadership, transactional leadership and laissez-faire leadership, with transformational and transactional leadership being the most frequently implemented (Loganathan, 2013).

The transformational leadership style has become popular in recent years. It is concerned with the empowerment and development of followers to function independently (Chaudhry, 2007). Transformational leaders lead and operate from a deeply held personal value system (Truter, 2016). Four transformational leadership behaviours were identified by Bass (1985), namely idealised influence, individual consideration, inspirational motivation, and intellectual stimulation (Bass & Avolio, 1992)
Transactional leadership is a task-oriented leadership style. The transactional leadership style, also referred to as managerial leadership, focuses on the function of group performance, supervision and organisation (Khumalo, 2015). This type of leadership is useful when projects need to be executed in a particular way and during emergencies and crises (Khumalo, 2015).

Laissez-faire leadership, according to McColl-Kennedy and Anderson (2005), is a passive leadership style characterised by high levels of avoidance, indecisiveness and indifference. This leader has no genuine authority.

2.5 The relationship between leadership styles and job satisfaction

The literature suggests that the leadership style strongly influences an employee’s job satisfaction (Loganathan, 2013). A leader and his leadership style have positive outcomes for the organisation if the leader is perceived as trustworthy (Chaudhry, 2007). Chaudhry (2007) determined that a company’s leadership style strongly influences the job satisfaction of employees in the construction industry. Fang, Chang & Chen (2010) found that the leadership style implemented in an organisation can positively affect employees’ commitment and work satisfaction.

Transformational leadership positively affects employee performance and job satisfaction (Price, 2009). According to this study, to achieve a higher degree of employee satisfaction and performance, building professionals should promote and adopt the use of transformational leadership in their interactions with employees in the workplace. Berson and Linton (2005) also found a positive correlation between transformational leadership and job satisfaction. Transformational leadership instills significant changes at the organisational level through the changing of attitudes and assumptions among employees and creating collective engagement (Truter, 2016). According to Liphadzi, Aigbavboa and Thwala (2015), a strong positive correlation exists between the success of a project and transactional leadership. They conclude that transactional leaders in the South African construction industry are more inclined to enjoy project success.

Bass (1985) supports a transformational–transactional continuum in leadership. He believes the two leadership styles should be viewed as different points on a single continuum rather than as two distinct leadership styles (Yammarino, Spangler & Bass, 1993). Transformational and transactional leadership styles, while distinct in some senses, are not mutually exclusive. A leader can use both styles at different times and situations (Bass & Avolio, 1992). Madlock (2008) claims that employees are most satisfied when they perceive their leaders are using a combination of leadership styles, namely relational (transformational) and task-oriented (transactional) behaviours. This combination of leadership styles is a hybrid type of leadership, a fluid leadership style, where the leader employs different types of leadership in different situations and with different personalities.

Nidadhavolu (2018) conducted a study on three companies in the construction industry in India and found a significant correlation between leadership styles and employees’ job satisfaction. The study revealed that the common leadership style in Company A is transformational and that the employees experienced high job satisfaction. In Company B, employees had low job satisfaction with implementing laissez-faire leadership. The laissez-faire leadership style used in Company B led to poor interpersonal relationships and reduced productivity. Company C’s leaders also implemented a predominantly laissez-faire leadership style, and the employees had low job satisfaction.

Loganathan (2013) found that respondents were dissatisfied with various attributes of laissez-faire leadership and transactional leadership and concluded that these leadership styles were not conducive to job satisfaction. He found that the transformational leadership style contributed most to job satisfaction, in particular through the aspect of intellectual stimulation. At the same time, Loganathan (2013) notes that little or no involvement of the leader with the employees could empower the employees; that is, the laissez-faire leadership style could lead to employee self-development. On the other hand, Madlock (2008:64) argues that laissez-faire leadership could lead to weak interpersonal relationships at work, contributing to job dissatisfaction and low productivity levels.

3. RESEARCH METHODOLOGY

The study’s research philosophy is positivist, which means that the researcher assumed that the prevalent leadership styles and their influence on the job satisfaction of quantity surveyors in South
Africa could be observed and quantified. Deductive reasoning using a survey approach was used to collect data from quantity surveyors. This study implemented a mono-method, meaning that the researchers only used the quantitative method to collect data.

3.1 Data Collection Methods

The questionnaire that was used in the study was divided into four sections. Section A collected demographic information, and Section B collected data on leadership with the Multifactor Leadership Questionnaire (MLQ) Form 6S. The leadership questionnaire consisted of 21 items on a five-point Likert scale. Bass and Avolio (1992) developed this form 6-S (MLQ-6S) questionnaire. The MLQ is the most frequently and thoroughly researched and validated leadership instrument globally (Tejeda, Scandura & Pillai, 2001). Respondents had to plot their responses on a five-point Likert scale ranging from ‘strongly disagree’ to ‘strongly agree’. The items in the questionnaire measured three different leadership styles, namely the transformational leadership style, the transactional leadership style and the laissez-faire leadership style.

Section C collected data on job satisfaction. The job satisfaction survey (JSS) that was used was developed by Spector (1985). The JSS consists of 36 items measured on a five-point Likert scale. The JSS consists of 36 items, measuring nine sub-scales: nature of work, supervision, co-workers, communication, contingent rewards, pay, fringe benefits, promotion and operating conditions. The respondents had to respond on a five-point Likert scale with their responses ranging from ‘strongly disagree’ to ‘strongly agree’.

3.2 Data Collection Procedures

The questionnaire was pilot tested on four registered professional quantity surveyors to increase its credibility and eliminate ambiguity issues before it was sent to the sample. Subsequently, the data were collected via a web-based, online questionnaire survey. The census sample comprised of all the candidate and professional quantity surveying members of the Association of South African Quantity Surveyors (ASAQS). A link to the questionnaire was posted on the ASAQS website and included in three weekly newsletters sent to all the members of the ASAQS. Seventy-seven questionnaires were completed by the closing date of the survey.

3.3 Data Analysis

Descriptive statistics were used to indicate the most prevailing leadership style and if quantity surveyors achieved job satisfaction.

To predict the influence of different leadership styles on job satisfaction, a multiple regression was run with total job satisfaction as the dependent variable and the three subscales representing leadership styles as the independent variables. Regression is an equation developed to predict the values of a dependent variable (Sauro & Lewis, 2016). All assumptions of multiple regression were tested and met (linearity, homoscedasticity, multicollinearity, outliers, leverage values and influential values, and normality).

3.4 Reliability of Data

Cronbach’s alpha was used to measure the reliability and consistency of the MLQ-6S and the Job Satisfaction Survey. An acceptable range of reliability coefficients for most instruments is between 0.70 and 0.90 (Taber, 2018). The results of the MLQ-6S questionnaire indicated that for transformational leadership, the reliability was 0.951, which is high. The Cronbach alpha showed 0.75 for the reliability of transactional leadership, which is also within the range of acceptable reliability. However, according to Cronbach’s alpha, the reliability for laissez-faire leadership was 0.457, which is low.

The reliability of the Job Satisfaction Survey for this study was 0.932, thereby showing high reliability. The reliability for the different factors contributing to job satisfaction were as follows: nature of work (0.839), supervision (0.797), co-workers (0.693), communication (0.80), contingent rewards (0.792), pay (0.73), fringe benefits (0.761), promotion (0.76) and operating conditions (0.33). As can be seen from these results, the reliability for the factor ‘operating conditions’ is unsatisfactory. However, since this subscale was not used in the analysis, it is not a problem. What is more important is that the total scale shows good internal consistency reliability, with Cronbach’s alpha = 0.932.
3.5 Ethical Considerations

Leadership and job satisfaction issues can be sensitive topics, and therefore confidentiality must be upheld. Participation in this study was entirely voluntary, and it was up to the individuals to participate or not. Therefore, the completed questionnaires were treated as evidence of informed consent. All the respondents remained anonymous during and after the study.

4. RESEARCH RESULTS AND DISCUSSION

4.1 Prevailing leadership styles

Figure 1 indicates that Transformational leadership (60%) is the leadership style most prevalent in the quantity surveying industry based on the MLQ Form 6S. Transactional leadership (29%) is the second most prevalent, while the least prevalent type of leadership style found in the quantity surveying industry is laissez-faire leadership (11%).

De Jager (2014) also found transformational leadership to be the most prevalent in South Africa. Quantity surveyors, therefore, make use of their close relationships with their employees to ensure that they produce satisfactory work. Other positive outcomes of implementing this leadership style are employee sense of well-being, organisational citizenship behaviour, productivity and organisational commitment (Truter, 2016).

The study found that the most prevalent leadership quality in the quantity surveying industry is idealised influence. Idealised influence is considered the most critical behaviour of a transformational leader, a value-based leadership style that leads to emotional bonds between leaders and followers (Weng, Su & Lai, 2011). According to Andrews (2003), effective leaders influence their employees to have positive aspirations, and these aspirations result in high levels of satisfaction among the employees. Loganathan (2013) argues that if employees gain trust in and admiration for their leaders, they are willing to make sacrifices to make their leaders' vision a reality.

4.2 Job satisfaction

The study results are ambiguous regarding whether quantity surveyors experience high levels of job satisfaction. A score of between 144 – 216 on the Job Satisfaction Survey indicates high levels of job satisfaction, and a score of between 36 – 108 indicates job dissatisfaction. The mean score in this study was 125. The results, therefore, show that quantity surveyors had neither job dissatisfaction nor high levels of job satisfaction. These findings contradict the findings of the other two major job satisfaction studies conducted in South Africa, which indicated that quantity surveyors experienced high levels of job satisfaction (Bowen & Cattell, 2008; Van Eck, 2016).
The scores for factors that contribute most to the job satisfaction of quantity surveyors were calculated from the mean responses. The factors contributing to the job satisfaction of quantity surveyors, according to the results of the Job Satisfaction Survey, are as follows, listed from most influential to least influential:

1. Nature of work
2. Supervision
3. Co-workers
4. Communication
5. Contingent Rewards
6. Pay
7. Fringe benefits
8. Promotion

The factor that contributes most to the job satisfaction of quantity surveyors is the nature of work they perform. Bowen and Cattell (2008) also found a positive correlation between the nature of the job and job satisfaction in quantity surveyors. Bowen et al. (2008) report that the fourth most important factor influencing job satisfaction is undertaking challenging and creative work. Chaudhry (2007) found the job itself to be the third biggest contributor to job satisfaction, and Cardy and Lengnick-Hall (2011) found being given challenging work the third biggest contributor to job satisfaction. All these findings are in agreement with the findings in this study.

The study also revealed that 'supervision', which is related to leadership in the organisation, is the second biggest factor influencing the job satisfaction of quantity surveyors. Chaudhry (2007) also reported that leadership is correlated with job satisfaction, and the results of Loga’athan’s (2013) study reaffirm leadership’s influence on employees’ job satisfaction.

Co-workers was the third biggest contributor to job satisfaction in the study. De Jager (2014) similarly found that quantity surveyors derived their primary satisfaction from the support and admiration of their co-workers. In contrast to the findings of this study, Bowen et al. (2008) found that issues of social interaction at work (co-workers) were among the least critical factors influencing job satisfaction.

'Pay' was only the sixth biggest contributor to job satisfaction. This is in line with a study done by Bowen et al. (2008), who found salary to be the least important factor contributing to the job satisfaction of quantity surveyors. However, the literature reveals contradictory findings. Chaudhry (2007) found pay to be the biggest contributing factor to job satisfaction, while Cardy & Lengnick-Hall (2011) reported that compensation is the second most important factor contributing to job satisfaction.

4.3 The relationship between leadership style and the level of job satisfaction

Multiple regression was used to predict the influence of the different leadership styles on the job satisfaction of quantity surveyors. The dependent variable was the total job satisfaction experienced by quantity surveyors. The independent variables were transactional, transformational, and laissez-faire leadership styles. Based on the multiple regression used, leadership styles explain 64.5% of the variance in total job satisfaction.
Table 1: Multiple regression results on leadership ‘styles’ effects on job satisfaction

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Standard Error of the Estimate</th>
<th>Durbin-Watson</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.812a</td>
<td>0.659</td>
<td>0.645</td>
<td>12.328</td>
<td>1.803</td>
</tr>
</tbody>
</table>

a. Independent variables: Transformational, Transactional and Laissez-faire Leadership

The bold cell in Table 1 above shows that the full model, with all independent variables included, explained 64.5% of the variance in total job satisfaction. This result indicates that in terms of any change experienced in job satisfaction in employees, 64.5% of that change can be explained by the leadership style implemented. This finding is very important as it proves the effect that leadership styles have on employees’ job satisfaction. The findings of this study reaffirm the results found in Choudry’s (2007) study namely that a company’s leadership style strongly influences the job satisfaction of employees in the construction industry.

The ANOVA table below was consulted to determine whether the overall model with all independent variables added statistically significantly predicted total job satisfaction.

Table 2: Results of ANOVA to determine the effect of the three leadership styles on job satisfaction

<table>
<thead>
<tr>
<th>Model</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>21429.953</td>
<td>3</td>
<td>7143.318</td>
<td>46.996</td>
<td>.000</td>
</tr>
<tr>
<td>1 Residual</td>
<td>11095,996</td>
<td>73</td>
<td>152,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>32525,948</td>
<td>76</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Independent Variables: Laissez-faire Leadership, Transformational Leadership, Transactional Leadership

From the value in the Sig. column in the ANOVA table above, it can be seen that the full model, with all independent variables, added, statistically significantly predicted total job satisfaction, F(3, 73) = 46.996, p < 0.05. It can, therefore, be concluded that leadership styles significantly predict job satisfaction experienced by employees.

The coefficients table below was consulted to determine which independent variables made a statistically significant unique contribution to the prediction of total job satisfaction after all other independent variables had been evaluated.

Table 3 Correlation coefficients to determine which leadership style made a statistically significant contribution to total job satisfaction

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardised Coefficients</th>
<th>Standardised Coefficients</th>
<th>T</th>
<th>Sig</th>
<th>95% Confidence Interval for B</th>
<th>Correlations</th>
<th>Collinearity Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B Std.Error Beta</td>
<td></td>
<td></td>
<td></td>
<td>Lower Bound Upper Bound Zero Order Partial Part Tolerance VIF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>74.589 5.994</td>
<td></td>
<td>12.444 .000</td>
<td>62.643 86.534</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transactional</td>
<td>0.698 0.677 0.145</td>
<td>1.030 0.307 -.653 2.048</td>
<td>0.702 0.120 0.070 0.237</td>
<td>4.216</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformational</td>
<td>1.388 0.271 0.695</td>
<td>5.131 .000 0.849 1.928</td>
<td>0.803 0.515 0.351 0.255</td>
<td>3.928</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laissez-faire</td>
<td>-1.154 0.679 -0.125</td>
<td>-1.700 .093 -2.506 0.199</td>
<td>0.006 -0.195 -0.116 0.864</td>
<td>1.157</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

From the table above, it can be seen that only transformational leadership made a statistically significant unique contribution to the prediction of total job satisfaction after all other variables were controlled for.
A one-unit increase in transformational leadership was associated with a 1.388 unit increase in total job satisfaction. Stated differently, greater transformational leadership is associated with higher total job satisfaction, and Transformational leadership is thus positively correlated with job satisfaction. The results also show that transformational leadership was present in the respondent's company with the highest score on the JSS, which supports the notion of a positive correlation between transformational leadership style and job satisfaction.

The information in the table also shows that laissez-faire leadership is negatively correlated with job satisfaction. This implies that if laissez-faire leadership is implemented in the quantity surveying industry, employees will experience less job satisfaction. This result was reaffirmed in that the laissez-faire leadership style was present in the company of the respondent who scored the lowest on JSS, which indicated that s/he was experiencing job dissatisfaction.

4.3.2 Interpretation

This study indicates that 64.5% of the variance in job satisfaction is due to the leadership style implemented by the leaders in the company. The results point to the importance of leadership styles and their effects on the job satisfaction of quantity surveyors in South Africa. Botha, Vrba and Smit (2021) maintain that the leadership styles adopted in an organisation significantly influence the job satisfaction of its employees and the retention of highly skilled employees. It is, therefore, of utmost importance that the correct leadership style is employed to maximise job satisfaction among quantity surveyors. The findings of this study reaffirm the findings of Chaudhry (2007) and Nidadhavolu (2018) that a company’s leadership style strongly influences employees’ job satisfaction in the construction industry.

Transformational leadership was found to be most conducive to job satisfaction in this study. This implies that if the transformational leadership style is implemented in an organisation, the employees will experience more job satisfaction. The finding was supported by the fact that the respondent with the highest score on the JSS, 168, indicated that their organisation was characterised by transformational leadership. The relationship between transformational leadership style and job satisfaction was therefore confirmed. Several studies have indicated that transformational leadership promotes higher levels of job satisfaction (Chaudhry, 2007; Adler & Reid, 2008; Loganathan, 2013). Therefore, the results reported in the literature support the findings of this study.

In this study, laissez-faire leadership was the least conducive to job satisfaction and negatively correlated. This implies that when a laissez-faire leadership style is used, it will lead to job dissatisfaction. This finding was supported by the fact that the leadership style in the organisation of the respondent who scored the lowest on the JSS, 77, was laissez-faire. Nidadhavolu’s (2018) findings are in line with the findings of this study, that the laissez-faire leadership style leads to job dissatisfaction in employees, leading to poor interpersonal relationships and low productivity.

5. CONCLUSION

Employees do not quit working for firms; they quit working for their bosses. Therefore, it is crucial to ensure that leaders within firms understand that they significantly influence employee job satisfaction and untimely employee turnover.

The study revealed that a transformational leadership style is predominantly implemented in the quantity surveying industry. Quantity surveyors, therefore, make use of their close relationships with their employees to ensure that they produce satisfactory work. The results were unclear on whether quantity surveyors experienced job satisfaction; it only indicated that they do not experience high levels of job satisfaction or job dissatisfaction. However, the transformational leadership style is positively correlated to job satisfaction. This implies that if the transformational leadership style is implemented, more job satisfaction is experienced by the employees.

Conversely, a laissez-faire leadership style is negatively correlated to job satisfaction. This means that if a laissez-faire leadership style is implemented, less job satisfaction is experienced by the employees. However, this result must be read with caution as the internal reliability (Cronbach alpha) of data for the laissez-faire leadership style was only 0.457, which is considered low.
The most important result of the study revealed that the leadership style could explain 64.5% of all the variance in job satisfaction in quantity surveyors that the leaders implement in the organisation. Thus, the leadership style used in a quantity surveying firm plays a significant role in employee job satisfaction.

From an employer’s perspective, it is important to note that transformational leadership is more conducive to job satisfaction than transactional or laissez-faire leadership styles. Therefore, leaders are encouraged to pursue the development of their leadership styles towards transformational leadership and implement it within the firm, as this will enhance employees’ job satisfaction. Additionally, it is recommended that the laissez-faire leadership style not be considered in the leadership mix as this style is viewed as an absence of leadership and this study found that it is negatively correlated to job satisfaction. Furthermore, it should be highlighted that the nature of work and supervision are the most influential factors for employee job satisfaction. Therefore, it is essential to monitor the nature of the work given to employees to avoid tedious tasks while ensuring proper supervision is provided.

From an employee perspective, it is important to note the importance of leadership styles on employee satisfaction when considering an employment opportunity with a firm. Employees could also benefit from this information as they progress to become future leaders within a firm. Furthermore, it is important to note that payment is not one of the most critical factors for job satisfaction. Traditionally, candidate quantity surveyors tend to put significant emphasis on remuneration when applying for their first job. However, as can be seen from this research, it is not the be-all and end-all of job satisfaction; various other factors play a more crucial role in job satisfaction which should be considered when considering a job offer. Insight into the most appropriate leadership style in quantity surveying plays a significant role in employee job satisfaction and retention. Therefore, the future of the quantity surveying profession rests in the hands of its transformational leaders.

6. REFERENCES


Challenges of the Supply Chain Management in The Construction Industry: An Analytical Study

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ABSTRACT AND KEY WORDS

Purpose of this paper
This research aims to investigate the challenges of Supply Chain Management (SCM) in the construction industry.

Design/methodology/approach
To achieve the abovementioned aim, the research adopted an analytical qualitative research approach. Comparative analysis of intensive literature review was conducted to build a comprehensive knowledge about the research topic through investigating the nature and characteristics of supply chain and SCM, dimensions of supply chain performance and challenges of SCM.

Finding:
Construction industry is a productive process that has numerous and complex interfaces between participants and many problems originated by the lack of coordination of these participants. SCM provides several principles to address this fragmentation and eliminate it. Some of the major benefits that construction organizations can achieve by applying SCM principles are: reduced actual costs, increase competitive advantages, on time delivery, productivity improvement, value creation, greater confidence in longer-term planning and better relationships between parties. The research identified many causes of challenges to apply SCM application in construction industry are and covered the different views, approaches and efforts conducted to adopt the concept of SCM in the construction industry. In addition, it discussed the different roles of SCM, dimensions and characteristics of SCM and stakeholders involved in construction supply chain.

Limitation:
The concept of supply chain (SC), and supply chain management (SCM) are relatively new to the construction industry, and the construction industry is limited to apply SCM technique and principles.

Practical Implication:
The research work presented in this paper enable governmental authorities, design and construction firms as well as other supply chain members to work collaboratively to overcome these challenges as an approach for enhancing the performance of the construction industry.

Keywords: Challenges of Supply Chain Management, Construction Industry, Supply Chain Management.
1 Introduction

Socially, it provides societies with projects and infrastructure facilities that meet their needs while improving people’s living standards and quality of life. Economically, it provides the majority of the country’s fixed capital assets, boosts GDP, creates job opportunities, and helps other industrial sectors thrive. However, the construction industry has a significant environmental impact. Construction materials consume approximately 3 billion tonnes of raw materials and accounts for around 45% - 50% of global energy usage, nearly 50% of worldwide water usage, and around 60% of the total usage of raw materials. In addition, the industry causes:

- 23% of air pollution,
- 50% of climate change gases,
- 40% of drinking water contamination and
- 50% of landfill wastes.

These unsustainable practices called for the construction industry to be more sustainable. Which can be realised through a collaborative effort of all parties involved in the project development process (e.g. designer, contractor, supplier, manufacturer, distributor, wholesaler, retailer, etc.). Because the construction supply chain (CSC) is human-based and consists of intensive activities, relationships, and operations, it faces several issues such as project cost uncertainty, poor quality, time delay, rework, lack of information, waste generation, and lack of integration and collaboration between different parties. As a result, the purpose of this paper is to investigate the challenges of SCM in the construction industry.

2 The Supply Chain

2.1 Definition and Types

There are three different types of supply chains based on the level and number of the organisations involved as follows.

Basic (direct) supply chain consists of an organisation, an instant supplier and an instant customer, which are directly linked via one of the upstream and downstream flows of products, services, finances and information.

Extended supply chain consists of suppliers of the immediate supplier and customers of the immediate customer, which are connected by one or more of the upstream and/or downstream flows of products, services, finances and information.

Ultimate supply chain includes all the organizations involved in all the upstream and downstream flows of products, services, finances and information from the ultimate supplier to the ultimate customer, see figure 3.
2.2 Evolution of Supply Chain Management

During 1960 to 1975, organisations were vertically aligned and the function was the main focus of optimization. Relationships with vendors were mainly winning-lose interactions. Starting from 1975, the benefit of interaction of functions as design and production was realized by many organisations. In the early 1980s, the concepts of transportation, distribution, and materials management started to combine into a term called ‘supply chain management’. In 1985, Michael Porter presented how to create a more profitable organization by analysing the five primary processes of supply chain namely, inbound logistics, operations, outbound logistics, sales and marketing and service. By 1990, the structure of organisations needed to change due to harsh national and international competition. SCM has been of substantial importance in the business environment. There has also been a change within organisations as employee empowerment has become an important solution for more flexibility in processes and organisations. Despite the fact that SCM entered the public awareness nearly 40 years ago, only a very small number of companies fully embraced the concept.

2.3 Supply chain management in construction

The nature of the construction industry is different in many ways from the manufacturing industry, from which many of the SCM concepts were originally developed. For example, the construction industry is characterised as project-based with temporary organizations while the manufacturing industry is more likely to have continuous production with a more permanent organisation. In order to cope with this different nature, it is necessary to position the framework of SCM in the context of the construction industry.

2.4 The Importance of Supply Chains in construction

SCM provides opportunities for improvement in all problematic issues in construction. It provides strong themes to improve the cohesion and controllability of construction supply chains as a whole. It aids in the optimisation of material and information flows in construction supply chains through measurement, redesign, and reengineering of the chain process. Furthermore, it opens up opportunities to improve operations, logistics, and materials management, as well as to increase collaboration and communication across the supply chain. managing construction supply chains through collaboration has dramatic effects on cost and cost predictability. It is expected to save about 31% off the tender price. This means that effectively managing the supply chain allows for significant cost savings on the project. competition in the construction industry over the next decade or two will be between supply chains rather than between individual companies.

2.5 Roles of SCM in Construction

There are four major roles for supply chain management in construction.

- First, the focus may be on the effects of the supply chain on site activities, with the goal of reducing site costs and durations. The primary concern is ensuring the flow of materials and labour to the site in order to avoid disruptions to the workflow. The main contractor is best placed to adopt this focus.
- Second, the focus is on the supply chain itself. The goal is to reduce the costs related to logistics, lead time and inventory. Material and component suppliers may adopt this focus.
- Third, the focus is on transferring activities from the site to earlier stages of the supply chain. The goal is to reduce the total costs and duration. This focus may be initiated by suppliers or contractors.
Fourth, the focus is on the integrated management and improvement of the supply chain and the site production, where site production is subsumed into SCM. This focus may be initiated by clients, suppliers or contractors.

2.7 Characteristic of construction supply chains

One obvious characteristic of construction supply chains is that they can be extremely complex, particularly in large construction projects. The number of different materials required on site and the number of parties required for a construction project, may contribute to the project's complexity.

The construction supply chains are typically make-to-order, converging, temporary and fragmented, as described below:

- **Converging supply chain**
  In construction projects, it is normal for materials, documents, operation capacity to be delivered and assembled on site by suppliers and subcontractors under the supervision of the main contractor.

- **Make-to-order supply chain**
  Traditionally, it is very often the end user who takes the initiative to start a construction project and that is why most construction project is customer driven. The production process of a construction project starts and ends with the end user.

- **Fragmented supply chain**
  Fragmentation in the construction process is one of the important characteristics of construction supply chain. Many participants are active in different stages of the construction process and the distribution of authority and responsibility changes often during the process. Fragmentation causes difficulties in collecting data, solving problems, developing new methods or taking appropriate action.

- **Temporary supply chain**
  The nature of construction is project-based. This means that when the project is completed, the organisations involved are normally dismissed. The organisations involved in the project have to end their roles as a consequence. This short-term coalition, with frequent changing members may result in a fluctuation of productivity.

2.8 Challenges of the Supply Chain Management in Construction

The construction industry is plagued with many challenges (e.g., low profit margin, delays, budget overruns, and is beset with claims and counterclaims). It was also reported that the typical contractor-subcontractor relationship is still traditional, arms-length, cost-driven and potentially adversarial. Delays which are common challenges in construction are reported to result in lower productivity and increase costs. Waste was also identified in many construction projects as a result of ineffective construction processes. Challenges in the construction industry may also be seen from demand and supply perspective. While demand issues include problems with low and discontinuous demand, frequent changes in specification, inappropriate selection criteria, and inappropriate allocation of risk, supply issues include poor quality, inefficient methods of construction, and poor public image.
The common issues include poor management, inadequate investment, adversarial culture, and fragmented industry structure.

- Poor management may occur either at company level or at site level and can lead to poor performance.
- The inadequate investment in training, research and development has become a problem in the construction industry and this may impact on quality in the industry.
- Adversarial culture. This has been a recognised problem for many years and may result in disadvantages for both clients and contractors and discourage the adoption of the best modern procurement processes.
- Fragmented industry structure. The fragmentation is not only in terms of the number and size of construction firms, but also the diversity of professions and trades. Many main contractors no longer undertake work directly. This leads the main contractors to subcontract the work to specialist subcontractors, hire plant, use labour-only subcontractors, and use many suppliers.

Most of these problems are not generated in the conversion process but in the different interfaces of different parties or functions, that exist within the supply chain. Some of the general challenges are as follows:
• **Client / Finance, Design Interface**: difficulties in finding out client's wishes, changes of client's wishes, long procedures to discuss changes, interfaces with other relevant parties throughout finance and design period.

• **Design / Engineering Interface**: incorrect documents, design changes, extended time for design changes and approval, wrong calculations, designs not in accordance with the well-known construction methods, no constructability.

• **Engineering / Procurement, Vendors Interface**: inaccurate data, engineering drawings not fit for use.

• **Engineering / Site Interface**: engineering team not present on site for the field engineering.

• **Engineering / Commissioning, Procurement / Commissioning, Main Contractor / Commissioning, Subcontractors, Suppliers / Commissioning Interfaces**: difficult interfaces between various disciplines, problematic completion due to quality problems.

• **Project Completion / Commissioning Interface**: problematic completion due to quality or safety problems, problems with local communities.

• **Procurement, Vendors / Suppliers Interface and Procurement, Vendors / Subcontractors**: inaccurate data, technical specifications not met, other changes, lack of coordination, collaboration and commitment between suppliers, poor quality of materials and components.

• **Procurement / Logistics Interface**: not proper logistic studies, not effective logistics routes, not obtained permits & licenses needed, customs clearance delay.

• **Logistics / Site Interface**: large shipments, not proper packing, bad weather or political conditions, long storage period.

• **Main Contractor / Subcontractors Interface**: deliveries not according to planning late deliveries of permanent materials, wrong and defective deliveries, large shipments, long storage period, interfaces with several subcontractors and suppliers, poor training of contractor's suppliers, subcontractors and workers, inadequate management within the supply chain, mainly poor.

• **Suppliers and Subcontractors / Site Interface**: deliveries not in conformance with planning, wrong and defective deliveries, long storage period, subcontracted work not delivered according to main design, contract and planning, low productivity of several subcontractors, poor training of workers, deficient communication and information transfer.

• **Site / Completion of Project and Project Completion / Commissioning Interfaces**: problematic completion due to quality or safety problems, problems with local communities.

• **Commissioning / Operation Interface**: unresolved quality and technical problems, delayed operational time due to late completion.

3. Conclusion

Being one of the biggest industries worldwide, the construction industry plays an important role towards achieving sustainable development objectives of countries worldwide. The construction sector deals with various stages from design to construction and renovation of buildings and infrastructure facilities. It also deals with manufacturing and production of construction materials for use in the building industry. However, the construction industry is plagued with a number of problems including delays, cost overrun and poor quality, waste generation, energy and water consumption, air and water pollution. The construction industry is based on a network of supply chain consists of various parties of the project stakeholders. Problems arise within the construction supply chain affect the industry performance. This research focused on investigating the challenges that affect the supply chain in the construction industry. The research studies the different views, approaches and efforts conducted to adopt the concept of SCM in the construction industry. This will enable governmental authorities, design and construction firms as well as other supply chain members to work collaboratively to overcome these challenges as an approach for enhancing the performance of the construction industry. The research work presented in this paper is unique in nature and covered a topic received scant attention in construction literature.

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Construction Infrastructure Project Cost Overrun and Cost Control/Management Techniques.

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ABSTRACT AND KEYWORDS

Purpose of this paper
The construction industry is distinct and different from other industries due to its multifaceted nature and the unpredictability it meets. Despite advancements in construction project management throughout the decades, cost overrun as proved to be a significant challenge for the industry with most of the construction and infrastructure projects encounter cost and schedule overruns due to challenges caused by inadequate cost management during the design and implementation stages. Hence, this research is set to identify and rate the elements that influence cost overruns and evaluate the cost management techniques in the UK construction sector.

Design/methodology/approach
The research was carried out using primary research, which takes the form of quantitative data collected through a questionnaire. This provides the required data for analysing cost overruns and determining the most effective cost management strategy. The Relative Importance Index (RII) rated the components.

Findings
Findings from the research show that erroneous estimating, unsuitable planned design standards, and information are the main militating factors influencing cost overruns in construction infrastructure projects (CIPs) with a relative important index (RII) of 0.938462 whilst budgeting ranked highest for all participants as a cost-control approach.

Original/value of paper
This is to gauge the position of middle management on the various challenges posed by cost overrun and delays. It was deduced from the research outcome that an experience professional should oversee complex or mega project and innovative design technology can be used to enhance design consideration right from the outline design stages.

Keywords: Cost overrun, Cost management, Cost control, Construction, and Infrastructure project
1.0 INTRODUCTION.

The construction business is complicated because of the multiple parties involved, such as clients, contractors, consultants, end users, shareholders, regulators, and others, whilst construction projects must meet three primary goals: they must finish on schedule, around budget, and to an acceptable standard of quality (Potts, 2013). Cost overruns have many issues. As reported in a study by UK Construction Media, less than 31 percent of projects were within the 10 percent threshold of the original project budget in the three years leading up to 2015 (UK Construction Media, 2017). The Department of Transport's (DIT) current estimate of the cost of HS2 (High-Speed Railway), an ongoing project in the UK, has spiralled even higher, from between £72-£98 billion, up roughly 120-200 per cent over the previous estimate of £32.7 billion in 2010 (BBC, 2018,2021). However, due to the construction and infrastructure industry's high costs and complexity, maintaining it in its current state has become unaffordable, despite its importance to the economy (McNulty, 2011). This, combined with rising expenses and an unprecedented funding crisis, has increased the pressure on the sectors to save money through a financially organised and long-term growth platform (McNulty, 2011; Kelly, 2007). As a result, the industry's ability to reduce costs while growing capacity to match present and prospective national growth trends have been scrutinised more closely (McNulty, 2011; Allport et al, 2008; Seidu et al., 2020).

Cost control is critical in every industry to ensure that a business makes the maximum profit or that a program's expenditure somehow does not surpass its initial worth. Honouring Ashworth (2004), cost and schedule control are essential management roles once a project is established. Determining the most efficient control measures is critical to the entire cost control process. However, according to research by Olawale and Sun (2010), many companies base their systems on an individual's knowledge and the most successful approaches for a specific project. Therefore, various strategies are used in the industry, making it complicated to establish the most efficient. Hence, the research is to critically evaluate the cost control methods and aspects leading to project budget overruns in UK construction and infrastructural industry for the process of ascertaining construction project performance.

2.0 Literature Review

2.1 The UK Construction and Infrastructure Industry

The construction industry is a crucial component of the UK economy, encompassing various products, services, and technologies. Figure 1 shows the types of activities and goods carried out by each sub-sector and their scale in terms of gross value added (GVA) and employment.

![Figure 1: Composition of the UK construction sector. Source: GVA and no. of businesses: ONS Annual Business Survey (2011). Employment: BIS analysis of ONS Labour Force Survey micro-data.](image-url)
Construction is one of the main sectors of the UK economy, contributing almost £90 billion in value-added to the UK economy (or 6.7 per cent), with over 280,000 enterprises covering 2.93 million workers or about 10% of total UK employment (ONS, 2021). Civil engineering works, building roads, houses, bridges, house repairs, maintenance, refurbishing, and infrastructure works are all examples of business activity in the construction industry (Hussain et al., 2013; Szymanski, 2008). The UK government, contractors/consultants (architects, quantity surveyors, builders, civil engineers), suppliers, and the local community are the primary players in the construction in the United Kingdom.

Despite the presence of professional and experienced stakeholders and the industry’s beneficial contribution to the UK economy, the UK construction industry faces significant challenges such as project delivery delays, cost overruns, and a shortage of skilled labour (Agapiou et al., 1995).

2.2 Experience and cause of Cost overruns in UK

According to Flyvbjerg et al. (2002), cost overrun is described as ‘cost increase’ Cantarelli et al (2010) term it ‘cost outturn’. Both Flyvbjerg et al. (2002); Cantarelli et al (2010a) define cost overrun as ‘increased amount of money established at the time of completing the project when compared to the estimated amount at the time of the decision to build a project’. According to Aljohani et al. (2017), construction and infrastructure industry has an issue when it comes to cost overrun with a consistently poor history of finishing under budget, is among the most prevalent concerns in construction performance measurement around the world. For example, The British Library, which first opened its doors in 1998, is one of the country’s largest public structures cost £511 million (Harlow and Syal, 1995), which was three times the initial estimate. Politicians and the management team and government agency were to blame for constantly changing project employees and duties (Spring, 1997). There was also criticism to the contractual arrangement, which used a cost-reimbursement model, meant that the consultants and contractors had limited financial incentives to stay within the budget constraints. Other UK examples is the channel Tunnel linking England with France running underneath the English Channel, the project was overrun by 80% increasing from £2.6 billion to £4.65 billion due to change of scope, poor communication, contract framework was based on lowest tender rather than most advantageous and economic tender (Winch, 2013). Similarly, Edinburgh Tram overrun costing £776 million from the initial estimate of £320 million amounting to 58% cost overrun resulting from dispute, multi-level decision, stakeholder pressure, utilities diversion, economic downturn, freezing temperature and lack of political support (Boateng et al., 2014).

The most common causes of cost overrun are frequent design changes during construction, contractors finance, payment delays, lack of contractors experience, poor cost estimation, poor tendering documents, poor materials management (Aljohani et al., 2017) whilst Proverbs et al., (2000); Jackson (2002); Olawale and Sun (2010) concur stating other causative factors include; scope changes, trust issues, a highly fragmented construction supply chain, poor communication, an old-fashioned procurement route, and poor cost estimations. Adjunct to that will have issues around procurement bottleneck due to border closure (Enshassi et al., 2009); security, political, labour disruptions and pandemic (Zafar, 2016); Project location, variations (addition, omission or changes in design, schedule and scope) are all contributing factors to cost overrun (Shane et al., 2009; Olawale and Sun, 2010; Seidu et al., 2021) Other factors identified recently by Zewdu and Aregaw (2015); Durdyev et al., 2017; Franca and Haddad (2018) comprise the impact of information technology is having on project management.

The most current influencing factor that causes cost overrun is the increase in construction cost. According to (RICS, 2021) Building Cost Index rose to 10.2 per cent in September 2021 compared to the same month a year ago. The BCIS Materials Cost Index has contributed the most to this rise, with the overall cost of materials in the index growing by 19.7% during the same period. Steel and timber saw the highest rises between January and September 2021, with significant volatility in every material category. However, the industry is already having difficulty attracting employees with certain talents, and competent subcontractors are in short supply. According to the Office for National Statistics (ONS, 2020), construction employment is expected to fall from 2.3 million in 2017 to 2.1 million by the end of 2020, which was exacerbated by the pandemic. The employment statistics constitute a 4% decrease in UK home workers but a far more considerable 42% decrease among EU workers. In terms
of Brexit, eliminating the right to free movement and implementing a points-based immigration system may result in construction companies no longer hiring EU workers. Experts believe that due to these developments, the cost of labour could rise by as much as 10%. At the same time, they are increased number of highly skilled migrants leaving the UK as the pound weakens, making the UK a less desirable work destination (Portes and Forte, 2017). Any limits on freedom of movement are also expected to impact recruiting (Wright et al., 2014), as firms will struggle to fill resource gaps produced by the limited free movement of workers (Portes and Forte, 2016; Young et al., 2019).

The UK Government VAT reverse charge policy that went into force in March 2021 is putting a significant burden on the cash flow of small and medium enterprises (SMEs) that operate as suppliers making cash flow among the most complex challenges for construction firms, while 1 in 5 construction companies believe cash flow is a persistent issue, with 84 per cent reporting cash flow issues. This policy, combined with growing material costs, will impact SMEs’ bottom lines (UK Construction Media, 2021).

2.3 Cost Control/Management Methods in the Construction Industry

According to Seidu et al., (2021), cost management must be utilised when dealing with project cost control in other to be able to manage all necessary cost associated with the project to ameliorate the effect of cost overruns. Potts (2008) and Potts & Ankrah (2013) suggested an integrated reporting system, a separate schedule and cost control system that focuses on and detect difficult area in the project so that the project team may take the necessary steps to resolve the issues as factors that must be considered while constructing a cost control system and recommend the following cost management options:

- **Cost-Value Reconciliation –CVR)** - This is the type of cost techniques implemented by construction firms; it aims to present a realistic and accurate picture of the company’s financial status at any given time by projecting its profitability, they are dependent on the quantity surveyor’s knowledge and judgment of the data collected (Potts & Ankrah, 2013).

- **Contract Variance** – This form the cost control report, like the cost-value reconciliation, they are applied when there are few high-value elements by civil engineering contractors. It includes a range of works that are separately (autonomously) accounted for and documented with unit costs for each component, such as concrete, steel, ground, and driving piles, may be compared to those in the tender. The distinction is determined by the difference between the cost of the job and the value of the work itself. The cost variance makes it easier for effective decision-making and forecasts the project’s profit and loss.

- **Earned Value Analysis –EVA)** - According to Potts & Ankrah (2013), this approach (earned value management) is the most powerful tool/system/model for cost control because it offers a quick status of the project at any point in time and can forecast future circumstances. As defined by Howes (2000) “it is “an established method for the evaluation and financial analysis of projects throughout their lifecycle.” It entails computing three key values for each activity in the work breakdown structure: The planned value (PV) also known as budgeted cost of work schedule (BCWS); Actual cost (AC) – actual cost of work performs (ACWP), and the earned value (EV) refer to as budgeted cost of work perform (BCWP).

- **Digitisation** - Due to technical improvements, digitalisation has also played a role in changing how cost cutting strategies are implemented. Software programmes can help with financial budgeting, task scheduling, and activity costing, making tasks more accessible and time-efficient (Webb, 2017). According to Jayaraman (2016), fine-grained cost monitoring and control have become practical and straightforward. While monitoring has been simplified, they both agree that the same amount of attention to detail is essential.

- **Contract Standardisation** - The Latham report (1994) allow for better cost reduction through effective cost management considering the current economic context and the government’s infrastructure spending plans. The report outlined several flaws in present methods, emphasising mechanisms for improving construction practices such as bettering worker relationships, fair payment tools, contract standardisation, and lowering disputes. Using standard contract form is more effective at resolving issues that can lead to project delays, disruption of contracting parties' relationships, cost overruns, and other problems. Its clarity and flexibility make it easier to read and understand than any bespoke contract, which still contains interpretive words, unnecessary legal interpretations, clause cross referencing, and confusing
expressions that could be misread and exploited by important unethical stakeholders (Lord, 2008; Forward, 2002).

There are various applications of cost-control measures; however, the table below show the most important elements:

**Table 1: Cost Control / Management Techniques**

<table>
<thead>
<tr>
<th>Cost Control Site Techniques</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Programme</td>
<td>Contractors used schedules to keep track of their progress and financial results. It’s a good method because job progress can be tracked and costed.</td>
</tr>
<tr>
<td>Inspections of Work</td>
<td>Examining the job and comparing it to the budget, since they are often appraised, they are inadequate.</td>
</tr>
<tr>
<td>Perform a preconstruction planning of projects task and resources</td>
<td>To be completed prior to the start of construction.</td>
</tr>
<tr>
<td>Site Meetings</td>
<td>Meetings are held to assess work progress and compare it to budgetary allocations. It is beneficial because it encourages workers and maintains other stakeholders informed about work progress.</td>
</tr>
<tr>
<td>Record Keeping</td>
<td>Documentation of actions performed in order to spot deviations from established norms early.</td>
</tr>
<tr>
<td>Monitoring work and cost performance</td>
<td>Schedules, budgets, inspections, and feedbacks were used by clients, consultants, and contractors to maintain track of cost performance. It generates successful outcomes when the correct control tools are used.</td>
</tr>
<tr>
<td>Evaluation of work carried out</td>
<td>Work quantity estimation and cost comparison in the bill of quantities Inspection was also reported to be used to assess work. This assists in ensuring that the work is progressing as planned.</td>
</tr>
</tbody>
</table>

Lewis (2007) stated that the most successful way to control project costs is for each responsible individual to control their components, accentuating cost reduction’s “human factor”. As a result, the personnel inside the organisation, not the procedures, are the most critical factor in cost reduction. It may be argued that the job definition of a cost consultant used to be confined to providing construction cost estimates (Designingbuildings, 2022). As a result, the method would be reactive rather than proactive, rendering Lewis, (2007) claim reductive.

Research conducted by Olawale & Sun (2010) in UK with 250 construction project organisations which was following with 15 interviews among experienced professionals then proposed remedies to curtail cost overruns into four categories: preventative, anticipatory, remedial, and organisational initiatives (culture). Also, Case Cunningham (2017) conducted a case study into the causes of cost overruns and inadequate financial management in the construction sector also come up with the following recommendations for a Building Construction Project’s Construction Phase details in the table below:
Table 2: Cost control for Building Construction Project’s during Construction Phase.

<table>
<thead>
<tr>
<th></th>
<th>Forecast preparation, comparator period, forecast vs reality, report analysis, action and execution, and budgeting controls are all part of the control circle.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Managing the account’s aspects, such as prime cost sums, provisional sums, provisional quantities, variations, fluctuations, delays and disruption claims, and the contingency amount.</td>
</tr>
<tr>
<td>3</td>
<td>Regulate consultants, promote change awareness, emphasise the need of collaboration, schedule meetings, generate cost reports, track cash flows, apply value management and engineering, and make full use of his knowledge and experience are all responsibilities of the Quantity Surveyor.</td>
</tr>
</tbody>
</table>


All the recommendation are beneficial to the industry, and more are currently being created. However, due to the intricacies of the construction industry, issues such as firms going out of business, budget overruns, and project failures, all of which suggest poor financial management, continue to exist (Varghese & Manacere, 2012; Aljohani et al, 2017). In the construction and infrastructure industry, there is need to involve or deploy new financial management paradigm/model/procedures.

3.0 Methodology

The quantitative approach is used to collect data and study relationships between facts and how such facts and relationships correspond to theories and findings from previous research. In contrast, the qualitative approach is used to gain insights and understand people’s perceptions of “the world,” whether individuals or groups (Fellows and Liu, 2008). The researchers utilise quantitative research questions to frame and sharply focus the study’s objective on quantitative investigations. Quantitative research questions inquire about the correlations between variables that the researcher is curious about within the selected research field. This study will solely incorporate research questions rather than hypotheses to prevent redundancy (Fellows, 2015).

The research data was capture with questionnaire which was available to the clients, consultants, and contractors, which ranks each question using (Likert Scale), ordinal scales and a Likert five-point scale was used to gauge the cost overrun factors in terms of importance and influence and evaluates cost-control solutions. Out of the 50 people who received the questionnaire, 26 responded, resulting in a 52 per cent response rate, which was a satisfactory response on this type of research (Fellow, 2015). The survey was structured around the primary 12 factors that influence cost overruns in construction infrastructure projects and cost management approaches/processes as detailed in table 5. The interviewer’s professional experience was crucial to the record since the questionnaire would provide insight based on the participant’s level of knowledge according to the study methodology. Therefore, Quantity surveyors, estimators, cost engineers and cost adviser/consultants working for the Clients, consultants and contractors in the construction infrastructure industry was proposed as significant participants due to their great deal of cost management experience with mega construction infrastructure projects. Given the research more credibility and authenticity base on respondents many years of experience in their various expertise area. Hence, shaping the research in meeting its dependability and validity requirements.

The questionnaire covered cost overruns influencing factors, cost-cutting methods and methods or systems for cost control. A pilot study was used to evaluate the topics among participants with 2-20 years of experience working in Senior position in mega construction projects to analyse the questions, detect any potential ambiguities, and assess the researchers’ data gathering procedure (Naoum, 2013) with the prototype to improve the readability of the questions which was corrected before the survey
questions was sent out to the participants. The participants have worked with different mega project, 11 respondents experience in mayor construction project, following by 10 respondents in mega infrastructure and the rest 4 respondents worked in mayor residential project while ‘others’ type of mega project had one respondent.

The data from the questionnaire survey was examined using the “Relative Importance Index” (RII) technique (Nesan, 1997). RII was calculated using the formula in table 3: The value of RII ranges from 0 to 1 when calculated using this formula, with 1 representing maximum strength and 0 representing minimum strength. The study’s representative sample was n=26 participants; The research implemented a non-random sample approach known as convenience sampling. The participant is drawn from 42% (11) of consultants, 31% (8) of Contractors, and 27% (7) of Clients completed the questionnaire with various years of experience between them. 46% (12) of respondents have 5 - 10 years of experience in the construction sector, 35% (9) have more than 10 years of experience, and 19% (5) have 1 - 4 years of experience. They have work in different project which include major construction project with 11 respondents follow by infrastructure 10 respondents, thirdly was residential with 4 respondents and ‘other project’ had one respondent, occupying a middle management position in their respective organisation.

Table 3: Showing Relative Important Index formula.

| RII= (1n 1 + 2n 2 + 3n 3 + 4n 4 + 5n 5) / (5xN) | - nx = the number of respondents agreeing with the x choice
| - N is the total number of people who responded. |

Kish (1965) demonstrated that the sample size can be calculated using the equation below with a 94 per cent confidence level (Moore et al., 2003). The study’s representative sample was n=26 participants while the research implemented a non-random sample approach known as convenience sampling.

Table 4: Showing Sample size formula.

<table>
<thead>
<tr>
<th>Sample size formula</th>
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<tbody>
<tr>
<td>n= n'/ [1+ (n'/N)]</td>
</tr>
<tr>
<td>- N is the total number of people in the population</td>
</tr>
<tr>
<td>- n is the number of samples taken from a finite population</td>
</tr>
<tr>
<td>- n’ is the sample size from infinite population = S2/V; where S2 is population element variance and V is sampling population standard error.</td>
</tr>
</tbody>
</table>

4.0 Research Findings and Analysis

The collected data has been analysed based on the result under the following subheading:
4.1 Factors that Influence Cost Overruns in Construction Projects.

The findings from this section of the research give an idea of the relative relevance index and ranking of factors impacting construction project cost overruns. The summary of variables ranking according to all respondents (Client, consultant, and contractors) is shown in Table 6.

**Table 5: Factor influencing cost overruns.**

<table>
<thead>
<tr>
<th>Factors</th>
<th>Overall</th>
<th>Consultant</th>
<th>Client</th>
<th>Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relative index indicator (RII)</td>
<td>Rank</td>
<td>Relative index indicator (RII)</td>
<td>Rank</td>
</tr>
<tr>
<td>Inaccurate or poor estimation of original cost</td>
<td>0.9538462</td>
<td>1</td>
<td>0.945455</td>
<td>1</td>
</tr>
<tr>
<td>Inflation of project cost</td>
<td>0.7769231</td>
<td>6</td>
<td>0.854545</td>
<td>6</td>
</tr>
<tr>
<td>Improper Planning</td>
<td>0.9384615</td>
<td>2</td>
<td>0.909091</td>
<td>3</td>
</tr>
<tr>
<td>Unforeseen site conditions</td>
<td>0.8692308</td>
<td>4</td>
<td>0.872727</td>
<td>5</td>
</tr>
<tr>
<td>Mistake in Design</td>
<td>0.9307692</td>
<td>3</td>
<td>0.927273</td>
<td>2</td>
</tr>
<tr>
<td>Construction Cost Underestimation</td>
<td>0.8538462</td>
<td>5</td>
<td>0.890909</td>
<td>4</td>
</tr>
<tr>
<td>Changes in Clients Brief</td>
<td>0.6076923</td>
<td>8</td>
<td>0.618182</td>
<td>7</td>
</tr>
<tr>
<td>Omissions and Errors in the Bill of Quantity</td>
<td>0.6384615</td>
<td>7</td>
<td>0.654545</td>
<td>6</td>
</tr>
<tr>
<td>Contractual Claims</td>
<td>0.6076923</td>
<td>8</td>
<td>0.654545</td>
<td>6</td>
</tr>
<tr>
<td>Lack of Experience for Contractors</td>
<td>0.5692308</td>
<td>9</td>
<td>0.600000</td>
<td>8</td>
</tr>
<tr>
<td>Force Majeure</td>
<td>0.3923077</td>
<td>11</td>
<td>0.454545</td>
<td>10</td>
</tr>
<tr>
<td>Unsuitable Construction Equipment and Methods</td>
<td>0.4692308</td>
<td>10</td>
<td>0.527273</td>
<td>9</td>
</tr>
</tbody>
</table>

Results from the research indicate that the respondents (contractors, consultants, and clients) have a considerable agreement in ranking aspects resulting from poor estimation, inappropriate planning, design standards, and information. When determining the project budget, it is usual to refer to costs incurred in a similar project. Even though this is a well-established and straightforward method of assessing project costs, it has drawbacks. Each project is unique. As a result, using different costing methodologies for each project is a good idea. Furthermore, the costing method employed should produce precise and reliable results. As a result, inaccurate cost estimates have little bearing on project profitability. There was a slight lack of agreement between contractors and consultants on market conditions (external factors) and project features. Furthermore, the findings show that the top ten factors affecting the accuracy of cost estimates are clear. Not every team member receives proper costing training, many firms have a costing and estimating department during the bid phase of the project. In addition, the project team fulfils this duty at the expense of regular project operations. As a result, project costs may be overestimated if unskilled or inexperienced people do cost estimates. Nevertheless, not everyone has the knowledge and experience required to decipher a lengthy contract’s refined vernacular. As a result, the costing team should be aware of the implications of their errors and omission. Reduced design complexity, fewer design modifications, and having the design as complete as possible at the pre-contract stage were all ways to contain budget, because design flaws have been recognised as one of the leading causes of cost overruns, effective design management is essential for cost control. If the design is complicated, little can be done after the contract is signed. Hence, cost consultants must be involved throughout the development phase to make cost recommendations.
4.2 Frequency of Cost overruns.

<table>
<thead>
<tr>
<th>General Issues on cost monitoring and control on site</th>
<th>Always</th>
<th>%</th>
<th>Generally</th>
<th>%</th>
<th>Usually</th>
<th>%</th>
<th>Occasionally</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>How often do you experience overruns on costs from individual cost codes or centres?</td>
<td>10</td>
<td>38%</td>
<td>6</td>
<td>23%</td>
<td>6</td>
<td>23%</td>
<td>4</td>
<td>15%</td>
</tr>
<tr>
<td>How often do you experience overruns on cost of overall project?</td>
<td>0</td>
<td>0%</td>
<td>14</td>
<td>54%</td>
<td>6</td>
<td>23%</td>
<td>6</td>
<td>23%</td>
</tr>
<tr>
<td>How often are overruns on costs and schedules directly related?</td>
<td>5</td>
<td>19%</td>
<td>12</td>
<td>46%</td>
<td>5</td>
<td>19%</td>
<td>4</td>
<td>15%</td>
</tr>
<tr>
<td>How frequently is format coordination accomplished between the project plan, budget, and performance data?</td>
<td>6</td>
<td>23%</td>
<td>10</td>
<td>38%</td>
<td>6</td>
<td>23%</td>
<td>4</td>
<td>15%</td>
</tr>
<tr>
<td>How frequently are corrective actions for cost and schedule errors based on time cost and production quantity performance predictions?</td>
<td>2</td>
<td>8%</td>
<td>4</td>
<td>15%</td>
<td>7</td>
<td>27%</td>
<td>13</td>
<td>50%</td>
</tr>
</tbody>
</table>

The construction industry’s experience with the problem of cost overruns, as well as its evaluation of its causes and corrective factors, was deemed necessary for a proper evaluation of the theoretical model for and issues relating to cost monitoring and control presented in the review, as well as for proposing another approach to effective cost monitoring and control on sites. As a result, respondents were polled about the frequency of cost overruns at various levels of the project cost structure and their opinions on a variety of cost overrun causes. Cost overruns on cost codes were seen by 38 per cent of participants regularly, while cost overruns, in general, were experienced by 23 per cent. In other words, cost overruns on specified cost codes occurred in at least 100% of all cases. In addition, a comparable percentage (54%) of respondents reported budget overruns in their projects as detail in above table 6.

4.3 Categorising the most effective Cost control techniques.

Budgeting was regarded as the most efficient cost control strategy, based on the overall results from table 6a and 6b. Rank 1 had an RII of 0.938, cost forecasting was second with an RII of 0.876, cost reporting was third with an RII of 0.792, and cashflow monitoring was fourth with an RII of 0.753. If managed, Budgeting may assist in cost management by ensuring that costs do not exceed the budget (Kirkham, 2015). It is appropriate to carry corrective action when cost overruns are recognised early (Ashworth and Perera, 2015). Cost forecasting must be the most efficient tool for successfully controlled costs. It allows for the initial discovery of budget overruns and the implementation of measures to limit them. Another reason for their widespread use is that they are simple and easy to deploy. Professionals will have experience with them before and understand what they involve. The technique’s inexpensive implementation costs will enable them to deploy on any project since it is cost-efficient.
Table 7a: Classifying Effective Cost Control Techniques

<table>
<thead>
<tr>
<th>Effective Cost Control Technique</th>
<th>Overall</th>
<th>Consulting</th>
<th>Contractor</th>
<th>Client</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relative index indicator (RII)</td>
<td>Rank</td>
<td>Relative index indicator (RII)</td>
<td>Rank</td>
</tr>
<tr>
<td>Earned Value</td>
<td>0.576923</td>
<td>8</td>
<td>0.654545</td>
<td>9</td>
</tr>
<tr>
<td>Value Engineering</td>
<td>0.638462</td>
<td>7</td>
<td>0.690909</td>
<td>8</td>
</tr>
<tr>
<td>Monitoring labour, material, equipment</td>
<td>0.669231</td>
<td>5</td>
<td>0.618182</td>
<td>10</td>
</tr>
<tr>
<td>Cashflow monitoring</td>
<td>0.753846</td>
<td>4</td>
<td>0.763636</td>
<td>4</td>
</tr>
<tr>
<td>Cost forecasting</td>
<td>0.876923</td>
<td>2</td>
<td>0.818182</td>
<td>2</td>
</tr>
<tr>
<td>Budgeting</td>
<td>0.938462</td>
<td>1</td>
<td>0.927273</td>
<td>1</td>
</tr>
<tr>
<td>Cost Reporting</td>
<td>0.792308</td>
<td>3</td>
<td>0.727273</td>
<td>6</td>
</tr>
<tr>
<td>Variation/change management</td>
<td>0.653846</td>
<td>6</td>
<td>0.781818</td>
<td>3</td>
</tr>
<tr>
<td>Interim valuation and certificates for payment</td>
<td>0.538462</td>
<td>10</td>
<td>0.709091</td>
<td>7</td>
</tr>
<tr>
<td>Post project reviews and site meetings</td>
<td>0.569231</td>
<td>9</td>
<td>0.745455</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 7b: Most effective cost control techniques.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Technique</th>
<th>RII Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Budgeting</td>
<td>0.938</td>
</tr>
<tr>
<td>2</td>
<td>Cost Forecasting</td>
<td>0.876</td>
</tr>
<tr>
<td>3</td>
<td>Cost Reporting</td>
<td>0.792</td>
</tr>
<tr>
<td>4</td>
<td>Cashflow Monitoring</td>
<td>0.753</td>
</tr>
</tbody>
</table>

Earned value is ranked eighth with an RII of 0.576, labour, material, and equipment monitoring are rank fifth with an RII of 0.669, interim valuation and payment are rank tenth with an RII of 0.538, and value engineering is ranked seventh with an RII of 0.638, see table 7a. Because earned value is uncommon method, some participants may never have used it, appearing ineffective. According to Webb (2017), this method is more complex and needs specialised computer software, making it more expensive and limited to major schemes. Monitoring labour, elements, equipment, and overheads are the least effective way (costs). Potts (2013) highlights that simply monitoring costs is unproductive, there is little to what the cost consultants can do once the expenses has been incur, demonstrating a lack of control. Figure 2 depicts the application of cost-cutting strategies across many disciplines. With an RII of 0.927,0.763, cost forecasting and budgeting is rank first in consulting, followed by variation/change management. The least rated factors include interim assessment and certificates for disbursement (0.538 RII), post-project evaluations and site meetings (0.569), and Earned value (0.569) as shown below.
Figure 2: Cost cutting strategies across many disciplines.

The lowest scores are for interim valuations and payment certification (0.538 RII), post-project review, and site visits (0.569 RII). With an RII of 0.550, Earned value ranks among the lowest in all categories except the client. Although contractors are the most likely to use earned value (PMI, 2005), other industries are less likely to have done so and may be unaware of its value. Earned value is not a 'one size fits all' and may not apply to every project type but to those with specified characteristics (Webb, 2017). All projects received a low grade for interim valuations and payment certifications, indicating that they are ineffective at budgetary control.

5.0 Discussion

Construction and Infrastructure project cost overruns are inevitable, and efficient cost containment measures should be employed. Design management, comprehensive and detailed cost estimation, client engagement, and automation may all contribute to and eliminate several of the specific challenges that have resulted in increased expenses. However, more precise time and cost forecasts and increased cooperation among parties are required for reducing cost overruns. The project will remain within the initial cost allocation if budgetary control is effective and implemented by the project team.

Cost forecasting can indeed be significant since it offers an advanced warning of expenditure, permitting the identification of cost escalation and the application of controls to minimise them. A further practical and straightforward approach for maintaining project budget allocation in line with the original budget is variation, otherwise known as change management. The numerous factors revealed in this study will decide the use of various cost cutting strategies (project, size, and time). As a result, the nature and scope of the project, the funds accessible, and the programs’ timeline determine the optimal cost-cutting approach. Budget control and expenditure forecasting are highly excellent resources that should be used continuously. On the other hand, EVA can only be employed on some projects and is not cost-efficient on smaller monetary value initiatives. Therefore, they are ineffective on most projects. Moreover, each construction project is unique; an institution’s budgetary control techniques must be adaptable and responsive to the project’s demands. Information can be obtained, kept, and evaluated more quickly and efficiently, and technological advancements have enabled cost containment to be manageable. Overall, this research project should indeed be considered as an enhancement of creating strategies for variables driving the adoption of efficient construction cost containment techniques in the UK, building on the research publications covering different area of project complexity like: time overrun (Chan and Kumaraswamy, 1997), cost overrun and risk management (Jackson, 2002), time and cost control (Olawale and Sun, 2010), cost overrun causation factors (Memon et al., 2011), causes of cost
overrun (Park and Papadopoulou, 2012), root cause of cost overrun (Rosenfeld, 2013), behavioural biases (Flyvbjerg et al., 2021), economic risk (Boateng et al., 2014), cost escalation (Winch, 2013), cost overrun (Cantarelli et al., 2010) with none of the research focusing on the middle management perspective. The divergent in causative factor is due to different data mining used by previous researcher whilst this research explored the perspective of cost management expert with construction infrastructure experience and cost strategies is based on organisational level of exposure.

6.0 Conclusion

Cost overruns has become a common phenomenon that have eaten the backbone of the industry, despite all the research in this area, it is still occurring without knowing when it will become history. Hence, the industry major players need a new dimension in resolving this incessant problem. Contractor will need to have an established supply chain in place and monitored all procurement strategy by ensuring construction materials are available in advance, monitoring quality of workmanship, materials and labour are readily available when required. Planning and scheduling must be an ongoing process and coordinated with the resources within the stipulated time. The use of lowest tender is not beneficiary instead the most economically advantageous tender should be use while payment to contractor is important to maintain adequate cashflow. Design changes should be control with innovative technology for complex design right from precontract stage with detail information made available and experience personnel who have perform similar roles should always be at the forefront of complex project, who can foresee any inherent risk on and applied the necessary contingency to cushion the effect and avoid possibility of cost overruns.

7.0 References


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Barriers Facing Retrofitting of Existing Building in Developing Countries: A Review of Literature

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ABSTRACT AND KEYWORDS

Purpose
The retrofitting of existing buildings has gained recent recognition in the built environment as an acceptable alternative to the construction of new buildings. New retrofitting technologies have become a means of achieving sustainability through efficient and effective practices in the construction industry. Therefore, this paper seeks to identify the barriers facing retrofitting buildings in the construction industry of developing countries.

Findings
The study found that various barriers to building retrofitting include a lack of technical expertise, a lack of capital investment, a lack of awareness, a lack of operation and maintenance support, limited financial support such as subsidies, low-interest rates as well as tax reductions, and a long payback period.

Design/Methodology/Approach
This study utilized a systematic examination of literature to identify the barriers to building retrofitting in developing countries. A literature search was conducted using the Scopus search engine.

Originality/Value
This study has contributed to the field of building retrofitting by identifying the barriers facing the practices of building retrofitting in developing countries. The finding of this study will facilitate the professionals and house owners to understand the barriers facing building retrofitting in their regions.

Implication
The paper provides significant findings from an economic, energy, and environmental point of view. To address the barriers to building retrofitting in the construction industry, it should inspire professionals to consider the barriers to retrofitting when designing the project to avoid delays.

Keywords: Retrofitting, Existing building, Sustainability, Developing countries, Barrier
1. INTRODUCTION

The building sector is the most prominent consumer and emitter of the world's primary energy and greenhouses gas emissions (World Green Building Council, 2020), which makes the buildings account for 40% and 39% of total global energy use and carbon emissions, respectively (World Green Building Council, 2020). As a result, high energy consumption and Co2 emission have negatively affected the environment, such as ozone layer depletion, environmental degradation, global warming, and climate change (Mewomo & Ejidike, 2021). This condition is worse in developing countries (Liu et al., 2020; Shirazi & Ashuri, 2020).

Improving energy efficiency and resources is vital in solving this problem, and the building sectors play a pivotal role in such efforts (Liu et al., 2020). Improving the energy efficiency of existing buildings is vital in achieving sustainable development in the built environment because new building construction contributes a small fraction of the building stock per year (Ashuri & Durnus-Pedini, 2010; Golubchikov & Deda, 2012; Zhou et al., 2016). Since then, existing buildings have utilized more resources due to poor energy performance and thermal comfort (Bednar & Reames, 2020; Golubchikov & Deda, 2012; Liu et al., 2020). Energy consumption is predicted to rise in existing buildings as urbanization, and living standards rise in developing countries like Nigeria, China, Ghana, and South Africa (Liang et al., 2015; Reischl et al., 2019). Therefore, retrofitting existing building stock is essential in achieving energy efficiency, thermal comfort and Co2 emission reduction in the built environment (Jafari & Valentin, 2018).

According to Decuypere et al. (2022), retrofitting is any action that modifies the physical fabric or its energy services with the specific objective of enhancing efficiency, reducing energy demand, or reducing associated CO2 emissions, therefore, upgrading or replacing the building element such as heating system, windows, and insulation. D'Angelo et al. (2022) further emphasized that building retrofitting provides significant opportunities to reduce the global energy and carbon emission in the construction sector. As a result, the primary goal of building retrofitting is to reduce the energy demand, operating cost, and carbon emissions, and provide suitable thermal comfort (Bravo et al., 2019; Gholami et al., 2014; Ma et al., 2012). Despite all the benefits of building retrofitting globally, the acceptance, practices and awareness of retrofitting existing buildings are still low in developing countries (Liu et al., 2020; Oguntona et al., 2019; Okorafor, 2019). Therefore, it is against this backdrop of building retrofitting practices that this review aims to identify the barriers facing the practice of building retrofitting in developing countries. By identifying and assessing the barriers, the review aims to enlighten and encourage professionals and house owners in the built environment on the need to incorporate building retrofitting measures in the construction process to achieve a sustainable built environment.

3. METHODOLOGY

A comprehensive literature evaluation on scientific research is the foundation for growing knowledge of a research field (Ejidike & Mewomo, 2023). Therefore, it facilitates the development of valuable theories for industrial and academic practices (Ghansah et al., 2020). This study is based mainly on a literature review of relevant articles on barriers to building retrofitting practices. A systematic literature search was conducted to retrieve relevant articles with the help of Elsevier’s Scopus search engine. The Scopus engine has similarly been utilized by (Darko & Chan, 2017; Ghansah et al., 2020; Osei-Kyedi & Chan, 2015) because of its recovering precision and accuracy in search performance. The search engine utilized Boolean keywords such as "barrier" OR "building" OR "retrofitting". The search in Scopus identifies 255 total articles as initial (26 March 2022).

The initial result was limited to the English language, subject area: engineering, environmental science, paper type: conference paper, and journal article, which was performed simultaneously which resulted to 168 articles. Content analysis was performed on the retrieved paper to have the final paper for review such as through topical analysis of the article then followed by abstract and the finding of the paper selected, similarly utilized by (Reeve et al., 2015). See figure1. The study used a systematic review technique and content analysis. Finally, barrier frequency was used to choose the most commonly reported barriers. Similarly utilized by (Darko & Chan, 2017; Ghansah et al., 2020) to perform a systematic literature review.
4. IDENTIFICATION OF BARRIERS TO BUILDING RETROFITTING.

A review of relevant literature was considered concerning the barriers to building retrofitting to determine barriers facing building retrofitting practices in developing countries. For instance, Liu et al. (2020) identify eleven barriers to building retrofitting in China, including a lack of capital investment, limited financial support such as subsidies, low-interest rates and tax reductions, a lack of continuity, flexibility, and consistency in retrofit policies, a lack of professional knowledge and skills, and a lack of novel technologies. Oguntona et al. (2019) revealed that lack of technical expertise, municipal support, poor quality installation, lack of incentive for investors, and the misconception of retrofitting technologies are the barriers in South Africa. Decuypere et al. (2022) identify a lack of knowledge and information, financial barriers, and lack of transparency among experts. According to Fasna & Gunatilake (2020), system failures in building retrofitting in Sri Lanka caused 36 barriers, including non-performance of post-occupancy assessments, delays in receiving ordered equipment, and stakeholder negligence. A total of 30 key barriers were found through a study of the 50 articles; however, only barriers identified in at least two studies are included in Table 1 for further discussion. Table 1 shows various barriers to the practice of building retrofitting, each of which has a matching reference. Only the top three (3) barriers are discussed in this study due to space and word constraints.

From the literature, other barriers facing building retrofitting were identified, which include a lack of operation and maintenance support, limited financial support such as subsidies, low-interest rates and tax reduction, long payback period, lack of comparative product information, high upfront capital costs, conflict of interest among professionals, the uncertainty of return on investment among others.

4.2 Discussion of some of the barriers.

The lack of technical expertise: Technical expertise appears the most in the barriers to building retrofitting, which could be attributed to the knowledge and experience of the professional in the field of retrofitting. Fasna & Gunatilake (2020) pointed out that it requires in-depth knowledge of the building’s current status and monitoring, which is vital in decision-making on the program’s planning. Liu et al.
(2020) emphasized that the lack of education and workshop training of the professionals on retrofitting has resulted in a shortage of professionals in building retrofitting.

**Lack of capital investment:** Capital is the backbone of small, medium, and more significant investments. Therefore, capital is crucial for building retrofitting activities (Liu et al., 2020). Further, explain that insufficient capital impedes the practice of building retrofitting. (Bobrova et al., 2022) Considering capital cost as the significant barrier to building retrofitting, the professionals and house owners must find a compromise between the retrofitting ambition and the price required.

**Lack of awareness:** The lack of awareness of retrofitting could be attributed to professionals and house owners lack of interest in building retrofitting. Liu et al. (2020) pointed out that many professionals lack awareness about energy efficiency programmers, limiting knowledge and information about building retrofitting. Furthermore, Alam et al. (2019) revealed that building owners and professionals have little knowledge about the consequences of their actions on energy and emission.

and below the table.

Table 1. Barriers to building retrofitting.

<table>
<thead>
<tr>
<th>Code</th>
<th>BARRIERS</th>
<th>REFERENCES</th>
<th>Times</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRB1</td>
<td>lack of technical expertise</td>
<td>(Bertone et al., 2018; Caputo &amp; Pasetti, 2015; D'Angelo et al., 2022; Decuyper et al., 2022; Fasna &amp; Gunatilake, 2020; Friedman et al., 2018; Gajić et al., 2021; Hrovat &amp; Zorić, 2018; Jensen &amp; Maslesa, 2015; Lasarte et al., 2021; Oguntona et al., 2019; Yau et al., 2021; Zuhaib et al., 2017)</td>
<td>13</td>
</tr>
<tr>
<td>BRB2</td>
<td>Lack of capital investment</td>
<td>(Bertone et al., 2018; Fasna &amp; Gunatilake, 2020; Friedman et al., 2018; Hrovat &amp; Zorić, 2018; Jensen &amp; Maslesa, 2015; Lai et al., 2022; Lasarte et al., 2021; Liu et al., 2020; Rodger et al., 2020; Yau et al., 2021; Yu et al., 2021; Zuhaib et al., 2017)</td>
<td>12</td>
</tr>
<tr>
<td>BRB3</td>
<td>Lack of awareness</td>
<td>(Bertone et al., 2018; Decuyper et al., 2022; Fasna &amp; Gunatilake, 2020; Friedman et al., 2018; García-Fuentes et al., 2019; Hrovat &amp; Zorić, 2018; Jensen &amp; Maslesa, 2015; Lai et al., 2022; Liu et al., 2020; Peel et al., 2020; Yau et al., 2021; Zuhaib et al., 2017)</td>
<td>12</td>
</tr>
<tr>
<td>BRB4</td>
<td>lack of operation and maintenance support</td>
<td>(Bertone et al., 2018; Caputo &amp; Pasetti, 2015; D'Angelo et al., 2022; Decuyper et al., 2022; Fasna &amp; Gunatilake, 2020; Friedman et al., 2018; Hrovat &amp; Zorić, 2018; Konstantinou et al., 2020; Nageli et al., 2019; Yau et al., 2021; Zuhaib et al., 2017)</td>
<td>11</td>
</tr>
<tr>
<td>BRB5</td>
<td>limited financial support such as subsidies, low-interest rates and tax reduction long payback period</td>
<td>(Bertone et al., 2018; Caceres, 2018; Friedman et al., 2018; Hrovat &amp; Zorić, 2018; Jensen &amp; Maslesa, 2015; Liu et al., 2020; Peel et al., 2020; Rodger et al., 2020; Yang et al., 2019)</td>
<td>9</td>
</tr>
<tr>
<td>BRB6</td>
<td>lack of operation and maintenance support</td>
<td>(Bertone et al., 2018; Bond, 2011; D'Angelo et al., 2022; Decuyper et al., 2022; Friedman et al., 2018; Lai et al., 2022; Liu et al., 2020; Yang et al., 2019; Zhou et al., 2016)</td>
<td>9</td>
</tr>
<tr>
<td>BRB7</td>
<td>Lack of comparative product information</td>
<td>(Bertone et al., 2018; D'Angelo et al., 2022; Decuyper et al., 2022; Fasna &amp; Gunatilake, 2020; Friedman et al., 2018; Gajić et al., 2021; Lambrechts et al., 2021; Lasarte et al., 2021; Zuhaib et al., 2017)</td>
<td>9</td>
</tr>
<tr>
<td>BRB8</td>
<td>High upfront capital costs</td>
<td>(Bertone et al., 2018; Bond, 2011; D'Angelo et al., 2022; Fasna &amp; Gunatilake, 2020; Hrovat &amp; Zorić, 2018; Lai et al., 2022; Liu et al., 2020; Oguntona et al., 2019; Zuhaib et al., 2017)</td>
<td>9</td>
</tr>
<tr>
<td>BRB9</td>
<td>Conflict of interest among professionals</td>
<td>(Bertone et al., 2018; Bobrova et al., 2022; Caceres, 2018; D'Angelo et al., 2022; Hrovat &amp; Zorić, 2018; Rodger et al., 2020; Yau et al., 2021; Zuhaib et al., 2017)</td>
<td>8</td>
</tr>
<tr>
<td>BRB10</td>
<td>Uncertainty of return on investment</td>
<td>(Bertone et al., 2018; D'Angelo et al., 2022; Fasna &amp; Gunatilake, 2020; Lai et al., 2022; Lambrechts et al., 2021; Liu et al., 2020; Nageli et al., 2019; Oguntona et al., 2019)</td>
<td>8</td>
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<tr>
<td>BRB11</td>
<td>Limited availability of recyclable products</td>
<td>(Bertone et al., 2018; Friedman et al., 2018; Hrovat &amp; Zorić, 2018; Yang et al., 2019; Zuhaib et al., 2017)</td>
<td>8</td>
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<tr>
<td>BRB12</td>
<td>lack of novel technologies</td>
<td>(Bertone et al., 2018; Bobrova et al., 2022; D'Angelo et al., 2022; García-Fuentes et al., 2019; Lasarte et al., 2021; Liu et al., 2020; Zuhaib et al., 2017)</td>
<td>7</td>
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<tr>
<td>BRB13</td>
<td>Lack of coordination mechanism</td>
<td>(Caputo &amp; Pasetti, 2015; D’Angelo et al., 2022; Fasna &amp; Gunatilake, 2020; Liu et al., 2020; Yau et al., 2021; Yu et al., 2021)</td>
<td>6</td>
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<td>Code</td>
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<tr>
<td>BRB 14</td>
<td>No overview of potential and priority</td>
<td>(Bertone et al., 2018; Caceres, 2018; Caputo &amp; Pasetti, 2017; D'Angelo et al., 2022; Garcia-Fuentes et al., 2019; Jensen &amp; Maslesa, 2015)</td>
<td>6</td>
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<tr>
<td>BRB 15</td>
<td>Poor project management practices</td>
<td>(Fasna &amp; Gunatilake, 2020; Garcia-Fuentes et al., 2019; Jensen &amp; Maslesa, 2015)</td>
<td>5</td>
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<tr>
<td>BRB 16</td>
<td>Interruptions in operations</td>
<td>(Liang et al., 2015; Passoni et al., 2021)</td>
<td>4</td>
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<tr>
<td>BRB 17</td>
<td>Lack of a stable and long-term building retrofitting program,</td>
<td>(Bertone et al., 2018; Bobrova et al., 2022; Caputo &amp; Pasetti, 2015; Friedman et al., 2018)</td>
<td>4</td>
</tr>
<tr>
<td>BRB 18</td>
<td>Lack of promotion Building retrofitting platforms and activities</td>
<td>(D’Angelo et al., 2022; Fasna &amp; Gunatilake, 2020; Liang et al., 2015; Liu et al., 2020)</td>
<td>4</td>
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<tr>
<td>BRB 19</td>
<td>Complex government procurement Process</td>
<td>(Bertone et al., 2018; D’Angelo et al., 2022; Lambrechts et al., 2021; Yu et al., 2021)</td>
<td>4</td>
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<tr>
<td>BRB 20</td>
<td>Lack of life cycle cost perspective</td>
<td>(D’Angelo et al., 2022; Friedman et al., 2018; Jensen &amp; Maslesa, 2015)</td>
<td>3</td>
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<tr>
<td>BRB 21</td>
<td>Partisan government policy</td>
<td>(Bertone et al., 2018; Caputo &amp; Pasetti, 2017)</td>
<td>3</td>
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<tr>
<td>BRB 22</td>
<td>No desire or support from the client to record data and monitor</td>
<td>(Bertone et al., 2018; Caceres, 2018; Zuhaib et al., 2017)</td>
<td>3</td>
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<tr>
<td>BRB 23</td>
<td>Difficult to evaluate and quantify the benefits of retrofitting uncertainty in measurement and verification</td>
<td>(D’Angelo et al., 2022; Fasna &amp; Gunatilake, 2020; Zuhaib et al., 2017)</td>
<td>3</td>
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<tr>
<td>BRB 24</td>
<td>Negative perceptions regarding the project</td>
<td>(Caputo &amp; Pasetti, 2015; D’Angelo et al., 2022; Fasna &amp; Gunatilake, 2020)</td>
<td>3</td>
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<tr>
<td>BRB 25</td>
<td>Few studies on the health impact of retrofits Interceptions to building operations and management</td>
<td>(Fasna &amp; Gunatilake, 2020; Liang et al., 2015)</td>
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<tr>
<td>BRB 26</td>
<td>Lack of staff training</td>
<td>(Caceres, 2018; Caputo &amp; Pasetti, 2015; Fasna &amp; Gunatilake, 2020)</td>
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<td>BRB 27</td>
<td>Lack of motivation</td>
<td>(Lambrechts et al., 2021; Zuhaib et al., 2017)</td>
<td>2</td>
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<tr>
<td>BRB 28</td>
<td>Few studies on the health impact of retrofits Interceptions to building operations and management</td>
<td>(Fasna &amp; Gunatilake, 2020; Liang et al., 2015)</td>
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<tr>
<td>BRB 29</td>
<td>Lack of motivation</td>
<td>(Alam et al., 2019; Fasna &amp; Gunatilake, 2020)</td>
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<tr>
<td>BRB 30</td>
<td>Lack of consistency and coordination in the policy framework</td>
<td>(Caputo &amp; Pasetti, 2017; Liu et al., 2020)</td>
<td>2</td>
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</tbody>
</table>

4. 5. CONCLUSION AND RECOMMENDATION.

This study focused on the barriers facing the practice of building retrofitting in developing countries. The study utilized the Scopus search engine to retrieve relevant literature for the systematic review. However, there are various barriers to the practices of building retrofitting, especially in developing countries. Therefore, this study identifies lack of technical expertise, lack of capital investment, lack of awareness, lack of operation and maintenance support, and limited financial support such as subsidies, low-interest rates and tax reductions as the top barriers facing building practices retrofitting. The study
provides some valuable insight for professionals and house owners on the barriers that might be encountered in undertaking practices of building retrofitting. Therefore, the study contributed to the knowledge on barriers to building retrofitting practices in developing countries. The finding of this study would assist professionals in understanding the barriers to building retrofitting. Therefore, this study recommends more enlightenment and education for professionals and motivation like subsidies, low-interest rates, and tax reduction to encourage professionals and house owners to engage in building retrofitting.

4. 6. REFERENCES


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Supply chain management practices and factors affecting project quality in Zambia

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ABSTRACT AND KEYWORDS

Purpose of this paper
The purpose of this study was to assess the supply chain management practices used in the Zambian construction industry and identify factors which affect project quality in the supply chain practices.

Design/methodology/approach
The study used a quantitative research approach with a survey questionnaire administered to contractors and consultants in the construction industry. Convenience sampling was used because the study was exploratory in nature and to avoid the difficulties associated with probability sampling methods. The data was first subjected to exploratory factor analysis to assess the dimensionality of the study scales. Reliability and validity were assessed using Cronbach’s alpha, item-total correlations, composite reliability, and average variance extracted. The relative importance index was then used to rank the predominant supply chain management practices and the factors which affect project quality.

Findings
The results show that the supply chain management practices factors into two broad categories relating to the internal practices of the contractors and to external supply chain management practices in relation to suppliers. Practices which affect project quality factored into contractor factors and project management supply chain related factors. Contractor supply chain factors ranked higher that project management related factors.

Research limitations/implications
The results are limited by the small sample size (55) and the exploratory nature of the study which relied on scales which are not widely validated. As a result, some of the reliability and validity statistics for some scales fell below the acceptable threshold. Therefore, the results should be interpreted with caution.

Keywords: Supply chain management, project quality, Zambian construction industry.
1. Introduction

Studies in relation to construction supply chain management (SCM) have identified numerous advantages that could benefit the quality of construction projects in the industry. SCM promotes better utilization of resources throughout the supply chain (Gadde and Dubois, 2010) which could lead to an efficient inventory (Hatmoko and Scott, 2010), improved productivity, well-organized procurement and purchasing processes, fulfillment of order and increased flexibility (Mukund, 2016). Furthermore, it also promotes a better coordination (Ahmed et al., 2002) as well as eliminating unpleasant behaviours (Briscoe et al., 2004) thus building trust and improved commitment towards the whole team (Al- werikat, 2017). In addition, SCM encourages information and knowledge sharing across the supply chain leading to improved information flow (Ahmed et al., 2002; Aloini et al., 2012), timely and accurate information dissemination and also facilitates proper decision making (Mukund, 2016). Other aspects of SCM such as long-term collaborations also lead to innovative ideas and innovative efforts (Skitmore, Ki and Cheung, 2011) as the accumulated set of skills, knowledge and experience of the partners could be utilized effectively. This will eventually lead to continuous improved quality and delivery time on construction projects.

Building a unified team with clients, designers, main contractors and subcontractors could better deliver value to the client (Cristina et al., 2017). Such an approach of establishing qualified partnering with main contractors and subcontractors through the supply network can significantly improve quality (Ghodke and Amber, 2019; Durdyev and Ismail, 2019). Lin and Gibson (2011) concluded that the quality-based paradigm has shifted from the traditional company-centred to involvement into supply chain systems. Some studies now define this integration between quality management and supply chain management as supply chain quality management (SCQM) (Serpell and Heredia, 2004).

The construction industry has been adjudged by different scholars to have been slow in the adoption of SCM principles which has proven to have worked perfectly in the manufacturing and service sectors (Akintoye, 2000; Saad, 2002). Even though the Egan’s report stated that SCM principles could prove to be rewarding in the construction industry by way of improving quality and efficiency if properly deployed, there still hasn’t been any deployment or application of the concept so far (Amade et al., 2016). However, past SCM initiatives in construction have had limited coverage, with studies restricted to split issues such as the contractor/supplier interface (Vrijhoef and Koskela, 2000), environmental performance, design management (Agapiou et al., 1998), service quality (Kaynak and Hartley, 2008) and purchasing behaviour (Gadde and Dubois, 2010). Furthermore, despite many researchers concluding clients mostly benefit from SCM (Brien et al., 2002), most research initiatives focus on the contractor’s supply chain, not particularly on SCM (Vrijhoef and Koskela, 2000).

Owing to the slow adoption of SCM principles by the construction industry, there is a dearth of studies which assess SCM practices and their contribution to project quality. Therefore, the current study assessed the SCM practices used in the Zambian construction industry and identified factors which affect project quality in the supply chain practices. As assessment of practices used in the construction industry and their effect on project quality could inform the project team of measures required to improve project quality through SCM.

This paper is structure as follows. The following section discusses various SCM concepts and principles. This is followed by the methods sections which explains the research design and approach followed. The results are then presented and discussed after which the conclusion is presented.

2. Supply chain management concepts and principles

2.1 Supply chains and supply chain management

While Swaminathan et al. (1996) defined supply chain as a network of autonomous or semi-autonomous business entities collectively responsible for procurement, manufacturing, and distribution activities associated with one or more families of related products. Similarly, Lee and Billington (1995) defined supply chain as a network of facilities that procure raw materials, transform them into intermediate goods and then final products, and deliver the products to customers through a distribution system. Additionally, Das et al. (2007) defined supply chain (SC) as a network of facilities and distribution options that functions to procure materials, transform these materials into intermediate and finished products, and distribute these finished products to customers. Nowadays, in a context of increasing
customer demand, business expansion and fierce competition, more and more companies are realizing the importance of managing their supply chain (Zeng and Tang, 2018).

Supply chain management (SCM) is the planning, execution and coordination of the moving of goods and services from the point of origin to where they are to be further processed into finished goods or consumption (Aloini et al., 2012). SCM is a philosophy that describes how organizations should manage their supply chains to achieve strategic advantages (Eid, 2017). Its goal is to synchronize the client requirements with the materials and information flows along the supply chain, until reaching a balance between the client satisfaction and the cost (Lee and Billington, 1995; Al-werikat, 2017). It refers then to the coordination of the activities of all that participate in the supply chain, to knowing the production requirements with the purpose of satisfying the client, to delivering of products of higher value and to reducing the costs of the organization that apply these principles (Papadopoulos et al., 2016).

In the construction industry, construction supply chain (CSC) is all the construction process, from the demands by the client, conceptual design, construction and maintenance and organizations, which are involved in the construction process, such as owner, designer, general contractors, subcontractors, suppliers, consultants, etc (Aloini et al., 2012; Amade et al., 2016; Studer et al, 2021). CSC is not a chain of construction business with business to business relationships but a network of multiple organizations and relationships, which includes the flow of information, the flow of material services or products, and the flow of funds between client, designer, contractor and supplier (Xue et al., 2005). The construction supply chain is related to the knowledge of engineering, logistics, management science and other aspects of knowledge. Therefore, it needs the collaboration of suppliers, owners, designers, contractors, subcontractors and other participants hence management in construction supply chain becomes more complicated.

2.2 Managing supply chains on construction projects

Supply chain involves the cost to convey the information, produce components, store them, transport them, and transfer funds and so on. The total cost of supply chain tends to increase due to many parameters like huge capital cost required for running global businesses, mounting real estate costs and freight charges (Harland, 1996). However, the perfect planning in SCM regarding material arrival, production schedule and distribution not only reduces the inventory and inventory cost but also reduces the wasted time and energy (Amade et al., 2016; Al-werikat, 2017). Supply chain management drastically alters inventory investment across a range of industries, and helps to tackle economic fluctuations (Gadde and Dubois, 2010).

The construction supply chain system based on general contractor is a chain system that intends to meet the demand of clients, integrate the material, information and capital flow under the assistance of information management, and make an integrated management between clients, suppliers, subcontractor or other participants (Taylor et al., 2015). SCM is suggested as a promising means for improving construction performance: the main idea being that supply chain processes should be integrated in order to provide better customer value (Yeo and Ning, 2002; Bankvall and Dubois, 2010; Eriksson, 2016). Construction supply chain management throughout the whole process of project is to achieve win-win relationships with relevant participants (Manu, 2014). At the initiative stage of the project, the clients may appoint a professional project management company to supervise the project. They can also directly select the general contractor to responsible for the design, bidding, and construction of the project. At the implementation stage, the general contractor responsible for the procurement of materials and the monitoring of project, as to the implementation of specific projects and logistics operations, they can be supported by suppliers, subcontractors or professional logistics service providers. Since the technical complexity of large projects, the general contractor tends to entrust a professional third-party logistics company to provide services (Aloini et al., 2012).

2.3 Problems of the construction supply chain

The construction industry and its supply chain suffer from many problems that affect it in a negative way. According to Yeo and Ning (2002), problems affecting the construction industry include budget overruns, delays, low profit margin and many legal claims and counter claims. Vrijhoef and Koskela (2000) stated that waste and problems are largely caused by myopic control of the construction supply chain. The problems are caused by myopic and independent control of the CSC. Love et al. (2004) and Saad et al. (2002) noted the highly fragmented characteristics of the construction industry. The CSC
characteristics may antagonize the application of SCM to construction through reinforcement of the problems. Therefore, further research and analysis of construction SCM should be undertaken. Construction industry problems can also be seen in Amade et al. (2016) work from a demand and supply perspective. They stated that problems in the construction industry resulted from supply, demand, and common issues. Demand issues contain inappropriate selection criteria, discontinuous and low demand problems, inappropriate allocation of risk and frequent changes in specification (Xue et al., 2005).

2.4 SCM in the Construction Industry

In a project, a supply chain includes the owner, planner, designer, architect, engineer, construction manager, general contractor, subcontractors, suppliers, distributors, and manufacturers (Eriksson, 2016). Throughout a firm’s business life, components of a supply chain may also include accounting, human resources, equipment fleet operations, etc. Within the construction project, the supply chain can be simply conceived with the owner at the top followed by designer, contractor, specialist contractors/subcontractors/suppliers etc., forming various levels of supply chain (Agapiou et al., 1998; Aloini et al., 2012). Construction supply chain management (CSCM) refers to the management of information, flow of materials and money in the development of a construction project. Due to the reason that construction process includes a certain standard procedure from planning, designing, procuring, constructing, maintaining to demolishing (Amade et al., 2016; Al-werikat, 2017), CSCM can also be interpreted as a system in which suppliers, contractors, clients and their agents work together in coordination to install and utilize information in order to produce and deliver materials, plant, temporary works, equipment and labour and/or other resources for construction projects. Project success has long been sought after by construction practitioners (Xue et al., 2005) and growing competition means that construction organisations need to find better ways to improve project success (Love et al., 2004; Utomo et al., 2010; Kim and Nguyen, 2020). This has resulted in an increased call for more collaborative approaches. Recently, initiatives have supported SCM as a new mechanism for effective construction management. In his report Manu (2014) urged the construction industry to engage higher integration, improve performance, nurture harmonious inter-organizational relationships and offer better value in projects.

SCM is a concept that originated and flourished within the automotive manufacturing industry and has recently gained the attention of the construction industry. It emerged in the late 1990’s (Saad et al., 2002) and has been the focus of construction industry ever since. SCM has been defined by Benton and McHenry (2010) as, “The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole”. Unlike traditional practice, SCM promotes competition between supply chains, not merely single entities (Serpell and Heredia, 2004), which motivates all parties to be competitive and productive (Saad et al., 2002). SCM is based on the notions that inter-firm and intra-firm relationships are important for organisations to be more agile in the global market.

SCM is said to be better than traditional practice in various aspects, such as reduced inventories, sustained improvement, cost efficiency, speedier operation, improved information flow, higher coordination and shared risks and rewards (Papadopoulos et al., 2016). It is necessary for the entire scope of the supply chain to be understood for successful implementation of SCM (Vrijhoef and Koskela, 2000). Past SCM initiatives in construction, however, have had limited coverage, with studies restricted to split issues such as the contractor/supplier interface (Vrijhoef and Koskela, 2000), environmental performance, design management (Agapiou et al., 1998), service quality (Kaynak and Hartley, 2008) and purchasing behaviour (Gadde and Dubois, 2010). Furthermore, despite many researchers concluding clients mostly benefit from SCM (Brien et al., 2002), most research initiatives focus on the contractor’s supply chain, not particularly on SCM (Vrijhoef and Koskela, 2000). This review invites the conclusion that SCM has a great potential within the local construction industry, especially for public sector projects which experience the most delays and quality shortfalls.

The construction industry has been adjudged by different scholars to have been slow in the adoption of SCM principles which has proven to have worked perfectly in the manufacturing and service sectors (Akintoye, 2000; Saad, 2002). Even though the Egan’s report stated that SCM principles could prove to be rewarding in the construction industry by way of improving quality and efficiency if properly deployed, there still hasn’t been any deployment or application of the concept so far (Amade et al., 2016).
2.5 Supply chain quality management

According to Kim (2020), implementing quality management only in a separate area or one party cannot enhance quality from a client perspective. In other words, in the construction industry, separate control of quality in main contractors and subcontractors could not achieve the goal of improved quality. To enhance quality, the concept of quality needs to be integrated through the whole supply chain and involve all employees from top to bottom. Supply chain management is a set of principles and practice aimed at managing and coordinating entire supply chains from raw material suppliers to the end customers, and emphasizes the importance of collaboration with every participant across the entire supply chain (Akintoye et al., 2000). Construction supply chain management requires establishing mutual interests between the main constructor and the subcontractor, discarding the short-term considerations, and then delivering maximum value to clients (Amade et al., 2016).

Wong and Fung (1999) concluded that SCM would help the main contractor better manage subcontractors and suppliers through working closely and cooperatively. A suggestion by Cristina et al. (2017) that building a unified team with clients, designers, main contractors and subcontractors could better deliver value to the client. The new approach of establishing qualified partnering with main contractors and subcontractors through the supply network can significantly improve quality (Ghodke and Amber, 2019). Traditional quality programs should now take a view from a supply chain perspective in order to improve quality and satisfy requirements of the marketplace (Durdyev and Ismail, 2019). Lin and Gibson (2011) concluded that the quality-based paradigm has shifted from the traditional company-centred to involvement into supply chain systems. Some studies now define this integration between quality management and supply chain management as the concept of supply chain quality management SCQM (Serpell and Heredia, 2004). From the aspect of quality management, construction supply chain could be recognized as delivering quality products and services across every organization in the supply chain, to clients’ expectations. Serpell and Heredia (2004) defined SCQM as the formal coordination and integration of business processes involving all partner organizations in the supply channel to measure, analyse and continually improve products, services, and processes in order to create value and achieve satisfaction of intermediate and final customers in the marketplace.

Adopting SCQM in construction industry seems to have a positive influence on quality improvement. Firstly, SCQM can build the common senses of quality for every participant in the supply chain without being restricted by the boundaries of organizations. Secondly, effective value-add deliveries of the components of construction and services can be achieved by adopting SCQM through process re-engineering and client focus (Abedini, 2014; Papadopoulos et al., 2016). Moreover, SCQM offers a scope of ‘big picture’ and is an effective way to overcome the nature of fragmentation and the weak linkages among supply partners in the construction business. Last but not least, SCQM is an approach that could help quality decisions be made wisely by considering whether processes can add value to the end product and not to sacrifice the interest of other participants, especially subcontractors (Studer, Carlos and Brito, 2021).

3. Methods

The study used a deductive research approach using a questionnaire survey in a cross-sectional quantitative research design to assess the supply chain management practices and factors used in the construction industry and which of these affect building project quality in Zambia. The study started with a literature review to identify supply chain management factors and practice used on construction sites. The factors and practices identified from literature were then formed into a structured questionnaire with a five-point Likert scales from (1=disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree). The questionnaire was administered to contractors and consultants in the construction industry in Zambia. The participants were selected by sending the questionnaires to construction and consultancy companies that were easily accessible for the different professionals in the companies to respond to the questionnaires. Therefore, the sampling approach was the non-probability convenient sampling approach. Subsequently, a sample of 55 respondents was obtained. The sample comprised of organisation involved 3.6% of the respondents work for the public works department, 1.8% for the quantity surveying firms, 65.5% for construction firms, 1.8% for electrical and mechanical firms, 7.3% are construction suppliers and 5.5% are from mines. Five respondents had the work experience ranging from 0–5 years, 14 respondents had 5–10 years of work experience while 2 respondents said that they had experience from 10 to 15 years. Furthermore, 15 respondents mentioned that they had working experience starting at 15 to 20 years and those whose working experience were 20 years and above
were 19. Based on the diverse distribution of the organization type and the work experience, the sample was deemed to be appropriate for the study objectives.

4. Results and discussion

The data was analysed in stages. Firstly, exploratory factor analysis (EFA) was conducted to determine the factor structure of the research constructs. Descriptive and reliability statistics for the various factors were then computed and then the relative importance index for the items was then computed to determine the most important supply chain management factors and practices which affect construction project quality.

Prior to these analyses, and in order to establish whether the data were suitable for EFA, the Kaiser-Meyer-Olkin measure of sampling adequacy and the Bartlett's Test of Sphericity were computed. According to Hair et al. (2010), the criteria to establish factorability include checking if the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is above 0.7; the Bartlett' Test of Sphericity (BTS) must be significant at p < .05 and all communalities should be above 0.3. The results of the KMO and the Bartlett's test show that the KMO for both constructs were below the recommended 0.70 but the Bartlett's test met the acceptance criteria. This means that the sample is not completely sufficient for the EFA and so the results have a limitation and should be interpreted with caution.

| Table 1: KMO and Bartlett's test for supply chain management practices |
|--------------------------|----------------|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | .672 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 91.286 |
| df | 15 |
| Sig. | 0.000 |

| Table 2: KMO and Bartlett's test for supply chain management practices affecting project performance |
|--------------------------|----------------|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | .579 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 95.169 |
| df | 15 |

| Table 3: KMO and Bartlett's test for supply management factors affecting project quality |
|--------------------------|----------------|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy | .795 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 117.628 |
| df | 36 |
| Sig. | .000 |

The results of the EFA, descriptive, and reliability statistics are shown in Table 3. The results show that the supply chain management practices in used in Zambia factor into two distinct practices namely, internal processes and practices, and external or supplier engagement practices. The supply chain management practices which affect construction project quality also factored into two distinct groups namely, project management factors, and contractor factors.
Table 4: EFA, descriptive and reliability statistics

<table>
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<tr>
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<th>Std. Dev</th>
<th>Cronbach's Alpha</th>
<th>Item-correlations</th>
<th>Factor Loadings</th>
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<td>1.300</td>
<td>0.792</td>
<td>0.603</td>
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<td>2.93</td>
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<td>0.762</td>
<td>0.492</td>
<td>0.327</td>
<td>0.846</td>
<td>0.839</td>
<td>0.647</td>
</tr>
<tr>
<td>2 EP2</td>
<td>1.85</td>
<td>0.826</td>
<td></td>
<td>0.327</td>
<td>0.761</td>
<td></td>
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<tr>
<td><strong>Supply chain management factors affecting project quality</strong></td>
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<tr>
<td><strong>Project management factors</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 PMF1</td>
<td>2.69</td>
<td>1.034</td>
<td>0.787</td>
<td>0.387</td>
<td>0.430</td>
<td>0.602</td>
<td>0.392</td>
</tr>
<tr>
<td>2 PMF2</td>
<td>2.62</td>
<td>1.045</td>
<td></td>
<td>0.634</td>
<td>0.779</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 PMF3</td>
<td>2.42</td>
<td>0.896</td>
<td></td>
<td>0.642</td>
<td>0.804</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 PMF4</td>
<td>2.38</td>
<td>1.009</td>
<td></td>
<td>0.498</td>
<td>0.593</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 PMF5</td>
<td>2.35</td>
<td>1.190</td>
<td></td>
<td>0.504</td>
<td>0.591</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 PMF6</td>
<td>2.16</td>
<td>0.996</td>
<td></td>
<td>0.523</td>
<td>0.724</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 PMF7</td>
<td>2.07</td>
<td>1.052</td>
<td></td>
<td>0.438</td>
<td>0.516</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contractor factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 CF1</td>
<td>3.13</td>
<td>1.123</td>
<td>0.633</td>
<td>0.469</td>
<td>0.816</td>
<td>0.870</td>
<td>0.682</td>
</tr>
<tr>
<td>2 CF2</td>
<td>2.91</td>
<td>1.323</td>
<td></td>
<td>0.469</td>
<td>0.835</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The reliability statistics show that the constructs are generally reliable with a few exhibiting reliability concerns. The construct measuring external supply chain factor (supplier engagement) exhibited a very low Cronbach's alpha but very good composite reliability and average variance extracted (0.839 and 0.647 respectively). One supply chain management factor affecting project quality (project management factor), exhibited poor composite reliability and average variance extracted (below 0.70 and below 0.50 respectively) but very good Cronbachs' alpha (0.787). While at least one aspect of the reliability of these constructs is questionable, other aspects are acceptable. Therefore, for this exploratory study, the constructs are acceptable. This means the results of this study can be relied upon albeit with some caution.

Having established that the constructs are fairly reliable, the data was subjected to the relative importance index (RII) to assess the most important items within each factor. The RII was then calculated based on the formula;

$$RII = \sum_{W} \frac{W}{AN}$$

where $W$ is the weighting assigned to each item by each respondent on a scale of one to five. A is the highest weight in the scale (i.e., 5 in our case) and N is the total number of the sample (Holt, 2014). The relative importance indexes were calculated for each variable and the overall rankings were established for each variable as well as within each cluster derived from EFA. The RII scores were calculated based on formula (1) and sorted in descending order from the highest to the lowest. The five important levels were deduced from the RII scores and interpreted as low (L) (0.0_RII _ 0.2), medium-low (M-L) (0.2_RII _ 0.4), medium (M) (0.4_RII _ 0.6), high-medium (H-M) (0.6_RII _ 0.8) and high (H) (0.8_RII _ 1) (Ahmed et al., 2020).

Table 5 shows the ranking of SCM practices engaged in by the construction industry in Zambia. SCM practices which focus on the internal processes and practices are the predominant SCM practices engaged in as these rank higher than the external practices and engagement with suppliers. This is indicative of a possible immaturity in the levels of SCM practices among the practitioners in the construction industry in Zambia. This is because, by definition, in the construction industry, construction supply chain (CSC) is all the construction processes, from the demands by the client, conceptual design, construction and maintenance and organizations, which are involved in the construction process, such as owner, designer, general contractors, subcontractors, suppliers, consultants, etc. (Aloini et al., 2012; Amade et al., 2016; Studer et al, 2021). This means a mature construction SCM will
have a strong focus on external engagement rather than a more inward-looking system which seems to be the case for this study.

Table 5: Supply chain management practices

<table>
<thead>
<tr>
<th>Internal processes and practices</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Our firm has models to measure the performance of suppliers and supply chains</td>
<td>IPP1</td>
<td>1</td>
<td>H-M</td>
</tr>
<tr>
<td>2. Our firm uses information technology to influence supply chain decision making</td>
<td>IPP2</td>
<td>2</td>
<td>M</td>
</tr>
<tr>
<td>3. Our firm uses information technology to support information management</td>
<td>IPP3</td>
<td>3</td>
<td>M</td>
</tr>
<tr>
<td>4. Our firm manages flow of services, finances, products and information systematically</td>
<td>IPP4</td>
<td>3</td>
<td>M</td>
</tr>
<tr>
<td>Average RII</td>
<td>0.611</td>
<td></td>
<td>H-M</td>
</tr>
</tbody>
</table>

**External practices/engagement with suppliers**

<table>
<thead>
<tr>
<th></th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Our firm minimizes engagement with poor performing suppliers</td>
<td>EP1</td>
<td>1</td>
<td>ML</td>
</tr>
<tr>
<td>2. Our firm enhances engagement and spending with top-performing suppliers</td>
<td>EP2</td>
<td>2</td>
<td>ML</td>
</tr>
<tr>
<td>Average RII</td>
<td>0.375</td>
<td></td>
<td>ML</td>
</tr>
</tbody>
</table>

Table 6 shows the relative ranking of the supply chain management factors which affect quality. Overall, the results show that contractor related factors rank as high medium while the project management factors rank as medium. This means that the supply chain management factors directly under the control of the contractors have a larger effect on the quality of construction projects. Therefore, contractors are best placed to improve project quality through SCQM as described by Serpell and Heredia (2004). This resonates with conclusions by Wong and Fung (1999) that SCM would help the main contractor better manage sub-contractors and suppliers through working closely and cooperatively. Project managers may also contribute to improving project quality through SCQM by improving the supervision of sub-contractors, better coordination with other project team members, improved planning and better supervision, and the provision of good quality specifications for the projects. Based on the results in Table 5, these aspects were found to be problematic with the project management team. Therefore, better SCM practices by both the contractors and the project management team can lead to project quality improvements and produce better customer value as suggested by several authors (Yeo and Ning, 2002; Bankvall and Dubois, 2010; Eriksson, 2016).

Table 6: Supply chain management factors affecting project quality

<table>
<thead>
<tr>
<th>Project management factors</th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. There is poor performance works by the sub-contractor</td>
<td>PMF1</td>
<td>0.538</td>
<td>M</td>
</tr>
<tr>
<td>2. There is lack of project coordination by the client, contractor and consultant</td>
<td>PMF2</td>
<td>0.524</td>
<td>M</td>
</tr>
<tr>
<td>3. There is inadequate project planning conducted by the design team</td>
<td>PMF3</td>
<td>0.484</td>
<td>M</td>
</tr>
<tr>
<td>4. There is long time lapse between assessment, procurement and implementation of the project</td>
<td>PMF4</td>
<td>0.476</td>
<td>M</td>
</tr>
<tr>
<td>5. There is inadequate supervision of projects by consultants</td>
<td>PMF5</td>
<td>0.469</td>
<td>M</td>
</tr>
<tr>
<td>6. There are some wrongly applied specifications of some materials.</td>
<td>PMF6</td>
<td>0.433</td>
<td>M</td>
</tr>
<tr>
<td>7. The inspections of the project’s progress is inadequate</td>
<td>PMF7</td>
<td>0.415</td>
<td>M</td>
</tr>
<tr>
<td>Average RII</td>
<td>0.477</td>
<td></td>
<td>M</td>
</tr>
</tbody>
</table>

**Contractor factors**

<table>
<thead>
<tr>
<th></th>
<th>RII</th>
<th>Rank</th>
<th>Importance level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. There is incompetence and lack of capacity by contractors to execute works.</td>
<td>CF1</td>
<td>0.625</td>
<td>H-M</td>
</tr>
<tr>
<td>2. There is poor financial management practiced by contractors.</td>
<td>CF2</td>
<td>0.582</td>
<td>M</td>
</tr>
<tr>
<td>Average RII</td>
<td>0.604</td>
<td></td>
<td>H-M</td>
</tr>
</tbody>
</table>
5. Conclusion

The study assessed the supply chain management practices used in the Zambian construction industry and identified supply chain management factors and practices which affect project quality. The results show that construction practitioners in Zambia have SCM practices which are more self-focused rather than externally oriented. This suggests that the SCM practices may be rather immature because they fail to achieve integration across the construction value chain. With regards to the SCM factors practices which affect quality, the results show that contractor related factors rank as high medium while the project management factors rank as medium in terms of how they impact on project quality. Therefore, the SCM practices by contractors have a larger impact on project quality and so contractors should look to improving their practices in order to improve project quality. Notwithstanding, the SCM practices by the project management team also have an impact on project quality. Therefore, the project management team can also contribute to improving project quality by improving their SCM practices.

These findings need to be interpreted with caution as they have some limitations. Firstly, some of the study scales had poor reliability and so further studies are required to validate these findings. Secondly, the study was exploratory in nature and relied on a small sample size. Future studies could assess the SCM practices with a much larger sample size in order to validate these findings.

6. References


The implementation of Building Information Modelling in the quantity surveying profession

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ABSTRACT AND KEYWORDS

Purpose of this paper
The aim of the research study was to determine the reasons why quantity surveying professional in South Africa being reluctant to implement Building Information Modelling (BIM).

Design/methodology/approach
To explore the problem identified and to achieve the purpose of the study, a quantitative study was executed. A structured questionnaire was used to facilitate the data collection. The research specifically targeted registered quantity surveyors in South Africa. The data was analysed by making use of descriptive statistics, which allowed for the arithmetically analysis of the data.

Findings
BIM knowledge possessed by quantity surveyors is insufficient and the collective efforts from the entire profession to increase the knowledge is slightly evident, however, these efforts are identified as important to improve their knowledge. Initial capital investment is identified as the main barrier for the implementation of BIM in the quantity surveying profession, within sufficient education and training as the second largest barrier followed by cultural resistance.

Research limitations/implications
There is a limited number of quantity surveyors in South Africa with BIM experience and therefore participation in the research was below average.

Practical implications
The results identify factors effecting the implementation of BIM and therefore identifying aspects which must be targeted through the development and implementation of strategies and programmes, which could reduce barriers and improve the knowledge possessed.

What is original/value of paper
The research study identifies the reasons behind the quantity surveying profession being opposed to implementing BIM.

Keywords: Quantity surveyor, Building Information Modelling, Barriers, Knowledge
1. INTRODUCTION

"Technological change defines the horizon of our material world as it shapes the limiting conditions of what is possible and what is barely imaginable. It erodes assumptions about the nature of our reality, the 'pattern' in which we dwell, and lays open new choices" (Zuboff, 2019). Zuboff infers that technology is advancing in exponentially, changing the way things work in ways we cannot fully grasp. In the same vein, we can apply a similar logic to Building Information Modelling (BIM) and the way this presents the opportunity to broaden the horizon of how work is executed in the construction industry, and how the execution of works is perceived.

The construction industry plays a vital role in the growth of the global economy. The construction industry contributes between 5 to 10% towards the global gross domestic product (GDP) and 10% of the global working population are employed within the industry (Eyiah-Botwe, Aigbavboa & Thwala, 2016). Quantity surveyors, or construction cost consultants, play a vital role within the construction industry (Monyane & Ramabodu, 2014; Venter, 2009). Quantity surveyors perform various tasks during the entire construction cycle, from determining and providing accurate estimates of proposed buildings to a complete quantities take-off of a building. The major difficulty encountered when performing these tasks, is the time-consuming nature and the potential of making minor errors, that may have massive consequences, resulting in detrimental effects to a project (Gerard, 2017:1).

According to Moodley, Mathye and Radebe (2016), the global construction industry is facing a crisis and BIM could be the solution to these problems. This crisis is also evident within the South African construction industry as the quality level of projects is drastically decreasing. Low productivity levels experienced and excessive cost overruns during the construction phase forms part of the crisis.

As previously identified, industry is continuously developing and moving forward, more recently at a faster rate. These developments are often than not technological developments, with the most auspicious development within the Architecture, Engineering, and Construction (AEC) industry being BIM (Cheng & Lu, 2015). BIM makes use of various inputs to produce a virtual model of a proposed building, which is an accurate representation of the physical and functional characteristics of the building (Eastman et al., 2008).

According to Lam, Mahdjoubi and Mason (2017), BIM is developing into the construction industry’s standard for the modelling and managing of buildings throughout their life cycles. The phase that BIM implementation has the most substantial influence on, is the design phase. Key decisions are made that have significant influence on the cost of the project and these decisions can also maximise reward and diminish risks that might occur by making assumptions on insufficient design information (Lam, Mahdjoubi & Mason, 2017; Gee, 2010). Due to an increase in information available at the design phase, producing very precise cost estimates will be much earlier in the life cycle of the project (Gee, 2010).

Gee (2010) further indicated that BIM will impact on how quantity surveyors perform their duties and the areas of the project life cycle that they are prominent in. BIM will allow quantity surveyors to produce more efficient and accurate work, which will enable them to gain a competitive advantage over their competition.

South America and large parts of Africa, including South Africa, are experiencing low levels of adoption and are falling behind the rest of the world (Wortmann, Root & Venkatachalam, 2016). There are various factors that prohibit or severely slow down the implementation of BIM globally.

2. LITERATURE

2.1 Defining BIM

BIM is defined by Smith (2013) as “a 3D object database that can be easily visualised, has rich data and structured information”. Smith goes on to state that BIM is also “a process of representing building and infrastructure over its whole life cycle”, thus it can be used for planning, design, construction, operations, maintenance and recycling of the project. BIM importantly provides a framework for collaboration, a multi-disciplinary environment that brings together all the parties that design, construct and operate a facility, thus providing an opportunity for a new model of procurement.
Eastman et al., (2008), Monyane and Ramabodu (2014), describe BIM as a computer based visual simulation of the proposed building, prior to the actual construction thereof, and is therefore labelled as the replacement of Computer-Aided Drafting (CAD). The digital prototype of the building on completion is accompanied by precise geometry and applicable data. This data consists of information pertaining to the construction and fabrication of the building and is used to create an overall picture of the building.

2.2 Quantity surveying profession

The level of knowledge possessed by the various role players in the construction industry are deemed to be insufficient. The level of knowledge possessed, should be improved and refined by themselves, the practices they work for, the government and by universities (Hatem, Abd & Abbas, 2018; Wong & Yew, 2017:25).

Quantity surveyors specifically will require new skills and knowledge if BIM is implemented. The implementation of BIM will push the boundaries of the quantity surveying profession and their ability to adopt to new innovations (Zhou et al., 2012). The skill level and knowledge related to BIM, including that of other professions, will need to be improved substantially to utilise the technology. This can be achieved by presenting multiple seminars and conferences where BIM experts share their knowledge and make the industry aware of the various benefits, difficulties and operation of BIM technology (Hatem, Abd & Abbas, 2018; Wong & Yew, 2017: 25).

If the decision is made to use BIM, a BIM manager needs to be appointed to enable decisions on the appropriate use for the project's specific goals (Walasek & Barszcz, 2017: 1230). Cappel (2019: 67) indicates that the implementation of BIM enables the project team to identify any conflicts that might occur prior to the field installation. For example, if the sprinkler system and any of the heating ventilation and cooling systems interfere with one another, BIM can identify these complications and rectify the problem before construction commences.

2.3 Implementation of BIM

The United States of America (USA) was one of the first countries to use BIM. The USA are a pioneer of BIM implementation and are currently the most prominent country to produce BIM technology, and the major consumer of BIM products (McGraw, 2012). The major reason for the USA's high BIM adoption, is the contribution from the government and organisations. The contribution by the different levels of the public sector is the major catalyst behind the USA's success. Every sector contributes in some way to the country’s high level of BIM implementation, from national organisations to public universities (Cheng & Lu, 2015: 445; Wortmann, Root & Venkatachalam, 2016: 2).

According to Wong and Yew (2017: 24), the private sector in Malaysia started to make use of BIM as early as 2009. The government in Malaysia monitored the progress of the project and they identified that BIM will add value to their construction industry. In 2010, BIM was adopted by the Malaysian public sector and the first building (National Cancer Institute) was constructed by using the technology.

Froise (2014: 183) found that we are experiencing a rapid development in the technological sector around the world. The study suggested that South Africa must start taking cognisance of the changes, particularly when it comes to the construction industry. The study concluded that, if the construction industry does not adopt these new technologies and methods, the industry may become more non-competitive and marginalised.

2.4 Implication of BIM on the Quantity Surveyor

Quantity surveying practices are attracted to BIM, as the new technology has the potential to yield numerous benefits, such as substantial reduction in the time required to perform key tasks (Levy, 2011: 5). This was reinforced by a study involving quantity surveyors in Durban, South Africa. This study concluded that through BIM, certain mundane and tedious tasks, normally performed by quantity surveyors, can be executed quicker and with less effort (Haupt & Hefer, 2016: 10).

Monyane and Ramabodu (2014: 423) indicated that if BIM was adopted and utilised for the completion of Bills of Quantities (BoQ), cost estimates, etc., the time spent on these activities will decrease substantially. The time conventionally spent on these activities take up to 80% of quantity surveyors’
time. This will allow quantity surveyors to focus their time on other value-adding activities. Zhou et al., (2012) agreed with the above and added that the introduction of BIM will allow quantity surveyors to produce a complete BoQ in hours/days, whereas the time required to produce it without BIM is weeks/months depending on the size and complexity of the project.

Construction programmes can be linked with BIM after the tender submission by the contractor. This provides the quantity surveyor and all the other parties of the team access to the programme, which could reduce the amount of variations that occur during the construction phase. This may result in cost savings and the reduction in time required to eliminate cost overruns from late completion. BIM provides the quantity surveying profession the opportunity to expand the amount of services they provide the client and the quality of the services. BIM will allow the quantity surveyor to offer the client additional information by enhancing the whole-life cycle costing approach (Zhou et al., 2012; Moses and Hampton (2017:50). Moses and Hampton (2017) further add that besides life cycle costing, BIM will also allow professionals to provide services such as value engineering and carbon costing.

2.5 Barriers against BIM implementations

Froise and Shakantu (2014: 909) identified several restrictions against the use of BIM within South Africa such as:

- Lack of awareness by large clients;
- Lack of awareness by the government;
- Lack of awareness by industry bodies; and
- A procurement process that discourages collaborative processes”.

According to a study conducted by Haupt and Hefer (2016:9) the main barrier was identified as the excessive initial capital cost associated with BIM, but also the high cost of getting a practice ready for BIM. Furthermore, it is identified that quantity surveyors do not fully understand the benefits, barriers and application of BIM, a further barrier to implementation.

A study was conducted by Kekana, Aigbavboa and Thwala (2015), to determine the barriers against BIM implementation in Tshwane, Johannesburg and Ekurhuleni, all situated in Gauteng, South Africa. They found that the main barrier was the lack of BIM skills development, with the lack of BIM education a very close second. The unavailability of qualified BIM personnel and the shortage of expertise in BIM possessed by professionals, were also identified as major barriers in South Africa.

Akintola (2018: 55) listed various contractual- and legal barriers hampering the implementation of BIM. This implementation results in alternative procurement routes and necessitate contractual arrangements, which will influence the legal side of the project execution. The risk experienced with the execution of project could also shift among the project members. Hatem, Abd and Abbas (2018:60) conducted a study in Iraq and identified that there was a lack of standard contracts that are specifically set up for BIM which was a legal barrier preventing BIM implementation.

Kekana, Aigbavboa and Thwala (2014: 110) examined the barriers against the implementation of BIM in the South African construction industry and identified insurability as a major barrier. The barrier arises when a decision needs to be made as to who owns the rights of the model in the project. These rights of the model must be insured, but insurance companies dealing with the construction industry, have not formulated stable BIM policies to address this.

Wong and Yew (2017: 27) investigated the main barriers influencing implementation of BIM in quantity surveying practices. The study identified eleven barriers and ranked these in descending order. The result showed that the quantity surveyors identified the high initial capital investment as the overarching barrier. Insufficient training, lack of knowledge and the lack of information to indicate that BIM yields a return on investment was also ranked as barriers that have a substantial effect on BIM implementation.

3. RESEARCH METHODOLOGY

This research was executed by using the quantitative research approach, more specifically by means of a structured questionnaire. The method makes use of various analytical techniques, like graphical- and statistical representations, which enables the exploration, description and comparison of
relationships and tendencies that have come forth within the data (Saunders, Lewis & Thornhill, 2007: 406,608). The results were analysed by making use of descriptive statistics, which allowed for the description and comparison of the various variables in an arithmetically format (Saunders, Lewis & Thornhill, 2007: 433). The quantitative method was adopted, as it provides the researcher with more control over the research proceedings and duration of the study. The quantitative method further provides a cost-efficient way of collecting data from a large population, which, for the purpose of this research, was all registered quantity surveyors in South Africa (Saunders, Lewis & Thornhill, 2007: 139).

The structured questionnaire was formulated to consist of three sections. Section one collected the demographic information and work-related data pertaining to the respondents. The second section was subdivided into two sub-sections, with each sub-section collecting the data related to the sub-problems and hypotheses formulated. The first sub-section collected data applicable to the level of knowledge and the evidence and importance of the professions efforts to improve BIM knowledge. The second sub-section determines which barrier the quantity surveyors viewed as the largest to affect the implementation of BIM. The final section consisted of open-ended questions, formulated to obtain additional information from respondents.

The questionnaire made use of a five-point Likert scale to obtain the required data. The pilot study was performed by means of hand delivering questionnaires to five registered professional quantity surveyors in Gqeberha (Port Elizabeth). On completion thereof, the relevant alterations were made to the questionnaire to make it more understandable, creditable and most importantly, to ensure the questionnaire achieved its intended objective. The population selected for the research were registered quantity surveyors with the Association of South African Quantity Surv (ASAQS). Questionnaires were distributed electronically with the assistance of the ASAQS. The questionnaires was completed by 57 respondents.

4. RESULTS AND FINDINGS

4.1 Demographics of respondents

67% of the respondents were males.

Respondents were from an even spread of the various age groups listed.

42% of respondents has more than 20 years of experience.

33% of respondents are in Gauteng with 25% from the Western Cape Province.

61% of respondent’s highest qualification is an Honours qualification.

47% of respondent’s practices have between 2 to 5 quantity surveyors.

61% of respondent’s practices do not use BIM.

4.2 Professions efforts to improve knowledge

The respondents possess a moderate level of BIM knowledge, with an average mean score of 2.91, which was calculated in terms of their general, purchasing, implementation, barriers and benefits knowledge. The highest mean score was recorded in the benefits category, with a mean score of 3.35, indicating that the respondents possess the moderate amount of knowledge pertaining to benefits provided. Mean scores of 2.23 and 2.58 were achieved for purchasing and implementation respectively, indicating a poor level of knowledge possessed in these areas.

The respondents further identify the extent and importance of the efforts enforced by various sectors of the profession to improve quantity surveyor’s possessed knowledge, as indicated in Table 1. These efforts are BIM conferences accessible to all, hosting of BIM workshops, BIM exposure at university level, mandatory BIM training enforced by practices and employee’s participation in training at their own expense. Figure 1 revealed that the importance (MS=3.67) of the efforts to improve knowledge is much higher than the evidence (MS=2.59) of the efforts. This is further reinforced by the average modes obtained, with the evidence having an average mode of 2.00 and the importance having a 3.80 average mode.
The most important effort was identified as the exposure of BIM at university level, which obtained the highest mean score and the strongest standard deviation, 4.40 and 0.90 respectively. The study viewed the exposure of BIM at university level as the most important requirement to improve the knowledge within the industry. In contrast, the evidence of these efforts within the industry was found to be slightly evident, with a mean score of 2.59 and a standard deviation of 1.31.

The efforts from the industry are therefore evident, with some efforts more important than the others, but what is alarming, is the low level of evidence of these efforts. All the efforts individually were found to be more important than what was evident. This is apparent in all the efforts, but it is particularly evident in two of these efforts, namely the incorporation of BIM at university level to improve the knowledge of students and, the mandatory training of employees by the respective practices. These two efforts achieved high mean scores when it came to importance to the respondents but when analysing whether these efforts are evident to the respondents, it shows that these efforts are only slightly evident.

<table>
<thead>
<tr>
<th>Table 1: The level of importance/evidence of efforts within the industry to improve BIM knowledge</th>
</tr>
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<tbody>
<tr>
<td><strong>1=Not important………….. 5=Very important (%)</strong></td>
</tr>
<tr>
<td><strong>BIM exposure at University level</strong></td>
</tr>
<tr>
<td>1,8</td>
</tr>
<tr>
<td><strong>Mandatory BIM training enforced by practices</strong></td>
</tr>
<tr>
<td><strong>Hosting of BIM workshops</strong></td>
</tr>
<tr>
<td><strong>BIM conferences accessible to all</strong></td>
</tr>
<tr>
<td><strong>Employees participate in training at their own expense</strong></td>
</tr>
</tbody>
</table>

| **1=Not evident……………… 5=Very evident (%)** |
| **BIM conferences accessible to all** | **10.5** | **21.1** | **31.6** | **24.6** | **12.3** | **0.0** | **3** | **3.07** | **1.18** | **1** |
| **Hosting of BIM workshops** | **12.3** | **24.6** | **28.1** | **19.3** | **15.8** | **0.0** | **3** | **3.02** | **1.26** | **2** |
| **BIM exposure at University level** | **21.1** | **42.1** | **7.0** | **14.0** | **14.0** | **1.8** | **2** | **2.63** | **1.42** | **3** |
| **Mandatory BIM training enforced by practices** | **54.4** | **10.5** | **10.5** | **10.5** | **12.3** | **1.8** | **1** | **2.14** | **1.49** | **4** |
| **Employees participate in training at their own expense** | **38.6** | **28.1** | **12.3** | **12.3** | **3.5** | **5.3** | **1** | **2.09** | **1.19** | **5** |
4.3 Barriers against BIM implementation

The research made use of 24 barriers against the implementation of BIM, as selected by the researcher based on previous research findings. The respondents indicated the extent to which they viewed each barrier to be a barrier. Thereafter, these barriers were ranked based on these mean scores obtained. It is evident from Table 2 that the initial cost of obtaining BIM software is the largest barrier against the implementation of BIM by quantity surveyors. This particular barrier has the highest mean score, 4.44, as well as the strongest standard deviation, 0.76. This suggested that all of the responses were very close to one another and all respondents have a very similar opinion about the severe extent of the initial cost being a barrier against the implementation of BIM.

The second largest barrier has been identified as insufficient education and training at universities and government centres, with a mean score of 4.36. The strong resistance to change, especially among the more experienced professionals (cultural resistance), was identified as the third highest barrier indicate in Table 2, with a mean score of 4.29. The top three barriers all have more than 50% of the respondents indicating them as being barriers to a large extent. With a mean score of 4.25, the lack of government mandates is the fourth largest barrier and the lack of awareness about the potential benefits that BIM can provide practices in fifth, with a 4.24 mean score. The effect on productivity, the legal component and the fact that BIM does not suit all projects was identified as the three least influential barrier on the implementation of BIM.
Table 2: Ranked barriers against the implementation of BIM by quantity surveyors

<table>
<thead>
<tr>
<th>Barriers</th>
<th>1=To no extent...</th>
<th>5=to a very large extent</th>
<th>Mean score</th>
<th>Std. Dev.</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>The initial cost of obtaining BIM software</td>
<td>0,0</td>
<td>3,5</td>
<td>5,3</td>
<td>3,5</td>
<td>5</td>
</tr>
<tr>
<td>Insufficient education and training at universities and government centre</td>
<td>0,0</td>
<td>7,0</td>
<td>8,8</td>
<td>24,6</td>
<td>5</td>
</tr>
<tr>
<td>The strong resistance to change, especially among the more experienced professionals (cultural resistance)</td>
<td>1,8</td>
<td>5,3</td>
<td>10,5</td>
<td>26,3</td>
<td>5</td>
</tr>
<tr>
<td>No government mandates in place</td>
<td>3,5</td>
<td>3,5</td>
<td>7,0</td>
<td>31,6</td>
<td>5</td>
</tr>
<tr>
<td>Lack of awareness about the potential benefits of using BIM</td>
<td>0,0</td>
<td>7,0</td>
<td>10,5</td>
<td>47,4</td>
<td>7</td>
</tr>
<tr>
<td>Lack of collaboration among the various members within the project team</td>
<td>0,0</td>
<td>8,8</td>
<td>8,8</td>
<td>36,8</td>
<td>4</td>
</tr>
<tr>
<td>Weak government efforts to implement BIM</td>
<td>1,8</td>
<td>8,8</td>
<td>3,5</td>
<td>43,9</td>
<td>4</td>
</tr>
<tr>
<td>Insufficient BIM standards and protocols enforced</td>
<td>1,8</td>
<td>8,8</td>
<td>8,8</td>
<td>24,6</td>
<td>4</td>
</tr>
<tr>
<td>Uncertainty about the application of BIM</td>
<td>0,0</td>
<td>14,0</td>
<td>15,8</td>
<td>42,1</td>
<td>5</td>
</tr>
<tr>
<td>Lack of standardised tools and protocols</td>
<td>0,0</td>
<td>5,3</td>
<td>24,6</td>
<td>31,6</td>
<td>4</td>
</tr>
<tr>
<td>Lack of knowledge possessed about BIM systems</td>
<td>0,0</td>
<td>7,0</td>
<td>24,6</td>
<td>36,8</td>
<td>4</td>
</tr>
<tr>
<td>The cost of updates</td>
<td>0,0</td>
<td>8,8</td>
<td>14,0</td>
<td>47,4</td>
<td>4</td>
</tr>
<tr>
<td>Lack of skilled personnel</td>
<td>0,0</td>
<td>8,8</td>
<td>33,3</td>
<td>29,9</td>
<td>4</td>
</tr>
<tr>
<td>Clients do not make the use of BIM mandatory for the execution of their work</td>
<td>3,5</td>
<td>12,3</td>
<td>15,8</td>
<td>33,3</td>
<td>4</td>
</tr>
<tr>
<td>The cost of the hardware required to operate BIM software</td>
<td>1,8</td>
<td>8,8</td>
<td>22,8</td>
<td>35,1</td>
<td>4</td>
</tr>
<tr>
<td>The belief that the current techniques are sufficient and that there is not a need to enhance the use of existing techniques by implementing BIM</td>
<td>1,8</td>
<td>12,3</td>
<td>24,6</td>
<td>31,6</td>
<td>4</td>
</tr>
<tr>
<td>Lack of qualified experts to train professionals about BIM software</td>
<td>0,0</td>
<td>8,8</td>
<td>38,6</td>
<td>26,3</td>
<td>3</td>
</tr>
<tr>
<td>The costs associated with the training of employees to enable BIM to be utilised</td>
<td>0,0</td>
<td>10,5</td>
<td>35,1</td>
<td>33,3</td>
<td>3</td>
</tr>
<tr>
<td>The cost of the recruitment of BIM specialists and additional staff</td>
<td>3,5</td>
<td>19,3</td>
<td>17,5</td>
<td>31,6</td>
<td>4</td>
</tr>
<tr>
<td>Shortage of experts in the BIM field</td>
<td>5,3</td>
<td>14,0</td>
<td>36,8</td>
<td>10,5</td>
<td>3</td>
</tr>
<tr>
<td>No established contractual framework for working with BIM</td>
<td>10,5</td>
<td>24,6</td>
<td>14,0</td>
<td>22,8</td>
<td>2&amp;5</td>
</tr>
<tr>
<td>The impact of introducing BIM on the current productivity in the practice</td>
<td>26,3</td>
<td>17,5</td>
<td>12,3</td>
<td>21,1</td>
<td>1</td>
</tr>
<tr>
<td>Legal requirements</td>
<td>8,8</td>
<td>24,6</td>
<td>31,6</td>
<td>15,8</td>
<td>3</td>
</tr>
<tr>
<td>BIM does not suit all projects</td>
<td>19,3</td>
<td>26,3</td>
<td>21,1</td>
<td>14,0</td>
<td>2</td>
</tr>
</tbody>
</table>

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5. CONCLUSIONS

The construction industry is currently seen as an extremely unstable environment, with the downturn in the economy negatively impacting on the sector, leading to a subsequent slump in the activities within the construction industry. To maintain competitiveness, practices must utilise alternative tools and techniques to increase their competitive advantage in order to obtain a larger market share.

The literature is very clear in identifying that the utilisation of BIM can yield numerous benefits to quantity surveyors and enhance their operations. BIM however, has barriers associated with it that makes it difficult to obtain and implement the technology. The purpose of this research was therefore to determine why there is a reluctance in the quantity surveying profession to adapt the technology.

The research found that the knowledge possessed by professionals is insufficient, and that it had to increase, the chances of an increase in BIM implementation would be substantial. The efforts from the industry to improve knowledge are not extremely evident, but these were viewed as important by professionals. Using the results obtained, it can be surmised that if the efforts from the industry improved, the knowledge of professionals would subsequently improve, and this may result in an increase in BIM implementation. The objective was to determine if efforts from the industry were evident. The results concluded that efforts are evident, however, not as evident as required by the industry to improve knowledge possessed. It was further found that the initial cost of software and training is the main barrier to the implementation of BIM. The barrier to entry cannot be easily overcome, however should a thorough analysis be performed to determine the long-term benefit and cost saving related to the implementation, then practices may be encouraged to overcome the barrier and subsequently reap the long-term advantages. Obtaining the new technology should be viewed as a capital investment, with the opportunity that it will provide a large return on investment, and the potential to create a competitive advantage for those who utilise it.

6. RECOMMENDATIONS

For the profession to overcome these barriers, numerous participants will need to change the way in which certain services and work are performed. A range of stakeholders, including quantity surveyors, the quantity surveying professional body, the ASAQs and other interested parties including tertiary institutions and government, will need to participate in this process.

The results confirm that tertiary institutions could be a catalyst for change. This was viewed as the most important component to improve the lack of knowledge in the industry. The universities should therefore include BIM based modules within built environment related programmes. The government can mandate BIM primarily for public projects, which in general has a ripple effect on implementation in the rest of the industry.

7. REFERENCES


Quantity surveyors’ level of knowledge relating to sustainable building principles

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ABSTRACT AND KEYWORDS

Purpose of this paper
This study aimed to identify the level of knowledge of quantity surveyors relating to green building principles and the level of involvement of the quantity surveyor in the selection process of green building projects. The study further investigated if and how the quantity surveyor is involved in the selection process of green building materials and products on projects.

Design/methodology/approach
A quantitative research approach was used with an online survey placed on the Association of South African Quantity Surveyors’ (ASAQS) Weekend Property and Construction Newsletter. The target population included registered professional quantity surveyors and candidate quantity surveyors. The data was analysed through descriptive statistics, which allowed for the arithmetically analysis of the data.

Findings
The green building principles which were mostly notified from the data includes: “the high-cost premium”; “benefits of reduced operating costs”; “green building products”; “benefit of return on investment on green buildings”; and “green buildings achieve higher market values”. The results further revealed that quantity surveyor provides cost advice on alternative green building materials and products to the design team even though the architect is primarily responsible for the selection process of green building products and materials.

Practical implications
The results identified areas where quantity surveyors’ knowledge is lacking which should be addressed.

What is original/value of paper
This study will add important information on the involvement of the quantity surveyor in the selection process of green building materials and products on sustainable building projects.

Keywords: Knowledge level, sustainable building principles, quantity surveyor, green building principles
1. INTRODUCTION

The construction industry contributes towards 50% of landfill wastes, 23% of air pollution, and 40% of potable water pollution (Celik, Kamili and Arayici, 2017). Ofori (2012) indicates that construction and operation of buildings causes biodiversity damage, deforestation, and degradation of soil. The introduction of green-house gases into the atmosphere results in negative effects for the environment as increasing temperatures which bring about heat waves in fragile areas, rising sea levels, crop failures, strong storms which cause damage to infrastructure and buildings and increased risk of flooding and drought (Heidari & Pearse, 2016). South Africa is a heavy emitter of carbon dioxide and is ranked 14th in the world due to the production in the manufacturing sector (Garidzirai, 2020).

As defined by Kibert (2007), sustainable construction is the management of a healthy and efficient built environment to preserve the natural environment and reduce the risks associated with the biodiversity surrounding the construction site. Cruywagen (2013) identified that green buildings produce less amounts of wasteful products, allows for the re-use of recyclable products, preserves the natural habitat, and controls the amount of pollution emitted into the atmosphere. Le Jeune, Nurick and Roux (2013) indicated that professionals in the construction industry lack the knowledge and understanding to produce projects with green building principles and concepts. According to Coetzee and Brent (2015: 12), construction professionals overstate the cost premium of sustainable buildings affording the client to resort to alternative options. Results of the above study also indicate that quantity surveyors have a more in depth understanding of costs related to green buildings compared to their professional counterparts.

Through identifying these problems, Masia, Kajimo-Shakantu and Opawole (2020) indicates that there is uncertainty as to the knowledge capacity of quantity surveyors regarding sustainable development projects. Without the quantity surveyor’s expert analysis on the cost premium of green buildings, the green building cost premium will continue to be overstated and lead to false presumptions of green construction.

It is therefore important to deduce the changing roles of the quantity surveyor towards sustainable roles and responsibilities. According to the RICS (2013) quantity surveyors will need to make an account for carbon emitted from a building and relay the costs involved. The quantity surveyor, as the building or construction economist is perfectly situated to account for these and other lifecycle costs which could be affected by sustainability measures, such as reduction in energy costs (Masia et al., 2020).

2. THE REVIEW OF THE RELATED LITERATURE

2.1 The need for sustainable construction

One of the primary definitions of sustainable construction defined by Kibert cited in Bordeau (1999) ‘Sustainable construction is the creation and responsible management of a healthy built environment based on resource efficient and ecological principles’. The International Council for Research and Innovation in Building and Construction explained sustainable construction as the reuse of buildings and construction and their components, use, demolition, maintenance, and sustainable production (CIB, 2004).

According to Second Nature (2015), green-house gas emissions from buildings is slightly higher at forty per cent where operation of the building sector accounts for twenty-three per cent of that amount (CIDB, 2009). Gunnell (2009) and Ofori (2012) both agree that construction processes cause degradation, loss of habitat, high level of energy consumption, water and air pollution and contributes between twenty-three per cent and forty per cent to green-house gas emissions. The construction industry not only places immense pressure on the natural resources but also deposits harmful waste products either into the atmosphere as gaseous waste, solid waste, or through the water supply as liquid waste (Frans, Cumberlege & Dent, 2013). These impacts on the environment and public infrastructure call for the utilisation of sustainable construction concepts and methods to ease the strain on the natural environment.
2.2 Barriers and challenges of sustainable construction

Green buildings have many challengers and barriers that affect the adoption of sustainable techniques on projects. Le Jeune et al., (2013) identify that lack of knowledge and understanding of green building standards and concepts is a major barrier in South Africa. LaBadie (2010) are also of the opinion that professionals and the design team lack knowledge in terms of designing, constructing, and maintaining a green building. It is therefore important for the design team to have sufficient knowledge on sustainable construction projects where they may advise clients on suitable products and techniques.

Shari and Soebarto (2012) also states that project team members lack the technical understanding to undertake a sustainability project. Furthermore, Agyekum, Adinyira, Baiden, Ampratwum and Duah (2019) identify those certain professionals such as architects and engineers, do not obtain sufficient green building knowledge to benefit sustainable construction projects. A study conducted by Masia et al., (2020) clearly shows that there is not only a lack of knowledge between the professionals and clients of green building techniques but also a lack of understanding by contractors, sub-contractors, suppliers, and manufacturers. To add to this problem, Le Jeune et al., (2013) further highlights the problem that there are not sufficient green building projects to allow professionals, contractors, and suppliers to gain experience and expertise.

Another barrier to sustainable construction is the apathy experienced by clients in terms of green building methods (Darko et al., 2017). Shi (2009) indicates that developers do not adopt green building techniques and methods on construction projects without rewards. Developers intend on making a profit and regard sustainable buildings as extra costs which are incurred (Agyekum et al., 2019). It was reported that the usage of new technologies and techniques by the design team and professionals halted the adoption of green construction (Chan, Darko & Ameyaw, 2017). Le Jeune et al., (2013), concluded that there is a lack of understanding of where to find sustainable products, designs, and technologies. According to Aghimien, Aigbavboa and Thwala (2019), one of the top five challengers to the adoption of sustainable construction was the lack of government incentives for green certification. The motivation from government to assist developers to adopt sustainability measures is noted by Bond and Perrett (2012) and Olanipekan, Chan, Paul, Xia, and Adedokun (2018). Governments could also enforce regulations and building codes to green building standards (Powmya & Abidin, 2014).

The main barrier preventing the adoption of sustainable buildings is the high-cost premium of the building (Robichaud & Anantatmula, 2011; Darko et al., 2017). Cruywagen (2013) noted that the cost difference between green buildings and conventional buildings is 7.58%. Matthiessen and Morris (2004) also confirms that the cost differential to be 8.6% while Windapo and Machaka (2018) also identified that the cost difference between sustainable construction and conventional construction was 8.55%. From these results it can be conclude that the cost differential is not that significant. Coetzee and Brent (2015) revealed that South African construction professionals felt that the cost differential between green and conventional buildings was 20.4% which seems to be extremely high. Results further revealed that eight green buildings in South Africa have an average cost premium differential of 4.95%, which shows that the perceptions of professionals in the industry is not positive from a green building perspective. According to Feinberg (2017) the fifty-four green star certified green office buildings in South Africa, cost roughly 5% more than conventional office buildings.

2.3 The level of knowledge of quantity surveyors on green buildings

Literature emphasises that professionals lack the knowledge and understanding of green building practices (Le Jeune et al., 2013; Hankinson & Breytenbach, 2012; Bond & Perrett, 2012). Professionals’ perceptions of cost premium in South Africa is extremely high for green buildings, while quantity surveyors averaged a cost premium at 12.7% which is more realistic according to Coetzee and Brent (2015). This indicates that the knowledge of the quantity surveying fraternity to be higher than their professional counterparts. Aghimien et al., (2019) also revealed that there is a vast amount of awareness of sustainable construction from quantity surveyors, construction managers and project managers. On the other hand, Bond and Perrett (2012) assert that due to the lack of understanding from quantity surveyors of green building principles, they overestimate the cost premium of green buildings. Shari and Soebarto (2012) indicate that project team members which include quantity surveyors, lack the technical understanding of green building concepts and sustainability measures.
Aigbavboa, Ohiomah and Zwane (2017) points out that estimators or quantity surveyors overstate the disadvantages of the costs of green construction without incorporating the operating cost savings involved with sustainable buildings. This could be due to lack of knowledge and experience on green building sites. Ernest, Samuel, Ayemang, Daniel and Caleb (2020) confirmed that quantity surveyors need to be fully equipped with sustainable construction knowledge and principles through Continuous Professional Development (CPD) interventions. Furthermore, Emmanuel (2011) explains three roles quantity surveyors can play to implement sustainability measures, first is building sustainability assessment, second is sustainability performance assessment and third is zero carbon and property value.

Initiatives for sustainable construction, from quantity surveyors’ perspective are:

**Approach**

- Understanding the natural process and their interaction with human needs (Wang, Chan & Nunn, 2010).
- Consideration of the environmental influences at design stage throughout the whole life span (Wang, Chan & Nunn, 2010).
- Public policy such as regulations, building codes, incentives (Kibert, 2007).
- Motivating community towards sustainability (Mateus & Braganca, 2011).

**Techniques**

- BIM (Bynum, Issa & Olbina, 2013).
- Reuse of buildings (Wilkinson, James & Reed, 2009).
- Lifecycle management (Olander, 2012).
- Value management (Abidin, 2008).

2.4 The involvement of quantity surveyor in the selection process of products

The quantity surveyor is not incorporated in the selection process of sustainable products and materials (Koigi, 2017) on a construction project. According to Kim and Rigdon (1998), the architect is the leading professional in selecting green building materials and products which are environmentally friendly. This is in contrast to what Ma and Luu (2013) state, that in a sustainable construction project, the quantity surveyor provides cost advice on alternative options to the design team. This clearly indicates a gap that quantity surveyors are involved in the selection process of sustainable products and materials.

3. RESEARCH METHODOLOGY

This research was executed by using the quantitative research approach, more specifically by means of a structured questionnaire. The method makes use of various analytical techniques, like graphical- and statistical representations, which enables the exploration, description and comparison of relationships and tendencies that have come forth within the data (Saunders, Lewis & Thornhill, 2007: 406,608). The results were analysed by making use of descriptive statistics, which allowed for the description and comparison of the various variables in an arithmetically format (Saunders, Lewis & Thornhill, 2007: 433). The quantitative method was adopted, as it provides the researcher with more control over the research proceedings and duration of the study. The quantitative method further provides a cost-efficient way of collecting data from a large population, which, for the purpose of this research, was all registered quantity surveyors in South Africa (Saunders, Lewis & Thornhill, 2007: 139).

The structured questionnaire was formulated to consist of four sections. Section one collected the demographic information pertaining to the respondents. The second section collected data to determine the quantity surveyor’s knowledge level relating to sustainable building principles while the third section establish the level of involvement of quantity surveyors in the selection process of sustainable building products. The final section consisted of open-ended questions, formulated to obtain additional information from respondents.
The questionnaire made use of a five-point Likert scale to obtain the required data. The pilot study was performed by means of hand delivering questionnaires to three registered professional quantity surveyors in Gqeberha (previously known as Port Elizabeth). On completion thereof, the relevant alterations were made to the questionnaire to make it more understandable, creditable and most importantly, to ensure the questionnaire achieved its intended objective. The population selected for the research were registered quantity surveyors with the Association of South African Quantity Surveyors (ASAQS). Questionnaires were distributed electronically with the assistance of the ASAQS. A low response rate of 7% was obtained.

4. RESULTS AND FINDINGS

4.1 Demographics of respondents

It can be noted that 65% of the respondents were males with 34% of respondents who falls within the age group of 31 to 40 years. Seventy one percent (71%) of respondents were registered quantity surveyors with almost half (46%) of the respondents having experience between 5 to 10 years.

4.2 Level of knowledge quantity surveyors should have relating to green building principles

Respondents indicated in Table 1 that sixteen of the seventeen principles were of “relatively high” to “high importance”. The green building principle, Waste ACT 59 of 2008 was considered “low” to “moderate importance” by respondents. Table 1 further illustrates the ranking in terms of “importance” of the listed principles and six of the most important principles of green building. These included “life cycle cost benefits of green building”; “the benefit of reduced operating costs”; “the benefit of return on investment from green buildings”; “green buildings achieve a higher rent premium" and lastly “green buildings achieve a higher market value”.

The next top four principles were “green building products”, “benefits of sustainable building on the natural environment”, “benefits of sustainable building on occupants”, and “benefits of sustainable building on the community”, with mean scores of 4,20; 4,13; 4,13; 4,13 respectively.

<table>
<thead>
<tr>
<th>Frequency (%)</th>
<th>Importance (1= Not important, 5= Very important)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Green Building Council of South Africa</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Green-star rating tool</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Green building products</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Benefits of sustainable building on the natural environment</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Benefits of sustainable building on occupants</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Benefits of sustainable building on the community</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Lifecycle cost benefits of green building</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>The benefit of reduced operating costs</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>The benefit of return on investment from green buildings</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Green buildings achieve a higher rent premium</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Green buildings achieve higher market values</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>The high-cost premium</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>The City of Cape Town Building Guidelines of 2008</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Waste ACT 59 of 2008</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>SANS Part XA</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>National Environment Management Act (NEMA) 107 of 1998</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Embodied carbon and energy in materials</td>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 1: Importance level of green building principles perceived by quantity surveyors.
In terms of evidence, Table 2 highlights that respondents have “sound” levels of knowledge in some departments of green building principles, while having “minimal” levels of knowledge in other areas of green building principles. Respondents indicated that they are most knowledgeable in areas such as, “the high-cost premium”; “green buildings achieve a higher rent premium”; “benefits of sustainable building on the natural environment”; “benefits of sustainable building on the community”; “green building products”; “the benefits of reduced operating costs”; “benefits of sustainable building on occupants”; “the benefit of return of investment on green building” and “green buildings achieve higher market values”. As a result of respondents being quantity surveyors and cost consultants, it stands to reason that the areas of most notable knowledge levels would be areas such as “high-cost premium”, “benefits of reduced operating costs”, “green building products”, “benefit of return on investment on green buildings”, and “green buildings achieve higher market values”.

However, areas where respondents felt they have “no”, or “minimal” levels of knowledge, were green building documentation such as the National Environment Management Act (NEMA) 107 of 1998 and the Waste ACT 59 of 2008 with mean scores of 2.47 respectively. Documentation for green building principles such as the City of Cape Town Building Guidelines of 2008 scored a mean score of 2.73 which is relatively low.

| Table 2: Current level of knowledge of quantity surveyors relating to green principles |
|---------------------------------|-----------------|----------------|----------------|----------------|----------------|
|                                 | Frequency (%)   | Importance (1= Not important, 5= Very important) | Mean          |
|---------------------------------|-----------------|----------------|----------------|----------------|----------------|
| The Green Building Council of South Africa | 20   | 7    | 27   | 27   | 20   | 3.20 |
| Green-star rating tool           | 20   | 13   | 33   | 7    | 20   | 3.13 |
| Green building products          | 0    | 20   | 27   | 27   | 20   | 3.67 |
| Benefits of sustainable building on the natural environment | 0 | 20 | 13 | 40 | 27 | 3.73 |
| Benefits of sustainable building on the community | 0 | 20 | 20 | 33 | 20 | 3.73 |
| Benefits of sustainable building on the occupant | 0 | 20 | 27 | 27 | 27 | 3.6 |
| Lifecycle cost benefits of green building | 0 | 20 | 40 | 20 | 20 | 3.4 |
| The benefit of reduced operating costs | 0 | 13 | 27 | 40 | 20 | 3.67 |
| The benefit of return on investment from green buildings | 0 | 20 | 33 | 20 | 27 | 3.53 |
| Green buildings achieve a higher rent premium | 0 | 20 | 20 | 33 | 20 | 3.73 |
| Green buildings achieve higher market values | 0 | 20 | 27 | 33 | 20 | 3.53 |
| The high-cost premium            | 7    | 14   | 14   | 29   | 29   | 3.79 |
| The City of Cape Town Building Guidelines of 2008 | 33 | 27 | 7 | 13 | 7 | 2.73 |
| Waste ACT 59 of 2008             | 40   | 20   | 7    | 20   | 13   | 2.47 |
| SANS Part XA                     | 27   | 27   | 13   | 13   | 20   | 2.73 |
| National Environment Management Act (NEMA) 107 of 1998 | 40 | 20 | 13 | 7 | 20 | 2.47 |
| Embodied carbon and energy in materials | 27 | 13 | 13 | 27 | 13 | 3.07 |

Results in Table 3 revealed that three statements are of “utmost” importance for the involvement of the quantity surveyor in the selection process of green building products. The first is; “the quantity surveyor provides cost advice on alternative green building materials and products to the design team”; the second is; “the quantity surveyor explains the financial pitfalls of green building”; and the third statement is: “the quantity surveyor explains the financial benefits to the client”. The ranking of these statements as “utmost” importance indicates that quantity surveyors in the industry feel that these functions are critical in a quantity surveyor’s skillset repertoire when conducting green building.
The mean scores from Table 4 show that respondents have “relatively high” evidence to “excessive” evidence relating to the selection of green building materials. The top four statements in ranking order are; “the architect is the chief professional in selecting green building materials, not the quantity surveyor”, “the quantity surveyor explains to the client the financial pitfalls of green building”, “the quantity surveyor provides cost advice on alternative green building materials and products to the design team”, and “the quantity surveyor explains the financial benefits of green building to the client”.

However, it is evident from the study that the quantity surveyor is in a position to supply advice to the design team on alternative materials which will ultimately contribute to a more efficient and cost-effective design.
5. CONCLUSIONS

The objective of this study was to determine the level of knowledge quantity surveyors have relating to green building products while the second objective was to establish the extend of the quantity surveyor’s involvement in the selection process of green buildings. The quantity surveyor’s level of knowledge relating to green buildings is critical in terms of quality of advice a quantity surveyor can provide to the design team and the effect a quantity surveyor can have on the cost of a green building project. The leading principles where quantity surveyors perceived to be fairly knowledgeable, were the high-cost premium, that green buildings achieve a higher rent premium than conventional buildings, benefits of sustainable building on the community, benefit of sustainable building on the natural environment, and green building products.

Being able to provide quality advice on green building to the client from the quantity surveyor’s perspective may persuade the client to either adopt or neglect green building principles on a project. Therefore, having knowledge on the abovementioned principles for green building is of utmost importance. The main cause of excessive building costs of projects with sustainable building products is a direct link between quantity surveyors not being involved in the selection process of products on these projects is found to be not supported, as the quantity surveyor does provide cost advice on alternative green building materials and products to the design team even though the quantity surveyor is not the chief professional.

Table 4: Evidence of involvement of quantity surveyors in the selection of green build material

<table>
<thead>
<tr>
<th>Importance (1 = Not important, 5 = Very important)</th>
<th>Frequency (%)</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5</td>
<td>13 7 27 7 40</td>
<td>3.73</td>
</tr>
<tr>
<td>The quantity surveyor is incorporated in the selection process of green building materials and products</td>
<td>13 7 7 13 60</td>
<td>4.00</td>
</tr>
<tr>
<td>The engineer is incorporated in the selection process of green building materials and products, instead of the quantity surveyor</td>
<td>13 27 7 13 40</td>
<td>3.40</td>
</tr>
<tr>
<td>The project manager is incorporated in the selection process of green building materials and products, instead of the quantity surveyor</td>
<td>13 27 7 20 33</td>
<td>3.33</td>
</tr>
<tr>
<td>The construction manager is incorporated in the selection process of green building materials and products, instead of the quantity surveyor</td>
<td>20 40 13 0 27</td>
<td>2.73</td>
</tr>
<tr>
<td>The quantity surveyor has an influence on the client's decision to implement green building materials and products</td>
<td>20 7 20 13 40</td>
<td>3.47</td>
</tr>
<tr>
<td>The quantity surveyor provides cost advice on alternative green building materials and products to the design team</td>
<td>8 8 8 15 62</td>
<td>4.15</td>
</tr>
<tr>
<td>The quantity surveyor explains to the client the financial pitfalls of green building</td>
<td>8 0 15 23 54</td>
<td>4.15</td>
</tr>
<tr>
<td>The quantity surveyor explains the financial benefits of green buildings to the client</td>
<td>7 0 14 21 57</td>
<td>4.21</td>
</tr>
</tbody>
</table>
6. RECOMMENDATIONS

Quantity surveyors within the industry who deal with green building projects may find the key principles determined in this study as important steppingstones in requiring knowledge in terms of green building principles. Quantity surveyors may use the key principles highlighted in the study to familiarise themselves with the relevant green building principles which are considered of “utmost” importance. The cost premium suggested by respondents provides construction professionals with more detail on the cost of constructing green or sustainable developments when encouraging their clients to implement green building techniques and designs.

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Effects of COVID-19 on employees in the construction and consulting engineering companies in the small and medium sector, South Africa

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ABSTRACT AND KEYWORDS

Purpose of this paper
The study aimed to establish the effect of the COVID-19 pandemic on employees within the construction and consulting engineering companies in South Africa.

Design/methodology/approach
This is a literature review paper which analyses empirical research carried on COVID-19 and its implications on employees within the small and medium enterprise sector. The literature review was limited to only the studies conducted between the periods of the COVID-19 pandemic (2019-2022).

Findings
The result of this study demonstrate that although the pandemic has impacted both large firms and small and medium enterprises, its effects are more significant on small and medium enterprises. It was found that compared with large firms, employees within the small and medium enterprises are more vulnerable to the COVID-19 pandemic, having been laid off or having reduced work hours and pay.

Original/value of paper
This study is significant because it contributes to the existing knowledge of the COVID-19 pandemic and its consequences on employees in small and medium enterprises. Moreover, the study serves as a valuable tool for organisations, especially small and medium enterprises, on how to respond to a pandemic of this nature. Additionally, the study will help promote the sustainability of small and medium enterprises by adopting different strategies to respond to the COVID-19 pandemic.

Keywords: COVID-19 pandemic, small and medium enterprises, South Africa.
1 INTRODUCTION

COVID-19 has exacerbated the challenges faced by small and medium enterprises (SMEs) as the pandemic is devastatingly impacting the survival and operation of SMEs globally. This is because many SMEs have experienced and will continue to experience a decline in their productivity and profitability due to the pandemic. The Institute of Business Administration (2020) reported that the COVID-19 outbreak had left every sector of the economy globally devastated, although preventive measures to curb its spread are in place. Scholarly researchers such as Balla-Elliott, Cullen, Glaeser, Luca and Stanton (2020), Bartik, Bertrand, Cullen, Glaeser, Luca and Stanton (2020), Dua, Ellingrud, Mahajan and Silberg (2020), Lindsay, Neha, Mahajan, Maxwell, and Pandher (2020) and Organisation for Economic Co-operation and Development (OECD) (2020) have acknowledged although the pandemic has impacted both large firms and SMEs, recent evidence suggests its effects are more significant on SMEs. According to Ganaie, Zafar and Seth (2020), 89% of SMEs is experiencing financial difficulties, while 60% have reported negative issues and concern in retailing their products.

Beglaryan and Shakhmuradyan (2020) believe that compared to large enterprises, employees within the SME sector are more vulnerable to the COVID-19 pandemic, having been laid off or having reduced work hours and pay. Furthermore, Beglaryan and Shakhmuradyan (2020) argue that people employed by SMEs double the likelihood of layoff and pay reduction. According to International Labour Organization (2020), and World Health Organization (2020), globally, due to lockdown measures, around 300 million full-time employees have become unemployed or have experienced reduced work hours and pay. Among these employees, those within the SME sectors are more affected by the pandemic. Research (Fernandes, 2020; Saltiel, 2020) suggests that irrespective of firm size, the effects of the pandemic on employment have been more significant in industries such as transportation, trade, arts and entertainment, food and hospitality and construction. Given the effects of COVID-19 on all sectors, social commentators expressed that the pandemic will increase income inequality within nations besides engendering poverty. This is because most of the jobs that can be performed remotely are relatively high-paying positions occupied by professionals with medium to high qualifications (Elliot Major & Machin, 2020; Furceri, Loungani, Ostry & Pizzuto, 2020; Palomino, Rodriguez & Sebastian, 2020; Sumner, Hoy & Ortiz-Juarez, 2020).

In a study by Bartik, Bertrand, Cullen, Glaeser, Luca and Stanton (2020), 43% of SMEs had temporarily closed, and nearly all of these closures were due to COVID-19. Furthermore, it was found that SMEs have reduced their active employment by 39% since January 2020. Bartik et al. (2020) estimated that the closures alone might lead to 32.7 million job losses if the crisis lasts for four months and 35.1 million job losses if the crisis lasts for six months. Robinson and Kengatharan (2020) observed that given the outbreak of the pandemic, SMEs have suffered from a shortage of workers and production inputs because of distortions that marred supply chains.

Biswa, Ghosh, Kar, Mondal, Ghosh and Bardhan (2021) argued that the construction and engineering around the world have been jeopardize in various way by the COVID-19 pandemic and many projects have closed. Because of this, there has been a financial recession in the construction industry in almost all countries and has created unemployment. Musonda and Rakolote (2022) also confirm that COVID-19 pandemic has negatively impacted several sectors of the economy worldwide. The regressed economic environment exacerbated its effects on the construction industry, especially in developing countries such as South Africa. Similarly, Iqbal, Ahmad, Waqas and Abrar (2021) concur that the main contribut’r to countries’ economies, the construction industry faced multiple challenges due to pandemics. Given the evidence from the empirical research, this study seeks to investigate the effects of COVID-19 on employees within the construction and consulting engineering industries.

2 LITERATURE REVIEW

2.1 Historical Background of the COVID-19 pandemic

In March 2019, the coronavirus, also known as the COVID-19 pandemic, was first detected in Wuhan City-Hubei Province, China, which changed the way of life, working, relationships, economies, needs and rights of the global population (Khoso & Noor, 2021). The coronavirus is a virus that affects mammals, animals and humans. According to Herawati (2021), within a short period, the COVID-19 outbreak spreads quickly to other parts of the world. Nguse and Wassenaar (2021) believed that COVID-19 is a disease caused by severe acute respiratory syndrome coronavirus 2, which has affected
most parts of the globe. Given the wide spread of the COVID-19 outbreak and death mortality, the World Health Organization (WHO), on January 30, 2020, declared the SARS-CoV-19 out-break an international public health emergency.

South Africa confirmed its first COVID-19 infection on 5 March 2020. Since March 2020, when the Minister of Health confirmed the first South African positive test of COVID-19, the virus has become integral to everyday life in South Africa (Nguse & Wassenaar, 2021). Given the widespread virus, South Africa went into a hard lockdown to limit the spread of the disease.

Following the promulgation of the lockdown on 27 March 2020, the government of South Africa issued regulations enforcing limitations of gatherings to 50 people, amongst other measures such as travel restrictions, self-isolating, and closing of schools and businesses (South African News Agency, 2020). According to Jain, Budlender, Zizzamia and Bassier (2020), the complete lockdown was untenable, despite the government's several interventions. The economic implications of the nationwide shutdown made it unsustainable. Since then, the government has reduced the levels of lockdown restrictions in phases to enable the economy to function again.

2.2 Profile of the South African Small and Medium Enterprise Sector

Post-1994, South Africa witnessed severe socio-economic challenges that required urgent solutions (Chimucheka, 2013). These challenges are the high unemployment rate, skills shortage, high illiteracy rate, escalating crime rate, and rural poverty. SMEs are considered vehicles through which the above challenges can be addressed. The South African SME sector is diverse and operates in different industries such as retailing, wholesaling, tourism, mining, farming, manufacturing, construction, and service.

For the last decades, the Department of Trade and Industry (DTI) has published comprehensive reports on the South African SME sector (DTI, 2015). However, as the economies evolve and adjust to new phenomena, so is the SME landscape in South Africa. This may be particularly true due to the major socioeconomic, political, and technological events of the last few years. Some of these events are namely, the financial crisis of 2008 and 2009, political instability, and now the COVID-19 pandemic. According to Makwara (2019), the South African social and economic development strategies are dependent on harnessing the entrepreneurial potential and supporting SMEs. Since the passage of the 1995 White Paper on small, micro, and medium enterprises (SMME) development, the investment in the SME sector by the South African government has become evident. Apart from the DTI, other institutions or agencies, such as the Ministry of SMMEs and Small Enterprises Development Agency (SEDA), were created to support the SME sector and contribute to economic growth (Bureau for Economic Research, 2016; Nhlapo, Nieuwenhuizen & Yazdani, 2011). According to Mukumba (2014), South Africa’s SME sector accounts for more than 90% of business operations and contributes to more than 50% of employment and GDP (Mukumba, 2014).

2.3 Impact of COVID-19 Pandemic on Construction and Consulting Firms

The impact of COVID-19 on the global construction and engineering sectors are well documented. According to Biswas et al. (2021), construction companies are facing a financial recession due to the COVID-19 pandemic. Moreover, Iqbal et al. (2021) observed that COVID-19 has an adverse effect on the construction sector of different developed and developing countries. It has been found that construction and engineering industries business are at risk because of the adverse impact of COVID-19 that leads to a decrease in economic growth. The restrictions on construction and engineering projects due to the pandemic crisis has weakened economic growth, enhanced unemployment, disturbed supply chain of construction materials, and increased the loss of investment (Bsisu, 2020). It has been estimated that international construction growth in the current year has been lessened from 3.1% to 0.5% (Global Data, 2020). Unfortunately, the crisis of the construction industry in COVID-19 develops an unprecedented opportunity to resolve the critical issues that belongs to the construction industry. The stakeholders of the construction sector, such as builders, contractors, and owners, faced the crisis of COVID-19 at a global level (Ogunnusi, Hamma-Adama, Salman & Kouider, 2020).
2.4 Hypotheses Development

There is a consensus among researchers that the COVID-19 pandemic has resulted in massive job loss. For example, a survey conducted by McKinsey (2020) reveals that in Europe, at least two of three jobs in the SME sector are at risk. Wanberg, Ali and Csillag (2020) noted that as the COVID-19 pandemic shut down industries such as travel, hospitality, sports, and entertainment, tens of millions in the US alone filed new unemployment claims in early 2020. Kretchmer (2020) claimed that the current G7 jobless ranges from 30 million in the United States to 1.76 million in Japan. Likewise, in Australia, 68% of jobs in SMEs are at risk (McKinsey, 2020). In Germany, Welter, Wolter and Kranzusch (2020) estimated that the lockdown exceeding six months would result in significant job losses between 850,000 and 1.6 million in the SME sector. Likewise, in the United States, more than 20 million jobs were lost in April 2021, of which the SMEs alone accounted for 11 million (McKinsey, 2020).

In Canada, a survey showed that women owned businesses laid off more than 80% of their workforce (McKinsey, 2020). Lu, Wu, Peng and Lu (2020) advocated that because of the lockdown restrictions and closure of most SMEs, majorities of the employees are losing their jobs. Gustavsson and Larsson (2020) noted that job loss is prevalent in the SME sectors such as tourism and travel, stock markets, entertainment, and manufacturing. In South Africa, Ranchhod and Daniels (2021) observed that one out of every three employees either lost their job or did not work and received no wages since April 2020. Moreover, the National Income Dynamics Study- Coronavirus Rapid Mobile Survey (NIDS-CRAM) (2020) reported that the period from February to April of 2020 saw an unprecedented decrease in employment. Posel, Oyenubi and Kollamparambil (2021) also observed that the COVID-19 pandemic significantly impacted employees' work. The following hypothesis was proposed based on the empirical findings.

H1 There is a positive relationship between COVID-19 pandemic and job creation in the small and medium enterprise sector

The shock to labour demand globally is likely to translate into a significant reduction in employees’ wages and working hours. Robinson and Kengatharan (2020) observed that given the outbreak of the pandemic, SMEs and employees have suffered from a shortage of workers and production inputs because of distortions that marred supply chains, negatively impacting their ability to fulfil the financial obligations and pay employees’ salaries. According to Wanberg et al. (2020), many employees are most likely to lose income due to the lockdown restrictions and closure of many firms. In South Africa, a study by Jain et al. (2020) revealed that nearly 17% of the respondents reported that they were currently not working any hours and had not received payment. The International Labor Organization (ILO) (2020) reported that 1.6 billion workers within the informal sector had been impacted by COVID-19, resulting in a 60% reduction in their earnings. Based on the above, the following hypothesis was advanced.

H2 There is a positive relationship between COVID-19 pandemic and employee income in the small and medium enterprise sector

2.5 The Theoretical Framework that Underpins the Study

Extant literature suggests that various theories support the growth and survival of SMEs. Nevertheless, the most appropriate theoretical framework that underpins the study is the strategic management theory. It is believed that in this turbulent business environment occasioned by the COVID-19 pandemic, firms require long-term strategies to remain sustainable. This assumption underpins the importance of the strategic management theory. Chandler (1962) was among the first scholars to provide a systematic account of corporate strategy and described the strategic and structural development of organisations, noting that “structure follows strategy.” Around the 1970s, the conceptualisation of strategy emerged around formulating policies, strategic planning, and adapting organisations to their business environments. Hofer and Schendel (1978) and Schendel and Hofer (1979) described the strategic elements of a firm based on goal formulation, environmental analysis, strategy formulation, strategy implementation, strategy evaluation, monitoring and control.

Mintzberg (2008) points out that the notion of the strategy was introduced as a technique for organisations to achieve their goals and objectives. Simmons (2000) argues that strategy refers to “how the company creates a value for customers and stands out from other competitors in the market.” In
other words, strategy can be understood as a perspective, position, plan, or pattern of behaviour. From the above explanations, it can be argued that the strategic management theory emerged to decide on organisational goals and means to achieve them. Scholars (Minzberg, 2009; Spender, 2014) believe that the strategic management theory assists firms in developing a long-term vision, identifying critical suppositions and converting data into reliable information. A long-term vision, identify critical suppositions and convert data into reliable information.

3 RESEARCH METHODOLOGY

The research aimed to determine the effects of the COVID-19 pandemic on employees in SMEs. To achieve the purpose of the study, a through literature review was carried out on the empirical research that investigated the impact of COVID-19 on employees globally. The literature review was limited to only the study conducted between the periods of the COVID-19 pandemic (2019-2022). The methodology adopted involved examining and analysing selected research related to COVID-19 and employees. The study adopted the quantitative research method. The quantitative research method was adopted because it is a formal, objective, rigorous, deductive approach, and systematic strategies for generating and refining knowledge to problem-solving (Burns & Grove, 2005). Moreover, the quantitative research method was employed to obtain accurate and reliable measurements about the subject matter (Rahman, 2017).

Furthermore, the study adopted the descriptive research design to adequately describe the subject matter. The descriptive research was carried out because the investigator has no control over the variables, hence cannot manipulate them. Another justification for adopting the descriptive research is to explain and validate the research findings. Secondary sources of data were used to gather information that relate to subject matter. The sources include journals, reports, archival, and published literature. The reliability and validity of the research findings were ensured as the information published was already audited and approved by the institutions concerned.

4 FINDINGS AND DISCUSSION

The study investigated the effects of the COVID-19 pandemic on employees within the SME sector. Two research hypotheses formulated were tested and achieved via the literature review. The overall findings revealed that the COVID-19 pandemic had impacted employees significantly in many ways. Hypothesis one determined the impact of the COVID-19 pandemic on job creation. The literature review suggests that the COVID-19 pandemic significantly impacted employees’ jobs in the SME sector. In Europe, a survey conducted by McKinsey (2020) reveals that at least two of three jobs within SMEs are at risk. Kretchmer (2020) asserts that the current G7 jobless ranges from 30 million in the United States to 1.76 million in Japan. Likewise, in Australia, 68% of jobs in SMEs are at risk (McKinsey, 2020). In Germany, Welter et al. (2020) estimated that the lockdown exceeding six months would result in significant job losses between 850 000 and 1.6 million in the SME sector. In Canada, a survey shows that women-owned businesses laid off more than 80% of their workforce (McKinsey, 2020). In South Africa, Ranchhod and Daniels (2021) observed that one out of every three employees either lost their job or did not work and received no wages since April 2020. Moreover, the National Income Dynamics Study- Coronavirus Rapid Mobile Survey (NIDS-CRAM) (2020) reported that the period from February to April of 2020 saw an unprecedented decrease in employment. Posel, Oyenubi and Kollamparambil (2021) also made a similar observation that COVID-19 pandemic had a significant impact on employees’ work.

Furthermore, hypothesis two assessed the impact of the COVID-19 pandemic on employee income/salary. The findings from previous empirical research confirmed that the COVID-19 outbreak negatively affected employees’ income during the lockdown and closure of businesses. Robinson and Kengatharan (2020) believed that given the outbreak of the pandemic, SMEs and employees have suffered from a shortage of workers and production inputs because of distortions that marred supply chains, negatively impacting their ability to fulfil the financial obligations and pay employees’ salaries. Wanberg et al. (2020) found that many employees are most likely to lose income due to the lockdown restrictions and closure of many firms. Moreover, in South Africa, a study by Jain et al. (2020) reveals that nearly 17% of the respondents reported that they were currently not working any hours and had not received payment. Similarly, The International Labor Organization (2020) reported that 1.6 billion
workers within the informal sector have been impacted by the COVID-19 resulting in 60% reduction in their earnings.

5 CONCLUSION AND FUTURE RESEARCH

The study analysed the impact of the COVID-19 pandemic on employees in SMEs in South Africa. A thorough literature review was conducted to test the research hypotheses. Findings from the literature review indicated that the COVID-19 pandemic negatively impacted employees within the SMEs in many ways, including but not limited to job loss, reduction in salary or loss of income, increase in stress and burnout and addiction. According to Ranchhod and Daniels (2021), in South Africa, one out of three employees either lost their job or did not work and received no wages since April 2020. Besides, Kretchmer (2020) claims that the current G7 jobless ranges from 30 million in the United States to 1.76 million in Japan. The study makes a practical contribution to SMEs because it sheds more light on how COVID-19 impacts employees. The findings will assist SMEs in responding to the challenges posed by the COVID-19 pandemic. In addition, this study is significant because it expands the knowledge of the COVID-19 pandemic and its consequences on employees in small and medium enterprises.

The scope of the investigation was limited to desktop research. This suggests that there is a lack of empirical research on the effect of the COVID-19 pandemic on employees in SMEs. Therefore, future research on the impact of the COVID-19 pandemic on employees should be based on field research.

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Investigation of Simplicity principle as a solution for Complexity within architectural design process

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ABSTRACT AND KEY WORDS

Purpose
This research aims to investigate the role of the simplicity principle towards overcoming the complexity of the architectural design as an approach for developing sustainable construction projects.

Design/methodology/approach
In order to achieve the above-mentioned aim, a scientometric analysis was conducted to identify the needed literature to be reviewed. This was followed by an investigative approach that determine the different factors that lead to complexity in the architectural domain. Moreover, different simplicity techniques that were used to reduce the complexity in architecture was revised. Finally, a deductive relationship matrix was developed to portray the relationship between Simplicity approaches and Complexity aspects.

Findings
The research identified the five core aspects of scientometric analysis for papers that relate to the scope of the study. Then through literature review, the research identified the main concept of complexity, its types and aspects as well as the simplicity concept and its use in the Architecture/Engineering/Construction industries concluding with a relationship matrix that propose simplicity techniques as a solution to the complexity aspects

Originality/value
The research is studying a relatively novel topic that has not been previously explored enough in the architecture domain. This can be due to the way of precision of the design process where to relate it to the complexity science. However, this research aims to isolate those research that focus on architecture and highlight the outcome in the literature section.

Keywords: Architecture Design Process; Design Sustainability; Complexity Theory; Simplicity Approaches
1. Introduction

Complexity has been an emerging challenge within multiple subject areas. In the construction industry, the complexity can be regarded within the sophisticated building geometry or the superstructure of high-rise buildings. Furthermore, it can be regarded within the technology used to transform the static behaviour of building to dynamic one. This can be seen in cyber physical systems where embedded building systems and sensor technologies helps the building adapt to its surrounding environment (Pantazis and Gerber, 2019). As Salngaros stated: “complexity is a generative tool”. It can be defined as a detailed structure of information of different components integrated together. There are various ways to perceive complexity whether it is through its level (high to low) or its structure (organized and disorganized) (Salingaros, 2014). Moreover, complexity can result from human action as negligence to information, designer’s low experience, designer’s unfamiliarity with different components and their characteristics, improper planning, lack of effective communication and design errors (Sasitharan Nagapan et al., 2011). However, to what extent complexity can be applicable in the real world and if it is applicable, to what extent it is beneficial. This research aims to answer this question by identify the concept of complexity within the architecture discipline and how it is addressed using simplicity approach. This will occur following a systematic investigation approach and scientometric analysis to understand the complexity theory within the AEC industry. Where it will be followed by identifying the types of complexity in architecture and the simplicity approaches that can be used as a solution concluding with a proposed relationship matrix based on studied literature.

2. Research Method

This paper follows a systematic investigation approach focusing on exploring the previous literature in order to identify a background on complexity theory and its emergence within the construction industry. To collect the relevant Literature, A process was conducted summarized in table (1). So that the first step was to determine data source of the literature. This paper limited the research scope by focusing on one valid data base that is Elsevier SciVerse Scopus as it is considered to have the largest Peer-reviewed work. Secondly, key words were determined to search for the relevant data for the research. Words as Complexity Theory, Architecture, Architecture Complexity, Design Complexity, Complexity management and Simplicity were used to find relevant sources. Furthermore, the third step was the determination of Data types to limit the research scope. It was decided to use open access Journal and conference paper as the main data source collected from 1980 to 2021. For the fourth step, an initial search took place to determine the potential data relevant to the research. After further manual screening, 310 sources were found to be assessed for their relevancy to the topic where 190 were relevant to the engineering discipline. Finally, a scientometric analysis was conducted for the chosen data sources using VOS viewer to draw science mappings. This analysis was based on the core aspects of scientometric analysis which are co-authorship, published journals, co-occurring keywords, and regions aiming to provide researchers with a clear understanding of the current research status. This will be followed by further identification of the relationship between complexity factors that impact the architecture design and the simplicity approaches that can be used as a solution.
Table 1: Summary of Conducted Method

<table>
<thead>
<tr>
<th>Step</th>
<th>Determine Database</th>
<th>Research Keywords</th>
<th>Complexity Theory, Architecture, Complexity management and Simplicity</th>
<th>Access, Years, Document Type, Publication Stage, Source Type, Language</th>
<th>All Open Access, 2021, 1980, Article, Final, Articles, Conference Paper, English</th>
</tr>
</thead>
</table>

Step 1 Determine Database - Elsevier SciVerse Scopus Accessed 13.01.2022

Step 2 Determine Research Keywords - Complexity Theory, Architecture, Complexity, Design Complexity

Step 3 Determine Research Limitations - Access, Years, Document Type, Publication Stage, Source Type, Language

Step 4 Initial Search - Journals Papers 310

Step 5 Manual Screening - Journal Papers 190

Step 6 Conduct a scientometric analysis using VOS Viewer for Scientific Mapping

Step 7 Identify the relationship between Complexity Parameters and simplicity approaches

3. Scientometric Analysis

As previously noted, the conducted research resulted in 310 paper that focused on the complexity theory within the engineering disciplines between 1980 and 2021. It was found that the number of published papers increased as shown in figure (1) which indicated the increase interest and the importance of this research domain.

![Graph showing number of publications per year](image)

Figure 2: Number of publication per year

The resulted paper included various subject areas where Engineering included 36 percent of the recommended papers and ranks in second place in the subject area field as shown in figure (2).
This shows the increasing interest in the complexity theory within the AEC industry. Furthermore, this can be confirmed by a research conducted by Pantazis et al. where the researchers conducted a comprehensive review of the complexity theory within 1980s to 2018. The study showed the constant publication trend in different subject areas as physics, mathematics, decision science and cybernetics. As for the architecture discipline, the study noted that very few publications were found in the early 1990s. However, a significant increase was noted in the number of publications later on. This can be due to the emergence of digital design tools and the Santa Fe institute dedication for studying complexity theory across various discipline (Pantazis and Gerber, 2019). Using VOS viewer scientometric analysis was further conducted. The mapping presents a network diagram (map) for each core aspect showing the connections between its elements as well as the significance of their contribution presented in the nodes size.

3.1 Co-Authorship Analysis

Academic Cooperation is common in the research field to enhance the productivity and quality of research. Parameters were set so that the minimum number of documents is two and the citation of a scholar is 2. This provided a total of 34 scholar meeting the set parameters where scholar only were connected as shown in Figure (3). The lack of connection between scholars can be due to various subject areas where each group focused on certain discipline.
Published Journals Analysis

As Research results are shared through publishing organizations, they were identified and presented in figure (4) to introduce the most influential Organizations in this study field. Parameters set for this analysis were number of documents which was set at 2 and number of citations which was set at 2. A total of 7 organizations met the required parameters, however none were connected. The nodes’ size of this map showed the equal contribution of the 7 organizations where each focus on specific field. Furthermore, each of the 7 organizations is located in different country showing the increase of interest worldwide.

![Publishing Organization Mapping]

Figure 5: Publishing Organization Mapping

3.3 Co-occurring Keywords Analysis

Keywords analysis is conducted to identify the scope of research topics and the future research directions. The parameters were set so that the number of occurrences of a keyword was 15 as shown in figure (5). This resulted in presenting 20 keywords. The mapping shows that the occurrence of the architecture design as a keyword has emerged between 2005 and 2010, where the rest of the keywords shows the research orientation towards computational design.
3.4 Region Analysis

The final analysis is region analysis which was conducted to identify the connection between different regions as well as the academic cooperation between them. For this analysis, the minimum number of documents was set at 5 while the citations of regions were set at 25. A total of 13 regions met the selection criteria shown in figure (6). The mapping shows that the leading country within this research domain is the USA with 65 documents followed by China with 21 documents.

4. Literature Review

After identifying the selected publication related to the scope of study. Manual Screening was conducted where the most important notes are highlighted in this section

4.1 Complexity theory

Complexity theory has been an emerging dominating scientific movement since the 1990s (Manson, 2001). It is a wide research scope that can relate to various subject areas. It studies the relationships between different components and their relationship with their surrounding environment within multiple systems. Furthermore, It explains the development, adaptation and changes within the connected systems and describes the effect of these interactions and relationships on the overall behaviour (Sammut-Bonnici, 2015). In other words, complexity presents interdisciplinary knowledge about the
dynamics of change in a certain adaptive system in relationship to the larger environment in which it operates in.

A study by Wood and Gidado (2008), indicated the Santa Fe institute overview on complex behaviour. The Santa Fe institute is a non-profit research institute dedicated to the theoretical research of the complex adaptive systems fundamentals across multiple disciplines. The institute highlighted that complex behaviour emerged from “a number of basic rules controlling parts of the system”. Meaning that no matter how much information on different components is known, complexity behaviour can only be identified by studying the interactions between these components. Furthermore, understanding these interactions can help in the prediction of future behaviour using identified patterns and rules.

Complexity is categorized into two types, organized complexity which is perceived as harmonious response and disorganized complexity which is regarded as randomness (Salingaros, 2014). Whereas organized complexity aims at prevention of information overload using different approaches as continuity, different types of symmetries, scaling, correlations and harmony, disorganized complexity is arbitrary, random, and wilful where its meaning is no-where to be found. To understand the difference between the two types, applicability of both can be regarded where organized complexity can be perceived in adaptive systems while disorganized complexity is applicable to both physical and artificial systems. For example, it can be found in the unpredictability of particles motion within a container (Pantazis and Gerber, 2019).

Furthermore, previous literature further indicated the theoretical nature of research of the perceived topic rather than practical application where opinions were oriented towards the difficulty of translating theory into practice. On the other hand, complexity science is regarded as a solution for multidisciplinary industrial and scientific problems (Wood and Gidado, 2008).

4.2 Complexity in Architecture

Complexity in architecture is yet to be defined. There is no unified definition till the present day. This can be due to the novelty of the study of architecture in relation to the complexity science. Where this is proven by the few number of publication relating to the field of study. This can be due to the way of precision of the design process where to relate it to the complexity science, it has to be regarded as systematic design process that depend on different components (parameters and elements) and their interaction with each other to solve an identified problem by generating various alternatives and evaluating them.

Furthermore, previous literature identified two domains of complexity within the architecture scope. Physical domain relates to quantity with field specific dimensions and functional domain relates to project constrains as information availability, time and energy, level of uncertainty in achieving design goals. Using both domains can help the designer in determining different types of project complexity relates to the geometry of the project, technological parameters, environmental parameters, building performance and user behaviour …etc. then identify its aspects.

4.3 Complexity types

According to San Cristóbal et al., project complexity is divided into four main types: structural, technological, directed, and temporal. Whereas further types were identified as operational and cognitive complexities.
Table 2: Summary of Identified Complexity Types (San Cristóbal et al., 2018).

<table>
<thead>
<tr>
<th>Complexity Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural Complexity</td>
<td>Large-scale projects, which are often divided down into individual tasks and distinct contracts</td>
</tr>
<tr>
<td>Technical Complexity</td>
<td>Found in architectural, industrial design, and R&amp;D projects that contain design features or technical components that are unknown or untested</td>
</tr>
<tr>
<td>Directional Complexity</td>
<td>Common in change initiatives if the project’s direction is unclear, and something must be done to remedy a poor condition</td>
</tr>
<tr>
<td>Temporal Complexity</td>
<td>Emerges in initiatives when there is a significant level of uncertainty about future limitations that might destabilize the project</td>
</tr>
<tr>
<td>Operational Complexity</td>
<td>Identifies the degree to which project organizations are independent when defining their operations to achieve given goals</td>
</tr>
<tr>
<td>Cognitive Complexity</td>
<td>Identifies the degree to which self-reflection, sense-making processes, the emergence of an identity, or even an organizational culture is possible</td>
</tr>
</tbody>
</table>

4.4 Complexity Aspects

According to Wood & Ashton (2010), there are 46 complexity factors that are categorized into 5 categories collected in table (3).

Table 3: Summary of Identified Complexity Aspects (Wood & Ashton, 2010)

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Factors</th>
</tr>
</thead>
</table>
| Organizational (people involved/relationships) | 1. The project partners’ relationships are strained.  
2. There are a lot of participants.  
3. Issues with the customer  
4. Project roles that aren’t clearly specified  
5. Ineffective communication  
6. Ineffective decision-making |
| Operational and technological | 7. Many electrical and mechanical systems are present.  
8. High level of technological sophistication  
9. Using state-of-the-art, cutting-edge, or modern technology  
10. For the first time, executing a procedure  
11. Regulations to be followed  
12. Physical dimensions  
13. There are a lot of deals involved.  
14. Roles with a high level of physical complexity  
15. Roles with a high level of technical complexity  
16. Role with no established method  
17. The construction process’ intrinsic difficulties |
| Planning and management       | 18. A process consists of a large number of pieces.  
19. Project coordination  
20. Organizational structure  
21. High level of interdependencies between processes  
22. Having a large number of essential path activities  
23. Overpriced  
24. Projects with a long timeline  
25. Sequence rigidity  
26. Degree of overlap of phases  
27. Interrelationship between actions in distinct overlapping portions  
28. Inadequate information creation, transmission, use, and feedback |
| Environmental                 | 29. Restricted-access sites  
30. Sites in a public setting  
31. Historic sites  
32. Exposed sites  
33. Sites on polluted ground  
34. Brownfield locations  
35. Recognizing market circumstances  
36. Recognize the legal landscape  
37. International initiatives |
| Uncertainty                   | 38. Inconsistency because of constant resource changes  
39. Inconsistency due to mechanical or other resource failure  
40. The impact of weather or climatic conditions  
41. Unpredictable subsurface conditions  
42. Undefined work in a new structure that is defined  
43. Lack of functioning drawings  
44. Undefined structure or insufficient buildability evaluation  
45. Uncertainty deriving from design and construction overlap  
46. A scarcity of skilled workers in the area |
4.5 Simplicity Approach

The term “simplicity” was often used in American architectural debate from the nineteenth through the early twentieth centuries (Esenwein, 2016). As Antoine de Saint stated: “Perfection is achieved not when there is nothing more to add, but when there is nothing left to take away”. Simple architectures are easier to communicate, build, deploy, operate, and evolve. However, they are harder to achieve. The simplicity approaches increase design efficiency and the probability of an error-free design not only to reduce the high design complexity (Palmer et al., 2010). In this research simplicity approaches are regarded as a solution for the complexity paradigm where different approaches were collected from previous literature in table (4).

<table>
<thead>
<tr>
<th>Simplicity Approaches</th>
<th>Summary</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational</td>
<td>Provide structure to the design process</td>
<td>(Geilen et al., 2001; Palmer et al., 2010; Vahid et al., 1995).</td>
</tr>
<tr>
<td>Division</td>
<td>Divide information to smallest parts possible</td>
<td>(Palmer et al., 2010).</td>
</tr>
<tr>
<td>Modularization</td>
<td>Group information</td>
<td>(Langlois, 2002; Palmer et al., 2010).</td>
</tr>
<tr>
<td>Holistic</td>
<td>Use all information within the scope</td>
<td>(Jiao &amp; Helander, 2006; Palmer et al., 2010).</td>
</tr>
<tr>
<td>Requirement Traceability</td>
<td>Follow requirement throughout process</td>
<td>(Gumus et al., 2005; Palmer et al., 2010).</td>
</tr>
<tr>
<td>Top-Down Approach</td>
<td>Start broad then form smaller groups</td>
<td>(Palmer et al., 2010).</td>
</tr>
<tr>
<td>Integrated Approach</td>
<td>Combine as many parts as possible</td>
<td>(A Bondavalli et al., 2001; Palmer et al., 2010).</td>
</tr>
<tr>
<td>Agent-Oriented Approach</td>
<td>Abstraction, Decomposition, and Organization</td>
<td>(Booch, 1994; Cossentino et al., 2007; Palmer et al., 2010).</td>
</tr>
<tr>
<td>Axiomatic Design</td>
<td>Breaks problem space to 4 domains</td>
<td>(Palmer et al., 2010; Yassine &amp; Falkenburg, 1999).</td>
</tr>
</tbody>
</table>

5. Discussion

Based on the previous sections, it was found that the 46 factors of complexity (categorized into 5 aspects) could be managed using approximately all the previously discussed simplicity approaches taking into consideration the availability of the needs for the use of each approach to be applied. Furthermore, it determines the need of guidelines for integrating simplicity approaches within architectural design process to manage complexity is provided.
Table 5: Relationship between Simplicity approaches and Complexity aspects

<table>
<thead>
<tr>
<th>Complexity Aspects Categories</th>
<th>Organizational</th>
<th>Division</th>
<th>Modularization</th>
<th>Standardization</th>
<th>Holistic</th>
<th>Requirement Traceability</th>
<th>Top-Down Approach</th>
<th>Integrated Approach</th>
<th>Agent-Oriented Approach</th>
<th>Axiomatic Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operational and technological Planning and management</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertainty</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. Conclusion and Recommendation

This research conducted basic research on the complexity science within the AEC Industry specifically the architecture domain. Mapping of scientometric analysis was conducted to identify the leading research authors, countries and organizations as well as the recent trends within the last 3 decades. This was followed by manual screening in order to highlight the important notes related to the architecture discipline. The research identified the main aspects of complexity in the architecture domain as its meaning, types, research trends and complexity aspects and their corresponding factors. Furthermore, an identification of simplicity approaches was done. Finally, relation between Complexity aspects and Simplicity was proposed through relationship matrix. Future research is recommended to address this domain specially within the architecture Engineering disciplines. Whereas as Complexity can be addressed as a philosophy adopted as a design approach (Design Phase) or applicability of complex designed projects (Construction and operation phase). Furthermore, Raising the awareness of the need to solve problems caused by complexity is needed especially in the early stage before it is already happened to preserve time and money. Finally, awareness of the concept of simplicity approaches as a solution to get the best results for the project is needed and recommended to be developed and tested on practical level.

7. References


Impact of Ethics and Professional Conduct on the Quality of Services Rendered by Construction Project Managers.

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ABSTRACT & KEYWORDS

Purpose
Construction and infrastructure development plays a significant role in improving the lives and the economy of South Africa. The construction project managers (CPM) are appointed to ensure that the project runs accordingly by offering required activities on time and within the allocated budget. The aim of the research was to determine whether stakeholders and project sponsors are being exploited in terms of unethical and unprofessional conduct by the CPMs. The objective of the research was to determine whether there is a collusion between the CPMs that have any impact on the quality of work in the construction sector. The South African government has professional councils in place that regulates and monitor the professional behaviour in the construction sector.

Methodology
A qualitative research method was used as a primary method to collect data from the eight respective participants. Publications from academic and government sources were used as secondary method to supplement the primary data.

Findings
The findings in the study have indicated that corruption is one of the contributing factors towards unethical behaviour and poor workmanship in the sector. There is still a significant gap between the professionals where skills transfer becomes a concern. Private sector relies primarily on experience as opposed to public sector which relies on professional registration.

Value
Relevant authorities such as the South African Council for the Project and Construction Management Professionals and law enforcement officers should strengthen the legislation that would enforce harsher penalties on parties that conduct unethical practices. The SACPCMP should regulate the profession in a manner that there is a separation of power where professionals operate as both principal agent and the CPM.

Keywords: Ethical Behaviour, Corruption, Registered Construction Project Manager, The Construction Sector
1 INTRODUCTION

Construction and infrastructure development plays a significant role in improving the lives and the economy of South Africa (SA). Proper planning and good workmanship have a positive impact in providing good quality infrastructure on time and within the allocated budget. The emphasis on good workmanship has a critical impact in providing good ethics within the construction sector. Professional conduct is one of the characteristics that could make or break a lucrative construction project that could have a significant impact on socio-economic factors in the society. Construction projects with unethical conduct have the potential of chasing away investments, and the quality of the product is often compromised.

There are professional councils in SA such The South African Council for the Project and Construction Management Professionals (SACPCMP) that are legislated and constituted to ensure that stakeholders and professionals adhere to set standards and professional fees are regulated in the process to ensure that there is value for money in every activity (Republic of South Africa, 2000a). Professional practice enables workers on-site to have better working conditions which have an impact on providing good workmanship. Professional conduct plays a significant role in the construction sector; clients and other stakeholders are protected and have an essence of value for money in paying for proper services. Humanity is very critical where stakeholders’ needs should be prioritised ahead of any other superior motives where quality is prioritised. The construction sector has been identified as one of the most corrupt industries globally making it easy for unethical practices to take place such as price-fixing, fierce competition, and paper-thin margins (Adnan, Hashim, Yusuwan and Ahmed, 2011: 719).

The sector has been identified as the most susceptible to unethical activities because it consists of substantial capital investment, provides opportunities at a larger scale for rent extraction, and investments that cannot be shifted around upon the implementation of the project. Construction companies survive in the industry by implementing very aggressive and unethical business practices such as non-competitive prices which keep them in operation. Construction project managers (CPM) are recruited to ensure that the project runs smoothly by delivering the product on time, within the allocated budget and the quality of work is maintained from the inception stage to project hand-over. CPM is responsible for quality deviations, non-conformations and personnel verify that the work is of good quality and according to regulated standards and there are no shot-cuts. Professional ethics and conduct within the construction project management sector have a serious impact on the quality of services rendered by CPM on both existing companies and the newly established small businesses.

The research consists of a primary question and three secondary questions which supports the initial question. The primary question focuses on the impact that the professional misconduct and unethical behaviour have on the quality of work carried out by the CPM and contractors on site. Secondary questions pay attention to the mechanisms that the CPM use to identify misconducts within a project and ways which could be used to mitigate such acts. The research aims to determine whether stakeholders and project sponsors are being exploited in terms of unethical and unprofessional conduct by the CPM. The objective of the research is to determine whether the unethical behaviour in the construction sector has any impact on the quality of work done by the CPM.

2 LITERATURE REVIEW

The construction sector is contributing significantly to the world economy in terms of employing and constructing infrastructure. The research has indicated that the cost adjustment on the construction and infrastructure development is more of a rule than an exception. Professional ethics influence the quality of construction work in the built environment. The construction sector has been labelled as one of the most corrupt industries in the world where corruption has led to underperformance, cost overrun, and quality of the product being compromised. According to Flyvbjerg, Holm and Buhl (2002) indicated that at least 90% of the construction development had initially under-estimated the prices and there is a common cost overrun of 50% to 100%. Unethical behaviour in the built environment has been created by the brutal competition between the professionals and the contractors. The competition has an impact to push for unethical behaviour in the relationship between the employer and employees (Bowen, Edwards and Cattell, 2012: 523).
The use of different languages, implementation of various cultures, and differences in national industry systems and legal frameworks make it challenging for parties to unite in the built environment. The system makes one region to be superior to the other and regions that lack in terms of resources will be taken advantage of and eventually become oppressed by the elite nations (Al-Emad and Rahman, 2017). CPM in the Middle and the Far East is mostly influenced by international companies that work in the region and more work should be done to empower local professionals in terms of providing proper education and establishing local professional councils that regulate the profession (Smith, 2014: 490). The Charted Institution of Building (CIOB) has indicated that the improvement of ethical behaviour in the built environment will improve the industry’s performance by creating a mutual understanding of the rights of each stakeholder in the sector and acknowledging the responsibility of each role player (CIOB, 2014). Most of the projects in Iran source their funding from the government and political interference plays a significant role in dictating who should secure the project and professionals who have political affiliations benefit from this initiative (Motlhatlhedi and Nel, 2019: 601). The concept already compromises the existing policies that have been published by authorities to regulate the sector.

Delays in the built environment have been identified as a global crisis where most of them are due to wrong designs, poor contract administration and shortage of employer supervision. The conflict and power struggle between role players in the built environment could lead to trust issues where the relationship could be jeopardised (Olugboyega and Windapo, 2019: 115). The crisis could lead to behavioural challenges where there could be a reluctance to verify the information and poor communication between parties which could subsequently break the relationship between them. Asian countries are encouraging transformation which revolves around the progressive upgrade of economies’ capability to offer complex and high-quality output and push for investment in infrastructure and introduction of policies to manage the development within the construction sector and entrepreneurship as well as empowering upcoming personnel through training and skills development (Musonda, Gumbo and Okoro, 2019: 77).

The African continent is becoming a very stronghold for the CPM profession where the profession is well represented through professional councils and the strength continues to grow. The serious challenge currently being experienced in the continent is the transfer of skills from those countries that are well established with good structures and well equipped to cater for CPM tasks. Occupational health and safety (H&S) has always been neglected in sub-Saharan Africa where the rating of H&S has been lower as compared to developed nations (Emuze and Khetheng, 2016: 221). Availability of personal protective equipment (PPE) and the number of incidents on site are influenced by sufficient professional conduct in adhering to the regulations of H&S. Africa is a developing continent and most of the developing nations are experiencing a shortage of resources. Lack of legal and institutional arrangement for the management of H&S has escalated the challenge of H&S in Africa.

South Africa has been affected by leadership challenges in the built environment which has forced the current leaders to reinvent themselves or resign and make way for new leaders to take up the task. Proper leadership plays a vital role in the built environment in SA as the project’s success is measured in terms of being completed on time and within the allocated funding. The lack of leadership in the country harms the industry as projects are slow and often not even completed. Project leaders can influence the behaviour of stakeholders and their leadership practice needs to be taken into consideration for the project to succeed (Liphadzi, Aigbavboa and Thwala, 2015: 285). The introduction of the National Development Plan (NDP) vision 2030 has instilled energy towards fulfilling the government’s mandate of improving infrastructure development in the country (Republic of South Africa, 2012a).

There are still concerns being raised even when the policy is in operation in terms of execution, satisfactory outcomes, operational efficiency, and proper project management within the allocated funding and on time. The SA built environment has always had a good source of funding and proper planning has always been in place; however, leadership has always been a concern. Leadership values and honesty have always been questioned by the CPM and there has been a criterion in place to link leadership styles for project successes (Liphadzi et al., 2015: 287). The unity amongst the team and good performance from each participant together with the performance of the whole team plays a significant role in the success of the project. The leader must set boundaries and ignite performing spirit
in the team to achieve a functional team. The leader must have a vision, clarity in reasoning and the ability to recruit an effective team.

Most of the organizations in the have designed ethical policies; however, there are still high cases of unethical conduct in the construction sector. The public expects both the public and private sector to be competent, responsible and show an interest in serving the community at large. The entities have adopted ethical principles and the enforcement of standard procedures has become more important to the public. Various professions and professionals increase, and the workplace becomes ethical sensitive as the credibility of the whole profession is in danger when lapses of ethical behaviour take place (Abdul-Rahman, Wang and Saimon, 2011: 3). The professional councils face challenges on how to regulate themselves efficiently to emphasise independence and on the other hand ensure that clients of the council’s members benefit from the profession and the professional’s actions and not become the victims of unethical practices.

The private and public sectors have established disciplinary hearings where serious allegations are being investigated and there are serious repercussions where the guilty party could either be dismissed or suspended. The SA government has a team that is designated to review documentation that is submitted for tender bidding where the committee evaluates submitted documents and identify any misrepresentations and report such incidences to the head of the institution for further actions (Republic of South Africa, 2012b: 18). The SA government has developed legislative frameworks which are monitored by various professional councils to guide and ensure that the profession is well-regulated and functional. The SACPCMP has introduced the continuous professional development (CPD) system that enables the CPM to partake in developing and creating innovative methods that would empower both the council and profession. The system also identifies gaps within the profession and come up with solutions to such challenges.

3 RESEARCH METHODOLOGY

The qualitative research method was used to gather data because the procedure has a way of highlighting and interpreting responses provided during the interviews. Qualitative research focuses on exploring and discovering critical challenges about the problem that has been identified because there is little knowledge about the matter under investigation (Lynch, 2014: 32). An in-depth interview was used to gather data. Interviews were used as the primary method of data collection and document analysis was considered as a secondary method of data collection.

The research consisted of registered CPM in the construction sector. The purpose of using registered professionals is that that personnel are regulated by legislation that is set out by the SA Government. Participants were chosen based on the vast experience, rich knowledge that they possess, and the willingness to articulate the experience by offering critical information which could guide and give the researcher a better understanding. A purposive sampling approach was utilised to identify participants for this research. A total of eight participants was identified in this research and the said amount was concluded since data saturation was reached, and no new information was revealed during the interviews (Mashangwane, 2013: 63). Data collection was done in two phases where the first phase was a primary source in a form of an in-depth interview with the participants and the secondary source was based on government publications and academic documents. A semi-structured interview was used as the primary method to acquire data from the participants. Data was thoroughly examined and compared during the coding process. The body language, pause, laughter and facial expressions were observed. The method assisted the researcher in creating a descriptive and multi-dimensional category that offers a preliminary framework for data analysis.

4 RESEARCH RESULTS AND DISCUSSION

Invitation to participate in the research interview was sent out through the SACPCMP and there was a total number of eight participants that took part in the study. The feedback has indicated that 88% of the participants were male and only 12% were female. The study focused on both the private and public sectors and the feedback indicates that the public sector was well represented with over 88% of participants while the private sector was represented by only 12%. Participants that took part in the study hold post-graduate qualifications ranging from construction management, civil engineering and
quantity surveying. Table 1 below represents the amount of experience that the participants have in the profession.

Table 1: Amount of experience amongst the participants in the profession.

<table>
<thead>
<tr>
<th>Years of experience</th>
<th>Number of participant(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5</td>
<td></td>
</tr>
<tr>
<td>6-10</td>
<td>37.50%</td>
</tr>
<tr>
<td>11-15</td>
<td>37.50%</td>
</tr>
<tr>
<td>15-20</td>
<td>12.50%</td>
</tr>
<tr>
<td>21-25</td>
<td>12.50%</td>
</tr>
<tr>
<td>26-30</td>
<td></td>
</tr>
<tr>
<td>31+</td>
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</tr>
</tbody>
</table>

Most of the participants have over five years’ experience in the industry and only a few participants have over 20 years’ experience in the fraternity as indicated in table. The low turnout from experienced professionals has raised a serious concern in terms of the gap in the profession especially since most of them have vast experience and occupy strategic positions and this should be used as an opportunity to transfer skills to the upcoming generation. Most of the private companies that were contacted had no registered CPM and relied mostly on experienced people who have been in the industry longer.

4.1 Response from the participants and the key findings:

4.2 Project induction:
The researcher asked the following question to the eight participants: “Are there any inductions about ethical behaviour prior to the commencement of the project? If so, who conducts it?” Most of the participants have indicated that the procedure is part of the conditions in the contract, and it is expected of them to be always aware of such. The participants further stated that the presentation is often done by a member who is not registered as CPM.

4.3 Mechanisms used for safety regulations:
The researcher asked the following question to the eight participants: “Which mechanisms do you utilise to ensure rules and safety regulations are properly implemented without compromising other activities?” The participants have stated that the contract and professional code of conduct documents are the key elements that are being utilised to emphasise the importance of safety in the sector.

4.4 Unethical practices experience:
The researcher asked the following question: “Have you ever experienced unethical practices on site, what was it and how did you deal with it?” One of the participants said that they were once a victim of unethical behaviour where the contractor wanted to claim an incomplete work without any proper arrangement and the CPM removed those incomplete activities from the claim and notice of delay (NOD) was issued to the perpetrator.

4.5 Impact of principal agent on site:
The researcher asked the following question: “Have you ever encountered challenges where principal agent makes critical decisions during the construction process without informing you? If so, how do you address the matter?” The responses indicates that there is still a communication problem in the construction sector where PA would rather act independently without consulting other role players.

4.6 Impact of unethical behaviour on and off-site:
The researcher asked the following question: “How does the unethical conduct both on site and office affect the performance and quality of work on construction site?” The response reiterates the issue of leadership as outlined in the literature where their values and honesty are always questioned. The
participant indicated that unethical conduct has led to a delay in couple of the project they were involved in due to workmanship.

4.7 The behaviour of contractors:

The researcher asked the following question to the participants: “Have you ever worked with a contractor who underquoted for a project and subsequently approached you to manipulate the system by compromising the quality of work/material in order to complete the project? If so, how did you address the matter?” The feedback from the participant indicates that they comply with the legislation and policies that regulate the profession which indicates that they are contributing positively towards the sustainability of the construction sector. One of the participants indicated that they rejected the offer and outlined that the project should run in line with the approved specifications.

4.8 Role of a supervisor on site:

The researcher asked the participants the following question: “Have you ever received instructions from your supervisor to compromise or bypass other stages to fast track the project? If so, how did you address the matter?” Supervisors in the construction sector are often the culprits in assisting contractors to produce poor-quality work. One of the participants from the public sector encountered a challenge where their supervisor instructed them to bypass some of the steps to fast-track the project.

4.9 Impact of prominent parties:

The researcher asked the participants the following question: “Have you ever been approached by a prominent developer who is well-connected to prioritise their projects over others? How did you deal with the situation?” Some of the participants have outlined that prominent people with influence often approach them to assist in acquiring the project. The other participant has outlined that they often reject offers from people with financial muscles to side-line other projects and prioritise theirs.

4.10 Application of code of conduct on projects:

The participants were asked the following question: “Is the professional code of conduct really being applied in the projects or is it only a formality to get the competency certificate and work done?” There are a lot of loopholes in the construction sector where there are “terms and conditions” to every project as outlined from the feedback. The professional code of conduct is often applied based on the budget of the contract where mega-projects often enjoy the benefits as most of them appoint a professional team as opposed to small projects where the contractor tends to appoint personnel with little or no knowledge of the construction sector.

4.11 Published documents on unethical behaviour in South Africa:

The SA government has outlined that unethical behaviour in the construction sector has led to constraints in infrastructure development with most of the projects unfinished due to price-fixing and corruption. Government invested more capital in quest to curb corruption in the sector. However, implementation has always been a problem where stakeholders are indeed the ones who act unethically. The state has indicated that there is a lack of collaboration from the private and public sectors in implementing ethical conduct in the profession. The state has further outlined that large developers use their financial power and network to acquire permits fraudulently.

5 FINDINGS AND DISCUSSIONS:

The response from the participants has indicated that ethical behaviour always leads the agenda prior to the commencement of the project where professionals are being told on how to conduct themselves but contrary to that the very same parties that attended the induction will proceed to be unethical by trying to solicit bribe and even produce substandard quality of work. The critical part is that the induction is often carried out by a person who is not affiliated to any professional body which makes it difficult for them to be held accountable should anything go wrong. It was discovered that communication is still a major concern in the construction sector where principal agent (PA) would take critical decisions without consulting other stakeholders. The literature has outlined that communication is still a major concern within the sector and as a result the lack of communication is more likely to create chaotic situations where there could be const over runs and poor workmanship. The PA often consult the CPM’s superiors
which often causes conflict as the one above uses their influence to convey their message to the CPM and as a result the professional’s decision is compromised. The literature has outlined that political interference is one of the many elements that creates instability in the construction site as decision are often biased to suit the person in charge. The political influence leads to poor communication which has always been the problem in the built-environment and this impact will affect the quality of work and relationship between the parties. The contractors have tried to claim for activities that they have never done and some of them even went further to amend the contract as they had undercharged and the CPM in charge rejected the claim.

The underquoting seems to be the common trend globally as the literature has indicated that 90% of the construction development starts on the wrong foot by under-estimating the costs. This practice has a negative financial impact on the client as they are pushed to amend the prices to accommodate the new ones. There is a lack of skills transfer in SA between the older and newer generation which creates a serious gap between the professionals. Contrary to the SA notion, the Middle and the Far East have programs in place that enables the skills transfer between parties which makes it easy to maintain a sustainable program in their respective countries. The SA older generation find it difficult to adapt to the latest developments and technologies and they are still using the older methods that they are familiar with and as a result it becomes difficult to share knowledge between the parties.

5 CONCLUSION

The construction sector is still considered to be one of the most corrupt in the world. Role players are exposing it even further by taking part in unethical behaviour that compromises the quality of services being rendered. Politics and financial power play a critical role in unethical behaviour as people abuse their power to secure projects and often try to take shortcuts to complete the project. Implementation of strict policies will guarantee foreign investors that the country is serious about corruption and that the sector is well regulated and legislated. CPM has over the years played their part in adhering to rules and the results are seen in their good services.

6 RECOMMENDATIONS

The researcher proposes that there should be new legislation that focuses on prosecution in the construction sector to ensure that harsher penalties are imposed on perpetrators. The lawmakers should hold a compulsory induction on ethical behaviour before construction commences to enlighten the contractors of what is expected of them. The SACPCMP should regulate the profession in a manner that contractors do not undercharge in a quest to secure projects and later try to amend the contract. Only professionals who are registered with the profession should be allowed to carry out the activities and proper background checks should be conducted to ensure that contractors are not fronting. There should be a separation of responsibilities in government departments to avoid instances where CPM carries out two roles as both PA and CPM as the move promotes conflict of interest. Contractors that fail to comply with safety regulations should get their contract permits revoked to avoid incidents of having unnecessary deaths in the construction sector.

7 REFERENCES


ABSTRACT & KEY WORDS

Purpose of this paper
This proposed study aims to evaluate the cost and socio-economic influence of sustainable construction on the realities of South African construction. The construction industry influences the environment as well as individual health and well-being. Sustainable construction contributes to the mitigation of problems associated with pollution, waste, and inactivity and presents alternative options subconsciously leading to healthier choices. This literature-based paper from the early stages of a doctoral study argues that the implementation of sustainable construction practices will increase if the knowledge gap among construction professionals is closed by advancing the benefits of life cycle costing of all immovable assets in the built environment.

Design/methodology/approach
The critical review methodology will be used to compile this paper.

Findings
The findings of this study will be based on the critical review of relevant literature.

Research limitation/implications
The study’s limitations include implementation barriers and little knowledge of sustainable construction practices and LCC in the QS profession. Further limitations will be investigated through the critical review of relevant literature.

Practical implications
Practical implications and key findings will be based on the critical review of relevant literature.

Originality/value of paper
The combination of sustainable construction knowledge combined with core QS skills provides an opportunity to promote the implementation of sustainability practices in the construction industry. The concept of life cycle costing as cost management tool in sustainable construction equips the QS profession with relevant data to ensure the best value from a whole life perspective.

Keywords: Construction, Cost Management, Sustainability, South Africa
1. INTRODUCTION

The construction industry is an enormous contributor to socio-economic growth on the one hand and pollution, waste and unhealthy lifestyles on the other (Rahim et al., 2014). Lopez (2012) indicates that the built environment provides the framework for how daily lives are structured. Lopez (2012) further states that the built environment is a significant contributor to individual health and well-being and represents an important pathway through which individuals are influenced in terms of health and wellness. Physical activity can be promoted by the excellent design of active-friendly buildings and neighbourhoods (Romaniuk, 2015).

Buildings shape individual health and well-being daily; thus, if attention is not given to climate, layout, and orientation, they can increase respiratory and cardiovascular diseases (Gonzalez-Moreno et al., 2017). The concept of sustainability challenges developers and the professional construction team to think outside the box. Sustainable design includes processes to reduce negative environmental impacts, promote healthy and productive environments and minimise waste (Kibert, 2016). If managed correctly, sustainable construction and design can reduce the current ecological loading on available resources (Strydom, 2013). Green design and construction often focus on reducing social and environmental impacts on the built environment whilst improving the quality of life for the building occupants (Cole, 2019). Construction activities impact communities in various ways, and green construction is promoted to mitigate adverse impacts (Heidari et al., 2016). Green infrastructure incorporates the interconnection between society and health, providing a way to control benefits, from mitigating urban heat to increased physical activity (Heidari et al., 2016). Sustainable design and green building practices focus on implementing construction practices to build buildings that will last longer, be more efficient, reduce operating costs, increase employees’ productivity, and contribute to healthy living (Kubba, 2010). However, the price is a significant barrier to implementing sustainable construction practices that may produce green buildings (Omotayo et al., 2021; Bolade-Oladepo et al., 2019).

That is perhaps why Abidin and Azizi (2016) note the importance of establishing building cost spending patterns to establish sustainable spending methodologies. To meet client requirements, architects model their ideas through parameters called design variables. These variables include building shape, height, size, storey-height, infrastructure, material specifications and circulation area and can be used to determine the cost of a construction project as well as to give solutions to problems related to building shape, the construction period, and economic factors (Abidin and Azizi, 2016; Odediran and Windapo, 2014). In the current economic environment, it is essential to achieve excellence in design through reasonable cost (Ashworth and Perera, 2015). The Quantity Surveyor’s role (QS) would be to ensure that sustainable construction makes economic sense (Ashworth and Perera, 2015). The application of life cycle costing models is encouraged to reduce ownership costs to achieve a financially viable investment (Rahim et al., 2014). Therefore, the proposed study aims to evaluate sustainable construction’s cost and socio-economic influence in relation to the realities of South African construction.

2. LITERATURE REVIEW

2.1. An Overview of Sustainability in Construction

Sustainability is the development said to meet present needs without compromising the future. Sustainability is supported by the “green” and “active design” movements, which aim to preserve the environment together with development-associated concerns, including the efficient use of resources, social and economic growth, and the suppression of poverty (Kibert, 2016; Dosumu and Algibavboa, 2021). Similarly, sustainable development consists of “need” and “limitations” (Strydom, 2013), which touch on economic-, socio-political and environmental concepts (Kibert, 2016).

Strydom (2013) claims that research regarding the vision of sustainable development points in the same direction, noting that it creates an opportunity for the construction industry to move towards optimal sustainability whilst considering the current economic, socio-economic, and environmental concerns. Ganiyu (2016) investigated the impact of sustainable buildings on the occupant’s performance and productivity. An empirical study of 18 buildings and survey data of roughly 1500 employees showed that the building had a definite impact on the user. Lo, Hui and Zhang (2014)
compared 12 sustainable office buildings to conventional buildings in China. The data were obtained through interviews and questionnaires with property managers and tenants. A total of 76 out of 400 responses were received back. In total, 44% noted less sick leave was taken, while 57% indicated a higher employee productivity level. A study by the U.S. Green Building Council (2015) states that an upfront “green investment” of 2% of construction cost can generate lifecycle savings of up to 10 times the initial investment. Research further indicates that green construction has proven to be an economic stimulus, adding $167 billion to the US GDP from 2011 to 2014 while supporting over 2.1 million jobs and more than $148 billion in labour earnings (U.S. Green Building Council, 2015).

Despite the consistent emphasis on sustainable construction in South Africa, implementation remains limited (Dosumu and Aigbavboa, 2021; Awuzie et al., 2021). Although sustainable construction combines economic, social, and environmental aspects of construction and requires the active use of building practices that minimise negative environmental influences, drivers of sustainability differ significantly between various sectors of the economy (Dosumu and Aigbavboa, 2021). Secondary data by Jacobs (2012) indicated that 84% of respondents who partook in a survey of 44 were in favour of increased “green” construction cost; however, the leading cause of resistance remains cost implications and limited knowledge regarding comparative life cycle cost analysis and the associated socio-economic benefits (Du Preez, 2014). Karji, et al. (2020: 11) further identified inadequate planning, financial constraints, the lack of efficient technology, the lack of commitment from upper-level management, lack of employee training, political impacts and client preferences to be some of the main barriers to the implementation of successful sustainable construction.

2.2. The concept of Life Cycle Costing in sustainable construction projects

Knauer and Moslang (2018) define Life Cycle Costing (LCC) as a well-known modern cost-management tool that focuses on long-term cost accounting, creates a fair comparison of solutions, and improves decision making and actual results by considering all relevant costs and benefits associated with a project including upfront and follow up construction costs. Effective LCC is necessary for sustainable construction to ensure the best value from a whole life perspective (Okereke, 2019). LCC assesses the project’s total cost performance over time, including the start-up, operating, maintenance and disposal costs. LCC earns its place in sustainable construction by determining the most effective way of reducing ownership costs to achieve financial feasibility (Langston, 2014). There is growing pressure on construction stakeholders to manage a project’s whole life performance, and it is no longer enough to consider only the initial capital investment. LCC thus offers a way through which sustainable construction could deliver value for money.

Okereke (2019) further strengthens the use of LCC as a cost management tool in sustainable construction by noting that LCC adds to all the various costs involved in construction projects over their lifespan and enables an assessment on a common basis for the period of interest leading to more accurate and informed decisions. The application of LCC from the first stage of the project life cycle is crucial. LCC applied during the design stage of a sustainable construction project provides the opportunity to explore and compare various options. Ashworth (2015) highlights the effectiveness of LCC during the pre-construction phase, noting that changes are more easily made during the conceptual and preliminary design stages. During these initial project phases, stakeholders work closely to develop the project’s concept. During these stages, a suitable procurement method is chosen, project and sustainability procedures are discussed, and the building design lifetime and organisational structure are determined. The initial project cost, maintenance costs and timescales are also dealt with. Environmental impacts, energy usage and life cycle costs are considered to have an enormous influence on sustainability and are to be addressed during the conceptual design phase (Okereke, 2019).

Life-cycle cost analysis is functional when project alternatives with divergent initial and operating costs have to be compared to select the best option based on maximising savings. LCC is fundamental to successfully implementing sustainable construction as it compares reached alternatives by considering initial capital costs, operation and maintenance and repair costs. LCC monitors the cost performance of the building over its lifespan. Further, LCC experts could be used as stewards to accelerate the understanding and implementation of sustainable construction through principles and techniques.
aimed at providing the best value from a whole life perspective (Akasah and Rum, 2011). LCC forms the link between the value created by sustainable construction and the maximisation thereof. When implemented during the early stages of a project, LCC can be a reliable means for creating vision whilst increasing the overall quality of projects for present and future generations (Rahim et al., 2014).

Although the use of LCC is highly rated, Haugbolle and Raffnsoe (2018) point out that there is limited use of LCC on sustainable construction projects due to the lack of accurate data. Ekundayo and Babatunde (2015) prove this by adding that construction professionals have limited LCC knowledge and skills and a considerable gap between theory and practice. The same gaps are noticeable on the client’s side. Difficulties such as a lack of understanding and multiple client needs add to the limited implementation (Ekundayo and Babatunde, 2015).

Sustainable construction approaches can be introduced at any stage in construction; hence the impact of the built environment should be addressed on a life cycle approach (Rahim et al., 2014). This approach can introduce long-term profit for both clients and occupants in helping to reduce environmental impacts and creating healthier spaces whilst reducing building operation and maintenance costs. There is value in sustainable construction. However, the country’s current economic state requires construction professionals to pay close attention to the cost to achieve that value. Therefore, implementing LCC in sustainable construction projects is of great significance to construct projects that will meet sustainability principles whilst proving to provide value for money (Ekundayo and Babatunde, 2015).

2.3. The Role of the Quantity Surveyor

The QS profession has had to adapt to several changes over the last decade (Cartlidge, 2017). Changing markets, construction industry changes, client needs, and the profession itself all lead the QS profession to examine its role (Chigara, et al., 2013). The QS plays an essential role in project administration, providing the client with expert advice on contractual and financial matters (Lee and Willis, 2014; Cartlidge, 2017; Kirkham, 2014). The QS is a crucial resource for any project to establish an accurate project budget, cash flow, cost-planning, management, and value for money (Kirkham, 2014).

The QS’s role in preliminary cost advice is vital and relevant to this study. In this phase, the QS gives practical advice on the indicative cost of the project (Sarhan, 2017). The QS can advise the client on materials and construction methods (Foster, 2013). Just as clients value pragmatism and realism in QS, an analytical approach directly from the measurement of construction works is a highly valued skill in the Quantity Surveying profession (Kirkham, 2014). The QS must be able to do a detailed analysis of construction drawings that will lead to a deeper understanding of the design and construction process (Ashworth, et al., 2013). Intimate knowledge of construction projects is of utmost importance for a QS to provide a competitive service to its clients (Cartlidge, 2011). The developing role of the future QS includes client focus, the use of information and communication technologies and sustainability of agenda (Waris, et al., 2012).

For the successful implementation of sustainable construction, the QS first needs to determine whether the performance will be viable (Cartlidge, 2017). Taken from the list mentioned above of skills, the QS should know about sustainable construction, in general, to provide sufficient support to the client in the form of a viability study (Lee and Willis, 2014; Hyari and Kandil, 2009). There is also increasing realisation of the interdependence of economic and natural processes, specifically concerning construction and individual wellbeing (Rehm and Ade, 2013). Buildings symbolise significant capital investment, both financially and environmentally, and Quantity Surveyors need to respond accordingly (Rehm and Ade, 2013; Haron, et al., 2017).

The combination of sustainable construction knowledge combined with core QS skills offers the opportunity to promote the implementation of sustainability practices. It is no secret that the QS profession faces several obstacles whilst trying to develop and extend its role in the various fields alongside continuous market changes. The QS is said to be one of the primary project consultants. Hence, adopting changing technologies in their practices is inevitable (Haron, Ibrahim and Rawi, 2017). Sustainable construction requires early involvement of the QS to ensure designs within set budget
allocations and to advise on the parameters of prices, design efficiencies, design factors and sustainable requirements. Research indicated that the traditional roles of QS have developed to accommodate sustainable construction with new parts. These changes include sustainable strategy development, life cycle cost appraisal, consultation on green star systems, advising on engineering service solutions and the valuation of the sustainable property (Yusuf, et al., 2013).

Sustainable construction based on a life-cycle approach benefits both building owners and the occupants. These include the reduction of environmental impacts; creating healthier indoor spaces whilst reducing building operation and maintenance costs (Rahim et al., 2014). In attaining a sustainable built environment, Omotayo, Tan and Ekundayo (2022) identified focal areas of sustainable clientship, including sustainable design, sustainable services design, sustainable cost management, sustainable construction, sustainable operation and sustainable deconstruction. The role of the QS fits into sustainable cost management-process and analysis for the QS to effectively perform these roles, understanding of the design phases is a prerequisite. Fisher et al., (2018), as cited by Omotayo et al., (2022), identified a list of sustainability services that construction professionals can offer. The main benefits of the QS profession under sustainable construction include but are not limited to the protection of the natural environment; encouragement of the use of sustainable resources; reduction of waste generation and motivation of responsible waste disposal; reduction of energy consumption; promotion of community development and social inclusion; minimisation of adverse social or environmental impacts; promotion of sustainable land use and transportation planning and management; promotion of sustainable design, development, and construction including whole life costing. Quantity Surveyors are encouraged to relook their roles and investigate value-added services that will accommodate the sustainable construction industry. Chamikara, et al., (2018) and that the sustainable construction industry requires influential Quantity Surveyors, offering various services contributing to cost advice on sustainable alternatives, flexible procurement management, sustainable risk and value management and cost engineering.

Sustainable construction practices integrate sustainability principles into the design, procurement and management processes whilst creating new opportunities for QS skill improvement, the need for development appraisal and preliminary cost advice (Chamikara, et al., 2018). Despite the challenges introduced by the global sustainability movement, it offers the opportunity for Quantity Surveyors to explore areas beyond their current roles in cost management (Omotayo et al., 2022). Quantity Surveyors should seek opportunities for constant improvement whilst defining the services they can provide under the changing procurement systems. Chandramohan et al. (2020) strengthen this phenomenon by adding that the QS should not operate in restriction of the traditional roles but develop new niches, cultivate new knowledge, and explore new skills whilst enhancing competitiveness. The QS profession should improve their practical skills and knowledge of sustainable development through research, qualification, and related seminars (Yusuf, et al., 2013).

A study done by Omotayo et al. (2022) highlights a list of challenges the QS profession is likely to encounter in the implementation of sustainable construction practices, of which the QS’s readiness for sustainable construction services and engagement, the awareness of sustainable construction in general, low knowledge of sustainable construction, the lack of experience in sustainable construction and the lack of skill and knowledge on life cycle costing and life cycle assessment gains much attention. The involvement of the QS profession in sustainable construction is still evolving. Although educational and organisational institutions are trying to keep their curriculum updated with the latest professional competencies, emerging concepts from the sustainable construction industry continue to influence the requirements. In addition to the challenges mentioned above, Bolade-Oladepo et al., (2019) further add that the modern-day client is well informed, more selective, and opinionated in their requirements regarding the professional team managing their projects. Clients today expect broad and flexible professional advice on cost, time and quality, thus expecting their consultant team to have extraordinary knowledge of sustainable building materials and design as well as the specifications of green materials, alternative materials and recyclable materials (Yusuf et al., 2013).

Although the QS profession is known to be dynamic and versatile in responding to change (Omotayo et al., 2022; Chamikara et al., 2020; Noor et al., 2020), the challenge of updating the higher education
curriculum, CPD and upskilling already experienced Quantity Surveyors exist. In addition, the lack of knowledge and awareness of sustainable construction practices in the QS profession should be addressed through regular related workshops, conferences and webinars (Bolade-Oladepo et al., 2019).

3. PROPOSED RESEARCH METHODOLOGY

The scope of the study is on the role of the QS in implementing sustainable construction principles in construction. The study focuses on identifying the cost and socio-economic implications of sustainability in construction.

The study’s limitations include implementation barriers and little knowledge of sustainable construction practices and LCC in the QS profession. Developers perceive reluctance to implement sustainable principles due to the lack of research and local models. Due to the limited knowledge gap in the South African construction industry, data collection may be complex, and participants may not answer questions truthfully. Empirical data on sustainable buildings in South Africa is also limited, making it difficult to compare the research data collected in this study with documented data in South Africa.

Despite various attempts to implement sustainable construction, the South African construction industry remains reluctant to adopt such opportunities. This study, therefore, argues that the performance of sustainable construction practices will increase if the knowledge gap among construction professionals is closed by advancing the benefits of the life cycle costing of all immovable assets in the built environment.

This study is based on a comprehensive literature review, a comprehensive investigation of the existing knowledge on the topic (Onwuegbuzie et al., 2016). The narrative literature review summarises and critiques the reviewed literature and is most used to provide a broad overview of a topic. The literature review was formulated based on the four phases described by Snyder (2019): design, conduct, analyse and write the review.

This study is a critical review of information investigating if the knowledge gap among construction professionals is closed by advancing the benefits of life cycle costing of all immovable assets in the built environment. This is a conceptual paper for a future study (PhD) and is merely a review of other content with no empirical data to be collected for evidence.

4. FINDINGS & DISCUSSIONS

Through review of the available literature using the methodology adopted for the study, it was clear that there is willingness from the construction industry to increase the implementation of sustainable construction practices. Aghimien and Aigbavboa (2019) highlighted that the long-term running cost of a building, far outweigh the initial start-up cost which means that all the relevant stakeholders in the construction industry need to reconsider their approach to the design decisions being made, construction methods adopted, and the material and equipment used on projects. The drivers of sustainable construction are challenged with barriers to adoption, both further discussed below.

4.1. Drivers of sustainable construction in South Africa

Dosumu and Aigbavboa (2021), Marsh, et al. (2019), Aghimien and Aigbavboa (2019), Ganiyu (2016), Chamikara, et al. (2018), and Omotayo et al. (2022) evaluated the main drivers of sustainable construction in South Africa to be cost, awareness and knowledge, material resources, government policies and resources, financial resources, financial incentives, interest, access, confidence, social reaction, and stakeholder perception and behaviour. It is clear from the literature review that several, inexhaustible factors are responsible for the adoption of sustainable construction practices in South Africa. Marsh, et al. (2020) recognises six main theme categories to illustrate the drivers of sustainable construction which include: Socio-cultural-, Environmental-, Stakeholder-, Political-, and Technological drivers.

4.2. Barriers to Sustainable construction in South Africa

The implementation of sustainable construction is however challenged by inherent barriers. Karji et al. (2020), Dosumu and Aigbavboa (2021), Simpeh and Smallwood (2015), and Marco and James (2016)
identified financial constraints, inadequate planning, non-commitment from management, lack of knowledge on sustainable systems, a weak economy, lack of government incentives, lack of innovation, lack of stakeholder participation, lack of social viability, lack of monitoring operation, lack of technology, poor sustainable education in academic institutions, ignorance of LCC benefits, and resource scarcity. Marsh, et al., (2020) supports this by categorising the barriers under five key themes which include: Socio-cultural, Economic-, Stakeholder-, Political-, and Technological barriers.

4.3. Drivers of LCC Implementation in the South African construction industry

Majority of the reviewed literature agreed that LCC is most effective when applied in the design stage of construction projects. Knauer and Moslang (2018), Okereke (2019), Langston, (2014), Ashworth, (2015), and Haugbolle and Raffnsoe (2018) further highlighted the following main factors that act as drivers to the implementation of LCC for increased sustainability in the South African construction industry: improved value in the design and construction of built assets, improved value for money, confidence in project decision making, facilitates an effective choice between alternative methods, indicates areas of potential savings, improved communication.

4.4. Challenges with LCC application in the South African construction industry

There is agreement among the reviewed literature on the main challenges of LCC application in the construction industry. Knauer and Moslang (2018), Okereke (2019), Langston, (2014), Ashworth, (2015), and Haugbolle and Raffnsoe (2018) asserts that the key barrier remains the acquisition of LCC knowledge and skills that are still in its early stages, with a noticeable gap between theory and practice. Ekundayo and Babatunde (2015) and Heralova (2017), further adds that a lack of guidelines, lack of client engagement and decision making, the separation of the capital cost of construction from the running cost, lack of motivation in cost optimisation, lack of understanding from the client, difficulty in obtaining proper information to base LCC on, lack of relevant historical information and data, incompatibility with selected projects, the lack of procurement and contract award incentives to use LCC are some of the most common challenges faced in the industry, and the availability of data in the early design stages. Okereke, (2019) categorizes the barriers to the application of LCC in the construction industry into three categories: on the part of the industry, on the part of the client, and on the part of the estimator.

The findings above revealed willingness from the South African industry to implement sustainable construction practices through the application of LCC. Based on the critical review of 48 articles, the LCC methodology proved to be a key element in supporting sustainability in the construction industry. The immediate implementation of both these concepts into most of the South African construction industry is however far-fetched. Rahim et al., (2014) supports this by highlighting the challenges to application as discussed above.

5. CONCLUSION AND RECOMMENDATIONS

This study aims to determine the cost- and socio-economic benefits of sustainable construction about the role of the QS. Despite the consistent emphasis being placed on sustainability, implementation remains limited. This study further highlights the barriers to and drivers for implementation of sustainable construction principles in the aforementioned construction industry. A possible way offered by literature to improve this is to increase knowledge of sustainable construction and LCC, among all stakeholders in the construction industry. The combination of sustainable construction and LCC knowledge combined with core QS skills provides an opportunity to promote the implementation of sustainability practices. Following the literature above, the QS profession must continuously adapt to changing markets and evolving sustainability practices; hence Quantity Surveyors should seek opportunities for constant improvement to provide value-added services under changing procurement. The concept of life cycle costing equips the QS profession with relevant data to ensure the best value from a whole life perspective.

Based on the conclusion of the study, it is evident that the challenges and drivers of sustainable construction have a general applicability to all stakeholders. Hence it is recommended that the knowledge gap among construction professionals is filled by creating an enabling environment for the concept of sustainable construction to be explored through mechanisms such as government
participation in the form of favourable policies and regulations, increased awareness through educational institutions, conferences, webinars, and professional bodies. It will assist QS’s, among others, to be trained in LCC and further studies need to be carried out on the perception of LCC among all construction stakeholders, with additional emphasis on construction clients. The results of this study will contribute greatly to the body of knowledge.

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Structural efficiency and energy: A consideration for sustainable construction in South Africa

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ABSTRACT AND KEYWORDS

Purpose of this paper
In South Africa, the environmental impact of inefficient construction methods is becoming unsustainable. To some extent, the impact can be mitigated through sustainable design and construction methods. With building demand expected to increase significantly over the next few decades, this will result in an intolerably high level of negative overall impact unless basic principles of sustainable building construction are incorporated into standards and then enforced. This paper examined inefficient construction methods by contrasting a specific unfavourable standard SANS 204 with a specific actual condition.

Design/methodology/approach
A review of SANS 204 conducted by other authors identifies areas for improvement and indicates that shortcomings may be overcome through a more rigorous examination of energy efficiency in order to achieve sustainable construction methods. Assessing the environmental impact of buildings necessitates the development of a building environmental assessment system, which requires, (1) an understanding of the various ways in which a process affects the environment; (2) a quantification of the magnitude of each of the process’s effects; and (3) a yardstick for determining the extent of environmental degradation.

Findings
The potential of an integrated paradigm to direct builders toward sustainable buildings is presented.

What is original/value of paper
This study contributes to the growing body of knowledge regarding the relationship between structural efficiency and energy consumption, and how they can contribute to the overall efficiency and sustainability of buildings.

Keywords: sustainable construction, structural efficiency, energy efficiency.
1. INTRODUCTION AND BACKGROUND

The conversation about global warming commenced as early as 1896, when a physical chemist predicted that if the amount of carbon dioxide in the atmosphere doubled, the average global temperature would rise by several degrees. It took a century; however, to collect sufficient evidence to convince climate experts that human activity would warm the planet (Weart, 2011). The prospect of catastrophic climate change as a result of uncontrolled greenhouse gas (GHGs) emissions is presently an urgent global threat (Allwood et al., 2011). Most construction materials involve the use of energy in the process of mining and manufacturing them. Among many common construction materials are: steel, cement, timber and masonry (such as clay bricks, concrete blocks, etc.) which have been discussed in this article. It is accepted that the production of construction materials results in a significant amount of carbon emission. The most prominent, cement manufacturing, is responsible for 5-7% of the world CO2 emissions (Shanks et al., 2019).

Applying sustainability principles to building construction, including all associated processes and activities, necessitates the active and responsible participation of all interested parties (South African National Standard, 2016). While the legal obligations and liabilities are regulated at the national or regional level, individual commitment and accountability are voluntary. Nonetheless, this commitment is a fundamental tenet of sustainable development, which includes the building and construction sector. The concepts underlying sustainability are extremely complex and are constantly being studied. There are no definitive methods for quantifying or confirming sustainability. Broad principles do not provide a basis for achieving sustainability. They may, however, be useful in determining the validity of sustainability claims.

The provision of housing in socialist countries has been a problem (Andrzejewski and Kucharski, 1970) and this persists to the present day (Charlier et al., 2019). Forrest and Xian (2018) also admit that there are challenges involved in providing housing for future generations. Therefore, whatever is built should be constructed in the most efficient and effective manner, so as to minimise the ecological strain. It has been argued that the major threats to the future of the construction industry reside in: the economic and environmental cost of construction materials (Sieffert et al., 2014); environmental impact of producing infrastructure (Wu et al., 2014) and poor-quality buildings (Manomano and Tanga, 2018).

One-third of the globally used energy is consumed in buildings (économiques, 2013). Broad adoption of ‘green’ building and construction standards is vital to improve energy-efficiency in the building sector (Fastenrath and Braun, 2018). This will drive sustainability transformation in the building sector alongside creative building designs, better materials and technologies, supportive policies, and new types of business practices and services (Fastenrath and Braun, 2018). Significant improvements, both on the supply and demand sides of the energy sector are required to enable the transition to a more sustainable economy (Rocha et al., 2016). Key stakeholders have an integral role to play in securing energy and determining how best this is utilised. Hence, the need to assess both energy consumption and carbon emissions involved in all phases of a building project. The building industry is not only known for the loss of large quantities of energy but also for its large potential savings (Wen et al., 2015). If efficient buildings are a priority, a holistic approach needs consideration by designers.

Sustainable buildings do have a major role to play in achieving sustainable development in the form of improving energy utilisation and environmental performance (Al-Tamimi, 2017). Buildings can contribute to environmental issues, ranging from overuse of natural resources during construction and material creation. This can result in the degradation of the local environment (Hussin et al., 2013). From the structural perspective, the design engineer must ensure that the structure can safely resist the applied forces and load effects in the most resource-effective manner (Anwar and Najam, 2016). Basically, structural efficiency is the mass that a structure can hold divided by the mass of the structure. The maximum possible loading on a structure and minimum structural mass yield an efficient structural component (Sobieszczanski et al., 1976). The production and use of most building materials require energy. This can be described quantitatively by the ratio of energy services out, to energy input. In efficiency terms, “It means getting the most out of every unit of energy you buy” (Herring, 2006), (i.e. using less energy to provide the same service). Improvements in energy efficiency by minimising energy usage have cost implications.

Harris (1999) used a quantitative approach to assess the environmental impact of building materials. He discovered that the materials used to construct a building significantly contributes to its overall environmental impact. This impact is felt in a variety of ways: locally, as a result of activities such as quarrying; globally, as a result of carbon dioxide released during the manufacturing process; and internally, as a result of the effects on the health of the building’s occupants. Some of these effects are
Buildings consume approximately 40% of total global energy in two phases: during construction as embodied energy and during operation as operating energy. Embodied energy is used in the production of building materials (mining and manufacturing), the delivery on-site, the construction and assembly on-site, as well as the renovation and final demolition. Ding (2008) stated that to increase the popularity of building assessment methods, there is a need for increased and improved communication, interaction, as well as the recognition of this amongst members of the design team and various sectors of the industry.

2. BUILDING MATERIALS

Buildings are produced using building materials. These materials are derived from rocks, sediments and other natural deposits (Klee and Graedel, 2004). Kalaitzi et al. (2018) questioned how manufacturing companies should respond to the growing competition for scarce natural resources. The illegal use of natural resources presents a global threat to biodiversity (Gavin et al., 2010). Resource-rich emerging countries appear unable to turn the inadequate capital into other productive assets (Frederick van der, 2011) in an ecologically responsible manner, possibly due to the non-existence of / or inadequate standards on sustainability in masonry building construction. Environmental debates call for sustainable governance of natural resources and alignment of conservation programmes with imperatives for rural economic development, as well as greater consideration of the effect of construction of buildings on climate change (Sachs et al., 2009, Vira et al., 2015, Scheel et al., 2020). The ecological impact of using construction materials, namely: steel; cement and clay masonry is elaborated upon below.

2.1 STEEL CO₂ EMISSION

Steel manufacturing is the world’s largest industrial source of CO₂ emission (Serrenho et al., 2016). This is mainly due to the requirement for coal to convert ore into molten iron (Allwood et al., 2012). Carbon emissions are produced by the combustion of fossil fuel by the industry (Babiker, 2005). Yellishetty et al. (2010) noted that the steel industry was contributing 10-15% of CO₂ emissions around the world. The global average consumption of steel per capita is growing at 3.6% per annum (Gutowski et al., 2013a). China increased its production steadily from 1978 to 2011, at an average annual rate of 9.7%, and in 1996 China became the largest steel producer in the world (Chen et al., 2014). In 2013, China produced 50% of the world’s Iron and Steel, emitting 16.2% of the global total emissions (Xu and Lin, 2017). They have taken drastic steps to reduce its energy intensity (consumption of energy per unit of gross domestic production) and carbon intensity (CO₂ per unit of GDP) (Zhou, 2011).

Allwood et al. (2010) estimate that the global implementation of efficiency improvements will not produce the energy and emission savings required to meet emerging countries’ emission reduction goals. One reason for this is that the construction sector is expanding continuously, with concomitant energy spending, whether in the residential sector or in the service sector (Tavares and Martins, 2007, Xu and Wang, 2020, Hu et al., 2020). With rising populations, as well as rising living standards, energy problems are becoming more and more common, because energy shortages will occur in the future (Yilmaz, 2007, Xu and Wang, 2020, Hu et al., 2020). Energy efficient, cost-effective and reliable building materials are important for sustainable building practices (Reddy and Lokras, 1998). Meeting the targets of Sustainable Development goals (or even coming close to these) will require materials of good quality, as well as carbon emission and energy reduction strategies (Gutowski et al., 2013a, Gutowski et al., 2013b).

There are various reasons why the conservation of valuable mineral resources, such as iron and steel, is significant (Michaelis and Jackson, 2000). Firstly, the supply of these resources is limited, as present use is taking place at the risk of continued future supply. Secondly, the environmental effects of the manufacturing, distribution, usage and disposal of these products continue to be a growing concern. In addition, the energy needed for collecting, refining, distributing and recycling these materials is high. This energy, of course, is mainly supplied by exhaustible fossil fuels that are themselves contaminating the atmosphere and contribute to global warming. Therefore, ensuring the flow of energy and materials
associated with these resources, and recognising any potential for resource conservation and mitigating environmental change, is of growing significance, both economically and environmentally. Holistically, this focuses on the concept of dematerialisation, which according to Cleveland and Ruth (1998) refers to the absolute or relative reduction in the quantities of materials used and/or the quantity of waste produced in the processing of an economic output unit. For engineers using structural steel, this means optimising designs with respect to the amount of steel used.

Therefore, utilising less steel in designs, as well as the efficient use of steel products, will assist in reducing the demand for steel. (Serrenho et al., 2016). Often, steel is used with other construction materials such as cement, which is discussed below.

2.2 CEMENT CO₂ PRODUCTION EMISSION

The most commonly used materials in the building industry are cemented materials, including concrete, mortar, grout and plaster (Habert et al., 2011). Since 1985, China has been ranked first in the world, accounting for 60% of global cement production in 2012 (Cement Global, 2012, Cement Global, 2013). Portland cement processing is one of the most energy-intensive processes of all the manufacturing materials (Li et al., 2020, Naqi and Jang, 2019, Turner and Collins, 2013). The Portland cement industry contributes significantly to global warming (Worrell et al., 2001, Van Oss and Padovani, 2003, Huntzinger and Eatmon, 2009, Stafford et al., 2016). In order to reduce global CO₂ emissions, it is important to pursue some effective approaches to reducing cement industry CO₂ emissions (Li et al., 2014, Shen et al., 2015). Mohammadi and South (2017) perceived that cement production has the highest contribution to concrete product CO₂ emissions. In addition, pollution due to concrete usage could be minimised by using less cement in concrete products, either by substituting it with supplementary cementitious products or by manufacturing cement with increased mineral additions. Utilising concrete products should be a responsible choice for construction (Mohammadi and South, 2017). Again, to minimise the quantity of materials used and/or the quantity of waste generated in the production of an economic output unit, a concept of dematerialisation is required. Applying this concept in the construction industry implies that improvements can be achieved by reducing the amount of cement used by engineers.

Therefore, the use of less cement in designs, and the effective use of products containing cement would help minimise the demand for cement. Often, cement is used together with masonry and steel in other building structures, namely; foundations, lintels over openings and brickforce.

2.3 CLAY CO₂ EMISSION

Clay units are the most common type of construction material in the construction industry, and have been used for thousands of years (Al-Sibahy and Edwards, 2017). Clay bricks are baked in the sun, and gained popularity due to their simplicity, low cost, and favourable thermal as well as acoustic properties. In addition, the ability to recycle the material by crushing, dampening or returning it to the original shape without any environmental impact at the end of a building’s life is also acknowledged. Sun-baked clay bricks are, nevertheless, prone to water damage, making this their only significant weakness (Oti et al., 2009a). Raw, unburnt clay can be used as a building material for both structural and non-structural elements (Žabičková et al., 2016). Clay bricks are used for various purposes, including private, commercial and public buildings (Molnár and Larsson Ivanov, 2016). The production of clay bricks uses an immense amount of clay. This can lead to deterioration of the environment because vast quantities of clay soil have to be extracted. The mining method affects the soil and vegetation, so soil erosion can result if performed carelessly without rehabilitation (Santhosh et al., 2013).

Many regions in the world have limited natural resources for manufacturing conventional bricks. This poses a challenge to the security of the environment and sustainable development (Zhang, 2013). The fired brick manufacturing process is carbon-intensive, as significant carbon is used to supply the energy to fire the kiln. The use of unfired clay bricks would therefore be better for the environment than the use of fired ones (Oti et al., 2009b). The global brick making industry has been described as a major source of air pollution and greenhouse-gas emissions in many parts of the world, especially in North, Central and Southwest Asia, Africa and Central America (Ferdausi et al., 2008, Croitoru and Sarraf, 2012, Lalchandani, 2012). Other issues are the deforestation and air pollution problems associated with the manufacturing processes of burned bricks (Hashemi et al., 2015). Therefore, reducing the embodied energy of locally generated bricks is crucial to mitigating the environmental harm caused by low-income housing, as is reported in East Africa (Hashemi et al., 2015).
2.4 TIMBER CO₂ EMISSION

Forests make up large ecosystems and can play an important role in mitigating the emissions of CO₂, the most important greenhouse gas. Different forest management regimes affect the ability of forests to sequester carbon. It is also important to understand the effect different actions taken to increase carbon sequestration, have on other products from forestry. Examples are: the harvest quantities, the availability of forest biofuel, and economic factors (e.g. labour practices) (Backéus et al., 2005). According to Myint et al. (2021), the management of plantation forests for multiple purposes is critical in the fight against climate change and the loss of natural forests. Natural forests lose 2.6% of their area each year, but only 0.02% of the area previously under natural forests is converted to plantation forests, according to the cited study. In both forest types (natural and plantation), it is anticipated that total growing stocks will increase from 8.9 million m³ in 2000 to an estimated 39.8 million m³ in 2040. Between 2000 and 2040, total carbon removals (sequestration) are estimated 1.2 Tg CO₂ yr⁻¹ and 1.3 Tg CO₂ yr⁻¹ respectively during the Paris Agreement timeframe. The use of thinned wood and wood biomasses to replace fossil combustion could reduce carbon emissions by 12.7 Tg CO₂ yr⁻¹. Careful plantation forest management can help to slow down climate change and cut down on the demand for wood from natural forests at the same time.

Cross laminated timber elements, beam-and-column using glulam (?) and laminated veneer lumber elements, as well as prefabricated modules using light-frame volume elements are some of the building systems available. A study by Dodoo et al. (2014), tracks the flows of carbon from fossil energy, industrial process reactions, changes in carbon stocks in materials, as well as potential avoided fossil fuel emissions from the substitution of fossil energy by woody residues during the lifecycle of buildings. The results show that the low-energy version of the cross-laminated timber building members utilises the least amount of carbon over its lifetime, while the traditional beam-and-column building structure uses the most. For a 50-year lifespan in Växjö, the low-energy designs reduce total carbon emissions (excluding tap water heating and household and facility electricity) by 9%, 8%, and 9% for cross laminated timber, beam-and-column, and modular systems, respectively, compared to conventional designs. Different levels of energy efficiency can be achieved by using appropriate construction materials. Insulation takes the lead in low-energy homes and plasterboard in conventional homes. Sasaki et al. (2012) maintained that logging practices can have a profound impact on timber production, forest structure, and forest-dependent communities. By shifting from conventional logging to reduced-impact logging practices, International Tropical Timber Organization producer countries could reduce carbon emissions by 1.5-2.1 billion tCO₂ year⁻¹ while still producing 164.9-280.8 million m³ of end-use wood over a 50-year project cycle, depending on the scenario chosen.

3 ENERGY EFFICIENCY IN SOUTH AFRICAN BUILDINGS

According to SANS 204 (2011), by incorporating thermal ceiling insulation and high-performance window systems into all new residential and commercial buildings today, approximately 3500 MW of electricity could be saved by 2020. Besides this initiative, South Africa is still experiencing an energy crisis (Fig, 2008). This principle (of ceiling insulation) was the guiding principle behind the publication of SANS 204 (2011): Energy efficiency is easily achievable by incorporating sensible and practical energy-saving measures into the design and construction of new buildings. By making SANS 204 a mandatory standard, the government will gradually begin to achieve energy savings and cost savings associated with energy provision.

The standard establishes general requirements for energy efficiency, beginning with performance parameters. These are then followed by methods of demonstrating compliance. Responsible persons (developer or owner) will submit plans to the local authority for approval. Additionally, a one-year energy audit will be necessary to demonstrate compliance and quantify the actual energy saved. This procedure is intended to facilitate any necessary revisions to the standards.

Certain sections of SANS 204 (2011) establish general performance requirements for achieving energy efficiency in all types of buildings. These will eventually become part of the National Building Regulations. Wherever possible, passive building design is encouraged (where systems used to heat or cool the building are kept to a minimum). The standard follows the same order as that in which a building is constructed, namely design (first) and construction (second). Its major sections are: (1) the location and seating (orientation and shading to face north and use of shading); (2) building design (foundation, floor, walls, fenestration, roof, and ceiling); (3) airtightness of the building (envelope, air infiltration, and leakage); and (4) products and services (lighting and power, hot-water services, and appliances).
4 BUILDING LIFE CYCLE AND MATERIALS SELECTION

Suzuki and Oka (1998) advised that in order to quantify a building’s life cycle energy consumption and CO₂ emissions, an estimate of the total quantity of domestic products and services consumed directly or indirectly (including the impact of the economy) during the building’s life cycle is required. Adalberth (1997b) made three critical recommendations based on the study’s findings in order to achieve an energy-efficient single-unit dwelling throughout its life cycle, namely: (1) Choose building materials that require little energy to manufacture; (2) Ascertain that the dwelling consumes minimal energy during the occupation stage; and (3) Monitor and supervise the construction stage (the actual erection of the building) in order to ensure the quality of the work.

The study by González and García Navarro (2006) on assessing the reduction of CO₂ emissions in the construction industry through material selection revealed that there are additional ways to reduce CO₂ consumption, beginning with the early stages of construction. The designer can make critical decisions during the design phase by defining a bioclimatic design and establishing future guidelines for selecting low environmental impact construction materials for the construction phase. Both design and construction materials are inextricably linked. The design is determined by the manner in which the construction materials have been chosen and must be used. A careful selection of materials and products is necessary to conserve energy and reduce CO₂ emissions. It is noted that SANS 204 precludes structural engineers from being fully involved in the process of ensuring sustainable building construction in South Africa, contrary to what this literature reference suggests.

Thormark (2006) concluded that, in order to reduce total energy consumption in buildings, it is critical to pay attention, during the design phase of new buildings, not only to operational energy requirements but also to material selection and recycling considerations. It is not sufficient to conclude that a material is recyclable; one must also consider the methods of recycling and how to facilitate disassembly. Maintenance should not be overlooked. Prolonging the life of the product and/or selecting materials with lower embodied energy can significantly mitigate the impact of maintenance. Today, the most critical measure for facilitating future recycling efforts is to use recyclable materials, to avoid materials that contaminate one another, and to avoid difficult-to-disassemble construction designs. This study presented various methods to reduce embodied energy by simple measures. According to the study, the embodied energy in conventional buildings can be reduced by approximately 10-15%. To significantly reduce embodied energy and increase the potential for re-use, attention must be paid to new constructions, both in terms of materials and connection detail design.

Research suggests that the embodied energy used in residential buildings could account for up to 40% of the total energy used in residential buildings (Chen et al., 2001). Historically, the energy used to produce the materials needed for building construction, known as embodied energy, was thought to be insignificant when compared to the energy consumed during the operational phase (Ortiz et al., 2009). This is no longer the case for low-energy houses, (Wallhagen et al., 2011), as the energy consumed during the service life is much lower, while the embodied energy is higher due to additional embodied energy of the construction materials as the energy consumed during the service life is much lower, while the embodied energy is higher due to additional embodied energy of the construction materials. The embodied energy requirement of a low-energy-consumption solar house is double that of a traditional design, while the total energy demand is reduced by 50% over a 50-year lifetime (Wallhagen et al., 2011). As a result, structural efficiency should be considered in the material selection because it affects the building’s embodied energy.

5 METHOD

To explore building efficiency with respect to energy used, examples were utilised to consider some underlying principles and differing views on this subject, i.e. how building materials can contribute to environmental degradation, and the possibilities for achieving optimum building efficiency.

A hermeneutic research methodology was selected because it allows for interpretations and a comprehensive understanding of the researched phenomenon - structural efficiency and energy in relation to sustainable construction in South Africa. In the study the significance of subjective interpretations is prioritized. Hermeneutic phenomenology research is conducted through empirical (experience collection) and reflective (meaning analysis) endeavors. The hermeneutical process begins with the element (building) to observe structural efficiency and energy; the second step consists of the notion that the process of construction must lead to an agreement, and the final step consists of reaching a common language agreement by considering sustainable building materials to produce
structural efficiency and sustainable buildings within the South African context. Hermeneutics is a mode of data interpretation utilized by qualitative researchers (Myers). The underlying assumption is that interpretation of a text or artefact should be approached from multiple perspectives. The method enables the study to promote an increasing advocacy for the management of the ecological impact of CO2 associated with buildings either during the construction process or during the operational phase of the built asset’s lifecycle. The criteria for selecting the cases from a pool of potential cases were as follows: (1) relevance to civil engineering projects, primarily residential houses; (2) ease of applying the method to the South African context and presenting less complexity; and (3) publication in reputable peer-reviewed journals. Adalberth (1997a), Chen et al. (2001), and Habert et al. (2012) were three studies of importance to this research, and Chen et al. (2001) was used as a paradigm and for discussion.

Sampling of case studies conducted by other authors was directed by the insight gained through the reviewed literature. Non-probability sampling was used, a form of sampling in which samples are chosen not at random but instead based on the expert opinion of the researcher. The method has been used by Shepherd and Frost (1995). Melamed and Robinson (2019) advise that case-control studies are an essential tool for researching unusual outcomes, although there exist numerous drawbacks, including vulnerability to bias. This drawback was reduced by triangulation between literature review, case studies, and critical review supported by mathematical relationships. The reasons for selecting cases vary from the interest to theoretical considerations for each particular case. This study investigated cases reported within the last 30 years. These examples narrated known facts (Delatte Jr, 2008) in order to address a larger problem.

6 CONCRETE AND STEEL

Cole (1998) examined the energy consumption and greenhouse gas emissions associated with the construction of structural building assemblies. The study found significant differences in the energy and greenhouse gas emissions associated with the construction of different structural assemblies - wood, steel, and concrete - with concrete typically consuming an order of magnitude more energy and emitting an order of magnitude more greenhouse gases. Typically, the transportation of the construction crew to and from the building site would be ignored during the construction task. It is asserted that construction accounts for 7-10% of the embodied energy and is typically high for wood and steel structures and low for concrete structures. Unlike materials manufacturing, which is heavily reliant on energy and machinery, a significant portion of building construction is labour-intensive. The more labour-intensive a process is, the more worker transportation is required. Transportation of workers to and from the construction site accounts for the largest proportion of energy consumed during construction for many structural assemblies, and, when included in the analysis, construction accounts for a much larger proportion of the initial embodied energy than is currently assumed.

Venkatarama Reddy and Jagadish (2003) estimate that a significant amount of energy is consumed during the manufacturing and transportation of various building materials. Energy conservation becomes critical when it comes to limiting greenhouse gas emissions into the atmosphere and lowering material costs. The total embodied energy of a multi-story building, a load-bearing brickwork structure, and a soil-cement block structure constructed with alternative building materials were compared. It has been demonstrated that when energy efficient/alternative building materials are used, the total embodied energy of load-bearing masonry buildings can be reduced significantly.

Morel et al. (2001) investigated the possibility of building houses using indigenous materials. Construction of 12 houses using indigenous materials such as soil, stone, and timber was investigated. Whenever possible, materials were sourced locally to minimize the new buildings’ environmental impact. The energy required to construct one house is compared to that required to construct a typical concrete house. According to this study, using locally sourced materials reduced the amount of energy used in construction by up to 215%, and the impact of transportation by 453%. It was noted that the loss of traditional building crafts and a lack of appropriate building standards can impede the adoption of indigenous materials in developed countries.

According to Monahan and Powell (2011), despite the fact that timber is the most commonly used structural and cladding material (in some countries), concrete is the most significant material in terms of embodied carbon, accounting for 36% of material-related embodied carbon. A significant portion of this is embodied in the substructure. When considering the construction process as a whole, additional embodied carbon savings can be realized through: (1) increased offsite manufacturing of components; (2) consideration of material specification and selection of sustainable or low-impact materials (e.g. cement substitutes); (3) structure design and material placement; and (4) efforts to reduce waste on-
site. Additionally, a systemic life-cycle approach is required. Making decisions based on a single issue, such as embodied carbon, can be deceptive and ultimately counterproductive. Concrete material is used as an example; while it does have a high embodied energy and carbon footprint, it is a useful material that can also help reduce occupational energy demand when used strategically within a structure. A sizable portion of this will be unaccounted for in national accounting systems and thus concealed within imported materials and products. The overall impact will be determined by the construction methods used and the degree to which the sustainable construction agenda is integrated throughout the supply chain, from conception to design, construction, occupation, and deconstruction.

Van Rooyen (2015) dealt with the energy usage of the various walling construction methods utilised in the South African masonry industry. The study also includes the practical use of energy required to sustain thermal comfort in buildings, as well as to increase the environmental efficiency during the operational period of the building life. Thermal comfort (a condition that expresses satisfaction with the thermal environment (Croitoru et al., 2015) is an important factor in design of buildings due to a correlation between thermal comfort and health as well as the productivity of the population (Leaman and Bordass, 2001). There are large variations in thermal comfort between people (Kim et al., 2018). Six typologies of building models were used to extrapolate future energy requirements. The building industry can make informed decisions about the future wall design and construction requirements. Given the primary cooling necessity in the South African context, the evidence points to a wisdom in continuing to construct day-time occupancy buildings with clay brick masonry and other high-mass solutions. The evidence also points to significant improvements in the built environment standards of the South African regulatory framework that would involve the use of higher levels of residential thermal resistance, for both masonry and non-masonry solutions. According to Van Rooyen - a 280 mm insulated cavity clay brick masonry wall is the most efficient South African walling system for residential buildings; light steel frame wall construction and timber frame walls are not as thermally effective compared to clay brick masonry cavity walls; a 140 mm hollow concrete block wall is the worst thermally efficient wall.

A study by Klunne (2002) on energy-efficient housing in South Africa yielded the principles of energy efficiency in housing. Energy-efficient techniques, or interventions, in housing involved the application of energy flow principles and climatic characteristics of a region in the design, construction and management of houses to achieve thermal comfort and other energy and water services, with minimal conventional energy or water input. It advocates the adherence to the principles of energy efficiency in housing in South Africa, namely: passive thermal interventions such as house orientation, appropriate building materials, daylighting, roof overhang; weather proofing and ventilation; wall insulation; flooring and shared walls where possible.

7 STRUCTURAL EFFICIENCY

According to Ashby and Bréchet (2003), hollow-box or I-section beams are stiffer and stronger than solid sections of the same cross-sectional area. Similarly, panels with ribs or waffle stiffeners, as well as those with an expanded core to form a sandwich, are stiffer and stronger when bent. These are just a few examples of how shape can be used to increase the efficiency/strength of a structure. To quantify this, we require a metric - a method for determining the structural efficiency of a section shape regardless of the material used to construct it.

According to Williams and Starke (2003), a recent trend in the transportation industry is to increase customer value through the use of advanced structural materials and emerging manufacturing technologies. The objective is to add value to a system by improving performance, lowering ownership costs, extending the system’s life, and minimizing environmental impact. Improved performance of materials typically translates into increased structural efficiency, resulting in a lighter product. Structural efficiency is the result of the combined effect of material capability and design methodology.

Bejan (2010) coined the term “structural efficiency.” Structural optimization is the process of improving the performance of a mechanical structure. We optimize structural performance to achieve a better structural response with the same material resources, or to use fewer material resources to achieve the same structural response. Even if structural optimization produces an optimal solution, it does not provide information about the material’s performance in its primary function - load bearing. This can only be demonstrated by employing a novel explicit concept: structural efficiency. The ideal structure is one in which the entire volume is subjected to the permissible stress. In this case, structural efficiency is equal to 100%. In practice, this level of efficacy is unattainable. It is critical to continue quantifying material consumption. This is accomplished by utilizing the structural efficiency factor.
According to Ardekani et al. (2020), efficient building design results in increased energy conservation and material reduction. Numerous structural and architectural interventions can help achieve adequate structural efficiency while utilizing fewer materials. Aerodynamic shapes can help improve structural efficiency by lowering the wind loads on buildings. Swiss Re, London (fosterandpartners.com), and Hearst Tower, New York (fosterandpartners.com), are two prominent tall buildings that have recently adopted this structural system concept to meet both architectural and structural efficiency objectives. Finding more efficient forms results in a reduction in structure weight, which may eventually have a noticeable and long-lasting effect on tall buildings. Increased structural efficiency enables the use of fewer or less structural materials and significant weight savings (Griffin and Zuteck, 2001). This study defines structural efficiency as a ratio of the mass a structure can support to the mass of the structure itself.

8 PARADIGM AND DISCUSSION

The case studies presented here illustrate the necessary approaches for addressing building efficiency, as well as the significance of a holistic and integrated approach to achieving structural efficiency. Various factors, such as the information and objectivity of the researchers, the validity and reliability of research methods, the time during which the analysis was conducted, the context in which it was conducted, and the fact that different disciplines have different approaches, all influence the results. The literature review, case studies selected, and scientific methods used to quantify environmental impact all underlined the need for a broader approach to quantifying building energy efficiency. It is possible for designers to evaluate and select energy-efficient strategies using frameworks such as the Integrated Energy Efficient Building Design Process (Kanagaraj and Mahalingam, 2011). According to the SANS 204 review, this does not appear to be sufficient because the determination and incorporation of structural efficiency have not been formally incorporated into the energy-efficiency process.

The literature defines structural efficiency as the ability to support an infinitely high load with the least amount of building material. This definition, in the authors’ view, lacks logical applicability. An energy-efficient structural system uses materials that require the least amount of energy to produce. Sustainable building construction requires structural and energy efficiency. In terms of structural efficiency, the process is often difficult to navigate, because architects and/or the owner/developer are often prescriptive, leaving design engineers little room to modify the architectural design scheme. In some cases, the architect and owner/developer must ensure the project complies with SANS 10400-XA and SANS 204 for authorities to approve it. According to the literature review, mining raw materials and/or recycled materials and transporting building materials for processing are energy-intensive processes. Manufacture of building components and products, transportation of materials to the construction site, occupation of the building, building maintenance, improvements/renovations, deconstruction, and rubble/material transportation all need to be taken into account in assessing structural efficiency.

In this study’s paradigm, three construction materials are examined to demonstrate the significance of the concept of structural efficiency in energy-efficiency evaluation. The model assumed an average design load of 67 kN (designed applied load equal to the factored resistant load). Concrete, steel, and wood members are all designed to withstand this force. The design of the concrete column conforms to SANS 10100-1:2000. The design of the wooden column conforms to SANS 10163-1:2010. SANS 10162-1:2005 specifies the optimal column size for steel structures. The self-weight of each section was then calculated in accordance with SANS10160-2:2011. The diagram below depicts the structural effectiveness of different materials used to resist the same load. After calculating the embodied energy of each material using Chen et al. (2001) values, the diagram below illustrates an integrated structural and energy efficiency (embodied) paradigm that includes structural efficiency.
Due to numerous variables such as the concrete cover over reinforcement; different grades of reinforcing steel (250, 450, 485 MPa); different grades of concrete (25, 30 and 40 MPa), and various shapes of possible section (circular, square, rectangular and irregular), different designers will arrive at different member sizes for a given design load. As a result, the structural efficiency is difficult to limit to a single value in practice. Another factor to consider, particularly in concrete, is the design solution’s practicality. It is difficult to accurately quantify the embodied energy of concrete as a construction material. This is due to a lack of reliable data for the amount of energy used in the mining of raw materials, manufacturing, and positioning of structural elements on site. Timber is available in a variety of grades (Pine plank – grade 5, 7, 10 and 14; Pine pole – grade 457-2 and 753; Gum pole – grade 457-2 and 753 and other), which can only be formed into a few specific shapes. As a result, there are numerous structural efficiencies that can be achieved with timber as a construction material. In order to calculate the amount of energy required for timber production, complex calculations must be performed that rely on data that is frequently difficult to obtain. The data also changes over time as a result of changes in manufacturing processes and technological advancements. Structural steel has a high level of structural efficiency and embodied energy. Steel manufacturing is the world’s largest industrial source of CO\textsubscript{2} emission associated with it (Serrenho et al., 2016). It is also difficult to assign a single structural efficiency value because there are so many different grades (commercial, HR43/25, 43A, 3CR12, 300W, 350W and S355JR) and shapes of steel to choose from (I section, H-section, channel, Angle, hollow sections). Because of uncertainties about various stages of the manufacturing process, as well as the difficulty and unreliability of data, the figure above allows for variation in the values of structural efficiency and embodied energy.

Given the two (structural and embodied energy efficiency) parameters, an obvious question arises: which material should be used? The best material to use is one that has a high structural efficiency while simultaneously also has a low embodied energy. As Hussin et al. (2013) state that excessive and inappropriate use of natural resources during construction and material creation should be avoided in order to avoid degrading the local environment. Recognizing the potential for resource conservation through better decision making is becoming increasingly important, both economically and environmentally, Cleveland and Ruth (1998) argue that there is a pressing need to focus on the concept of dematerialisation, which refers to the need for absolute or relative reduction in the amount of materials used and/or waste produced in the processing of an economic output unit. As Harris (1999) stated, determining the severity of some effects is difficult. As a result, attempting to develop a single parameter for a building’s overall environmental impact is difficult and irrational.

A profile is required to integrate multiple indicators, including that of structural efficiency. According to Ardekani et al. (2020), efficient building design results in increased energy conservation and material reduction. Therefore, it is critical to constantly be aware of the various ways in which a process or design decision affects the environment. Additionally, it is critical to quantify the magnitude of the effect of each process as accurately as possible. Although it is outside the scope of this research, it is important to note that including a comprehensive energy requirement for the building lifecycle process, as suggested by Chen et al. (2001), has the potential to make a significant difference in terms of reducing energy usage. This is because the energy required during the building’s construction, use and end of life has had up to now little, if any, impact on its structural efficiency. However, structural designers must play
a role in decision-making, because the designs have an effect on the amount of embodied energy in a building. This emphasizes the importance of increased communication, interaction, and recognition between design team members and various sectors of the construction industry in order to facilitate more informed decision-making (Ding, 2008).

9 CONCLUSIONS AND RECOMMENDATIONS

The production of construction materials results in a significant amount of carbon emissions which have a major effect on climate change. Most, if not all, construction materials involve the use of energy in the process of mining and manufacturing. Common construction materials are steel, cement, timber, and masonry. Buildings should be constructed in the most efficient and effective manner so as to minimise the ecological strain, energy consumption and remedial building costs. Broad adoption of “green” building and construction standards is vital to improving energy efficiency in the building sector. Sustainable buildings have an essential role to play in achieving sustainable development by improving energy utilisation and environmental performance. The materials used to construct a building significantly contribute to its overall environmental impact. Design of buildings and structures and use of construction materials are inextricably linked. A careful selection of materials and products is necessary to conserve energy and reduce CO₂ emissions. Improved performance, as determined by materials, typically translates into increased structural efficiency. The ideal structure is one in which the maximum allowable stress is applied to the entire volume. In practice, this level of efficacy is unattainable. More efficient structural members that cut down on the weight of structures, can have long-term beneficial effects on buildings.

The ideal of structural efficiency is the ability to support an infinitely high load while using the smallest amount of building material possible. This ideal is unattainable, however a structural system that utilizes materials that require the least amount of energy to manufacture is the most environmentally friendly from an energy-efficiency standpoint. There are several factors to consider in terms of energy consumption, including: mining of raw materials; transportation of building materials for processing; manufacturing of building components and placement. Three construction materials were investigated to demonstrate the importance of structural efficiency in the energy-efficiency assessment. The study assumed a typical design load of 67 kN. Each material is engineered to withstand this force according to appropriate South African National Standards. After that, each section’s self-weight was calculated in accordance with SANS10160-2:2011. After calculating the embodied energy of each material using Chen et al. (2001) values, the study demonstrated a structural efficiency paradigm. Due to variables discussed in the study, the structural efficiency of each material cannot be set to a single value. Because of uncertainties at various stages of the manufacturing process, as well as the difficulty and unreliability of data, the figure above allows for variation in structural efficiency and embodied energy. Given the two parameters (structural efficiency and embodied energy efficiency), an obvious question arises: which material should be used? The best material to use is one that has high structural efficiency while also having a low embodied energy.

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Sustainable construction developments for low-income housing projects: lessons for South Africa in local governments

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ABSTRACT & KEYWORDS

Purpose of this paper
Low-income housing remains one of the most pressing infrastructure deficiencies in South African local governments. This study aim is to presents the factors that would enhance sustainable low-income housing developments and performance of contractors during the construction process.

Design/methodology/approach
The study was descriptive and exploratory in nature using a quantitative design. Data was gathered through structured questionnaires using stratified random technique to ensure that medium to large scale construction companies are well represented in the selection relating to low-income housing within Polokwane Municipality.

Findings
Findings suggest that causes of poor quality in low-cost houses is perceived to be related to the use of inexperienced contractors who are presumably not tested enough, and to the untrained workers by the contractors. The finding of this study also provides a platform for improving quality of housing design, construction projects, sustainability and an opportunity for local and international design and construction professionals to rethink design in the context of low-income housing project.

Research limitations/implications
Managers in low-income housing projects and contractors may also use the results of this study as a benchmark for competitive advantage. The results also provide a guideline for sustainable construction developments for low-income housing projects for South Africa in local governments.

Value of paper
This study is of value to designers/consultants and managers in the local governments as it helps to establish the factors affecting the sustainable construction developments for low-income housing projects.

Keywords: Low-income housing, contractors, building construction, quality design
1. INTRODUCTION

The quality of low-income housing in Southern Africa is challenging because there are many multidimensional tasks and operational measures to adhere to (Zunguzane, Smallwood & Emuze, 2012: 19; Aigbavhoa, Oke, Akinradewo, Aghimien & Okgone, 2019:2). Low-income housing can be described as a social housing, which provides medium density, affordable, rental housing to low- and middle-income households (Statistics South Africa, 2015:2). The South African local government is obliged to provide low-income housing to the local communities they serve. Low-income housing is also known as Reconstruction and Development Programme (RDP houses) (Cloete & Massey, 2017). A house is the heart of people’s life, a home of retreat, confidentiality, shelter, relief and provision for work and leisure activities (Department of Human Settlements, 2017).

Housing beneficiaries have needs such as security, shelter, status and fulfilment of ambitions; hence, quality of the dwelling is of concern. Kissi and Badu (2016:455) discovered that professionals, construction organisations, incorrect use or installation of materials and lack of knowledge by contractors, make building design errors. It is also caused by poor design which contributes 50% in building errors; 40% is in the construction stage and 10% is the product failure, of which mistakes in roofing and leakages mostly indicate improper design (Agrawal, Tausif, Khan & Kesharwani, 2017:20). One of the Department of Human Settlements’ areas of obligation in the delivery of human settlements narrates to the bottom end of the market, where it affords housing grants to the poor (DHS), 2017:1). Cloete and Massey (2017:151) remarked that the gap housing market includes people who characteristically earn between R3 500 and R15 000 per month, which is too little to qualify them to participate in the private property market, yet too much to enable for government assistance.

The South African government has built almost 3 million low-income homes since 1994 and a further 3 million are targeted by 2025 (Department of Human Settlements (DHS), 2017:1). The White Paper’s views provide an overall description of the housing condition when the African National Congress (ANC) government took power in 1994 (Statistics South Africa, 2015:2). The White Paper delineated numerous policies to ensure the provision of sustainable adequate housing through ensuring the strengthening public-private partnerships, encouraging treasuries, providing funding assistance to disadvantaged individuals (Housing Development Agency, 2013:2). The provision of sustainable low-income housing projects contributes to development, economic growth and redistribution of proper design and adequate quality of construction. The high quality of low-income housing projects not only contributes to improve the socio-economic conditions of communities, but also supports conformance to quality to the original set standard (Dwijendra, 2013:70). The establishment of effective co-ordinating constructions throughout government to promote efficiency in low-income housing projects are necessary effort of service delivery. The construction industry requires the clearer systems to deliver its services on time to the right people, efficiently and effectively (Statistics South Africa, 2015:2).

Quality procedures, policies, techniques and constructions can be developed to improve quality in the construction industry. However, low-income housing projects within the Polokwane Municipality are confronted with countless uncertainties and problems such as deliberate non-compliance to specifications by the contractor defects of materials used, accidents, use of unskilled labour, substandard quality of workmanship, wrong equipment being used and poor communication during the construction phase (Ramoroka, 2021:3).

2 Literature review

2.1 Construction quality issues in low-income housing

The utmost mutual examples of quality defects in low-income housing include; roof cracks, leaking plumbing, faulty electrical systems, and many others. Low-quality materials, lack of auditing, lack of proper supervision, design complexity, design concept among others are some of the common sources of construction defects (Nykala, Ramoroka & Ramdass, 2021:25). Studies have revealed that poor quality houses are instigated by non-conformance with the provided building codes and existing regulations and rules (Zewdu, & Aregaw, 2015; George, 2016; Keinan, 2018; Agrawal). In extreme cases, poor quality RDP houses, limited quality of construction and inappropriate design can harm the economic viewpoint of a project, thereby turning a potentially profitable organisation into an ineffective construction project (Statistics South Africa, 2015:2). This condition highlights the collective expedition for tools, systems, and processes involving quality measurement in low-income housing projects.
low-income housing quality defects, the low-quality standards and the low quality of constructability and the undetailed drawings causes the problem to the contractor and will further cause the mistakes in the building and the building safety not being guaranteed (Zunguzane et al., 2012).

Foundation failure, cracking and defective plaster contribute poor quality of lost income housing project (Kumar & Sriram, 2016:329). Cracking and defective plaster are also caused by water percolation and corroded reinforcement that causes fragmented material. The structural distresses the safety while the non-structural distresses the appearance and has the impression of defective work. Kumar and Sriram (2016:329) mentions that the structural cracks contribute to low-income housing. These are usually structural imperfections, which cause cracks, faulty ventilation, timber rot fungus and mould infection that can also happen (Jogdand & Deshmukh, 2017; Nyakala et al., 2021). Disasters and defective are mostly caused by the improper assessment of the bearing capacity of the soil causing, the wrong interpretation of geotechnical investigation and the poor-quality materials used. The housing sector is mostly built, operated, designed, maintained and decommissioned by construction organisations, which are comprised directly in construction design and buildings and civil engineering infrastructure.

2.2 Development of sustainable low-income project

Quality policies should clearly define objectives to be accomplished. It is critical for any contractor to create the operating procedures, authority, responsibility and resources in different phases of the process (Jumah, Faithy, Rami & Jamal, 2015:58). Housing project managers should provide specific documented standards, procedures to be followed by all employees during construction process. This view is also supported by Jogdand & Deshmukh (2017) who stated that suitable testing, inspection, audit programs as well as examination should take place at appropriate stages in the construction project. Based on the conducted research by Rumane (2013) quality planning can be viewed as a systematic process that interprets quality policy into measurable objectives and requirements. Quality plans are useful in assuring conformance to customer expectations, facilitating quality traceability and also classifying gaps that can be occupied by quality team. This is the motive why numerous authors have emphasised that policies and procedures, internal guidelines and good practices are required to meet customer expectations. In the setting of housing project, quality planning remains important because it stipulate quality standards, practices, structure and resources of activities relevant to a specific job being performed (Zhang, 2000; Jung, Wang & Wu, 2009).

2.3 Improving quality of low-income housing projects

Experienced engineers or designers are required to identify the defects in a building to determine the causes of it (Aigbavhoa & Thwala, 2014). These are usually structural imperfections, which cause cracks, faulty ventilation, timber rot fungus and mould infection that can also happen. Disasters and defective are mostly caused by the improper assessment of the bearing capacity of the soil causing, the wrong interpretation of geotechnical investigation and the poor-quality materials used (Kumar & Sriram, 2016). The housing sector is mostly built, operated, designed, maintained and decommissioned by construction organisations, which are comprised directly in construction design and buildings and civil engineering infrastructure. Together with the housing project team, the unit responsible for quality control tries to determine whether the beneficiaries are appropriately satisfied according to inclusive targets of the housing project performance (Aigbavhoa, Oke, Akinrade, Aghimien & Okgonne, 2019). Nyakala, Pretorius & Vermeulen (2019) discovered that top management, design, teamwork, employee empowerment and customer satisfaction are the critical factors that influence the construction of low-cost housing within municipal areas. A key factor determining an effective housing project and creating performance for municipal effectiveness is leadership. Leadership as one of the most critical ingredients in most construction projects.

2.4 Customer satisfaction

Customer satisfaction is a significant indicator used in low-income housing and is a measurement of how products and services supplied by a contractor meet customers’ requirements (Emuze & Mhlwa, 2015). Customer information necessities to be applicable and on time, while still being accurate and making it easy to understand when dealing with housing projects (Egbu, Ellis, R. & Gorse, 2004). External monitors and authorities should be appointed to evaluate and account on the construction process carried out by contractors towards achieving quality of low-income housing project. Daily construction processes are other important considerations to be assessed by the low-income housing...
beneficiaries’ representative and community project leader. Housing project managers should create weekly plans and draw up daily or monthly meetings with community leaders. Contractors and housing sector authorities should analyse their organisational values and attitudes towards the implementation process for quality assurance (Nyakala et al., 2021). Research by George (2016:23) reveals that emerging contractors in developing countries use the critical incident technique to elicit financial challenges. It is important to implement and facilitate quality of low-income housing and performance of contractors in the South African local government concluded by quality experts. This finding is in line with the studies of Nyakala et al. (2021) which indicate that in construction projects, a project fails due to the lack of conducive embracing of corporate structure beliefs for measuring quality performance and profit generating, ensuring efficiency and cost reduction. It is clear that housing project teams and organisational structure of efficiency assists in measuring tasks of poor quality and promotes consumer gratification in the housing sector (Zunguzane et al., 2012).

3 Methodology

In this study, quantitative research within the setting of a descriptive and exploratory research designs was used to determine the key factors contributing to poor quality of low-income housing within Polokwane Municipality. The quantitative approach relies comprehensively on statistics and numbers in the analysis and interpretation of findings that are generalised from the sample to the population. The quantitative research approach interprets reality as objective, out there independent of the researcher (Creswell, 2014:11). The positivist approach emphasis observable facts over subjective thought. It relies upon measurement, counting, and the use of several scales (Bless et al., 2018:16). Creswell (2014) further explains that objectives can be measured by applying an instrument or questionnaire.

3.1 Sampling method and response rate

The sample focused on the one-hundred three (103) consisting of housing beneficiaries, civil engineers, project managers, contractors, and consultants within the Polokwane Municipality. The present study chosen a purposive sampling method to provide understanding into the detailed fields of interest (Creswell, 2014:50). It is a process that includes identification and select of individuals or groups of individuals that are capable and well informed about a phenomenon of interest (Kothari, 2004:42). The sample strata consist of housing beneficiaries from Seshego within Polokwane Municipality and housing contractors identifiable through the NHBRC database. The Seshego Low-Cost Housing in Polokwane Municipality was selected because of the accessibility for the primary investigator. Table 1 summarise response rate. Fifty-five (55) out of the ninety (90) questionnaires delivered by hand to contractors were collected, which constitutes a 61% response rate, and forty-eight (48) housing beneficiaries completed and returned questionnaires. This constitutes a 69% response rate.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Sent</th>
<th>Returned</th>
<th>Not returned</th>
<th>Response rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractors (Civil engineers, managers, consultants)</td>
<td>160</td>
<td>103</td>
<td>57</td>
<td>64.0</td>
</tr>
</tbody>
</table>

3.2 Data collection

The self-administered questionnaires were disseminated to the potential respondents who worked in the low-cost housing projects within Polokwane Municipality. The measuring instrument used in this study comprised a structured questionnaire survey using Likert-ranking scales as well as closed-ended questions to generate quantitative data. A summated Likert scale was adopted whereby each respondent specified the degree to which they agreed or disagreed with its contents, hence emphasising the importance of selecting the anticipated response (Cooper & Schindler, 2014:55). A research questionnaire was used for the present study as a form of data collection method. The questionnaire was developed and used to assist the respondents to provide the best information. Henceforth, it aided to decrease the number of errors. The questionnaire was complemented by guidelines on it was to be accomplished.
A questionnaire was used to identify the factors contributing to poor quality of low-cost housing within Polokwane Municipality. This was developed using a 1-to-5-point Likert scale (where 1 represented “strongly disagree or least important” and “5 represented “strongly agree and very important”) to rate each of its items. These variables were ranked and used to identify quality factors that can improve quality of low-cost housing within Polokwane Municipality. Open-ended questions were included so that participants could express and explain their views to reveal issues not captured in the reviewed literature. The questionnaire was accompanied by a covering letter which explained the purpose of the study. It assured confidential treatment of responses and anonymity of respondents. In summary, the instrument about contractors was posted and e-mailed to them individually, while the instrument meant for housing beneficiaries was delivered by hand. The questions for housing beneficiaries were compiled in Sepedi and English to accommodate people who can only speak one of these languages. The questionnaires were also short and to the point in order to avoid reducing the interest of the participants. The questions were developed in such a way that participants were not required to reveal confidential information of any kind. The questionnaire (research or information gathering instrument) was developed with three (3) main sections, namely; Section A dealt with the causes of poor quality of low-cost housing. Section B dealt with factors contributing to poor, while Section C dealt with tools or techniques which could improve the quality of the low-cost housing projects.

3.3 Analysis and interpretation of the data

The data analysis used the Microsoft Excel 2013 statistical package and Statistical Package for the Social Sciences (SPSS) version 24 in order to produce a combination of descriptive and non-parametric statistics (Field, 2013). Descriptive statistics was used to determine the relative importance of the critical factors for the effective quality improvement tools or techniques related to low-cost housing. In order to establish the statistics findings, the study made use of tables, graphs, percentages and frequency distribution tables. Chi-square was the statistical test used for analysing the categorical data (Field, 2013). Data were coded, arranged and captured on a computer using MS Excel software package for storage. A computer programme, namely, Windows version 24 of the SPSS was adopted to analyse the data. The answers to the questions were coded, and a spreadsheet was articulated in which all closed-ended questions of the questionnaire were captured. Bearing this coding pattern in mind, the present study outlined descriptive statistics, which encompassed means, standard deviations and frequencies that were calculated for the quantitative data.

4. Results and discussion

4.1 Respondents’ biographical profile: Contractors

Findings from workable and completed questionnaires indicated that 85% of the respondents are male and 15% are female with an average age of 35 years. 37% are Quantity Surveyors, 7% are Architects, 11% are Engineers, 12.5% are Project Managers, 15% are Construction Managers, 5% are Construction Project Managers, 3% Project administrators, 9.5% working in consulting businesses. Also, 60% are employed by contractors, 15% are Town Planners, Building Inspectors, Site agents and 17.5% are employees of government at various levels. All of the respondents are currently involved in low-cost housing projects. 70.5% works in the private sector, 25.5% in the public sector and 4% work in both sectors. The forty-eight (48) participants had different years of experience in building the low-cost housing. The figure 1 presents the participants’ years working in the low-cost housing project and total number of responses for this question was 92.5% of respondents. 8% of respondents, which least have between 0-5years of experience, followed by 22% of respondents with 6-10years of experience. Further, the results display that 40% of respondents have between 11-15years and 30% of respondents have more than 16 years working in the low-cost housing projects. Notably the highest experienced respondents have 11-15 years working in the low-cost house building projects.
4.2 Factors affecting quality of low-cost Housing Projects

Table 2 shows the ranking factors affecting the building of poor-quality low-cost housing projects in the study area using mean item score and standard deviation. The highest ranked factor is low quality of materials and equipment with 4.48 and 1.92 MIS and SD values respectively. This was followed by unskilled/incompetent site workers with MS of 4.41, inappropriate mode of financing project with MIS of 4.36, poor contract administration with MS of 4.28, project control problems with MIS of 4.26, involvement of large number of participants of project and problem of communication and coordination with MIS of 4.13 and 4.00 respectively. Others are shortage of site workers, poor relationship between project team members, poor safety management, delay in interim payment, and inappropriate risk allocation among project team. The factors ranked in the last three are inappropriate pricing/ incentives of services rendered by contractors or consultants, unexpected bad economic conditions and unfavourable government policy.

Table 2: Ranking contractors’ perceptions on building of low-cost housing

<table>
<thead>
<tr>
<th>Statement</th>
<th>MIS</th>
<th>Std. Dev</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low quality of materials and equipment</td>
<td>4.48</td>
<td>1.92</td>
<td>1</td>
</tr>
<tr>
<td>Unskilled/ incompetent site workers</td>
<td>4.41</td>
<td>1.62</td>
<td>2</td>
</tr>
<tr>
<td>Inappropriate mode of financing project</td>
<td>4.36</td>
<td>1.93</td>
<td>3</td>
</tr>
<tr>
<td>Poor contract administration</td>
<td>4.28</td>
<td>1.53</td>
<td>4</td>
</tr>
<tr>
<td>Project control problems</td>
<td>4.26</td>
<td>1.93</td>
<td>5</td>
</tr>
<tr>
<td>Involvement of large number of participants of project</td>
<td>4.13</td>
<td>1.80</td>
<td>6</td>
</tr>
<tr>
<td>Problem of communication and coordination</td>
<td>4.00</td>
<td>1.57</td>
<td>7</td>
</tr>
<tr>
<td>Shortage of site workers</td>
<td>3.97</td>
<td>1.29</td>
<td>8</td>
</tr>
<tr>
<td>Poor relationship between project team members</td>
<td>3.85</td>
<td>1.72</td>
<td>9</td>
</tr>
<tr>
<td>Poor safety management</td>
<td>3.79</td>
<td>1.38</td>
<td>10</td>
</tr>
<tr>
<td>Delay in interim payment</td>
<td>3.61</td>
<td>1.29</td>
<td>11</td>
</tr>
<tr>
<td>Inappropriate risk allocation among project team</td>
<td>3.60</td>
<td>1.27</td>
<td>12</td>
</tr>
<tr>
<td>Inappropriate pricing/ incentives of services rendered by contractors or consultants</td>
<td>3.56</td>
<td>1.32</td>
<td>13</td>
</tr>
<tr>
<td>Inappropriate project planning and scheduling</td>
<td>2.94</td>
<td>2.69</td>
<td>14</td>
</tr>
<tr>
<td>Unexpected bad economic conditions</td>
<td>2.92</td>
<td>2.67</td>
<td>15</td>
</tr>
<tr>
<td>Unfavourable government policy</td>
<td>2.75</td>
<td>2.75</td>
<td>16</td>
</tr>
</tbody>
</table>

4.3 Implications of poor-quality housing projects

The major effect of poor quality of Low-Cost Housing project as ranked by respondent in Table 3 are poor quality control with MIS of 4.50, lack of cooperation from local authorities with MIS of 4.43, difficult of design and construction with MIS of 4.32, unclear lines of responsibility and authority with MIS of 4.32, high accident rates with MIS of 4.14. Other are faulty buildings, scope and time overruns, faulty tender processes, lack of trust from the community members, mitigation, court cases, impact on project performance and loss of income to contractors.
Table 3: Implications of poor-quality housing projects

<table>
<thead>
<tr>
<th>Implications</th>
<th>MIS</th>
<th>SD</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor quality control</td>
<td>4.50</td>
<td>1.81</td>
<td>1</td>
</tr>
<tr>
<td>Lack of cooperation from local authorities</td>
<td>4.43</td>
<td>1.78</td>
<td>2</td>
</tr>
<tr>
<td>Difficult of design and construction</td>
<td>4.32</td>
<td>1.86</td>
<td>3</td>
</tr>
<tr>
<td>Unclear lines of responsibility and authority</td>
<td>4.32</td>
<td>1.23</td>
<td>4</td>
</tr>
<tr>
<td>High accident rates</td>
<td>4.26</td>
<td>1.09</td>
<td>5</td>
</tr>
<tr>
<td>Faulty buildings</td>
<td>4.14</td>
<td>1.15</td>
<td>6</td>
</tr>
<tr>
<td>Cost overruns</td>
<td>3.99</td>
<td>1.33</td>
<td>7</td>
</tr>
<tr>
<td>Time overruns</td>
<td>3.96</td>
<td>1.62</td>
<td>8</td>
</tr>
<tr>
<td>Faulty tender processes</td>
<td>3.91</td>
<td>1.49</td>
<td>9</td>
</tr>
<tr>
<td>Lack of trust from the community members</td>
<td>3.64</td>
<td>1.66</td>
<td>10</td>
</tr>
<tr>
<td>Mitigation</td>
<td>3.61</td>
<td>1.79</td>
<td>11</td>
</tr>
<tr>
<td>Court cases</td>
<td>3.45</td>
<td>1.74</td>
<td>12</td>
</tr>
<tr>
<td>Impact on project performance</td>
<td>3.16</td>
<td>1.89</td>
<td>13</td>
</tr>
<tr>
<td>Loss of income to contractors</td>
<td>3.00</td>
<td>1.09</td>
<td>14</td>
</tr>
</tbody>
</table>

4.4 Measures to improve quality of low-cost housing projects

In evaluating measures to improve quality of Low-Cost Housing Project, Table 4 indicate different initiatives that could be taken to minimise non-conformance to quality of Low Cost Housing as ranked by the respondents. Contractors’ planning and scheduling is the most important factor with a MIS of 4.21 and SD of 1.61, followed by time-cost trade-offs, selecting right supplier’s, budget control and good communications with MIS of 4.12, 4.03, and 4.00 respectively. Others are teamwork, the use of skilled labour, reporting corruption, workers participation, top-down commitment, accurate construction management, organisational structure, monitoring and controlling.

Table 4. Measures to improve the Quality of Low-Cost Housing Projects

<table>
<thead>
<tr>
<th>Measures</th>
<th>MIS</th>
<th>SD</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning and scheduling</td>
<td>4.21</td>
<td>1.61</td>
<td>1</td>
</tr>
<tr>
<td>Time-cost trade-offs</td>
<td>4.12</td>
<td>1.40</td>
<td>2</td>
</tr>
<tr>
<td>Selecting right supplier’s</td>
<td>4.03</td>
<td>1.02</td>
<td>3</td>
</tr>
<tr>
<td>Budget control</td>
<td>4.00</td>
<td>1.80</td>
<td>4</td>
</tr>
<tr>
<td>Good communications</td>
<td>4.00</td>
<td>1.57</td>
<td>5</td>
</tr>
<tr>
<td>Teamwork</td>
<td>3.97</td>
<td>1.77</td>
<td>6</td>
</tr>
<tr>
<td>The use of skilled labour</td>
<td>3.85</td>
<td>1.72</td>
<td>7</td>
</tr>
<tr>
<td>Reporting corruption</td>
<td>3.85</td>
<td>1.38</td>
<td>8</td>
</tr>
<tr>
<td>Workers participation</td>
<td>3.79</td>
<td>1.24</td>
<td>9</td>
</tr>
<tr>
<td>Top-down commitment</td>
<td>3.61</td>
<td>1.42</td>
<td>10</td>
</tr>
<tr>
<td>Accurate construction management</td>
<td>3.56</td>
<td>1.81</td>
<td>11</td>
</tr>
<tr>
<td>Organisational structure</td>
<td>3.48</td>
<td>1.29</td>
<td>12</td>
</tr>
<tr>
<td>Monitoring and controlling</td>
<td>3.36</td>
<td>1.18</td>
<td>13</td>
</tr>
</tbody>
</table>

5. Discussion

In support of the results of this study, Zewdu and Aregaw (2015) observed that contractor cost overrun, inexperienced and incompetence of workers, and poor construction design are factors leading to non-conformance to quality in construction projects. Correspondingly, the results of Addo (2015) indicated that poor planning and scheduling and delay on the delivery of construction project is the major causes of non-conformance to quality as pointed out also by the findings of this study. These factors have argumentative effect indicating ineffective budget control and poor construction management, it also leads to dissatisfaction of stakeholders, particularly end-users and clients. The delivery of low-cost housing project to the poor in South Africa is performing below expectations due to a number of factors. There are major problems in all aspects related to the provision of low-income houses. Starting at governmental departments, such as municipalities that award and oversee low-income housing projects, to the contractors who build the houses, impediments seem to be overflow.

Keinan (2018) noted that variations in housing satisfaction and health status in four lower socio-economic housing typologies. They found that the cost overruns and that non-conformance to required
quality will constantly to damage status of the contracting organisation in contract to the result acquired by this study as the implications of poor quality of Low-Cost Housing projects in the local government of South Africa. In order to limit, manage and control this threat, Keinan (2018) suggested that total quality management practices which includes employee empowerment, teamwork, training and education are possible solutions. This is in agreement with this study where top-down commitment, accurate construction management, appropriate organisational structure as well as good communications are the major control measures. Low-cost housing contractors are able to commit and understanding the high importance of customer satisfaction. Future research can be undertaken to promote quality standards and requirements and how emerging contractors, particularly in terms of construction materials and methods. Through the total quality management analysis, municipal inspectors and NHBRC top officials should be able to encourage all contractors involved in low-cost housing projects to register with a quality assurance bodies in order to facilitate quality improvement audits.

6. Conclusion and recommendation

The provision of Low-Income Housing project to the poor in South Africa is performing below expectations due to a number for factors. The study has been able to identify and evaluate the factors causing non-conformance to quality of Low-Income Housing projects, implications of poor-quality Low-Income Housing projects and measures for ensuring quality in Low Income Housing projects in Seshego, Polokwane Municipality of South Africa. It can be concluded that housing projects are regulated by NHBRC but little is given to government RDP housing projects.

In order to minimise the challenge of poor quality of Low-Income Housing projects, measures that can be taken by construction professionals and other stakeholders are related to proper planning and scheduling, selecting right supplier for high materials, effective budget control system in place, good communications among stakeholders, make use of skilled workers, report corruption, accurate construction and have a proper organisational structure. In view of this, it is recommended that reskilling about housing and training of all employees involved in the construction of Low-Income Housing project must be taken into consideration mostly by construction professionals and stakeholders.

Contractors should be tasked with the responsibility of ensuring their employees obtain adequate training on total quality management. Competent professionals should be engaged in the construction of Low-Income Housing projects to ensure that the technical necessities are met. It is also essential for professionals to possess themselves abreast with the appropriate building regulations and codes and be more attentive in the implementation of these standards. Formal quality training programmes in the built environment disciplines should be promoted among contractors, particularly in terms of construction materials and building codes. All contractors involved in Low Income Housing projects should be encouraged to register with a quality assurance body in order to facilitate performance audits.

REFERENCES


The Potential Benefits of Using E-Tendering in South African Construction Projects

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ABSTRACT & KEYWORDS

Purpose
The South African Construction Industry (SACI) in its broadest sense had to change from the normal and ancient way in order to meet the global sustainability objective. However, there are challenges encountered in adopting and implementing sustainable technological construction practices. This study aims to fill the knowledge gap through investigating the Potential benefits of e-tendering in the south African construction Projects.

Design
A Questionnaire was prepared and distributed electronically to Professionals in the South African Construction Industry and out of the 110 sent out only 91 responses were received. The SPSS Package, descriptive analysis (mean item score) and exploratory factor analysis (EFA) were used to analyze the data obtained.

Findings
The findings of the study show that the top three potential benefits of e-tendering are: increased distribution speed of tenders, increased efficiency and effectiveness, and improved tender management.

Value
The effective deployment of an electronic tendering (e-tendering) systems, according to various authors, is one of the tactics that may be used to increase transparency, accountability, and eliminate corruption.

Keywords: e-Tendering, innovation adoption, South African construction industry.
1. INTRODUCTION

1.1 Background

Tendering is now widely regarded as one of the most transparent methods of awarding government contracts, as well as one of the most likely to result in a favorable conclusion for a government when it comes to spending public funds. Tendering processes are thought to be a good way for governments to assign contracts for construction projects fairly (Balogun, et al., 2016). Balut and Yen (2013) indicate that throughout the lifecycle of a construction project, the tendering phase is considered to be the most significant and important. The contractual and legislative agreements between the client, consultant team, contractor, and other project partners are claimed to be shaped at this phase. Tendering decisions have a significant impact on the successful completion of a building project (Anthony, 2018).

The tendering phase is information-intensive and has a lot of paperwork. It includes the invitation of Contractors to tender, form of tender, designs, bill of quantities preparations, health and safety and contractual agreements (Anthony, 2018). The preparations of the documents aforementioned is expensive, time consuming and confusing at times. Once the preparation of the tender document is complete and ready to be distributed to interested bidders, during this phase that’s when many problems arise (Balogun, et al., 2016).

The problems include but not limited to, incomplete information or tender document, mixing up of information or documents, lack of enough copies to distribute to interested bidders, information leak, addressing of queries, organizing of tender clarification meetings, and issuing of addendums (Laryea & Ibem, 2014).

Electronic tendering could resolve many of the aforementioned issues in the Construction Industry. Electronic tendering is the process of procuring goods and services electronically. It refers to any online/digital tendering process (Yen & Bulut, 2013). Layea & Ibema (2014) further defined e-tendering as the process of replacing the traditional paper tendering system in the procuring of services by electronically inviting, evaluation and appointing of suitable service providers. E-tendering has brought many benefits in the construction industry, among the major benefits of e-tendering is cost reduction, shortened tender period and a secured method of receiving and sending tenders. This has had a major impact on the productivity and performance of the construction industry (Ibem & Laryea, 2017).

2. THE POTENTIAL BENEFITS OF E-TENDERING

One of the benefits of centralizing the tendering process and documents is that it makes it easier for everyone to get their hands on tender documents (Anthony, 2018). Eadie et al. (2007) assessed the existing literature of e-tendering to establish the following list of e-Tendering benefits:

2.1 Price reduction in tendering

E-tendering enable all tender parties to electronically access tender information in the comfort of their own offices instead of travelling long distances to attend tender meetings. By doing so it does not only save them time, but it also saves travelling costs. E-tendering also reduces documentation costs and other funds associated with the paper-based method of tendering (Ibem & Laryea, 2015).

2.2 Reduction in time to source materials

Creates a platform where there is an effective and fast communication between all parties involved in a tender, including material suppliers resulting in reduction in time to source and purchase materials from different suppliers (Inzofu, 2016).

2.3 Reduction of administration costs

Administration costs are reduced because everything is handled and done electronically (Afolabi et al., 2019).

2.4 Staffing levels reduction in procurement

Fewer persons are involved during the tendering of works (Sithole, 2017).
2.5 Gains in competitive advantage

Competitive advantage can come from the benefits of a collaborative electronic environment, such as increased speed, efficiency, effectiveness, and data accuracy in the tendering stage, which can help a company get a better deal (Lou & Alshawi, 2009).

2.6 Improvements in communication

Communication is improved and able to reach all parties involved in the procurement process since everyone who is authorized can access the tender information anytime and anywhere (Afolabi, et al., 2019).

The implementation of e-Tendering has different benefits for different parties involved in the tendering stage of a construction project (Balogun, et al., 2016). The benefits for the parties tendering for the advertised job are as follows:

- Fast and uncomplicated access to tendering information/data
- Increased tender opportunities.
- Improved and easy access for geographically isolated organizations
- Increased market share and competitiveness
- Cost reduction of resources.

The benefits for the clients and government organizations are as follows:

- Increased efficiency and effectiveness
- Consistent tendering processes across the government.
- Costs Reduction (preparations, copying and distributing tender documents)
- Reduced time through efficient adoption and use of technology.
- Increased advantage regarding geographical location
- Enhanced the fast distribution of tenders
- Improved communication between parties
- Improved tender management processes.
- Reduced time spent on tender administration.

The aim of e-tendering is to try and eliminate the paper-based method of tendering while shortening the time taken to submit and respond to tender processes (Abubakar, 2021).

3. RESEARCH METHOD

This study evaluated the benefits of e-tendering in South African construction industry. The population for this study were active professionals in the Gauteng Province of the South African construction industry. The targeted professionals/Participants were Project Managers, Quantity Surveyors, Construction Managers, and Artisans. These construction professionals were chosen because, in the pilot study, they indicated knowledgeable contributions to meeting the aim of the study. The standard for selecting respondents for this study was based on their involvement in the tendering phase of construction projects in South Africa. This study employed self-selection and random sampling which gives all participants an equal chance of being selected for the study.

Data for this study was obtained through primary and secondary sources. The primary data collated for this study was achieved through administering of a well-structured questionnaire, which is mostly used for quantitative research [15]. The questionnaire was designed based on the reviewed literature. The secondary data used in this study was derived from existing literature published in government reports, conference papers and journals. Data for this study was collected with the aid of a well-structured questionnaire to evaluate the benefits of e-tendering in South African construction industry. Data collection took approximately twelve weeks. The respondents were given an average of fifteen minutes to complete the questionnaire without any form of coercion or disturbance. 91 questionnaires were retrieved from a total of 110 administered. It is important to note that these numbers were highly based on the availability, willingness, and consent of the participants to partake in the study. From the pilot study, there were signs that indigences of the Gauteng province are liberal. As such, their cultural, traditional, or religious predispositions did not seem to have posed a barrier or limitation to their
willingness to partake in the study nor did it hinder them from freely disclosing their opinions and sharing their knowledge with respect to the subject matter. Nevertheless, the general knowledge base and opinions of the respondents in this study are considered vital as they offer a basis for comparison between respondents, provide crucial insights to the subject matter and indicate pertinent dynamics on the study of the benefits of e-tendering in South African construction industry.

The analysis of data in this study employed descriptive analysis and exploratory factor analysis (EFA). Descriptive analysis used mean item score (MIS) and standard deviations to measure the significance of all the variables and to rank them. The questionnaire consisted of questions that were ranked using a five-point Likert scale to analyze and acquire the respondents’ opinion on the benefits of e-tendering in South African construction industry. The adopted scales are as follow:

1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; and 5 = Strongly Agree.

The five-point Likert scale was converted into mean item score (MIS) for each of the benefits of e-tendering in South African construction industry as proffered by the respondents. This made it possible to determine the rank of each item. The comparison of the MIS of the items as judged by the respondents was easy because the items were ranked. This helped in analyzing data collected from the survey questionnaire. The MIS was derived from the summation of the weight given to each factor by the respondents to the ratio or in relation to the product of the highest weight and the total number of respondents on a specific aspect, in which case, the weighting ranged from 1 to 5 with 1 being the lowest level of effect and 5 being the highest level of effect in the study. This was based on the principle that the respondents’ scores on the specific criteria when measured together are the empirically determined mean score. The MIS was calculated for each item using equation (1) presented below:

\[ \text{MIS} = \frac{1n1 + 2n2 + 3n3 + 4n4 + 5n5}{N} \]  \hspace{1cm} \text{Equation (1)}

Where:

- \( n1 \) = Number of respondents for strongly disagree.
- \( n2 \) = Number of respondents for disagree.
- \( n3 \) = Number of respondents for neutral.
- \( n4 \) = Number of respondents for agree.
- \( n5 \) = Number of respondents for extremely likely or strongly agree.
- \( N \) = Total number of respondents

After mathematical computations, the criteria were then ranked in descending order of their mean item score (from the highest to the lowest).

EFA was also used in this study to analyze the whole data set and determine the factors and groups of factors measured by the questionnaire. The rationale for using factor analysis for this study was to reduce the number of variables, find the relationship between variables and to categorize them. EFA also identifies variables that share common ideas through the means of factors or clusters of factors. The Eigen values and Scree plot were studied to determine the number of factors. From this, the conceptual factors and cluster factors measured by the questionnaire were identified. The EFA was conducted using SPSS version 28.

4. RESULT

Table 1 presents the mean score ranking and the standard deviation (SD) of the respondents’ opinion on the potential benefits of using e-tendering in South African construction industry. The respondents ranked the variables using a Five-point Likert scale where: 1= Strongly Disagree; 2= Disagree; 3= Neutral; 4= Agree; 5= Strongly Agree.
Table 1: Factors that encourage the use of e-tendering in South African Construction Projects

<table>
<thead>
<tr>
<th>Codes</th>
<th>Factors that encourage the use of e-tendering</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>C9.1</td>
<td>Price Reduction in tendering Process</td>
<td>3.89</td>
<td>1.100</td>
<td>1</td>
</tr>
<tr>
<td>C9.7</td>
<td>Client and User Satisfaction</td>
<td>3.71</td>
<td>0.793</td>
<td>2</td>
</tr>
<tr>
<td>C9.2</td>
<td>Improvement in Communication Between Parties</td>
<td>3.71</td>
<td>1.118</td>
<td>3</td>
</tr>
<tr>
<td>C9.6</td>
<td>Reduces Corruption</td>
<td>3.67</td>
<td>0.955</td>
<td>4</td>
</tr>
<tr>
<td>C9.3</td>
<td>Enhanced Decision Making</td>
<td>3.67</td>
<td>1.033</td>
<td>5</td>
</tr>
<tr>
<td>C9.8</td>
<td>Efficient Information Sharing and Reuse</td>
<td>3.65</td>
<td>0.935</td>
<td>6</td>
</tr>
<tr>
<td>C9.5</td>
<td>Efficiency and Effectiveness in Project Management</td>
<td>3.58</td>
<td>1.034</td>
<td>7</td>
</tr>
<tr>
<td>C9.4</td>
<td>Easy Access to tendering Data</td>
<td>3.54</td>
<td>1.205</td>
<td>8</td>
</tr>
</tbody>
</table>

5. Findings

The Mean value ranking and the Standard Deviation (SD) of the respondents’ opinion on the factors that encourage the use of electronic tendering in South African construction projects are ranked below. The respondents ranked the variables using a Five-point Likert scale where: 1= Strongly Disagree; 2= Disagree; 3= Neutral; 4= Agree; 5= Strongly Agree. Price Reduction in tendering Process was ranked first with a mean value of 3.89 and SD of 1.100; Client and User Satisfaction was ranked second with a mean value of 3.71 and SD of 0.793; Improvement in Communication Between Parties was ranked third with a mean value of 3.71 and SD of 1.118; Reduces Corruption was ranked fourth with a mean value of 3.67 and SD of 0.955; Enhanced Decision Making was ranked fifth with a mean value of 3.67 and SD of 1.033; Efficient Information Sharing and Reuse was ranked sixth with a mean value of 3.65 and SD of 0.935; Efficiency and Effectiveness in Project Management was ranked seventh with a mean value of 3.58 and SD of 1.034; Easy Access to tendering Data was ranked eighth with a mean value of 3.54 and SD of 1.205.

Also, the rotated factor matrix for the variables factored into two clusters based on the inherent relationship of variables in that cluster. A total of five variables are loaded in cluster 1. These variables include Efficiency and Effectiveness in Project Management (82.3%); Reduces Corruption (78.7%); Easy Access to tendering Data (70.5%); Client and User Satisfaction (69.7%); and Efficient Information Sharing and Reuse (69.7%). All the five mentioned variables in this cluster can be said to relate to efficiency in e-tendering. Therefore, this cluster can be termed Efficiency in E-tendering. This cluster accounted for 47.978% of the total variance. Loaded in cluster 2 are three variables which are Price Reduction in tendering Process (90.2%); Enhanced Decision Making (90.0%), and Improvement in Communication Between Parties (71.4%). With a total variance of 14.46%, this cluster can be labelled as Price Reduction in E-tendering.

6. DISCUSSION

The study revealed that the major drivers that encourage the use of electronic tendering in South African construction projects are, price reduction in tendering process, client and user satisfaction, and improvement in communication between parties with mean values of 3.89, 3.71, and 3.71 respectively. Other factors are less than 3.70 mean item score, this is a strong indication that the above stated factors are the key drivers that encourage the use of electronic tendering in South African Construction projects. Buttress this fact is the factor analysis in which price reduction in tendering process, has the highest loading value of 90.2%. The fact that e-tendering time and cost encourages it usage among the construction professionals in the construction industry. A reasonable amount of time is saved because there is no need for continuous checking and rekeying of documents in the paper form. Also, the costs cut on administration and printing are savings on the project. Corresponding to the findings of this study is the report of Booty (2004) who expressly stated that the adoption of e-tendering on a project carried out in England saved 30% of the contract sum. The price reduction on the project was cut from photocopying and necessary area needed to achieve the tender package.
7. LIMITATIONS

This study only took part in south Africa and the people who took part in the study were construction professionals in South Africa's Gauteng Province. They were architects, quantity surveyors, civil engineers, construction managers, and project managers. The choice of selecting the Gauteng province as the Research study area was due to the concentration of construction professionals and major construction works. This study only assessed the potential benefits of e-tendering in south African construction Industry.

8. CONCLUSION

This study was aimed at evaluating the potential benefits of e-tendering to the South African construction industry. The findings from the survey instrument distributed to the respondents reveals that that the top potential benefit of e-tendering is increased distribution speed of tenders. In addition, from the factor analysis, increased distribution speed of tenders appears the most beneficiary factor with a clustered component value of 94.8%. This supports the popular saying that e-tendering is aimed at eradicating paper-formed methodology of tendering while reducing the total duration required in the tender process and its submission. Hierarchically, other potentially benefits are increased efficiency and effectiveness, improved tender management, quick and easy access to tendering information, reduction of staffing levels in procurement, increased market share and competitiveness, increased transparency and accountability, and cost and time reduction in tendering. This therefore indicates that the aim of the study was achieved.

9. REFERENCES


Decentralized Treatment for Wastewater: Practices Towards Sustainability in Wastewater Management: A Bibliometric Review

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ABSTRACT & KEYWORDS

Purpose of the paper
Limitations of the centralized wastewater treatment systems and the rapid increase in urbanization have increased the need for sustainable efficient alternatives. The purpose of the study was to identify the research trends in publications on decentralized wastewater treatment practices for sustainable wastewater management.

Methodology
A bibliometric methodology was adopted in the study. The bibliometric analysis was conducted using the VOSviewer software. A total of 93 peer-reviewed journal articles from Scopus were quantitatively reviewed using a variety of methods such as co-occurrence analysis, co-authorship analysis, and co-citation analysis.

Findings
The identified research clusters revealed that there is a strong linkage between decentralized technologies and wastewater reclamation, resource conservation, and water conservation. However, the lack of extensive collaboration among researchers is concerning especially, for the growth and refinement of ideas in the research area.

Research Limitations
The study only used the Scopus database. Further investigations are therefore needed to understand the operation and processes of decentralized wastewater technologies drawing information from other databases.

Value of paper
The identified research trends can help push for the adoption of decentralized wastewater systems for sustainable wastewater management in the wastewater sector.

Keywords: Decentralized wastewater systems, Onsite wastewater treatment, Sustainable sanitation
1.0 INTRODUCTION

Sanitation is one of the most important and fundamental infrastructure sectors for human health, well-being, and environmental sustainability (Kazor & Mourad, 2018). Poor sanitation frameworks across the globe have various effects, including a detrimental influence on water quality and health hazards for the populations affected (Nansubuga et al., 2016). Hafeez et al., (2021) state that 80% of the wastewater produced globally is released without treatment, leading to a shortage of fresh water and the spread of waterborne diseases. One of the primary reasons for the lack of adequate wastewater treatment globally is the expensive nature of conventional procedures, which is mainly felt in developing countries (Zang et al., 2021). According to Zhu et al., (2013), it is clear that the present sanitation systems are ineffective and contain gaps, which emphasizes the need for a shift in wastewater management to incorporate sustainable interventions that will make basic sanitation attainable for everyone. The United Nations Nations World Water Assessment Programme (UN-Water, 2017) reports that with the shifting paradigm from wastewater treatment to the resource recovery system, the sanitation sector holds the most prospering potential in change toward a sustainability transition. Meerholz & Brent, (2013) reiterate that water is internationally acknowledged as a valuable resource; due to limited water supplies across the globe, water optimization and reuse are becoming increasingly important, especially in the wastewater sector. Adoption of rigidly engineered solutions, rapidly expanding urbanization, and the introduction of new urban toxins have resulted in damage to water sources (Castañer et al., 2020). Grey infrastructure, like conventional drainage systems and centralized wastewater treatment plans, has typically been incorporated into these planning processes for water security (Garfi et al., 2017). However, according to (Nansubuga et al., 2016), in many instances, the outcomes of the application and adoption of these grey infrastructures have not met the anticipated targets in terms of safe and sustainable sanitation. A variety of authors, therefore, suggest that these limitations can be overcome by adopting green infrastructure such as decentralized wastewater treatment systems in the wastewater sector (Chirisa et al., 2017; Massoud et al., 2009; Zang et al., 2021). By definition, decentralized wastewater systems refer to a range of methods for collection, treatment, and disposal or reusing wastewater at or near the point of generation (Molinos-Senante et al., 2014). Therefore, according to Capodaglio et al., (2017), decentralization can help contribute to the continuing progress and completion of the United Nations’ Millennium development goals promoting environmental sustainability and reversing the loss of ecological resources. Therefore, this paper seeks to consolidate the publications on the decentralization of wastewater treatment to measure the influence in the field in relation to sustainability practices in the wastewater sector.

1.1 THEORETICAL BACKGROUND

Since the Industrial Revolution, wastewater treatment and collection have traditionally been based on conventional or centralized systems. Centralized wastewater treatment is when the wastewater of a large urban area is unified, collected, and transported to large wastewater treatment plants (Ferreira et al., 2021). According to de Feo et al., (2014), centralized systems became common in the world in the middle of the 19th century. Early centralized sewerage evidence dates as early as 1858 in London, when the construction of the Balzagette began and was completed in 1865 (Lofrano & Brown, 2010). Centralized systems were part of the wastewater treatment management of European countries during most of the 19th and 20th centuries. The latter part of the 20th century witnessed a revolution in wastewater management, environmental science, and societal views on pollution as it became more apparent that inadequate sanitation was one of the leading causes of environmental harm (de Feo et al., 2014; Lofrano & Brown, 2010). With more stringent rules and governments beginning to mandate wastewater treatment, new technologies were also developed to work hand in hand with the conventional systems. Amongst such systems were the Constructed wetlands created in the 1950s, the UASBs developed in the 1970s, and the MBRs developed in the 1990s (Lofrano & Brown, 2010). These decentralized wastewater systems have been at the forefront of wastewater treatment in recent years as the world tries to move on to sustainable systems, especially in sanitation, as SDG goal number 6 from United Nations entails. Sustainability is the most well-known paradigm for managing natural resources because it balances the opposing demands of social fairness, efficiency, economic development, and environmental conservation (Leigh & Lee, 2019). Therefore, according to (Massoud et al., 2009), the interest in decentralized technologies is fostered by the fact that decentralized wastewater systems are a more sustainable alternative to conventional systems, especially in
developing countries that feel the full effect of the limitations of the centralized system mainly due to the lack of expertise and the lack of funds for repairs and maintenance. Decentralized technologies’ water-saving capacity improves the economic efficiency of the wastewater systems by lowering energy utilization and decreasing the environmental impact, all of which increase the sustainability of the systems as a whole (Leigh and Lee, 2019). Juan-García et al., (2017) further explain that decentralized systems also reduce the ecological footprint of wastewater systems through nutrient recovery, water resources recovery, and in some instances, energy creation using sludge and water.

2.0 METHODOLOGY

In this paper, the established research objectives were analyzed, visualized, and reviewed utilizing a quantitative approach based on bibliometric methodologies. The chosen method was used to identify new patterns in the performance of published literature, especially journal articles, cooperation patterns, and research elements, and to investigate the intellectual framework of decentralization in wastewater treatment. The bibliometric analysis approach in decentralized wastewater treatment is still novel; however, it has previously been used in wastewater treatment studies. The approach was used by (Durán-Sánchez et al., 2020) in the paper "Wastewater Management: Bibliometric Analysis of Scientific Literature” and by (Patyal et al., 2020) in the article "Wastewater Treatment Technologies: A Bibliometric Analysis.”

2.1 Bibliometric Analysis

The bibliometric methodology refers to the use of quantitative methods to bibliometric data, such as units of publishing and citation through bibliometric analysis or citation analysis (Donthu et al., 2021). According to Durán-Sánchez et al., (2020), bibliometrics is the quantitative description of a group of interconnected documents that gives a broad perspective of a study field in relation to a wide range of indicators. Cooper (2015) further states when dealing with bibliometrics, the main focus is usually on a mathematical and statistical analysis of bibliographic data. For a deeper understanding of the study field, (Donthu et al., 2021) states that bibliometric analysis uses science mapping to analyze the structural relationships and intellectual exchanges between research elements. Oliveira et al., (2021) allude that scientific mapping methods include co-authorship analysis, co-word analysis, co-citation analysis, citation analysis, and bibliographic coupling. Therefore, when paired with network analysis, these methods help demonstrate a study topic’s intellectual and bibliometric structure (Patyal et al., 2020).

As highlighted by Cooper (2015); Donthu et al., (2021), to make it easier to analyze bibliographic data in a reasonably practical manner, bibliometric software tools such as VOSviewer, Leximancer, or Gephi are used. Both (Patyal et al., 2020) and (Durán-Sánchez et al., 2020) use VOSviewer as the analysis software in their bibliometric analysis studies. VOSviewer is an analysis software that provides visually comprehensible, aesthetically beautiful, and decipherable bibliometric maps and graphs, which allow users to see interactions, links, networks, and comparisons among bibliographic data (Onososen & Musonda, 2022). Furthermore, Donthu et al., (2021); Oliveira et al., (2021) state that it is advantageous because it is user-friendly and can use different databases simultaneously. Therefore, the researcher used the same software for the present study. Figure 1 below shows the methodological scheme followed in the bibliometric analysis.
There are a host of databases where researchers can obtain data for scientific enquiry, chief amongst them are the most popular google scholar, Web of Science, and Scopus. The researcher in this study used Scopus as the database for data retrieval, as shown in figure 1. Web of science was disqualified as a database for data retrieval because almost all of the scientific publications in Web of Science are also found in Scopus. Google Scholar is a much more extensive repository than both Scopus and Web of Science, but as (Onososen & Musonda, 2022) highlighted, it has issues indexing publications since it counts conference abstracts, and this inevitably leads to an enormous increase in the number of papers, therefore, making it difficult to conduct a bibliometric analysis. Hence, the choice to use Scopus.

Key search words were therefore entered in Scopus, as shown in table 1, and the results showed about 1583 documents. There was no year limitation, and the search was left to include all countries as the study's objective is to try and understand the practice and application of the systems in relation to sustainability globally and over time. The search was then refined to the subject area of engineering and the English language; the resulting tab showed about 135 relevant documents, as illustrated in figure 1. Further refinery was done through abstract filtering. The researcher read through the abstracts of all 135 documents to eliminate all the documents that were irrelevant to the topic of decentralization in wastewater treatment. Forty-two documents were identified as false positives and were removed; the remaining 93 documents were retrieved for analysis. The 93 documents were then analyzed in Vosviewer using the following analysis techniques: Co-occurrence, Co-authorship, and Co-citation.

Table 1 below shows the essential parameters of the search strategy used in Scopus for data retrieval.
Table 1: Parameters of the search strategy

<table>
<thead>
<tr>
<th>Search Words</th>
<th>Decentralized wastewater systems or decentralized wastewater treatment or onsite wastewater treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Document type</td>
<td>Journal Article</td>
</tr>
<tr>
<td>Subject Area</td>
<td>Engineering</td>
</tr>
<tr>
<td>Period time</td>
<td>≤ 2022</td>
</tr>
<tr>
<td>Language</td>
<td>English</td>
</tr>
<tr>
<td>Limit to (Query)</td>
<td>Scopus: Title-Abs-Key (decentralized and wastewater and systems or decentralized and wastewater and treatment or onsite wastewater treatment) and refined by (Document type: Article; Subject Area: Engineering; Key Words: Wastewater treatment, wastewater management; Language: English; Source Type: Journal)</td>
</tr>
<tr>
<td>Search Date</td>
<td>August 2022</td>
</tr>
</tbody>
</table>

3.0 RESULTS AND DISCUSSION

3.1 Country and territory of publications

Fig 2 below shows the country and territory of the publications which were analyzed in this study. China had the most publications recording a total of 19, followed by the United States of America, which had a total of 17 publications. European countries like Spain, Germany, France, and the Netherlands had 9, 6, 4, and 4 publications, respectively. In South America, Brazil had the most publications with 6 documents. African countries have not published a lot in the subject area of decentralized wastewater systems; it was only Egypt with 3 publications.

China leads in research outputs in the subject area primarily because of the need to address its many water-related concerns; as (Zhang & Tan, 2010) state, the rapid population increase (highest in the
world), urbanization, and significant economic growth have led to unsustainable water usage leaving the country in dire need of new water sources. Whereas the study area is not relatively new, interest in decentralized wastewater systems has recently spiked because of the need to change to sustainable sanitation systems. This can be concluded about the high number of publications in developed countries like the USA, Spain, Canada, and Australia. The amount of research publications in Africa, or the lack thereof, is very concerning as the African continent is the most affected when it comes to inadequate and unsustainable sanitation practices. As was highlighted by one of the few researchers in Africa, (Abdel-Kader, 2013), stating that the emergence of decentralized treatment for wastewater which allows water reuse as a significant research area should compel African researchers to dive deeper into the subject as it is mostly the nations in the continent which face the dire challenges of inadequate sanitation facilities. The lack of research outputs in the subject area in African countries can be attributed to many factors, one of them being a lack of collaboration between African researchers and developed world researchers in the subject area. One can also argue that sometimes sanitation is usually the least worry that African countries have as they have a host of economic problems that they need to solve; therefore, this will also limit funding for research. However, it is not entirely true to assume a lack of research is a lack of practice, but in forethought, a lack of research means that there is no advancement in the field, so even if there is practice there is always that risk of obsolescence due to the stagnancy of the field.

3.2 Co-occurrence of keywords analysis

According to Donthu et al., (2021), co-occurrence or co-word analysis is an analysis technique used by the software VOSviewer to analyze how many times keywords appear in the documents under analysis and usually puts them in clusters under the assumption that commonly occurring words have a thematic connection. However, both Durán-Sánchez et al., (2020) and Patyal et al., (2020) warn that the technique has drawbacks in the sense that certain words can be termed as keywords even though they are out of context, and in addition, general words can be termed as keywords as well. Therefore, for a word to be included, the minimum number of co-occurrences of that particular word was supposed to be five. Out of 1414 words, only 92 met the threshold. Further refinement was done before analysis by removing generic terms and the terms that were not necessary to the topic under discussion. Table 2 below shows the clusters which the keywords fall under, and figure 3 shows the co-occurrence of the keywords.

<table>
<thead>
<tr>
<th>Cluster one</th>
<th>Clusters two and three</th>
<th>Cluster Four</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainable development</td>
<td>Anaerobic baffled reactor</td>
<td>Reclamation</td>
</tr>
<tr>
<td>Developing countries</td>
<td>Anaerobic digestion</td>
<td>Irrigation</td>
</tr>
<tr>
<td>Environmental management</td>
<td>Biodegradation</td>
<td>Wastewater reclamation</td>
</tr>
<tr>
<td>Life cycle assessment</td>
<td>bioreactors</td>
<td>Water conservation</td>
</tr>
<tr>
<td>Optimization</td>
<td>Constructed wetlands</td>
<td>Wastewater reuse</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Membrane bioreactors</td>
<td>Water recycling</td>
</tr>
<tr>
<td>Sustainability</td>
<td>Pollutant removal</td>
<td>Energy</td>
</tr>
<tr>
<td>Cost-effectiveness</td>
<td>Water pollution</td>
<td></td>
</tr>
<tr>
<td>Life cycle assessments</td>
<td>Decentralized wastewater systems</td>
<td></td>
</tr>
<tr>
<td>Cost-benefit analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population statistics</td>
<td></td>
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</tbody>
</table>

Four clusters emerged from the analysis, as shown by the 4 different colours in figure 3. Cluster one was represented by the colour red. The sub-themes identified in cluster one are sustainability, sustainable development, developing countries, cost-effectiveness, etc., as tabulated in table 4. Clusters two and three identified the same sub-themes, hence the decision to combine them. The sub-themes in clusters two and three were mainly to do with the decentralized technologies, as can be seen in the nodes; the clusters were represented by the colours blue and green, respectively. Cluster four in the colour yellow identified sub-themes such as wastewater reclamation, water conservation, wastewater reuse, energy utilization, etc.
Cluster One

Cluster one in interpretation reflects on the relationship between sustainable development and developing countries in relation to decentralized wastewater systems. The sustainability of decentralized wastewater systems is the main driving force behind the push for the adoption of the systems, hence the increased number of research publications in the research area in recent years. Zhu et al., (2013), in the study about CWs, conclude that decentralized wastewater systems, due to low power consumption, high efficacy, low operating costs, and cheap investment costs, are a sustainable option for wastewater treatment, particularly in developing countries. Decentralized wastewater treatment systems are environmentally sustainable in that they promote resource conservation, economically sustainable in that they are cost-effective, and socially sustainable in that they encourage healthy sanitation. Therefore, one can conclude that decentralized wastewater treatment systems can be a cost-effective and sustainable alternative to centralized wastewater infrastructure in developing countries facing inadequate sanitation problems due to increased urbanization. Yes, developing countries should be the ones to jump at the opportunity of adopting decentralized wastewater systems; however, it is not entirely accurate to suggest that only developing countries are in need. This is perfectly illustrated in figure one, where the likes of the USA, Spain, Australia, and Canada are also part of the leading countries in research in the subject area. A life cycle assessment study conducted by (Jeong et al., 2018) in Atlanta, Georgia, concluded that developed cities could decrease the life cycle impacts of wastewater infrastructure by replacing the conventional systems with decentralized systems. This can lead to the optimization of water resources, which will be explained later in the discussion.

Fig 3 Co-occurrence of keywords

Clusters two and three

The main reason for combining clusters two and three was that the sub-themes were more of the same; they were speaking to one broad subject: the technologies used in decentralized wastewater treatment. It can be noted from table 2 that the technologies also go hand in hand with the processes, e.g., anaerobic baffled reactors make use of anaerobic digestion to get rid of pollutants in the wastewater. Contrastingly aerobic treatment systems like membrane bioreactors and CWs use biodegradation to break down organic matter in the wastewater. In a systematic literature review conducted by (Ferreira et al., 2021) in Brazil on the same subject area, it was noted that the most commonly used decentralized
wastewater treatment systems are constructed wetlands. The same is also affirmed by a study done in Spain by (Garfí et al., 2017), where it was concluded that constructed wetlands are one of the best alternatives to replace activated sludge treatment plants because of their low ecological footprint. This can be related to the earlier discussion as it shows that decentralized technologies are not energy intensive and have a very low impact on the environment, all of which make a strong case for how sustainable they are.

**Cluster Four**

The sub-themes in cluster four point out resource conservation. The main sub-theme from this cluster is reclamation, which can be in three ways: water reclamation, nutrient reclamation, and energy reclamation. Water reclamation comes as wastewater reuse; according, to a study done in Brazil by (Castañer et al., 2020), one of the socio-environmental benefits of using constructed wetlands in Sao-Paulo city is water reuse. As highlighted in fig 3 in the far-right corner, the strong link between water reuse and irrigation simply means that the main activity used for the recycled water from decentralized technologies is used to irrigate crops or green urban spaces such as golf courses or parks. Water is a scarce resource; therefore, the fact that decentralized wastewater systems offer a solution to an alternative water source makes them all the more imperative. Consequently, one can argue that by reusing wastewater in crop irrigation, you are returning nutrients such as phosphorus to the soil, which are crucial in crop growth. Finally, energy reclamation can be in the form of renewable energy production, e.g., anaerobic digestion processes usually produce biogas, which can be used for cooking, heating, etc. Elawwad & Hazem (2017) concluded the same in their study about UASBs in Egypt. In time, with better energy harnessing technologies, renewable energy sources like biogas can be used to replace environmentally harmful energy sources such as fossil fuels. All this and more enhances the credibility of decentralized wastewater systems as environmentally, socially, and economically sustainable alternatives to the conventional systems in wastewater treatment.

**3.3 Co-authorship Analysis**

Co-authorship analysis looks at how researchers connect with each other. According to Donthu et al., (2021), understanding how academics engage with one another is crucial because it is a formal way of measuring and assessing collaboration amongst researchers, identifying leading countries, organizations, or individual scientists in a particular research area. A co-authorship network for the present study is shown in fig 4. A co-authorship network analysis was done for researchers who contributed significantly to decentralized or onsite wastewater treatment systems. The analysis was conducted as follows; the minimum number of documents per author was set at 2, and the minimum number of citations per author was set at 5. Out of the 401 authors in the 93 documents analyzed, only 27 met the threshold.

The most active researchers, as shown in fig 4 are Zhang X, Zhang Y, Zhang L, Lui Y, and Maurer M, each with 3 documents. Highly separated nodes show that there is no extensive collaboration amongst researchers, especially between regions or countries in the area of decentralized wastewater systems. However, Asian authors, particularly China, seem to collaborate a lot with each other, as indicated by the highly interconnected nodes between them. This has led to many publications from China in this subject area, as highlighted earlier in fig 1. The lack of African authors in terms of collaborations is a bit concerning as it indicates that there is no knowledge flow from the developed world to developing countries. Patyal et al., (2020) argue that scientific research collaborations through shared knowledge, funds, and specialties are essential in advancing this developing research field. Therefore, Information exchange is particularly necessary because it is the only way authors can refine and better their ideas and, in time, come up with exceptional research that can make meaningful contributions to society and the world at large. In terms of the time the documents were published, it can be seen that the interest in the subject area is relatively new as all the authors in the network analysis have published within the last 6 years. However, the most recent publications were from authors like Huang G or Zhang L, represented by the colour yellow in Figure 4.
3.4 Co-citation Analysis

Co-citation analysis is a scientific mapping approach that makes assumptions that documents that are often referenced together have comparable themes, and the analysis can be used to reveal the studies’ underlying ideas (Donthu et al., 2021). Only author co-citation analysis was done in the study. Fig 5 below shows the author’s co-citation density map.
For an accurate analysis, the minimum number of citations per author was set at 10. Out of the 7918 authors identified, only 81 met the threshold. However, as discussed in earlier paragraphs, the most cited authors do not have that many citations due to the recency of most publications in the area. Durán-Sánchez et al., (2020), however, states that it is very important to note that authors do not reach their maximum citation level until after 10 years after their first publication. One can therefore argue that although the most influential authors do not have that many citations, because the interest in the research area is still new but as time goes more and more publications will be released with the sole focus of decentralization in the wastewater sector. As can be seen from the density map, the most influential authors in the study area were Zeeman G, Tchobanoglous G, and Peng Y, with 49, 42, and 33 citations, respectively. Except for Asian authors, the density map is limited, suggesting that there is a need for more collaborations when it comes to decentralized wastewater systems.

In their earlier works, the underlying theme laid out by one of the most influential authors in the subject area, Zeeman G, revolved around sustainability. In the review, which compared decentralized sanitation and centralized sanitation systems (Zeeman, 2009) concluded that decentralized sanitation systems enable local resource utilization at the same time while aligning supply and demand, therefore, making them a more sustainable alternative to centralized systems. The talk became practice over the past decade, especially in China, where various authors engaged in performance assessments of decentralized wastewater technologies, thereby suggesting successful adoption of the systems. (P. Zhang et al., 2019; X. Zhang et al., 2020), all concluded and echoed the same sentiments after conducting performance assessments of different decentralized technologies stating that the water saving and resource recovering abilities of decentralized wastewater treatment technologies are very crucial in this day in age where the world is facing a water shortage crisis that has progressed over time due to unsustainable water usage methods such as the centralized wastewater treatment systems.

Recently, the discussion on decentralized wastewater systems has garnered much interest worldwide, especially as the United Nations are pushing for the attainment of Sustainable Development Goal 6, which advocates for sustainable sanitation for all.
4.0 Conclusion

Decentralization in the wastewater sector has been a discussion for quite some time now, but research in the area is still relatively new. Recently the subject has garnered a lot of interest because of the need to protect the environment by moving to sustainable alternatives, especially in the engineering and built environment sector. The research identified the research trends in decentralized wastewater treatment and onsite wastewater treatment through a bibliometric review. It was identified that countries like the USA and China led in publications in the subject area, mainly because of the need for sustainable sanitation options for their hugely populated cities. A lack of collaboration amongst institutions is, however, concerning for the growth of the research area as information exchange is necessary for refining ideas. More African researchers are encouraged to write and collaborate with other researchers because the effects and limitations of inadequate sanitation are very apparent in African nations. It can, therefore, be concluded that decentralized wastewater systems potentially offer reliable, effective, and sustainable alternatives to centralized wastewater systems. The study was, however, limited in that it was conducted using datasets generated from the Scopus database only. Therefore, future research should include other databases and focus on the emerging trends, operation and processes of decentralized technologies for more safer and sustainable sanitation practices.

Declaration of Competing Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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5.0 REFERENCES


An Integrated Framework for Catalysing Development and Sustainability of Small and Medium-sized Contractors: A case of Namibia

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ABSTRACT AND KEYWORDS

Purpose of this paper
This study sought to develop a framework that catalyses development and sustainability of small and medium-sized contractors (SMCs) in Namibia.

Design/methodology/approach
The study employed a multi-method qualitative approach to validate the conceptualised framework. Data were collected in two phases using purposive sampling. Phase 1 entailed semi-structured interviews with twenty-two (22) industry stakeholders, while Phase 2 involved structured interviews with five (5) experts and a semi-structured interview with a director of an established indigenous construction company. Data were analysed using thematic analysis.

Findings
The findings validated the conceptualised framework, culminating in the development of the final integrated framework for catalysing development and sustainability of SMCs in Namibia.

Research limitations/implications
The developed framework needs to be adapted to other settings with caution.

Practical implications
The developed integrated framework could aid government, policymakers, and other relevant stakeholders to enhance development and sustainability of SMCs in Namibia and similar settings.

Originality/value of paper
The study argues that the adoption of the proposed integrated framework would stimulate development and sustainability of SMCs in the Namibian and similar contexts since there is paucity of literature regarding a framework focusing on Namibia.

Keywords: Integrated framework, SMC development and sustainability, Namibia
1. INTRODUCTION

Small and medium-sized contractors (SMCs) are widely recognised in championing employment creation, redressing social disparities and infrastructure development worldwide (Aigbavboa, Aghimiein, Oke and Mabasa, 2018: p.100; ILO, 2019: p.3; Prasanna et al., 2019: p.1; Thwala, Mustapha and Aigbavboa, 2019: p.587). Additionally, these enterprises are believed to constitute over 90% of formal businesses globally (Aigbavboa and Thwala,2014: p.771, OECD, 2019: p.3 Offei, Kissi and Nani, 2019: pp.49-50; Anugwo and Shakantu, 2020, p.1930). Moreover, their contribution to GDP in developed countries is approximated between 50 to 60% (OECD, 2019: p.5) while in developing countries like South Africa, it is estimated between 51 to 57% (Anugwo and Shakantu, 2020: p.1930).

There is no unanimity in the definition of an SMC, though most scholars use the criteria that involve number of employees, capital outlay, income turnover, and physical assets (Lello and Mtendamema, 2018; Bikitsa and Amoah, 2020; Shan, Hwang and Lye, 2020). Therefore, the study adopted the definition prescribed in Namibia’s National Policy on Micro, Small and Medium Enterprises (2016: p.7) which defines an SME as an enterprise with full-time employees ranging from 11 to 100, and an annual turnover spanning from N$300 001 to N$10 000 000.

Despite the potential of SMCs in driving socio-economic development agenda across the globe, especially in developing countries, these enterprises encounter enumerable challenges that threaten their survival (Mofokeng and Thwala, 2013: p.180; Modilim, 2016: p.1; Mukata and Swanepoel, 2017: pp. 199-200). Anugwo and Shakantu (2020: p.1930) who investigated on the strategies for enhancing managerial capabilities of SME contractors in South Africa, reiterated that 80% of these firms extinct within few years of their establishment. Similarly, Mukata and Swanepoel observed that twelve percent (12%) of the SMCs in Namibia discontinue their businesses yearly (p.200). This phenomenon is ongoing as evidenced in a recent study by Wentzel, Fapohunda and Haldenwang (2022: p.1) who questioned the sustainability of SMCs after observing that 70 to 80% of these organisations in South Africa close their businesses before their fifth anniversary.

However, it is critical to note that the survival of these enterprises does not only benefit themselves but also positively impact sustainable socio-economic development, largely in developing countries as observed by Pu, Qamruzzaman, Mehla, Naqvi and Karim (2021: p.1) in Bangladesh. As argued by Lello and Mtendamema (2018: p.777), the growth of SMCs inadvertently impacts the growth of the entire construction industry due to their predominance and geographical dispersal.

Over the years, governments, policymakers, researchers, and practitioners worldwide have been grappling with how to develop models or frameworks that could enhance meaningful development and sustainability of SMCs (Ofori, 1980; 1991; 2001; Adams, 1995; 1996; 1997; 1998; Miles, 1997; Dlungwana and Rwelamila, 2005). Evidently, most of these efforts yielded little success in developing and sustaining SMCs due to a myriad of factors. As raised by Ofori (1991), most contractor development programmes (CDPs) in developing countries at the time lacked comprehensiveness, harmony, contextualisation, clarity of targets as well as monitoring and evaluation mechanisms. These sentiments resonate with Adams (1996) who around the same period observed in the context of Nigeria that finance and work opportunities were being given to SMCs without proper training.

As such, there has been increasing call among scholars for robust contractor development models, culminating in Dlungwana, Nxumalo, Huysteen, Rwelamila and Noyana (2002) to develop the South African Construction Excellence Model (SACEM) which they deemed comprehensive in enhancing total quality management among SMCs in South Africa. SACEM was further applauded by Dlungwana and Rwelamila (2005) who claimed that it is holistic and integrative to boost SMCs' managerial capabilities if the model is coupled with procurement preferential treatment, all relevant stakeholders' support and enabling business environment. Following these suggestions, numerous CDPs were introduced by the South African government to spur development and sustainability of SMCs countrywide (CIDB, 2018; 2022). Sadly, Dapaah, Thwala and Musonda (2017) who reviewed the impact of these CDPs in transforming SMCs revealed marginal impact on beneficiaries, citing low outreach, lack of continuity and absence of follow up mentorship programmes to nurture the beneficiaries for effective development and growth.
Clearly, this shows that the concept of SMC sustainability requires further interrogation in research. Sustainability in this context refers to survival or persistence of the enterprise as defined by Constanza and Pattern (1995: p.193). In other words, the study views sustainability as “successful adaptation” or “survival instinct” as advanced by Watts, Cope and Hulme (1998: p.103). Mamman et al. (2019: pp.304-315) argue that most developing countries in Sub-Saharan Africa have adopted Eurocentric policies and models which are incompatible with their business environmental conditions. As such, this could be one of the reasons for the failure of most CDPs in African countries.

Nguyen, Alam and Prajogo (2008: p.113) who reviewed SME development in Vietnam, categorically stated that “no adopted model from one country to another country would be suitable without consideration”. This is reinforced by Rwelamila and Ogunlana (2015) who articulated the research roadmap for construction in developing countries and emphasised the criticalness of context when approaching problems.

Scholars like Fox and Skitmore (2007) and Thomas et al. (2009) developed frameworks for construction industries. These frameworks outlined pertinent aspects required to develop the construction industry at large, such as government policies and strategies supporting construction business, industry-led better practice and culture, financial resources and skills training, research and development for construction and exploring alternative markets. While the attributes of these frameworks are broadly critical, the frameworks are too generalised and do not give intricate details on how SMCs should be developed since these contractors form a segment within the construction industry and exhibit heterogenous characteristics.

Therefore, there is need to develop a comprehensive framework that focus on developing and sustaining SMCs, particularly in the Namibian context where little is known. There is paucity of literature on previous studies that developed a framework for stimulating development of SMCs based on the Namibia context. In view of the incessant SMCs’ sustainability challenges, the study advances that a comprehensive and contextualised framework is required to stimulate development and sustainability of SMCs in Namibia, and global south in general.

To develop a comprehensive framework, extant literature shows that the framework ought to present strategies for creating an enabling construction business environment (Huda, Setiyo, Siswoyo and Azizah, 2018; Mamman et al., 2019; Santosso and Permana, 2021), training of SMCs (Amoah and Shakantu, 2019; Akinsiku and Oyediran, 2020; Ofori, Zhang and Ling, 2020), access to adequate and affordable capital financing (Hove, 2016; Iyagba and Mafimidiwo, 2016; Anamege, 2019; Offei, Kissi and Nani, 2019; Tayeh, Alaloul and Muhaisen, 2019), consistent work supply (Dapaah, Thwala and Musonda, 2017; Windapo, Adediran and Olugboyega, 2019; Ogbo and Asuquo, 2019; Bikitshe and Amoah, 2020), firm owner’s positive entrepreneurial culture (Weber, Geneste and Connell, 2015; Lello and Mtendamema, 2018; Anugwo and Shakantu, 2020) and collaborative public and private institutions’ support (Songling, Ishtiaq, Anwar and Ahmed, 2018; OECD, 2019; Alkahtani, Nordin and Khan, 2020). Informed by these factors, the study postulated a conceptual framework for catalysing development and sustainability of SMC in Namibia as indicated of Figure 1.

The conceptual framework indicates that the key enablers of SMC development include enabling construction business environment, training of SMC, access to adequate and affordable capital financing, consistent work supply, firm owner’s entrepreneurial culture and collaborative public and private institutions’ support. Each of these factors is proposed to be having a direct positive influence on SMC development. On the other hand, institutional support is proposed to have a moderating effect on each of the identified enablers by improving its influence on SMC development. The study further conceptualised that the level of SMC development has a direct positive influence on SMC sustainability.

Critically, the study further proposes that when SMC becomes sustainable, the sustainability would have a direct positive influence on SMC development through reinvesting into the business, diversification and or market expansion. This situation is conceptualised to create a cyclical relationship between SMC development and SMC sustainability as the firm passes through different growth stages. The conceptualised framework was then validated by multi-method qualitative design described in the succeeding section to ensure that it is appropriate in the context of Namibia.
Critically, the study further proposes that when SMC becomes sustainable, the sustainability would have a direct positive influence on SMC development through reinvesting into the business, diversification and or market expansion. This situation is conceptualised to create a cyclical relationship between SMC development and SMC sustainability as the firm passes through different growth stages.

The conceptualised framework was then validated by multi-method qualitative design described in the succeeding section to ensure that it is appropriate in the context of Namibia.

2. METHODOLOGY

The conceptual framework was validated in two phases using multi-method qualitative design. The first phase of data collection involved semi-structured interviews. The participants were purposively selected...
from construction industry stakeholders in Namibia’s two regions namely Khomas and Oshana region. Khomas region is the hub of commercial activities, with Capital City-Windhoek being located there. As such, over 95% of SMCs and construction professional consultants reside in the Khomas region. On the other hand, Oshana region has the highest rural population, with few SMCs operating in that region. The categories of participants selected for the study are indicated on Table 1. A distinct interview guide comprising open ended questions was developed for each category to gather diverse views from the participants. A total of twenty-two (22) participants were considered for the study as indicated on Table 1.

The interviews were one on one, with some conducted face to face, while others were done telephonically and through Zoom meetings. Both physical and remote methods were employed in collecting data because of participant choices. All covid protocols as outlined by Ministry of Health and Social Services in Namibia and WHO were adhered to during face-to-face interviews. These included social distancing of about three (3) metres and face masking. Further, the study minimised sharing of hardcopy documents with participants to curb the spread of Covid-19. Interview protocol involved a brief explanation of the aim of the study, request for the participant’s consent and a pledge by the researcher to comply to ethical issues. The first phase of data collection sought to establish the key enablers of development and sustainability of SMCs in Namibia. The main research question was on which key enablers drive development and sustainability of SMCs in Namibia. The data collected were recorded and transcribed by an independent specialist transcriber. Thereafter, all the transcripts were checked for accuracy and then analysed using thematic and frequency analysis. The findings of phase 1 were further validated by phase 2 of data collection which comprised five (5) purposively selected experts with vast experience in academia, government capital projects and construction industry as profiled in Table 2. Structured interviews were conducted with experts to confirm the key factors required to stimulate development and sustainability of SMCs. Further, conceptualised relationships derived from the conceptual framework were validated by the interviewed experts. The views of the experts were further triangulated by a single case study of a well-established large Namibian construction company which survived for 50 years, from which one of the directors was interviewed using a semi-structured interview guide. The inclusion of the case study approach was meant to gather insights on the strategies employed by the company to reach its current level in a bid to assess the appropriateness of the proposed framework.

Table 1: Phase 1 Data Collection: Profile of Participants for Semi-structured interviews

<table>
<thead>
<tr>
<th>Participant Category</th>
<th>Participant Designation</th>
<th>Total Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMC</td>
<td>Owners</td>
<td>6</td>
</tr>
<tr>
<td>Government</td>
<td>Director- Capital Projects Management, Ministry of Works and Transport</td>
<td>1</td>
</tr>
<tr>
<td>Contractors’ association</td>
<td>General Manager- Construction Industries Federation of Namibia</td>
<td>1</td>
</tr>
<tr>
<td>Training Institutions</td>
<td>HoD- Architecture and Spatial Planning- Namibia University of Science and Technology</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Instructor- Joinery and Carpentry- Windhoek Vocational Training Centre</td>
<td>1</td>
</tr>
<tr>
<td>Microfinance institutions</td>
<td>Sales Consultants</td>
<td>2</td>
</tr>
<tr>
<td>Registered construction Professional Consultants</td>
<td>Quantity Surveyors</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Architects</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Civil Engineers</td>
<td>3</td>
</tr>
<tr>
<td>Total Study Participants</td>
<td></td>
<td>22</td>
</tr>
</tbody>
</table>
Table 2: Phase 2 Data Collection: Structured interviews with experts/key informants and single case study approach

<table>
<thead>
<tr>
<th>Participant Code</th>
<th>Participant’s Highest Academic Qualification</th>
<th>Experience</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>Doctorate</td>
<td>30 years</td>
<td>Planner and Project Manager responsible for African Development Bank (ADB) financed projects at Ministry of Education in Namibia</td>
</tr>
<tr>
<td>E2</td>
<td>Professor</td>
<td>30 years</td>
<td>Professor at Namibia University of Science and Technology in Namibia. He is also a registered consultant architect</td>
</tr>
<tr>
<td>E3</td>
<td>Doctorate</td>
<td>25 years</td>
<td>Former Chief Architect at Ministry of Work and Transport, Namibia, where he was responsible for architectural services and capital projects management</td>
</tr>
<tr>
<td>E4</td>
<td>Masters</td>
<td>15 years</td>
<td>Deputy Director-Architectural Services at Ministry of Works and Transport in Namibia. Is responsible for architectural services and capital projects management</td>
</tr>
<tr>
<td>E5</td>
<td>Honours</td>
<td>Over 30 years</td>
<td>Principal Director- Quantity Surveying consultant firm. Worked on numerous government projects where SMCs were involved</td>
</tr>
</tbody>
</table>

Single case study approach

<table>
<thead>
<tr>
<th>Code</th>
<th>Highest Academic Qualification</th>
<th>Experience</th>
<th>Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Honours</td>
<td>Over 25 years</td>
<td>Director of a large indigenous Namibian construction company. The director has an Honours degree in quantity surveying. The company was established in 1972, thus it is now 50 years old.</td>
</tr>
</tbody>
</table>

Total Participants for Phase 2 of the study | 6

3. RESULTS AND DISCUSSION

3.1 Phase 1: Semi-structured interviews

The results of the semi-structured interviews revealed five (5) key enablers of SMC development and sustainability which include collaborative public and private institutions’ support (100%), training of SMCs (73%), creating enabling business environment (55%), access to adequate and affordable finance (45%) and consistent work supply (27%). To enhance anonymity, the participants were coded using P1 to P22.

Regarding public and private sector collaborative support, all the participants interviewed concurred that both public and private institutions are instrumental in promoting development of SMCs. For instance, P7 who is a director of one of the key government ministries stated that:

“… government can come up with one unified organisation where they will even make efforts to channel finance, through that one unit in government and finance which will go along with the training…”.[P7].

On the other hand, P14 posited that the government and CIF should coordinate effectively unlike the current status:
“I think there is like a lack of coordination or cohesion between these two entities, the government and the regulator which are the CIF”.[P14]

Further, P11 who proposed collaboration between government and training institutions like universities and VTCs. P11 stated:

“…one would possibly have to look at sort of partnership approach between government that could structure certain initiatives… in sort of learning institutions that could offer…training opportunities that are really tailored…for financial management or whatever aspect needs to be improved …”.[P11]

In terms of training, most owner managers (P1, P2, P3, P4 and P5) confirmed firmed that its critical. This was further supported by all the construction professional consultants who were interviewed. For instance, P1 stated:

“I think SMCs need training in different areas”. [P1]

Likewise, P7 shared that the previous interventions by government yielded little results due to lack of training. P7 stated:

“Training is very critical…the government even tried to put … an association of contractors, there was an association of contractors…it did not succeed properly because of that aspect of training”. [P7]

Pertaining to the enabling construction business environment, P6 stated:

“I think we need to regulate the industry…”[P6]

In concurrence, P14 also expressed that:

“…we have… to regulate the construction industry…” [P14]

Therefore, the findings resonate with extant literature (Amoah and Shakantu, 2019; OCED, 2019; Akinsiku and Oyediran; 2020 and Bikitsha and Amoah, 2020; Santoso and Permana, 2021) which identified support of public and private institutions, training, access to affordable and adequate financing, consistent work opportunities and enabling business environment as catalysts of development and sustainability of SMCs. As such, the results confirm most of the key enablers that were proposed by the conceptual framework. However, the results could not clearly confirm the aspect of firm owner’s entrepreneurial culture as observed in literature. Further, the attributes of each of the identified key enablers like strategies for affordable and adequate financing and training needs were not conclusive hence required further verification. Moreover, some propositions made in the conceptualised framework like cyclical relationship between SMC development and SMC sustainability could not be ascertained through semi-structured interviews conducted in phase 1 of data collection.

The study therefore conducted phase 2 of data collection to validate these outstanding issues by interviewing five (5) experts in academia, public service and the construction industry including interviewing the director of an established large indigenous Namibian contractor. The results of phase 2 are presented in the succeeding section.

3.2 Phase 2: Results of structured interviews with key informants and single case study approach.

Interviews with five (5) experts were conducted to further interrogate the key factors that should inform a robust framework for catalysing development and sustainability of SMCs. Further, experts were required to validate the relationships of variables and propositions made in the conceptualised framework in a bid to develop the final framework that is appropriate to develop and sustain SMCs in the context of Namibia. The profile of the interviewed experts is outlined on Table 2. The findings of these interviews are presented in succeeding sections.
3.2.1 Importance of the conceptualised factors in driving development and sustainability of SME contractors

The experts were asked about how they viewed the importance of each of the factors that was conceptualised to drive development and sustainability of SMC. From the interviews, all the five (5) experts concurred that the conceptualised factors namely enabling construction business environment, training of SMCs, collaborative public and private sector institutions’ support, access to adequate and affordable finance, consistent work supply and firm owner’s entrepreneurial culture broadly cover the key drivers of development and sustainability of SMCs in Namibia. For instance, E1 mentioned that adequate and affordability financing and training are both critical. E1 stated:

“You can train them but if they do not have access and affordable capital financing, then still is going to be very difficult for them…”[E1]

Similarly, E2 expressed:

“I think they are all relevant… Obviously if you do not have an enabling business environment, there is nothing… training is highly critical. Your support within various sectors is important, yes…I think that they were all highly, highly critical…”[E2]

Likewise, E3 concurred by stating that:

“I think looking at them, I would say what I think is very important is training of SMCs. I find that very critical in that if they are not adequately trained then the reality is then more or less do not know what they are doing. So, I think that one is extremely important as well access to adequate and affordable financing because most times they come from a background where they do not have capital or any other means for them to get into construction project… Consistent work supply, yes, I think in the long run that becomes important in terms of allowing them to be sustainable. So, in the long run collaborative public and sector institutions support, yes, this is also something that can be ongoing and long term. Enabling construction business environment, yes, this is also very important in order for them to penetrate those markets. Firm owners’ entrepreneurial culture, yes, I think this is also another driver that if the owner then, yah the owner has to be someone who is self-driven and someone who really does not give up easily because construction comes with, construction can be very complex and complicated. So, I think yes, you do need an element of that entrepreneurial spirit and that business minded.”[E3]

Additionally, E4 strongly agreed that all the conceptualised factors are critical by stating that:

“All the factors listed here have a very significant role to play because firstly the environment should be conducive… in the sense that yes, legislation, policies and everything should be in place, not just to safeguard the contractors but the service receivers as well.”[E4]

Further, E4 stressed the importance of training by demystifying the misconception held by some SMCs that construction business is where one makes quick money. E4 shared:

“…if you look at the aspect of training, most of the people who venture into construction from what we have noticed in this country, and not just in this country mind you, we have seen it in other countries, in Zimbabwe as well, where people believe that construction is the easiest thing to do. They, first of all do not understand even very simple things like just reading the drawing, reading and understanding the drawing, to them is building, is so building, building, brick and water then you are done. So is necessary for them to undergo the necessary training in terms of technical skills yes, financial management, project management, all as listed here and understanding the market.”[E4]

In concurring with the conceptualised key factors, E5 shared that:

“I quite honestly believe that the document that you have presented … accurately reflects the situation here in Namibia. Is a very good reflection of the situation. I think if I go through each individual topic here, listed each individual enabler you have, you have hit the nail on the head.”[E5]
The identified key enablers were also confirmed by C1 - a director of the selected successful indigenous Namibian construction company. C1 highlighted that some of the key success factors employed by the companies include maintaining good relationships with financiers and material suppliers which enhanced adequate financing of projects, developing financial management systems, entrepreneurial skills, strategic partnerships with local and international partners, globalising the business, maintaining good relationships with employees and retain them for quality consistency, adhering to business ethics, reinvesting some of the profits into the business for its growth and sustenance, and strategic decision making during crisis.

So, the findings are consistent with literature (Amoah and Shakantu, 2019; OECD, 2019; Santoso and Permana, 2021) hence further confirmed the conceptualised key enablers of SMC development and sustainability.

3.2.2 Level of influence of each of the conceptualised key factors on development and sustainability of SMC in Namibia

The experts were asked how they perceived the influence of each of the conceptualised factors which include enabling construction business environment, training of SMCs, collaborative support of public and private institutions, access to adequate and affordable finance, consistent work supply and firm owner’s entrepreneurial culture on the development and sustainability of SMCs. All the experts interviewed mentioned that each of the conceptualised factors has a direct positive influence on the development and sustainability of SMCs. In supporting this notion, E1 stated:

“Definitely, I have no doubt what you put here definitely have got a direct positive influence… all has got a positive influence on developing SMEs.” [E1]

On the other hand, E2 argued that the present situation in Namibia reflects unconducive business environment, lack of training of SMCs, lack of consistent work supply, lack of access to adequate financing and little collaborative support of public and private institutions, hence negatively influencing SMC development and sustainability. Ideally, E2 stated that these factors should have positive influence on SMCs for them to develop and grow. In a nutshell, E2 stated:

“All of the things that you are mentioning, I think that will be extremely useful.”[E2]

Also, E3 pointed out that the identified factors have a positive influence on SMC development. E3 shared:

Okay, this one I think all of them are positive… Especially like now, enabling construction business environment right now we do not have that. What we are experiencing now are Covid and you know with the war in Ukraine and how that has affected and impacted us here. You can see that the business environment is not so conducive. And you can see the negative impact that that currently has on the development of SME contractors.”[E3]

Further, E4 also concurred with E1, E2 and E3 that the identified factors exhibit positive influence on SMC development by mentioning that:

“Consistent work supply is necessary. Yes, is necessary because you start a venture you have one project, you are done with it then nothing else comes on board, definitely you have to lay off people, maybe have equipment which are still paying off, maybe you have a property which you are still paying off, you end up losing all those things… lack of work will lead to bankruptcy… and closure of all these endeavors.”[E4]

However, E4 argued that consistent work supply should correspond with consistent performance of the SMC, citing that it is counterproductive to give more work to SMCs that do not reciprocate with performance. E4 echoed:

“So, is important but let us also not forget that consistent work supply should go with consistent in terms of performance on contractor side.”[E4]
Additionally, E4 mentioned that collaboration of public and private institutions stimulate development of SMCs. E4 shared:

“...if you look at collaborative public and private institution support, we are talking about here international development agencies, financial institutions, training institutions, construction consultants, contractors’ association, material suppliers and large contractors...So, that collaboration is needed because SMCs, the contractors do not have the necessary cash flow to purchase I mean materials on cash basis…”[E4]

This resonated with E5 who stated that all the six factors positively influence SMCs’ development and sustainability:

“This mostly can have a direct positive influence. Basically, every single one of them.”[E5]

As such, the findings confirmed the proposition made based on literature (Offei, Kissi and Nani, 2019; Anugwo and Shakantu, 2020; Alkahtani, Nordin and Khan, 2020) that all the conceptualised factors have a direct positive influence on development and sustainability of SMCs.

3.2.3 Moderating role of Institutional Support

The study asked experts on how they viewed the influence of institutional support like government policies, laws, and regulations on the relationship between conceptualised key enablers and SMC development and sustainability. The results from the interviews showed mixed views on the moderating role of institutional support.

E1 expressed mixed views by saying:

“Not necessarily, this is definitely have got influence in some of these. In terms of improvement of this.”[E1]

On the other hand, E2 pointed out that institutional support is critical, citing that its absence has resulted into failure of most SMCs. E2 stated:

“And if institutional support in terms of all of the things that you have mentioned, if it is there, if it is clearly understood and applied, many of these guys will not have gone under.”[E2]

Further, E3 mentioned that government policies, laws or regulations can improve or retard the influence of the conceptualised key factors on SMC development. E3 stated:

“I think that yes, they are definitely supposed to improve and that is always the aim when these directives and regulations are setup. But I think that based on experience you can find that sometimes they can also be a hindrance… So, I think that is where it can be a negative, it can reduce.”[E3]

Also, E4 asserted that institutional support is instrumental in improving the influence of key enablers of SME development. E4 echoed:

“They, institutional support, yes in terms of all this is important, and if you look at enabling construction business environment. The government cannot take a sort of wait and see approach. Because the government is simply supposed to be the neutral enabler. If I, by neutral enabler I mean is supposed to take into account, into perspective the interest of all the role Players. Come up with a position which enables everybody. And yes, that is the rule of government institutions, that is the rule of government, that is facilitation.”[E4]

On the contrary, E5 echoed that government policies and regulations are currently hindering development of SMCs. E5 stated:

“I do know whether government has got the capability of doing this. They are not doing what they should be doing. They are hindering by not passing laws that will make it easier for contractors to survive on the projects.”[E5]

The findings are consistent with extant literature (Songling et al., 2018; Anugwo and Shakantu, 2020; Bikisha and Amoah, 2020) who contended that government is primarily responsible for creating an
enabling business environment, financial support, and non-financial support to stimulate development and sustainability of SMCs. Thus, the findings largely confirm the proposition that institutional support improves the influence of the identified key enablers on SMC development and sustainability.

3.2.4 The relationship between SMC development and SMC sustainability

The study asked the experts on how they viewed the conceptualised relationship between SMC development and SMC sustainability. The results show that there is unanimity among experts that there exists a cyclical relationship between SMC development and SMC sustainability. For instance, E1 stated:

“… this model as I said definitely, it speak clearly…Contractor development and also sustainability, those are two things which definitely you cannot separate, yah. There must be definitely cohesion.”[E1]

Similarly, E2 professed that the relationship between the two variables is a positive.

“Yah, it is almost a direct one.”[E2]

Further, E3 also submitted that SMC development and SMC sustainability are inextricably linked.

“I think they are very linked and I think that development is important because you have to, it is almost like this is your foundation, this is your basic. You have to get that right. And once you get it right with all these development aspects that we have talked about then sustainability should now be easier in the long term.”[E3]

Also, E4 concurred that development and sustainability as related to SMCs exhibit a cyclical relationship. Firstly, E4 stated:

“So, SME contractor development, development is all about sustainability. Can it be continued…? where will I be within the next 20 years? Will I still be there within the next 5 years? Or am I done after this project? So is more important, that is how any company develops and grows. Then it all comes down to what you are talking about SME contractor development and influencing… sustainability.”[E4]

Secondly, regarding the influence of SME sustainability on SME contractor development, E4 pointed out that there is relationship by saying:

And for you to move from low-cost housing to middle class or upper-class housing, your company should be growing. You should be reinvesting as you put it here, are you getting…your profits and dedicating a certain percentage to the growth of your business…” [E4]

Likewise, E5 concurred with other participants that development and sustainability are double linked.

Further, C1 who is an established contractor confirmed that the company reinvested reserves in its operations to grow and sustain itself even during economic crisis like that caused by Covid pandemic. C1 stated:

“…so, we have reinvested our profits … back in our business…”[C1]

Therefore, the findings are in line with existing literature (Asante, Kissi and Badu, 2018; Lello and Mtendamema, 2018; Wentzel, Fapohunda and Haldenwang, 2022) which argued that SMCs could sustain their businesses if they improve their capabilities and capacities. Thus, the findings confirmed the conceptualised proposition that there is a cyclical relationship between SMC development and SMC sustainability. Clearly, the results indicated that if the relationship is broken, it would be daunting for the business to adapt to the everchanging business environment as noted by Watts, Cope and Hulme (1998: p.103) who submitted that the business will extinct.

3.2.5 Relevance of the conceptualised framework

The study asked the experts to share the general view on the appropriateness of the conceptualised framework in catalysing development and sustainability of SMCs in Namibia. All the experts interviewed
pointed out that the framework is largely appropriate in the context of Namibia. However, to ensure that the framework is effectively implemented, the participants suggested that it should be underpinned by adequate resources, commitment of stakeholders, monitoring and, evaluation at all levels. For instance, E2 consented that the framework is relevant and stated that:

“Yah, I think so, I think the success or failure of any… framework would be the flexibility thereof. So, there should be both self-reflective measurement, so, they can assist and measure the success of the different things… So, I think the framework is fine but there should be a measure whereby you know one tracks success or failures of that specific system and you adjust it, and adjust it, and adjust it.” [E2]

In addition, E3 also echoed that the framework is appropriate by sharing that:

“Yes, I think it is very good, I think it is very appropriate. However, obviously more attention should be given to monitoring… how do you monitor… and who monitors? And who sets the criteria and what that criteria…? [E3]

Like others, E4 stated that:

“Generally, is quite okay. Is bringing out a lot of positive things if properly and objectively implemented, it can help a lot.” [E4]

E4 added that there is need to review what is existing and suggest improvement:

“But, like we said in terms of the regulatory policy frameworks and everything, it is important to look at what is in place. Then bringing something new on top of that or improve it.” [E4]

On the other hand, E5 supported the conceptualised framework by stating that it perfectly reflects the Namibian environment:

“I quite honestly believe that the document that you have presented… accurately reflects the situation here in Namibia. Is a very good reflection of the situation.” [E5]

Therefore, based on the findings from the experts and single case study approach, a final integrated framework was developed as indicated on Figure 2.
The final integrated framework for catalysing development and sustainability of SMCs advances the need to create an enabling construction business environment, training of SMCs, provision of adequate and affordable finance, consistent work opportunities, collaborative support from public and private institutions and firm owner’s entrepreneurial culture. For the framework to be a success, it is envisioned that the framework should be underpinned by adequate resources from government and the private sector, committed stakeholders, and strict monitoring, evaluations, and review of strategies at all levels of the contractor development process.
4. CONCLUSIONS AND RECOMMENDATIONS

This study sought to develop a comprehensive and contextualised framework to catalyse development and sustainability of SMCs in the Namibian context. Firstly, extensive literature review was conducted, resulting in the postulation of conceptual framework which is indicated on Figure 1. The conceptualised framework was then validated by a multi-method qualitative approach comprising industrywide semi-structured interviews consisting of twenty-two (22) participants, structured interviews with five (5) experts from the construction industry, public service and academia, and semi-structured interviews with a director of one of the established indigenous Namibian construction companies. The findings of the study culminated in the development of a final integrated framework for catalysing development and sustainability of SMCs (IFCDS-SMC) which is presented on Figure 2. IFCDS-SMC is characterised by six (6) key enablers which include enabling construction business environment, training of SMCs, provision of adequate and affordable finance, consistent work opportunities, collaborative support of public and private institutions, firm owner’s entrepreneurial culture and institutional support. Further, the final framework is underpinned by adequate resource base to support the implementation of key enablers of SMC development and sustainability, committed stakeholders and enforcement of monitoring, evaluations, and review techniques at all levels of the contractor development process. The framework is envisioned to meaningfully guide development and sustainability of SMCs in Namibia and other contexts, particularly in global south, which share similar conditions as the Namibian environment. The study further argues that the framework is adaptable to other settings with caution.

Consequently, the study recommends the adoption of IFCDS-SMC by the Namibian government, policy makers and relevant stakeholders in a bid to catalyse development and sustainability of SMCs in Namibia.

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An Investigation into the Factors Influencing the Uptake of Electronic Tendering (e-Tendering) in South African Construction Projects

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ABSTRACT & KEYWORDS

Purpose
Against the backdrop of increasing use of e-tendering in construction management, there is a need for adequate knowledge of the factors that influence the decision by organizations in the construction industry to use e-tendering. This study aims to fill the knowledge gap through investigating the factors influencing the uptake of e-tendering.

Design
A well-structured questionnaire was used to gather data and, on the data, sourced in a questionnaire survey involving 91 professionals in the South African construction industry. Using the SPSS Package, descriptive analysis (mean item score) and exploratory factor analysis (EFA) were used to analyze the data obtained.

Findings
It was observed that out of the 8 identified factors investigated in the study, three most important factors influencing the uptake of e-tendering in South African construction projects, in order of importance, were: price reduction in tendering process, client and user satisfaction / improvement in communication between parties, and corruption reduction / enhanced decision making.

Value
The study concludes by identifying strategies that should be engaged in increasing the uptake and maximizing the benefits of e-tendering in the South African construction industry.

Keywords: e-Tendering, innovation adoption, South African construction industry.
1 INTRODUCTION

1.1 Background

Since the emergence of the Internet in the 1990s, the use of Internet-supported information and communication technologies (ICTs) by construction firms to manage intra and inter-firm activities, has been on the increase. However, one aspect of this development that has shown great potential for improving the performance of the construction industry is the use of electronic communications and transaction processes involving purchase of supplies and services or conducting tendering for works, which is usually referred to as electronic tendering (e-tendering) (Bauasa, Kourtidis, Liljemo, Loozen, Rodrigues, and Snaprud, 2013). However, many construction firms especially in developing countries like South Africa are facing a lot of challenges that hinder the fast adoption of e-tendering and are still stuck in the old traditional way of tendering.

The issues being experienced by many small and medium construction firms brought this research investigation to light, in order to enable respondents and other parties on the potential benefits of electronic tendering (e-tendering), the impact and the barriers slowing the fast adoption of this method of tendering. The adoption of this method of tendering is very essential in empowering small and medium firms in South Africa, since it mitigates corruption, costs and time, but it is not only advantageous to small and medium business but large firms and the Public sector as well (Jacobsen and Kocha, 2013).

The adoption of ICTs in the construction industry is a form of technological innovation (Williams and Hardy, 2005). Hence, Laryea and Ibem (2014) described e-tendering as the adoption of innovation. Existing literatures have explored the use of e-tendering in construction in several countries, including the USA (Ibem, Aduwo, Tunji-Olayeni, Ayo-Vaughan, and Uwakonye, 2017), Canada and Nigeria (Oyediran and Akintola, 2011), Australia (Zuo and Seo, 2006), the UK (Eadie, Perera, and Heaney, 2011), and South Africa (Ibem and Laryea, 2015). Others have evaluated the strategies, opportunities, operational benefits, barriers of e-tendering and the factors influencing its uptake in the construction industry (Farzin and Nezhad, 2010; Aduwo, Ibem, Tunji-Olayeni, Uwakonye, and Ayo-Vaughan, 2016). However, as noted by Hashim, Said, and Idris (2014), e-tendering in the construction industry was not widespread, and that there has been limited research into the factors that affect its adoption in the industry. Ibem and Laryea (2015) observed that this is evident especially in African countries where the adoption of e-tendering in construction related areas appears to be at its developing stage. It was against this background that this study investigated the factors influencing the uptake of e-tendering in the South African construction industry.

2. FACTORS THAT ENCOURAGE THE USE OF E-TENDERING IN SOUTH AFRICAN PROJECTS

Many contractors are under a lot of pressure to cut costs while still meeting deadlines and giving quality standards (Jacobsen and Kocha, 2013). The cancellation of projects, cost overruns, and long delays can happen if procurement policies are not consistent. This can also lead to staff displeasure and litigation. Procurement policies must indicate the needs of the organization in question (Azmi and Rahman, 2015). After you have policies in place, you can choose the right electronic tendering resources and tools through careful analysis. This can help you resolve your procurement problems. Companies of all sizes and types that used to be encouraged to improve procurement processes and reduce construction costs are now required to adopt this technique. E-tendering is at the top of the list for every company that wants to be more efficient (Walker and Brammer, 2012).

According to Anthony (2018), procurement departments often have to make this happen with fewer resources than they would like. Recent years have seen a lot of pressure on public and private sector organizations to improve how they buy things from each other. There have been cancelled projects, cost overruns, and delays, as well as staff dissatisfaction and lawsuits because of inconsistencies in procurement policies. Organizations are being asked to be more accountable to their stakeholders, shareholders, and the public (Draheim, 2020). Traditional tendering methods are mostly done by hand and involve managing paper or using email to send and receive documents, addenda, communications, bid submissions, and award notices, as well as to send and receive bids (Afolabi, Ibem, Aduwo, Tunji-Olayeni, and Oluwunmi, 2019). The manual tendering process points out the following areas of concern.
for many businesses: Dealing with paper bids can put suppliers outside of a certain area at a disadvantage if they need to pick up a bid package or deliver a submission in a certain place. Tracking addenda, plans, and drawings can take up a lot of time and money. The lack of a good paper trail and audit history can make it hard to settle disputes (Jacobsen and Kocha, 2013).

Owing to the fact that it takes a lot of time and money to keep track of the tendering process effectively and provide audit trails, stakeholders in the construction industry are often left with inaccurate or outdated information because they don’t have the resources to do that (Abubakar, 2021). They are also under a lot of pressure to find the best contractors at the best prices. A lot of the time, when a tender is put out, there aren’t many bids. With only a few bids to look at, value for money is often lost (Ibem et al., 2017). Traditional tendering not only costs more money and takes longer, but it also puts a strain on resources that are already stretched thin (Balogun, Opawole and Ujaddughe, 2010). In addition to the outside processes that need to be handled, there are also many levels of internal approval that need to be done before a tender can be made. This can cause even more delays and costs to happen. Distribution, administration, and clerical work are some of the other costs of traditional paper-based tendering (Balogun et al., 2010). Electronic tendering is becoming more popular due to the problems associated with traditional/paper-based tendering (Alyahya and Panuwatwanich, 2017).

Electronic tendering is a centralized process that helps businesses improve efficiency and accountability while cutting down on the costs of traditional tendering (Afolabi et al., 219). E-tendering has become more popular in the last few years. Support for specific commodity procurement, virtual plan rooms to help with construction procurement, more integration with current procurement processes and electronic bid submission are just a few of the recent changes (Abubakar, 2021). Suppliers are also becoming more comfortable with electronic tendering practices. These reasons made many businesses not only in South Africa but all over the world want to learn about and use e-tendering (Afolabi et al., 219).

2.1 E-TENDERING FACTORS THAT CAN BE PROVIDED TO AN ORGANIZATION INCLUDES:

2.1.1 Time saving

If the contractors get tender documents, the estimator doesn’t have to re-enter all that information again when he or she makes price estimates. This can save a lot of time, which can be seen as the main benefit of e-tendering (Sithole, 2017). The Building Centre Trust (BCT) used case studies to analyze how these simple changes in the process worked in real life. One of the studies conducted by Ibem and Laryea (2015), found out that about 95% of time was saved because the tender document was sent to the main contractor electronically. This 95% of time saved came from the fact that 50 pages of the tender didn’t have to be “scanned, printed, and checked” which could have taken up to three hours. Instead, the documents were sent to the surveyor in an electronic format, which meant they could be downloaded in just three minutes.

2.1.2 Improved quality

In a paper-based system, mistakes can be made when a bill of quantities (BOQ) is filled out by hand and the tender sum is calculated. This is also known as “ink.” The Construction Industry Development Board (CIDB) (2010) made a lot of mention of this. They said that specific terms should be used in the tender documents to describe problems with calculations in a BOQ. Specifically, the terms should say whether the tender rates or the total price is more important when there is an error. With e-Tendering, these math mistakes should not happen. This is how the software that is used to input the information will figure out the total price over time based on these rates. A mistake in computation can be removed from the process, which will make it easier to finish Price reduction in tendering (Alyahya and Panuwatwanich, 2017). Respondents to CITA’s e-Tendering Survey in 2006 said that this was one of the main things that drew them to the system.
2.1.3 Client satisfaction

A client can be able to view and keep track on the progress of the project since the overall project information is digitalized and available to all members involved in the project hence, it provides the client with sufficient information and satisfactory of the project information (Draheim, 2020).

2.1.4 Cost saving

There is also be cost reductions on individual construction tenders because staff won’t have to spend a lot of time re-entering and verifying project information because they won’t have to spend so much time. However, this isn’t the only way that e-tendering saves money (Balogun et al., 2010). There are also other ways. There are also savings to be made on the costs of administration and printing, which can be done. Booty (2004) said that because of a closed-bid e-tendering, a lot of money was saved on a project that was done in England. About 30% of the total project funds were saved. This was just in the photocopying and other areas that were needed to finish the tender package.

2.1.5 Security

The ability to keep data and operations inside the system safe from people who don’t belong to them at all times during the tender’s life. As a result of this, tenderers didn’t feel as safe as they needed to be that their private information was safe. In addition to that, Booty (2004) talked about how the technology is available, when it is carefully integrated into the e-tendering system, so that all access, uploads, and downloads to the system can be fully secured. This would not only make the system more efficient, but it would also make it more secure and reliable.

2.1.6 Increased transparency

E-tendering also provides transparency to all parties involved, everyone has the ability to see progress and the appointment of subcontractors and suppliers. Providing everything the traditional way of tendering was unable to provide (Balogun et al., 2010).

2.1.7 Speed of information transfer

Easier and fast exchange of data from one party to another like the transferring of data to team members of the clients or tenderers such as architects who can be required to upload drawings and other required information (Anthony, 2018).

2.1.8 Increased accessibility

The system is accessible worldwide, with just the provision of the internet and user detail. Every member involved will have access to the project information at any given time and date (Ibem and Laryea, 2015).

2.1.9 Less corruption

The paper-based method of tendering is easily manipulated by the tenderers and the people responsible in awarding the project contracts hence there is a lot of corruption. E-tendering provides transparency in every decision making and since everyone can be able to see everything the chances of manipulating the system are very slim leading to reduced corruption (Ibem and Laryea, 2015).

3. RESEARCH METHOD

This study evaluated the benefits of e-tendering in South African construction industry. The population for this study were active professionals in the Gauteng Province of the South African construction industry. The targeted professionals/Participants were Project Managers, Quantity Surveyors, Construction Managers, and Artisans. These construction professionals were chosen because, in the pilot study, they indicated knowledgeable contributions to meeting the aim of the study. The standard for selecting respondents for this study was based on their involvement in the tendering phase of construction projects in South Africa. This study employed self-selection and random sampling which gives all participants an equal chance of being selected for the study.

Data for this study was obtained through primary and secondary sources. The primary data collated for this study was achieved through administering of a well-structured questionnaire, which is mostly used
for quantitative research [15]. The questionnaire was designed based on the reviewed literature. The secondary data used in this study was derived from existing literature published in government reports, conference papers and journals. Data for this study was collected with the aid of a well-structured questionnaire to evaluate the benefits of e-tendering in South African construction industry. Data collection took approximately twelve weeks. The respondents were given an average of fifteen minutes to complete the questionnaire without any form of coercion or disturbance. 91 questionnaires were retrieved from a total of 110 administered. It is important to note that these numbers were highly based on the availability, willingness, and consent of the participants to partake in the study. From the pilot study, there were signs that indigenes of the Gauteng province are liberal. As such, their cultural, traditional, or religious predispositions did not seem to have posed a barrier or limitation to their willingness to partake in the study nor did it hinder them from freely disclosing their opinions and sharing their knowledge with respect to the subject matter. Nevertheless, the general knowledge base and opinions of the respondents in this study are considered vital as they offer a basis for comparison between respondents, provide crucial insights to the subject matter and indicate pertinent dynamics on the study of the benefits of e-tendering in South African construction industry.

The analysis of data in this study employed descriptive analysis and exploratory factor analysis (EFA). Descriptive analysis used mean item score (MIS) and standard deviations to measure the significance of all the variables and to rank them. The questionnaire consisted of questions that were ranked using a five-point Likert scale to analyze and acquire the respondents’ opinion on the benefits of e-tendering in South African construction industry. The adopted scales are as follow: 7
1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; and 5 = Strongly Agree.

The five-point Likert scale was converted into mean item score (MIS) for each of the benefits of e-tendering in South African construction industry as proffered by the respondents. This made it possible to determine the rank of each item. The comparison of the MIS of the items as judged by the respondents was easy because the items were ranked. This helped in analyzing data collected from the survey questionnaire. The MIS was derived from the summation of the weight given to each factor by the respondents to the ratio or in relation to the product of the highest weight and the total number of respondents on a specific aspect, in which case, the weighting ranged from 1 to 5 with 1 being the lowest level of effect and 5 being the highest level of effect in the study. This was based on the principle that the respondents’ scores on the specific criteria when measured together are the empirically determined mean score. The MIS was calculated for each item using equation (1) presented below:

\[ \text{MIS} = \frac{1n_1 + 2n_2 + 3n_3 + 4n_4 + 5n_5}{\Sigma N} \]  
\[ \text{Equation (1)} \]

where:
\[ n_1 = \text{Number of respondents for strongly disagree}. \]
\[ n_2 = \text{Number of respondents for disagree}. \]
\[ n_3 = \text{Number of respondents for neutral}. \]
\[ n_4 = \text{Number of respondents for agree}. \]
\[ n_5 = \text{Number of respondents for extremely likely or strongly agree}. \]
\[ N = \text{Total number of respondents} \]

After mathematical computations, the criteria were then ranked in descending order of their mean item score (from the highest to the lowest).

EFA was also used in this study to analyze the whole data set and determine the factors and groups of factors measured by the questionnaire. The rationale for using factor analysis for this study was to reduce the number of variables, find the relationship between variables and to categorize them. EFA also identifies variables that share common ideas through the means of factors or clusters of factors.
The Eigen values and Scree plot were studied to determine the number of factors. From this, the conceptual factors and cluster factors measured by the questionnaire were identified. The EFA was conducted using SPSS version 28.

4. RESULT

Table 1 presents the mean score ranking and the standard deviation (SD) of the respondents’ opinion on the potential benefits of using e-tendering in South African construction industry. The respondents ranked the variables using a Five-point Likert scale where: 1= Strongly Disagree; 2= Disagree; 3= Neutral; 4= Agree; 5= Strongly Agree.

Table 1: Potential benefits of using e-tendering in South African construction industry

<table>
<thead>
<tr>
<th>Potential benefits of e-tendering</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased distribution speed of tenders</td>
<td>3.69</td>
<td>1.072</td>
<td>1st</td>
</tr>
<tr>
<td>Increased efficiency and effectiveness</td>
<td>3.62</td>
<td>1.073</td>
<td>2nd</td>
</tr>
<tr>
<td>Improved tender management</td>
<td>3.59</td>
<td>1.164</td>
<td>3rd</td>
</tr>
<tr>
<td>Quick and easy access to tendering information</td>
<td>3.57</td>
<td>1.156</td>
<td>4th</td>
</tr>
<tr>
<td>Reduction of staffing levels in procurement</td>
<td>3.54</td>
<td>0.935</td>
<td>5th</td>
</tr>
<tr>
<td>Increased market share and competitiveness</td>
<td>3.53</td>
<td>0.923</td>
<td>6th</td>
</tr>
<tr>
<td>Increased transparency and accountability</td>
<td>3.49</td>
<td>0.970</td>
<td>7th</td>
</tr>
<tr>
<td>Cost and time reduction in tendering</td>
<td>3.41</td>
<td>1.135</td>
<td>8th</td>
</tr>
</tbody>
</table>

Increased distribution speed of tenders was ranked first with a mean item score (MIS) of 3.69 and SD of 1.072; Increased efficiency and effectiveness was ranked second with the MIS of 3.62 and SD of 1.073; Improved tender management was ranked third with a MIS of 3.59 and SD of 1.164; Quick and easy access to tendering information was ranked fourth with a MIS of 3.57 and SD of 1.156; Reduction of staffing levels in procurement was ranked fifth with a MIS of 3.54 and SD of 0.935; Increased market share and competitiveness was ranked sixth with a MIS of 3.53 and SD of 0.923; Increased transparency and accountability was ranked seventh with a MIS of 3.49 and SD of 0.970. The least ranked was Cost and time reduction in tendering with a MIS of 3.41 and SD of 1.135.

Also, the rotated factor matrix for the variables factored into two clusters based on the inherent relationship of variables in that cluster.

i. Loaded in cluster 1 are six variables which are Increased distribution speed of tenders (94.8%); Increased market share and competitiveness (81.2%); Cost and Time Reduction in Tendering (78.9%); Improved tender management (66.0%); Quick and easy access to tendering information (57.1%); and Increased Efficiency and Effectiveness (52.8%). Therefore, this cluster can be named Speed and Cost Precision. This cluster accounted for 51.265% of the total variance.

ii. Loaded in cluster 2 are two variables which are Reduction of staffing levels in procurement (91.8%); and Increased Transparency and Accountability (69.0%). The stated variables in this cluster relate to staffing level. Therefore, this cluster can be named Staffing level reduction This cluster accounted for 13.333% of the total variance.

5. DISCUSSION

The findings of the study revealed that the top three potential benefits of e-tendering are increased distribution speed of tenders, increased efficiency and effectiveness, and improved tender management with 3.69, 3.62, and 3.59 9 mean item scores respectively. Additionally, from the factor analysis, increased distribution speed of tenders appears the most beneficiary factor with a clustered component value of 94.8%. The findings of this study are in submission with the study of [16], who concluded that e-tendering is aimed at eradicating traditional paper-formed methodology of tendering while reducing the total duration required in the tender process and its submission.
6. LIMITATIONS
This study only took part in South Africa and the people who took part in the study were construction professionals in South Africa's Gauteng Province. They were architects, quantity surveyors, civil engineers, construction managers, and project managers. The choice of selecting the Gauteng province as the Research study area was due to the concentration of construction professionals and major construction works. This study only assessed the potential benefits of e-tendering in South African construction Industry.

7. CONCLUSION
This study was aimed at evaluating the potential benefits of e-tendering to the South African construction industry. The findings from the survey instrument distributed to the respondents reveals that the top potential benefit of e-tendering is increased distribution speed of tenders. In addition, from the factor analysis, increased distribution speed of tenders appears the most beneficiary factor with a clustered component value of 94.8%. This supports the popular saying that e-tendering is aimed at eradicating paper-formed methodology of tendering while reducing the total duration required in the tender process and its submission. Hierarchically, other potentially benefits are increased efficiency and effectiveness, improved tender management, quick and easy access to tendering information, reduction of staffing levels in procurement, increased market share and competitiveness, increased transparency and accountability, and cost and time reduction in tendering. This therefore indicates that the aim of the study was achieved.

8. REFERENCES


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SUB-THEME: DIGITALIZATION

An overview of the use of Building Information Modelling (BIM) by general contractors and the potential benefits for emerging contractors

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ABSTRACT AND KEYWORDS

Purpose
The purpose of this paper is to identify Building Information Modelling (BIM) uses and benefits for General Contractors (GCs) and then to explore the extent to which Emerging Contractors (ECs) can also benefit from this novel innovation.

Design
In exploring the comprehensive benefits derived by GCs from using BIM during the project execution phases, this paper explores the extent to which the specific challenges experienced by ECs in project execution can be addressed by BIM technology. The benefits investigated include management of project scope, schedule control, cost management, and quality of workmanship.

Findings
The findings suggest that GCs can use BIM for various associated beneficial functions. ECs can also benefit from BIM. The use of BIM can benefit and assist ECs to overcome challenges during the project execution phase. This study proposes that the challenges experienced by ECs can be addressed by introducing a lean approach to the BIM concepts.

Value
This paper addresses two research gaps, it holistically reviews and synthesizes extant studies and identifies extensive BIM project use opportunities for GCs and proposes potential BIM project uses to benefit ECs and lay the foundation for further studies.

Keywords: Emerging Contractors (ECs), General Contractor (GCs), Building Information Modelling (BIM), Developing Country, Project Manager (PM)
1 INTRODUCTION

The construction industry generally is subject to many challenges from the traditional fragmented way of working, due to project complexity, health and safety control, lack of communication, and difficulty with time, cost, and quality control (Hinze, 2011). Construction, however, requires the execution of projects as efficiently and safely as possible. Building Information Modelling (BIM) can assist contractors in achieving this (Arayici, 2012). BIM as an “integrator” (Saka & Chan, 2020) can be used to improve communication, coordination, and collaboration on projects, ultimately inter alia increasing operational efficiency (Bataw et al., 2014; Eastman, 2011). Accurate, clear, and regular information is therefore essential for management in assisting project teams with everyday decision-making and for strategic planning. Barlish & Sullivan (2012) state that although BIM has many advantages, one of the biggest threats is that professional teams do not really understand the technology. While many countries have embraced the adoption and the use of BIM, South Africa (SA) like many other developing countries still lags more than a decade behind the rest of the continent (Sergey et al., 2020; Saka & Chan, 2019).

BIM use in field operations to support daily activities during the construction phase is still lacking when compared with design and office-related activities such as design, clash detection, estimating, and planning in the Owner–Architecture–Engineering–Construction (OAEC) industry (Britani & Thais, 2019). Santos et al. (2017) further adds that regardless of BIM benefits to contractors, few studies address the use of BIM to directly support field operations. This is further exacerbated by the fact that the construction players especially contractors are still unclear about what BIM truly is, and how and when to use it (Hilfie, 2019). Consequently, BIM is not widely used by construction project teams in South Africa. It is certainly not used by Emerging Contractors (ECs), and if so, to a very limited extent, and there are no studies available that address the potential use and benefit of BIM for ECs. ECs can be defined as an enterprise that is owned managed and controlled by previously disadvantaged persons and which is overcoming business impediments arising from the legacy of apartheid.

The participation of ECs dates back to post-1994 when South Africa experienced an influx of new contractors infiltrating the construction industry, Green & Lenard (1999) however state that ECs are reportedly beset with a prevalence of client dissatisfaction as a result of weak project performance. In response, the government in the year 2000 established the Construction Industry Development Board (CIDB) to regulate the construction industry (Act 38 of 2000). The continuous failure of ECs to deliver construction projects (Mathinye, 2016; CIDB, 2015; Mofokeng, 2012) is an indication that a shortfall still exists in effective and systematic project delivery systems, as well as a shortage in skills to deliver projects according to the required scope as was identified by Thwala et al., (2009).

Using BIM methods, compared with the traditional working model, can help achieve coordination, cooperation, and integration whilst improving information flow and processing (He et al., 2014). However, BIM adoption in SMEs is complicated, in which numerous stakeholders and various influencing factors are involved (Li et al., 2019). Unless BIM adoption obstacles and hindrances such as lack of resources, lack of awareness, ignorance, and misunderstanding of the diversity of BIM uses and potential benefits are addressed, the South African construction industry will continue to lag behind its international colleagues in BIM application. This situation will exacerbate the prevailing challenges experienced by most South African ECs during the project execution phase.

The reason why BIM is considered for ECs in this study is the utilitarian visualisation part of BIM which can be most beneficial to supporting EC construction-related activities. Designing a computer interface accessible to semi-literate/poorly educated (based on lean BIM principles) is therefore considered a fundamental essential tool that can appeal to a wider targeted EC end-user market. This approach can ensure that ECs also benefit from the powerful information visualisation capabilities offered by BIM.

This study firstly aims to identify a wide array of BIM opportunities available for construction contractors, while addressing the pertinent question regarding what BIM is for contractors. This involves the process of systematically reviewing the extant studies with a view to synthesizing the findings. This is done by reviewing, consolidating, and defining BIM uses and associated benefits for the General Contractors (GCs) based on global lessons, experience, and trends. The study then aims, based on the information gained from step one, to explore the extent to which BIM can be adopted and implemented at a level that can be beneficial for ECs construction project use. A need, therefore, exists for a lean BIM concept to be developed, making BIM accessible and relevant for empowering and supporting ECs during the
project execution phases. The ultimate research goal is to improve the overall construction project operational efficiency of ECs by using BIM for sustainable long-lasting results.

2 LITERATURE REVIEW

BIM, inter alia, is expected to be a major driver in enabling 3D visualisation and detailing cost reduction, speeding up the delivery time, highlighting service clashes, providing opportunities for value engineering, and reducing waste in all phases of design and construction (Georgiadou, 2019). The challenge however still exists if contractors know what BIM really is, where, and how to use it. A need also exists to establish the extent to which ECs can take advantage of the benefits associated with BIM, this however can be achieved once the challenges associated with BIM adoption, implementation, and use in the emerging market have been addressed. ECs are considered the backbone of the construction industry for creating employment and for economic stimulation.

2.1 Optimising BIM use to support construction execution/field operations for contractors

Although BIM is used mostly for the design phase, it is not fully recognized for the execution phase in the construction sector (Kouch, 2018) stymieing the overall potential for the use of BIM in the construction industry (Britani & Thais, 2019). Britani & Thais (2019) further add that unless this research gap is addressed, the opportunities for increased productivity and project flow improvement resulting from the use of BIM at the field level may remain uncovered. A study by Hassan (2018), suggested that BIM implementation in low-cost housing design and construction can improve the following processes: Design optimization; efficiency improvement (effective project information management); sustainability enhancement; cost reduction or control; time reduction or control; communication improvement; coordination improvement; and quality increase or control. Findings by Britani & Thais (2019) support the importance of using BIM to visualize and plan field operations and prevent wasteful interactions between resources (workers, equipment, and time).

2.2 BIM challenges and obstacles in emerging markets

The idea that BIM is only for big business is challenged by the growing number of Small and Medium Enterprises (SMEs) that can demonstrate a return on investment (NBS, 2012). Nevertheless, BIM obstacles are greater in small markets where design and construction companies are small and have limited resources to obtain and maintain BIM software tools (Migilinskas et al., 2013). As the rate of complex projects is increasing, many smaller organisations are reluctant in adopting BIM as they face major difficulties in meeting their objectives in a cost-effective manner (Georgiadou, 2019). Muñoz & Arayici (2015) and Bataw et al. (2014) add that BIM can be challenging to implement and requires high investment costs and extensive professional staff training which is the main hindrance for the emerging market. However, while “BIM use” tends to be more focused on the product (technology) than process innovation, Machado et al. (2016) suggest that process improvements and knowledge management can incrementally reduce costs and increase competitiveness for SMEs. Finally, even though BIM use may not be a panacea to all the problems in the construction industry (Qian, 2012) it is expected to have a positive improvement on how projects are delivered in SA. Davidson (2009) concurs that BIM is to be perceived as being able to eradicate almost all the inadequacies that arise in the process of construction, but it is not the solution to all the problems in construction. The earlier the construction industry realise that BIM will be the future of the industry the better (Munir et al., 2013). Based on experiences from more BIM mature countries, the implementation of BIM technology in South Africa poses many challenges that would affect its adoption in the Architectural, Engineering, and Construction (AEC) sector (Chimhundu, 2015). The sentiment that BIM (digital construction) has not yet been embraced or adopted by the majority of the contractors in South Africa is echoed by Saka & Chan (2019), especially not by emerging contractors as the latest advanced technological project delivery tool. The technical and financial benefits of BIM are therefore not efficiently achieved by the firms, especially by the SME contractors, because the building industry and the construction sector hesitate to employ BIM (Ghaffarianhoseini et al., 2017).

2.3 The need for lean BIM protocols in support of the emerging market

Although BIM has constituted a technological and team coordination breakthrough in the AEC industry, it has been mainly adopted for commercial and/or large-scale building projects while being mostly neglected by small or residential building project teams (Migilinskas et al., 2019; NAHB, 2016). Hashemi
(2014) concurs that while BIM is mostly used in large and complex construction projects offering notable improvements in the design and construction processes; however, the relevance of BIM to housing construction, where projects are relatively smaller, simpler, and more repetitive, is less understood and documented. Yet, there are several examples where BIM has been successfully used in small, medium, and large housing projects. While BIM promises more benefits for residential projects, it will take a long time for small house development companies to cover BIM deployment costs and start making profits (Miglianskas et al., 2019). The challenges and obstacles in the emerging markets, therefore, necessitate the modification and further development of the current BIM protocols. A BIM protocol involves the integration of the modelling, and management to ensure proper BIM implementation and use.

3 RESEARCH METHODOLOGY

The methodology used for this paper consists of a literature study. The methodology adopted in this study is divided into two parts and explained as follows:

1. The literature review of BIM in general
2. The three-step literature study of BIM in the construction phase: Step One: An overview of BIM project use and benefits for the general contractor at various stages. The literature study consists of reviewing a wide variety of extant publications on BIM for contractors and the use of BIM during various construction project phases. The publications on BIM for contractors were retrieved from a number of different search engines or databases which included Google Scholar/Science Direct/Compendex/Science Citation Index and Stellenbosch University Library SUNSearch with no year limitation. The search engine result output returned 109 documents (data set); the data set was subsequently refined to 63 documents that meet the criteria set for this study.

Step Two: The evaluations of key concepts and benefits of BIM from the publications reviewed. Then the identification of the overall general contractor and long-term BIM benefits, and the collective stakeholders’ project benefit Step Three: The establishment of the need for BIM for emerging contractors in South Africa and establishing benefits that can be derived from BIM for ECs based on study findings This paper reports on an initial step in a larger research project. For the larger project, suitable methodologies will be followed to obtain input from the construction industry role players. Such methods could consist of interviews, questionnaires, or case studies. These would be a subsequent step. This paper reports on the initial research to define the needs and requirements for the study.

4 BIM IN THE CONSTRUCTION PHASE

4.1 BIM construction project use and benefits for the general contractor
<table>
<thead>
<tr>
<th>BIM use</th>
<th>Summary BIM benefits / Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-construction / Bidding / Tendering Phase</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Existing conditions modelling/Field capturing</td>
<td>Existing conditions documentation, and field capturing etc.</td>
<td>TISE, 2021; Kjartansdóttir et al., 2017</td>
</tr>
<tr>
<td>2. Scope management</td>
<td>Visualization for better understanding and clarification of the project for bidding and purchasing.</td>
<td>Beveridge, 2012; Hergunsel, 2011; AGC, 2010</td>
</tr>
<tr>
<td>3. Constructability review/Simulation of construction</td>
<td>Review of the construction processes then generates constructability reports.</td>
<td>Beveridge, 2012; Hergunsel, 2011; Eastman et al., 2008</td>
</tr>
<tr>
<td>4. General visual aid &amp; Onsite technology</td>
<td>Visual aid and ease of getting information on site. iPad/smartphone etc. for mobile access to the model onsite.</td>
<td>Hassan, 2018; Kjartansdóttir et al., 2017; Yalcinkaya, 2013; Beveridge, 2012; McGraw-Hill, 2010</td>
</tr>
<tr>
<td>5. Interactive 3D Walk-throughs/Fly-throughs (these terms are often used interchangeably)</td>
<td>3D Walkthroughs for final product review, this improves scope and quality management. Walkthroughs are more related to the interior aspect of a building while flythroughs often encompass both interior and exterior components.</td>
<td>Garcia, 2016; Sears, 2015; Beveridge, 2012; Hergunsel, 2011; Wang, 2007</td>
</tr>
<tr>
<td>6. Augmented Reality (AR)/Virtual Construction Arrangements (VCA)</td>
<td>AR is used to plan a virtual construction worksite. AR improves the productiveness of on-site work.</td>
<td>Li, 2014; BSRIA, 2013; Wang, 2007</td>
</tr>
<tr>
<td>7. 4D BIM (3D plus &quot;time&quot;) Project scheduling /Programming works/4D simulation</td>
<td>Identification of schedule, sequencing, or phasing issues, and supports project phasing simulations.</td>
<td>Hassan, 2018; Kjartansdóttir et al., 2017; Li, 2014; Kaber, 2010; Yan &amp; Damian, 2008</td>
</tr>
<tr>
<td>11. Site utilization planning (Spatial constrain analysis/co-ordination) &amp; Construction logistics model/Project strategic planning</td>
<td>Visualization of permanent and temporary facilities on site. Quickly identify potential and critical space and time conflicts. Rehearse yard operation and site logistics for &quot;what if&quot; scenarios. Select a feasible construction scheme. Computation of material breakdown &amp; evaluation of the site layout for safety concerns and much more.</td>
<td>Hassan, 2018; Kjartansdóttir et al., 2017; Azhar, 2011; Hergunsel, 2011; AGC, 2010; Kaber, 2010</td>
</tr>
<tr>
<td>12. 3D Safety &amp; logistics models</td>
<td>Simulating the equipment handling and movement for assembly through a 4D model in order to inspect the safety condition. Accurately evaluate site layout for all safety concerns.</td>
<td>Hassan, 2018; Kjartansdóttir et al., 2017; Mahalingam et al., 2010; Yan &amp; Damian, 2008</td>
</tr>
<tr>
<td>13. 3D Coordination/Communication &amp; collaboration</td>
<td>Increased and improved coordination, communication, and collaboration within project teams.</td>
<td>Kjartansdóttir et al., 2017; Eastman et al., 2011; Hergunsel, 2011; Grilo &amp; Jardim-Goncalves, 2010; McAdam, 2010; Lee, 2008</td>
</tr>
<tr>
<td>14. Clash detection for interference checks</td>
<td>Clash detection software is used to coordinate field conflicts by comparing 3D models of building system.</td>
<td>Kjartansdóttir et al, 2017; Kiprotich, 2014; Kaber, 2010</td>
</tr>
<tr>
<td>15. Digital Fabrications/Shop drawings</td>
<td>Digital information is used to facilitate the fabrication of construction materials or assemblies. BIM assists in developing shop drawings for different systems of buildings.</td>
<td>Kjartansdóttir et al., 2017; Kiprotich, 2014; Azhar, 2011; Barton Malow, 2011</td>
</tr>
</tbody>
</table>

Table 4.1: BIM construction project use and benefit/value for Construction Contractors (CCs) or General Contractors (GCs) based on global experience.
### Table 4.1: BIM construction project use and benefit/value for Construction Contractors (CCs) or General Contractors (GCs) based on global experience

<table>
<thead>
<tr>
<th>BIM use</th>
<th>Summary BIM benefits / Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. Construction information retrieval</td>
<td>BIM aids with the visual aid and ease of getting information on site, improving productivity.</td>
<td>Kjartansdóttir et al., 2017; Kaber, 2010</td>
</tr>
<tr>
<td>17. 2D site-specific drawings extraction/ Work plan drawings/lift drawings</td>
<td>All 2D site-specific drawings can be easily and automatically extracted from the BIM model. Lift drawings contain only the detailed information required for a specific task.</td>
<td>Indovance, 2015; Beveridge, 2012</td>
</tr>
<tr>
<td>18. Geographic Information Systems (GIS)</td>
<td>GIS can be incorporated at several stages of the model. GIS can be used to display site plans or surrounding areas.</td>
<td>Beveridge, 2012</td>
</tr>
<tr>
<td>19. Scope management</td>
<td>Continuous improved project scope clarification. Visualisation of what exactly is to be built in a simulated environment</td>
<td>Bryde et al., 2013; AGC, 2010; Kaber, 2010</td>
</tr>
<tr>
<td>21. Image-based 3D reconstruction for progress monitoring</td>
<td>Images and videos can be recorded daily on site. 3D reconstruction is the key to connecting the Building Information Model and the project schedule to daily construction images, which enables managers to compare as-planned with as-built status and detect deviations and therefore monitor project progress.</td>
<td>Xue et al., 2021</td>
</tr>
<tr>
<td>22. Artificial intelligence (AI) via 360° cameras</td>
<td>Controlling construction processes using hard hat-mounted 360° cameras to collect live data on site using AI &amp; BIM</td>
<td>Buddoo, 2022</td>
</tr>
<tr>
<td>23. Tracking time</td>
<td>BIM model used to track the time spent by each employee on a project, the lead times for materials, or the time being spent on a specific task or phase.</td>
<td>Beveridge, 2012</td>
</tr>
<tr>
<td>24. Cost management – 5D BIM</td>
<td>Cost estimates help track budgets throughout the project and keep tight reins, and more reports to monitor progress. Progress payments facilitation via visual validation for payment approval.</td>
<td>Hassan, 2018; Kjartansdóttir et al., 2017; Bryde et al., 2013; Cerovsek, 2011; Allison, 2010</td>
</tr>
<tr>
<td>25. Automated cross-system updates</td>
<td>An integrated 5D BIM model updates both the schedule and budget when any design or scope change occurs.</td>
<td>Kiprotich, 2014; Allison, 2010</td>
</tr>
<tr>
<td>26. Quality management/Safety management (Field/manage tracking)</td>
<td>Used to manage, track, task, and report on quality (QA/QC), safety, documents to the field, commissioning and handover programs, connected to the 3D models to ensure conformance and compliance. Quality increase or control.</td>
<td>Kjartansdóttir et al., 2017; Bryde et al., 2013; He-gunsel, 2011; Kaber, 2010; Yan&amp;Damian, 2008</td>
</tr>
<tr>
<td>27. Clash detection for risk management/ Collisions identification</td>
<td>Clash detection, and negative risk reduction.</td>
<td>Kiprotich, 2014; Bryde et al., 2013; AGC, 2010; Allison, 2010</td>
</tr>
<tr>
<td>28. Site safety</td>
<td>The site is safer due to fewer materials and fabrications on site due to the accuracy of virtual design, and more.</td>
<td>Beveridge, 2012; Smith, 2007</td>
</tr>
<tr>
<td>30. 3D Laser scanning</td>
<td>Used to monitor the progress of designed 3D Model. This as-built data can be manually checked against the original designed model to detect deviations for quality control. It can also be used for renovation projects</td>
<td>Hassan, 2018; Beveridge, 2012; Hergunsel, 2011; Azhar, 2011</td>
</tr>
<tr>
<td>31. Communication &amp; collaboration</td>
<td>4D visualisation used as a communication tool to show project progress to project team and stakeholders and for revealing potential</td>
<td>Bryde et al., 2013; Allison, 2010</td>
</tr>
<tr>
<td>BIM use</td>
<td>Summary BIM benefits / Value</td>
<td>Source</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>32. Construction coordination</td>
<td>BIM helps in field design changes and the remote coordination between construction technical offices and engineers on site through cloud communication. BIM results in increased coordination of construction documents.</td>
<td>Hassan, 2018; Bryde et al., 2013; Kaber, 2010; Eastman, et al., 2008</td>
</tr>
<tr>
<td>33. Virtual mock-ups/Construction system</td>
<td>Virtual mock-ups such as laboratories or building envelope/curtain wall can be generated, and used to review 3D shop drawing. Used also to generate, design and analyse the construction of a building system such as form work, glazing, tie-backs etc. in order to increase planning of resources and sequencing alternatives.</td>
<td>Kjartansdóttir et al., 2017; Hergunsel, 2011; Khemlani, 2011</td>
</tr>
<tr>
<td>34. Curtain wall systems/Building envelope</td>
<td>Curtain wall systems whether panelised or stick system, can be used with BIM to pre-fabricate parts &amp; components.</td>
<td>Hergunsel, 2011</td>
</tr>
<tr>
<td>35. Pre-fabrication &amp; modular construction</td>
<td>More pre-fabrication of materials and even some assembly in a controlled off site, factory environment which typically results in higher quality at a lower cost and reduced wastage.</td>
<td>Beveridge, 2012; AGC, 2010; Kaber, 2010; Smith, 2007</td>
</tr>
<tr>
<td>36. Fabrication</td>
<td>BIM used for time, procurement, and quality management during the fabrication process</td>
<td>TISE, 2021; Kiprotich, 2014</td>
</tr>
<tr>
<td>37. Organization improvement &amp; logistics/Path planning</td>
<td>Path planning involves materials flow rules, level of access to materials, work sequence, etc. Once site utilization planning has been done, BIM can be used to improve site logistics.</td>
<td>Bryde et al., 2013; Morad et al., 1992</td>
</tr>
<tr>
<td>38. Tracking materials</td>
<td>Once ordered materials can be tracked offsite to ensure on time delivery, no stockpiles. Tracking with RFID.</td>
<td>Beveridge, 2012; Smith, 2007</td>
</tr>
<tr>
<td>39. Environmental constraints assessment</td>
<td>BIM can be employed to minimise adverse environmental constraints impact.</td>
<td>Wang, 2007</td>
</tr>
<tr>
<td>40. Spatial co-ordination</td>
<td>Information models are used to visualize permanent and temporary facilities on site during multiple phases of the construction process. Improved spatial co-ordination control can be maintained.</td>
<td>Hassan, 2018; Kjartansdóttir et al., 2017; Wang, 2007; Elbeltagi &amp; Hegazy, 2001; Choo &amp; Tommelein, 1999</td>
</tr>
<tr>
<td>41. Hiring and controlling the sub-contractors</td>
<td>Having a handle on clash detection and coordination plays a key role in keeping sub-contractors’ work predictable.</td>
<td>AGC, 2010; Allison, 2010</td>
</tr>
<tr>
<td>42. RFIs, TQs, VOs &amp; COs management</td>
<td>Fewer errors and corrections in the field. BIM used to coordination construction documents; Change Orders (COs) due to field design changes can be better managed. Reduced number of Requests for Information (RFIs), Variation Orders (VOs) &amp; Technical Questions (TQs)</td>
<td>Hassan, 2018; Kalinchuk, 2015; Nanajkar, 2014; Eastman, et al., 2011; Allison, 2010; AGC, 2010; Kaber, 2010</td>
</tr>
<tr>
<td>43. 3D control and planning/Digital layout</td>
<td>An information model is used to layout facility assemblies or automate control of equipment’s movement and location.</td>
<td>Kjartansdóttir et al., 2017; Kaber, 2010</td>
</tr>
<tr>
<td>44. Drones in BIM</td>
<td>Drones can be used for monitoring the progress of a construction project, site planning and safety, surveying, simulations, project coordination and more.</td>
<td>Sanchez, 2019; Panjehpour, 2019</td>
</tr>
<tr>
<td>45. Digital plans workstations</td>
<td>Onsite workstation contains drawings, plans and specs, the model can be shared by all the site workers, including subcontractors.</td>
<td>Beveridge, 2012</td>
</tr>
</tbody>
</table>
Large strides have been made in understanding BIM’s impact on the AEC field, but current research into the present state of BIM usage at the operational level is lacking. These limitations in the use of BIM during the planning and completion of site work represent a knowledge gap in the AEC industry, which is ripe for exploration. To further the evolution of BIM in construction research and analysis of this gap between the current uses of BIM and their potential to support trades in the field is needed (Britani & Thais, 2019). BIM is viewed as intelligent objects for bidding, ordering, and for storing gained information (Goldswain, 2016). However, contractors are still unclear about what BIM truly is, how and when to use it, and how using BIM during the construction phases can benefit them. To address these issues, related literature was studied to identify instances of BIM use by GCs during various construction phases as shown in Table 4.1. Proper understanding of BIM can reduce instances of missed opportunities for contractors and optimise operational efficiency. The proper use of BIM can assist contractors to gain a better understanding of the operations ahead of time and shield production against uncertainties.

### 4.1.1 Summary of BIM use and benefits for general contractors

As a result of further BIM evolution, literature is bound with case studies that highlight benefits associated with the utilisation of BIM by GCs for the planning and the execution of construction and including project close-out. These benefits as captured in Table 4.1 have been summarised in Table 4.2. This table has been prepared as a guide for GCs to appreciate the opportunities that BIM creates, it is designed to help GCs to capitalise on these utilitarian opportunities. Although this list is thorough, it may however not be all-inclusive as BIM construction project use is continuously evolving.

<table>
<thead>
<tr>
<th>BIM use</th>
<th>Summary BIM benefits / Value</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>46. X-ray &amp; Sonar</td>
<td>X-ray linked to the model is used on existing structures, to determine where unknown components such as rebar are located. Sonar is similar to X-ray, but sonar equipment is used to detect where underground components are located.</td>
<td>Beveridge, 2012</td>
</tr>
<tr>
<td>47. Project start-up &amp; closeout/Building turnover information</td>
<td>During commissioning/start-up, the model helps to test the whole concept and design as it is constructed. Successful completion of the project and the final transfer of assets to the client.</td>
<td>Tabesh, 2015; Allison, 2010</td>
</tr>
<tr>
<td>48. BIM as built/Record modelling</td>
<td>Contractors can use BIM to update the model to BIM “as-built” model. This information together with the closeout information can then be used by the client for future Facility Management Application - 7D BIM.</td>
<td>Georgiadou, 2019; Kjartansdóttir et al., 2017; H-assan, 2018; Beveridge, 2012; Hergunsel, 2011</td>
</tr>
</tbody>
</table>
It is evident from Table 4.2 that during the planning phase contractors use BIM mostly for project costing and 5D simulations, as a general visual aid tool, for project 3D coordination, and the 4D simulations and scheduling. Literature is however silent if GCs take advantage of utilising the intelligent information provided by BIM during this stage. During the execution phase, the most recorded BIM use by GCs is the 4D schedule control, followed by RFIs, TQs & COs management, spatial co-ordination and then 5D BIM cost management. GCs prioritise costing ahead of scheduling in the planning phase and schedule control over cost management during the execution phase (i.e., 4D BIM and 5D BIM roles alternate respectively). During the handover phase, BIM is used mostly for BIM as built/record modelling.

4.2 The collective project benefits and the general contractor’s strategic benefits business

The BIM benefits based on the literature review of short and long-term benefits for the General Contractor (GC) as a business, as well as the collective project benefits, are presented in Table 4.3. These can be compared to the identified BIM adoption and implementation obstacles and hindrances as described above. The results from the reviewed literature indicate that the overall benefits associated with the adoption and implementation of BIM for GCs potentially outweigh the identified challenges. The results also indicate that GCs are more focused on reducing waste, and increasing productivity in order to grow their business, yet not prioritising quality, collaboration, or customer satisfaction.

<table>
<thead>
<tr>
<th>Project / Firm goals</th>
<th>Benefits / Value derived from using BIM</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced costs</td>
<td>Overall reduced project costs. Overall reduced project wastage, through managing risk and cost.</td>
<td>Kiprotich, 2014; Beveridge, 2012; Qian, 2012; Kaber, 2010</td>
</tr>
<tr>
<td>Wastage control/reduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity improvements</td>
<td>Improved overall project productivity (less re-work, conflict, and changes). Fewer call-backs and, thus, lower warranty costs.</td>
<td>Kalinichuk, 2015; Qian, 2012; AGC, 2010; Kaber, 2010</td>
</tr>
<tr>
<td>Firm Growth</td>
<td>Creates an atmosphere for new revenue and business opportunities. Successfully completed projects with 5D BIM leads to efficient and more confident contractors which in turn contributes to positive firm growth.</td>
<td>Nanajkar, 2014; Qian, 2012; AGC, 2010; Allison, 2010</td>
</tr>
<tr>
<td>Marketing new business</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project delivery</td>
<td>Faster and efficient overall project delivery (increased speed of delivery).</td>
<td>Qian, 2012; Kaber, 2010</td>
</tr>
<tr>
<td>Profit margins</td>
<td>Greater productivity, reduced project duration, reduced overall costs associated with construction, and higher quality of work leading to higher profit margins.</td>
<td>Nanajkar, 2014; Allison, 2010</td>
</tr>
<tr>
<td>Quality &amp; performance</td>
<td>Optimised overall project quality and performance.</td>
<td>Qian, 2012</td>
</tr>
<tr>
<td>Collaboration &amp; control</td>
<td>Enhanced overall project collaboration and control among stakeholders, including communication and coordination.</td>
<td>Qian, 2012</td>
</tr>
<tr>
<td>Owner’s/Client’s/Customer experience &amp; satisfaction</td>
<td>Optimised owner’s experience and satisfaction. The owner has more confidence in the GC. Client is satisfied as client’s output requirements (BIM brief) are met.</td>
<td>Allison, 2010</td>
</tr>
</tbody>
</table>
4.3 The need for further interventions for emerging contractors in South Africa

ECs continue to dominate the construction industry in South Africa (CIDB, 2015) in terms of the number of CIDB registered contractors. However, their performance has been widely reported over the years as being less than desirable as discussed below. Most of the ECs fail within the first five years of establishment (Mofokeng, 2012) and fall before advancing more than three levels within the CIDB Register of Contractors (RoC) (Govender, 2017). An increase of at least three CIDB grades was stated in a study by Windapo & Cattell (2011) to define a successful construction company.

The CIDB has realised that a vibrant and successful construction industry is only possible if those employed within it have the required skills and competency to function effectively in their roles (Dlamini, 2018; Ntuli & Allopi, 2014). A study undertaken by the South African Government in 2002 to determine the issues and gaps in the delivery of infrastructure reported that there was a shortfall in effective and systematic delivery systems, as well as a shortage in skills to deliver projects as per requirements (SAICE, 2016). The failure of ECs is often a result of a broad number of factors and not a one-even situation. Most ECs operate with inadequate financial, managerial, and technical capacity (Dlamini, 2018; Govender, 2017; Mohlala, 2015; Thwala et al., 2009). Mohlala (2015) also found that contractors with technical qualifications and experience generally perform better than those with no technical background. It was also found that where there is no technical background, the level of education also affects the level of project performance. The lack of construction education appears to be one of the major hurdles for small enterprises (Ntuli & Allopi, 2014). Dlamini (2018) recommends that emerging and poorly educated contractors should have accessible tools to enable them to improve themselves.

According to Kaber (2010) and AGC (2010), BIM makes it possible for non-technical people to better visualize the final result. BIM seems to be attracting home builders’ attention thereby promising a qualitative leap in residential project outcomes including time, cost, quality, and sustainability (Poirier et al., 2015). This means that BIM is not irrelevant for small-scale projects but can also be beneficial to small business companies such as ECs but only if further developed specifically to cater for ECs project use and also if implemented properly (by using relevant construction processes) into any BIM-enabled project. The powerful information visualisation capabilities offered by BIM can empower struggling ECs (including those who are semi-literate/poorly educated) better understand and appreciate the relevant construction processes. This can subsequently contribute positively to improved construction project performance by ECs.

It is important to note that BIM, is not an independent technology (Sergey et al., 2020) but a technology-enabled process of collaboration, with approximately 90% process and 10% technology (Munir & Jerey, 2013). For contractors, the word ‘process’ refers to the BIM construction process which can empower ECs to implement any BIM-enabled project in an effective structured, and systematic manner. While relevant and appropriate BIM tools can support ECs with the knowledge and capacities to perform field-specific tasks (technical skills). Therefore, a combination of the processes and the tools can ensure the successful implementation and use of BIM in a construction project.

4.3.1 Project and BIM goals for emerging contractors

BIM offers many Project Management (PM) related benefits (Table 4.1) in its product portfolio. Nonetheless, its utilisation in various PM knowledge areas such as integration, scope, time, cost, resource, procurement, communication, quality, risk, safety, environmental, financial, and claim management (PMI, 2008) are not fully realised in SA (Kiptoitich, 2014). In defining project performance by GCs and ECs by extension, it was found that this measure of the degree in which project goals are met, can be measured against time, cost, and quality (Mohlala, 2015; Fazli et al, 2014) as well as according to its scope and client satisfaction (Fazli et al, 2014). Considering that client satisfaction is the crucial variable underpinning current and future prospects in the building industry, it is necessary to investigate the challenges facing the ECs. Result-oriented Key Performance Indicators (KPIs) namely; time, cost, quality, and customer satisfaction goals for construction projects can therefore be used as the theoretical lens to further discuss the benefits that can be provided by BIM for ECs. The project goals of ECs are therefore delivering quality projects on time and within the budget while ensuring customer satisfaction. These goals can be realised by the benefits offered by BIM. The project goals of ECs, therefore, form the fundamental bases for the BIM goals for ECs when executing any BIM-driven project. Aligning project and BIM goals ensure that the project is successfully executed, and the ECs project performance can then be measured through the result oriented KPIs.
4.3.2 BIM construction/building uses for emerging contractors based on the BIM goals

In an effort to address ECs’ poor performance, this paper seeks to highlight the benefits associated with introducing the adoption, implementation, and use during the project execution phases (planning & execution) of BIM technology. It is however evident as highlighted in paragraph 2.2 that BIM in its current format poses threats rather than benefits for ECs. A lean BIM approach, therefore, suggests a new solution to the noted issues, without compromising the fundamental BIM principles. This can be realised by using the visualisation benefits of BIM and by making the information contained in BIM available to ECs. Such benefits include but are not limited to project scope clarification/management, scheduling/schedule control, costing/cost management, and quality assurance/control.

5 CONCLUSIONS

The use of BIM for various construction applications and its benefits for GCs can be characterised as nascent and evolving. From the diversity of BIM applications presented in Table 4.1, it can be concluded that there are a plethora of benefits for GCs in adopting, implementing, and using BIM for their BIMenabled projects. Global research also connotes that BIM can be a valuable and sustainable approach that can assist GCs to deliver projects more efficiently. The use of BIM by contractors not only offers collective project benefits but can also yield a positive effect on the business as captured in Table 4.3.

This paper also presents the benefits that ECs can derive in adopting, implementing, and using BIM during the project execution phases. In doing so, it helps raise the awareness that BIM is not only relevant and useful for mega and complicated projects but can also be beneficial for smaller-sized projects. Previous studies in SA on ECs failure revealed that the lack of technical skills was the cause of failure during the project execution phase. BIM makes it possible for non-technical people to better visualise the final result. However, BIM in its current format can be complicated, challenging, and costly, consequently hindering most contractors from adopting it and reaping benefits associated with BIM adoption. Therefore, an alternative simplified BIM protocol is necessary to extract information contained in BIM for the implementation by ECs. Odubiyi et al., (2019) suggest that proper training should also be provided to users while developers of BIM applications should align and simplify BIM concepts. It is recommended that BIM tools and processes for schedule control and cost management be further explored and promoted among industry practitioners (John, 2018), this will allow small role players in the construction industry to also benefit from BIM. Learning the basics of BIM ECs can unlock the potential to master new ways of working while remaining technologically relevant and sustainable which is considered an essential catalyst for future business growth.

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Progressing Production Performance on Projects through the adoption of Building Information Modelling

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ABSTRACT AND KEYWORDS

Purpose of this paper
In recent years, new technologies and project delivery methods have emerged that promise efficiency, cost savings, and productivity increases to the commercial construction industry. BIM and integrated project delivery (IPD) are technologies and project delivery methods. This study aims to ascertain how the adoption of Building Information Modelling (BIM) has affected construction projects’ production performance (time, cost, quality).

Design/methodology/approach
The study used a literature review and a qualitative research approach that employs personal interviews in collecting primary data to address the research objective.

Findings
The study found that the general adoption of BIM on construction projects was very low in South Africa. This is due to a lack of awareness of BIM and a lack of understanding of BIM by the professionals who know about it. Most of the research samples utilized a BIM platform, but none used a full suite of platforms and could not optimally use the software. It was also found that in some cases, using a BIM platform has negatively impacted project performance.

What is original/value of paper
This study’s findings add considerably to the body of information about BIM in South Africa. The conclusion is crucial for the adoption of BIM in the built environment of South Africa, resulting in increased efficiency, cost savings, and productivity in the commercial construction sector.

Keywords: Building Information Modelling, Costs, Performance, Quality, Skills, Time
1. INTRODUCTION

The concept of Building Information Modelling (BIM) took shape in the late 1970s. Since its development, it has evolved and extended its reach across many different aspects of construction. These aspects include design, estimation, construction process, building life cycle, performance, and technology (Latiffi et al., 2014). Over the last ten years, BIM has slowly integrated into the South African construction industry. According to the National BIM Standard (NBIMS) Project Committee of the BuildingSMARTalliance (2010), BIM is a digital model of a building. It also serves as a shared knowledge resource for information about a project, forming a reliable basis for decisions during construction.

The rate of adoption of BIM varies across countries. The United States is the world leader in BIM use and development (Wong et al., 2009). BIM is used in cost control systems over many projects across the United States of America. Integrating BIM into projects allows the project team to assess cost implications better and avoid cost overruns. BIM incurs costs in training staff and the purchase and installation of the various software used (Bryde et al., 2013). In contrast, India and China are still in the early stages of BIM adoption. It is noted in McGraw Hill (2014) that the scale of construction in India is not wide enough to necessitate BIM in the construction process, while China faces barriers to BIM use, such as a lack of incentives to use BIM and a refusal among contractors to deviate from the traditional methods. The UK is second to the US regarding its current implementation of BIM. However, it has set laws in motion mandating the use of BIM in government projects. Following the UK's example, Australia has also been implementing measures to intensify the use of BIM across the country (Ghaffarianhoseini et al., 2017).

The adoption of BIM in South Africa has been relatively slow over the past decade. This has been attributed to industry professionals' lack of awareness of BIM (Shakantu and Froise, 2014). The lack of awareness has caused the South African construction industry to fall behind other countries. The construction industry has long sought techniques to decrease project costs, increase productivity and quality, and reduce project delivery time. Due to the construction environment being unstable with adverse risk events, the need to evaluate the effects of BIM on the production performance of construction projects has become increasingly important. For example, design and documentation processes were done serially (Architect to Engineer), which has been perceived as time-consuming (Wong and Fan, 2013).

Despite advancements in construction delivery methods/processes, such as BIM, which has been shown to improve the delivery of complex projects, the construction industry in South Africa continues to fail if successfully delivering projects in terms of time, cost, and quality. In contrast to BIM adopted methods, traditional project delivery processes remain fragmented and depend on paper-based communication (Level 0). Each independent project team works separately on the drawings (2D) with only the elements they are responsible for. This leads to project budget and schedule overruns and unsatisfactory quality of assembly. Errors and omissions in paper-based documents often cause unforeseen site costs, delays and inevitable contractual problems between the various parties in the project team. These problems, therefore, cause tension, financial expense and time delays (Olofsson et al., 2008). Therefore, this research examines BIM adoption in the project delivery process and whether it impacts production performance in the South African construction industry.

2. LITERATURE REVIEW

2.1 Overview of the Use of BIM in the Building Production

BIM is both software and process. It uses the data-rich model by making significant workflow changes and project delivery processes (Hardin, 2009). Building Information Modelling supports the concept of integrated project delivery, which is an approach to integrating people, systems, business structures and practices into a collaborative process to reduce waste and ensure efficiency through the project delivery process (Glick and Guggemos, 2009). Various Building Information Modelling (BIM) applications have been identified in literature over the years. Some primary purposes for using a building information model include Visualization: 3D renderings; Code reviews; Fabrication/Shop
drawings; Cost estimating; Construction sequencing/planning; Conflict, interference and clash
detection; Forensic analysis; and Facilities management (Azhar, 2011).

Figure 2.1 shows the process flow for a typical project where BIM is implemented. In this situation, the
project team works together in an environment that is suited to their practice on either a 3D, BIM or
hybrid building model. The contractor or the consultant manages the integration of these various
models, which are independently developed by the different project teams and then merged into a
collaborative model. The collaborative model becomes the basis for all construction activities used by
the team for planning, quantity take-off, coordination, and other functions to meet the project objectives
successfully. This, therefore, results in a reduction in time and cost compared to traditional practices
(Olofsson et al., 2008).

![Figure 2.1: Process flow for BIM project (Source: Olofsson et al., 2008).](image)

For Design and Construction purposes, building information models are commonly understood and
identified in terms of dimensions. The dimension range is from 3D to 7D. The characteristics of each
dimension describe the visual, spatial and operational potential associated with it. Three-dimensional
(3D) uses spatial dimensions of width, length and depth to represent a model that is Design models and
space programming tools. The model enables 3D visualizations, walkthroughs, clash detection and
coordination, and item scheduling. The fourth dimension (4D) can link the individual 3D model parts or
assemblies with the project delivery timeline, including the scheduling of resources and quantities and
modular prefabrication to assist in tracking and project phasing, in addition to collaboration. 4D
visualizations of the model function as communication tools to reveal potential obstructions. Contractors
can, therefore, use BIM onsite for verification, guidance and tracking/planning of construction activities
(Cerovsek, 2011).

The fifth dimension (5D) allows for design integration with estimating, scheduling and costing, including
generating material quantities and applying productivity rates and labour costs. The sixth
dimension (6D) is the information needed to use the model in asset operation, which includes
specification, maintenance schedules and facilities management information, and taking the asset right
through to remodel or disposal. Lastly, the seventh dimension (7D) is a Facility Management
application. The database is extended with detailed information for each embedded element: building
structure, finishes and all equipment. The relevant information is the type of the item, its specification,
the time of the following maintenance or replacement, the warranty period, and the time consumption.
This will allow for efficient building maintenance, and problems will be quickly located and rectified
(Czmoch and Pękala, 2014).

2.2 Production Performance in Construction

The measurement of production performance forms the basis for determining project success. De Wit
(1988) describes production performance measurement as an essential part of project management.
According to Rosenbaum et al. (2013), production performance can be considered process measures
concerning costs, time, productivity, and quality. Performance measurement plays a vital role in
ensuring the project's success and its subsequent usefulness to the sponsoring organization (Pillai et al., 2002). So, the crux of production performance in the construction industry, according to Ahmad et al. (2016), is to "attempt to optimize the design of project and its construction process to achieve reduced lead times, and improved quality and cost by integration of design, fabrication, construction and erection activities and by maximizing concurrency and collaboration in working practices."

According to Omar and Fayek (2016), in modern-day construction environments, construction entities measure their performance against a set of predefined performance measures that are governed by the ability of the organization to maintain necessary sets of competencies that contribute to the successful execution of its construction projects. These performance measurements can simply refer to as 'Key Performance Indicators (KPI). 'Cost' and 'time' are the most frequent performance indicators used in the construction industry.

### 2.3 Benefit of BIM Use in Construction Projects

**Cost and time reduction:** BIM has resulted in contractors saving up to 2% on projects; in most cases, it outweighed the design costs (Barlish and Sullivan, 2012). The return on investment (ROI) from BIM, according to Gudgel (2008), rests at a moderate level or above. Studies conducted by Azhar (2011) not only confirm this but also show that the overall ROI of BIM increases as the level of complexity increases. Yan and Demian (2008) note that BIM's most important/significant benefit was its ability to reduce the project duration. Migilinskas et al. (2013) found that BIM reduced the times' work had to be redone and resulted in reduced costs and project duration.

**Quality improvement:** BIM databases contain a vast amount of data, including U-values, fire ratings, cost data etc. all this data ensures that designs meet all legal and structural safety and cost requirements (Ibrahim and Krawczyk, 2003). Monitoring the process of construction has also been made more accessible and more efficient with BIM (Boukamp and Akinci, 2007).

**Communication coordination and organization improvement:** according to Miettinen and Paavola (2014), BIM encourages and facilitates cooperation and collaboration between the professionals involved in the construction process. BIM allows construction designs to be represented by 3-D models and shared between various software in a company or even across professions. Design changes are easily communicated and managed via the BIM database (Son et al., 2015). BIM facilitates interoperability and the exchange of information (Miettinen and Paavola, 2014) and can coordinate and communicate plans and documents to various role players (Kymnell, 2007). BIM promotes integrated project delivery (IPD), encouraging all parties to view a project holistically and process complex construction information efficiently and coherently for all involved (Rokooei, 2015).

**Risk reduction:** BIM detects particular clashes on projects (Chiu et al., 2011). Most research on BIM does not refer to risk directly; however, by addressing other issues, BIM indirectly reduces risk on a project (Zou et al., 2017). Chiu et al. (2011) used BIM for clash detection during the construction of a steel bridge. This function was then advanced to cover quality control based on predetermined models (Chen and Luo, 2014). Economic benefits: Lee et al. (2012) found that BIM indirectly increases the return on investment by reducing time delays and cost overruns.

### 3. RESEARCH METHODOLOGY

The study adopts a qualitative research approach and a case study design to address the research objective. Arayici et al. (2011) used a case study research design to demonstrate how efficiency gains have been achieved towards a lean architectural practice. The scope of the chosen cases was defined by the definition of BIM and its functions that were stated in the literature review. The selection was based on the project's complexity to ensure that the researchers obtained relevant data from the chosen case studies. BIM must be included in the construction and development process. However, of the projects identified from the interviewing process, only one of the projects met our criteria and adopted BIM in the construction process to an extent to which impacts could be measured. This is not to say that this particular project was unique; instead, if more interviews were conducted, it would most likely result in more projects of similar nature.
3.1 Methods of Data Collection

Interviews with the users of the BIM tools under consideration were conducted to gain understanding and knowledge about their usage. Each company representative (interviewee) chosen for this study was interviewed separately. This was done because part of the study was intended to find out the level of BIM adoption undertaken by each company on specific projects that they were/are involved in; therefore, this could not be done in group sessions with members of other construction firms. One-on-one interviews would enable the researchers to extract particular views and experiences from the interviewees that they wouldn't have shared in a group interview with other professionals. To ensure privacy during the interview, the researchers proposed to meet the interviewee in a private room onsite/in the office or at an agreed upon location after work hours.

The interviewee from each company was carefully chosen to ensure that a certain level of detail and the required amount of information was obtained from the interview. The interviewees were selected based on their level of experience, level of authority, and their experience with and knowledge of BIM. It was preferred that the chosen individuals should have direct project involvement throughout the construction delivery process. After the interviewees were identified, they were invited to participate in the research. However, of the ten companies invited to participate, only three responded positively.

3.2 Data Analysis Techniques

The study used qualitative data analysis techniques to analyze the data collected. There are no obvious or defined qualitative analysis methods (Denzin & Lincoln, 2011); however, Lacey and Luff (2001) outlined two approaches, grounded theory and framework analysis. Grounded Theory is a method by which a theory is allowed to take form through the critical analysis of data (Strauss & Corbin, 1998). This method is suited for research that seeks to find or formulate an idea based on a comprehensive data set and then validate the idea through repeated and increasingly more specific data analysis. This research collected a limited data set; in this case, a repetitive analysis technique is far too time-consuming. Framework analysis is a more recent and popular method of qualitative analysis (Spencer and Ritchie, 2002). Framework shares most of the characteristics of thematic analysis in that data is collected, categorized and interpreted (Lacey and Luff, 2001). This method analyses the data collected in this study, drawing themes in line with the research objectives.

3.3 Ethics

Ethical clearance was granted before any data collection began. All participants were free to participate and withdraw or refuse to comment at any point during the interview. As an added privacy measure, all participants were anonymized using a coded index ranging from P1 to P3; however, their titles and a brief description of their jobs have been given to add validity to their statements. This information will not be substantial enough to identify the participants.

3.4 Limitation of the Study

Interviews were the primary source of data in this paper. Interviews allow a certain degree of freedom to interviewees allowing them to structure their answer and justify it in their own words. The drawback is the time lost in arranging, preparing for, and conducting the interviews. Transcription and organization further increase the time required for the interview process. This leads to unreliable information as it is difficult to claim that the data reflect the entire industry. For this reason, fewer interviews were conducted.

4. DATA PRESENTATION, ANALYSIS AND DISCUSSION

The participants in the interviews are construction professionals. The questions addressed key aspects such as BIM adoption on projects, BIM applications, and the impact of BIM on production performance.
Table 1. Interviewee profiles

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Role in the project</th>
<th>Nature of Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respondent 1</td>
<td>Quantity Surveyor</td>
<td>Responsible for generating BoQs for construction projects from BIM software.</td>
</tr>
<tr>
<td>Respondent 2</td>
<td>Project Coordinator</td>
<td>In charge of quality information and time management. Responsible for monitoring projects and reporting on their performance.</td>
</tr>
<tr>
<td>Respondent 3</td>
<td>Quantity Surveyor</td>
<td>Responsibilities include project supervision onsite and offsite.</td>
</tr>
</tbody>
</table>

4.1 Usage of BIM by the Organization

For Respondent 1, there is a greater capacity for BIM utilization from the stakeholders involved in a particular project because it has already been applied in several projects, especially complex ones. Although it is not used further than the project documentation stage, the usage qualifies to be an expressively used platform in the organization. The second respondent suggested that the use of BIM, as was defined, is not significantly used in the organization and that specialized software was used in the organization to service construction projects. Respondent 3’s organization uses software compatible with BIM; however not considered a BIM application by the organization.

4.2 Level of Adoption of BIM on the construction Projects

It emerged that Respondents 1 and 3 clearly understood the scope of BIM and could list the number of projects that utilized BIM. Whereas respondent 2 gave a general system response as opposed to BIMspecific adoption. According to Respondent 1, he has been involved in “only three projects” that adopted BIM, while Respondent 3 stated that he has been involved in “…about five projects.” Respondent 3 described quantity surveying software that is compatible with BIM products that were used on these projects. Five projects in five years show that the level of BIM use in the company is still low and has not yet been adopted to a large scale. Respondent 2 noted that their company had been integrating various software into their projects over time. According to Respondent 2, “I won’t talk about one specific project, simply because when a new system is adopted, we adopt it on all of our projects all at once.”

4.3 Common BIM Software used in Projects

The interviewees noted two main BIM platforms used, which were aimed at playing a particular role in delivering their respective projects. However, Respondents 2 and 3 generally use quantity surveying software that doesn’t fall under any of the common BIM platforms. According to Respondent 1, “We’ve used Revit, we’ve used some AutoDesk applications, we had Navisworks as a trial run, and then our main one is BIM 360 Docs.” Of the three software packages used by this organization, BIM 360 Docs is the principal BIM software used. Meanwhile, Respondent 2 identified “…AutoCAD, Revit, Indesign, SnagR SketchUp, Candy, WinQS” as the applications used on their projects. Respondent 3 stated that his team utilizes Cost X, Dim X and Candy……externally all role-players use Dropbox for collaboration. Two of the software used by Respondent 3’s organization on construction projects are BIM compatible, but they have not utilized them to their full potential. However, they also use a data-sharing environment (dropbox) on every project; even though it is not necessarily part of a specific BIM platform, it helps with collaboration and communication of project information.

4.4 The Production Performance of BIM-adopted Construction Projects

The respondents were asked about the extent to which their projects performed, from a time, cost and quality perspective, to assess the production performance of BIM-adopted construction projects. The projects used in responding to the interview questions on performance comprise a 6-storey high-end luxury apartment block on top of an existing parking garage, high-end luxury residential projects and a four-floor apartment building with 90 apartments 30 duplex units and 60 one-and two-bedroom units. Respondent 1’s company is the only one which fully utilizes BIM in all phases of its projects. In contrast, respondents 2 and 3’s companies use software compatible with BIM but do not utilize BIM in the construction phase.
Respondent 1 reported that although the construction is not done yet, the estimates done after BIM was more detailed because more details the design team pushed out more information as they updated the drawings. The 3D visualization is available for everyone to see, "so we were able to provide costing at a higher level, we picked up more stuff that was missed." Respondents 2 and 3 offered information on the project cost, time, and quality performance on which they reported. They noted that the projects were over-budget for several factors that were not considered before construction and others revolving around the competency of resources. In terms of time, while Respondent 2 noted that all their projects are overscheduled and "Project A" finished two months overdue (and technically is still not finished six months on – the building is completed, but contractually there are hang-ups, Respondent 3 states that the projects are within schedule with some of the apartments already handed over this month. Regarding project quality, Respondent 2 notes that "Project A had at least four reworks. Most of which involves the building services, usually where design clashes have occurred." Respondent 3 stated that "many things regarding the design kept constantly changing, which resulted in several reworks." These responses show that BIM did not reduce the number of reworks done on the respective projects. In defence of BIM, Respondent 2 noted that the reworks were in all areas except structural and that the structural aspect of the building was designed using 3-D modelling software. Respondent 3, who only used measurement software, was affected by design changes causing reworks.

5 DISCUSSION OF FINDINGS

It can be inferred from the respondents' responses that BIM is not yet widely adopted in the South African construction industry. BIM models were acquired through third-party architects/designers or an integrated approach with the entire project team. The highest level of development (L.O.D) adopted by the companies on construction projects was found to be Construction Documentation. This means that the adoption of BIM during the fabrication and operation level has not been implemented on projects as extensively as intended by the various BIM platforms. This is aligned with the finding of previous studies by Kekana et al. (2015) that South Africa is still not taking its stake in being one of the leading users of SMART technologies.

It also emerged from the study that there were contradictory findings in terms of time performance; At the same time, one respondent with an ongoing project was overscheduled, and the other result showed that the projects were on time. This made it difficult to reach a definite conclusion regarding time performance-wise because of the lack of trends in the data obtained. However, various authors, including Migilinskas et al. (2013) and Yan and Demian (2008), have alluded to the time savings and improved efficiency of BIM.

6 CONCLUSIONS

The study sought to ascertain how the adoption of Building Information Modelling (BIM) has affected construction projects' production performance (time, cost, quality). The study found that several BIM functions were used on the projects identified; however, these functions were not fully utilized and therefore, it wasn't easy to conclude that BIM impacted the projects' production performance. However, the one project that adopted higher levels of BIM function experienced a positive impact because of the platforms they used. Based on these findings, the study recommends developing national BIM standards for use in the South African construction industry. It also advocates that all Construction related degrees/diplomas offer a BIM course as a minimum standard for qualification so that young professionals entering the industry after graduation can be familiar with the application of BIM on projects to improve the production performance of construction projects. It is also recommended that further research be undertaken using a larger sample size to enhance the generalizability of the results and provide more robust conclusions.

7 ACKNOWLEDGEMENTS

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A bibliometric review on application of digital technologies in green building

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ABSTRACT AND KEYWORDS

Purpose – Green buildings (GB) has been identified as a feasible solution to the ecological problems emanating from the construction industry. At the same time, using advanced digital technologies such as artificial intelligence, the internet of things, blockchain, 4D printing, and whatnot in GB is an excellent approach to boost the sector's efficiency, resilience, and sustainability. While extant studies have considered applying one or more of these digital technologies, a complete examination of their integrated applications in the GB spectrum is still sparse. To this end, this study seeks to fill this gap.

Design/methodology/approach – To attain the study's objectives, a data-mining technique in the form of bibliometric analysis of research articles within the context of green buildings and relevant digital technologies was conducted using the Web of Science core collection as a database. Retrieved articles were screened for eligibility while the relevant studies were synthesized using the VOSviewer bibliometric analysis tool.

Findings – The application of digital technologies came into its inception about three decades after the green building evolution. Most of these technologies were mainly deployed in developed economies and top-tier academic institutions, primarily from Asia, North America, and Europe. Synthesis of keywords and critical analysis of retrieved articles revealed that BIM had been the dominant digital technology incorporated into green building development. Most of these digital technologies focus more on green building projects' design and construction phase. Moreover, their concentration is veering towards energy efficiency and environmental aspects of sustainability.

Original/Value – This paper contributes to the knowledge corpus on the nexus between green buildings and cutting-edge digital technologies of the present era, while grey areas where some of the technologies are still nascent were pinpointed. It encourages researchers and stakeholders, particularly in developing climes like sub-Saharan Africa, to fully explore these auspicious technologies to promote a resilient and viable built environment.

Keywords: Sustainable building; Digital technologies, Building information modelling, Artificial intelligence, Review
1. INTRODUCTION

The built environment is regarded as an energy-intensive, resource-consuming and carbon-emitting sector as it accounts for 40% and 30% of the world’s final energy outlay and CO₂ emissions, respectively; leading to resource depletion, climate change and allied adverse effects on humans and ecosystem (Aghimien et al., 2021; Geng et al., 2019). These worries have spurred researchers and stakeholders to develop and implement strategies to assuage the construction sector’s anthropogenic impacts, protect biodiversity, heighen efficiency and sustainability, and so on (Wuni et al., 2019). Promisingly, green building (GB) evolution and movement offer concrete solutions to these worries and provide a positive approach toward an eco-friendly world and realising sustainable development goals. The Singapore Green Building Council (SGBC) described GB as one that is resource-efficient and ecologically conscious from planning to design through construction, operation, upkeep, refurbishment, and demolition (SGBC, 2015). On the whole, GB seeks to address the interplay between humans, architecture, and nature, focusing on improved energy efficiency, reduced carbon emissions and ecological hazards (Li et al., 2020).

Thanks to its potential benefits, GB has been accorded intense accentuation via enacted standards, development projects alongside research publications across diverse topics such as drivers, barriers, benefits, critical success factors, rating systems, and potential delivery attributes, and such like in previous decades (Darko et al., 2018; Seyis and Ergen, 2017; Shen et al., 2017). For instance, Olubunmi et al. (2016) provided a systematic study on GB incentives and affirmed the need for governments to revamp their GB incentive strategies. Lu et al. (2020) gave an overview of GB projects' carbon emissions via data mining. With respect to energy efficiency, Chan (2022) utilized the weather data from different latitudinal regions to explore how photovoltaic panels perform under neighbouring shading effects. Additionally, Yadegaridehkordi et al. (2020) evaluated the GB sustainability indicators in Malaysia via a multi-criteria decision-making approach. In a broader sense, Wuni et al. (2019), Li et al. (2021), Wu et al. (2021), to name a few, presented all-inclusive reviews on state-of-the-art research on GB from a global viewpoint via qualitative or quantitative methods.

In the meantime, the construction engineering and management (CEM) field is fruitfully impacted by the continuous progress in the digital revolution to address complex issues. Actually, several scholars have recommended that digital technologies (DT) such as building information modelling (BIM), artificial intelligence (AI), internet of things (IoT), blockchain technology, 3D printing, 4D printing, and whatnot, should be applied within the genre of CEM research (Darko and Chan, 2016; Li et al., 2020; Mushi et al., 2022). Consequently, some researchers have adopted such digital technologies as BIM and AI (Collinge et al., 2022; Maureira et al., 2021; Pan and Zhang, 2021) in their studies. Of late, some review studies have been conducted to identify these cutting-edge digital technologies in the CEM field because of their benefits. Abioye et al. (2021) reviewed the techniques, opportunities and challenges of applying AI to CEM. Scott et al. (2021) employed a mixed-methods strategy to give an insightful overview of applied blockchain to specific subject areas of the AEC. The study of Tushar et al. (2018b) presented an IoT-based processing techniques applied to GB subsystems. Lu et al. (2017) discussed applied BIM in GB development concerning building lifecycle, analyses and assessment, while Debrah et al. (2022) recently provided an in-depth literature survey on applications of AI specifically for GB.

While there is a growing body of excellent scholarly work on the subject matter, some limitations are still apparent. It was discovered that most of these previous studies concentrated on applying these digital technologies to the broad field of AEC/CEM with little focus on specifics such as GB. Also, holistic reviews considering the integrated application of these state-of-the-art DTs in GB are lacking. Thus, the core objective of this study is to closely examine the current applications of digital technologies in GB development through bibliometric literature analysis. By the way, an in-depth investigation considering applied AI and ICT in GB is essential to enable the research community, policymakers and allied stakeholders in the built environment.

2. METHODOLOGY

2.1 Data Sources

This literature overview delineates the scope of application of present-day cutting-edge digital technologies in GB development. The study chose the Web of Science (WoS) core collection as the preferred source of data due to its high-quality data structure and has been reckoned to have the most informative, relevant and influential journals [25] compared with Scopus, which is argued to have
overlapped data sometimes. Besides, extant reviews within the confines of CEM research have utilized WoS for scientometric visualization and bibliometric analysis (Li et al., 2020; Li et al., 2021; Wu et al., 2021).

2.2 Data Retrieval and Article Selection Strategy

The bibliometric search was initiated by entering keywords relevant to the study’s scope in WoS. The study employed the combination of related keywords within the context of GB and DT using Boolean operators "OR" and "AND" together with fuzzy search, which is denoted by an asterisk (*), and this provided an initial result of 372 bibliographic data. Meanwhile, for article selection, the results from the search inquiry were refined to focus only on relevant quantitative and empirical research articles between 2007 and 2022, written in English and published in peer-reviewed journals having undergone thorough investigation with verifiable results. It is noteworthy that it is impractical to explore and exhaust the entire search queries within a research field of study, which forms part of this paper’s limitation. Table 1 summarises the search strategy and results after the exclusion criteria.

2.3 Tool for Research Method

This study selected version 1.6.18 of VOSviewer as the preferred software (van Eck and Waltman, 2010). The rationale for selecting this tool is based on its open-source attribute, capacity to present bibliometric network visualization, unravelling and analysing research development trends within an academic setting (Wang et al., 2021). In addition, this study considered VOSviewer as an adequate tool because it has been utilized in different CEM topics (Wuni et al., 2019).

3. ANALYSIS AND FINDINGS

3.1 Yearly Publication Trend

Figure 1 presents the annual publishing and citation pattern of articles that considered DT applied in GB, which emerged in the earlier millennia. Vakili-Ardebili and Boussabaine (2007) provided the foremost study on the subject matter as their research provided a fuzzy logic modelling and representation methodology for eco-building design indicators. This indicates that the notion behind incorporating digital technologies in GB surfaced about 30 years after the GB concept transpired (Wuni et al., 2019).

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Search Keywords</th>
<th>Query link</th>
<th>Results</th>
</tr>
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<tr>
<td>WoS</td>
<td>(&quot;green build*&quot; OR &quot;sustainable build*&quot; OR &quot;sustainable construct*&quot; OR &quot;sustainable hou*&quot; OR &quot;green home*&quot; OR &quot;green construct*&quot; OR &quot;sustainable home*&quot; OR &quot;high-performance build*&quot; OR &quot;eco-friendly build*&quot; OR &quot;eco-friendly home&quot;) AND (&quot;artificial intelligence&quot; OR &quot;AI&quot; OR &quot;machine learning&quot; OR &quot;deep learning&quot; OR &quot;fuzzy logic&quot; OR &quot;neural network&quot; OR &quot;3D printing&quot; OR &quot;4D printing&quot; OR &quot;building information modeling&quot; OR &quot;BIM&quot; OR &quot;robotics&quot; OR &quot;digital twin&quot; OR &quot;augmented reality&quot; OR &quot;virtual reality&quot; OR &quot;internet of things&quot; OR &quot;IoT&quot; OR &quot;blockchain&quot; OR &quot;data mining&quot; OR &quot;cognitive computing&quot; OR &quot;K-Means&quot; OR &quot;human-machine interface&quot;) AND (&quot;application*&quot; OR &quot;applied&quot; OR &quot;use&quot;)</td>
<td>WoSQueryLink</td>
<td>334</td>
</tr>
</tbody>
</table>

Table 1: Search query and results retrieved for the study
Albeit, the application of DT in GB went unsung for nearly a decade as only three publications were made between 2007 and 2011, revealing its slow adoption. In 2012, research on application of DT in GB gained resurgence and witnessed a varying steady growth annually although some declines were evident in 2016 and 2018. Promisingly, the last four years have experienced exponential research, with 2021 recording the highest number of publications (89) and citations (1559). This can be attributed to more emphasis on incorporating DT in this industrial revolution era, particularly in the AEC sector. From Figure 1, it is envisaged that this trend will skyrocket in the upcoming years (Abioye et al., 2021).

3.2 Keyword co-occurrence analysis

Keywords, vital and informative terms in co-word analysis, are essential in spotting and comprehending research ideas and contents. Figure 2 depicts the keyword co-occurrence network, of which 55 out of 1857 keywords met the threshold, indicating the research frontiers and development regarding the theme of this study. The co-occurrence, fractional counting, and all keywords were selected options for the analysis type, counting method and analysis unit, respectively, from VOSviewer, which conforms to the standard proffered by van Eck and Waltman (2010). From the analysis, it can be vividly observed that there is a strong nexus between green building and BIM, thus showing the vital application of BIM throughout the entire lifecycle phase of GB or sustainable construction. In the meantime, new techniques such as machine learning, additive manufacturing, and blockchain are just emerging in GB projects, and this can be seen as room for further research.
3.3 Journal Citation Analysis

To determine the highly cited journals, a journal citation network was created on VOSviewer which yielded an analytical of 13 journals from 5 clusters and an overall link strength of 115. Consequently, Table 2 illustrates the descending order of top-tier research outlets (sources) that considered the application of advanced DT in GB. These journals have cite scores ranging between 3.7 (Applied Sciences) and 20.4 (Applied Energy). Overall, ‘Automation in Construction’ leads the poll with 11 articles and 841 citations. This implies that most scholars deemed it fit to publish their work in a journal that focuses on applied research of DT in GB.

Figure 2: Keyword co-occurrence network
Table 2: Analysis of major research outlets on the application of advanced DT in GB

<table>
<thead>
<tr>
<th>S/N</th>
<th>Source (Journal name)</th>
<th>No of Documents</th>
<th>No of Citations</th>
<th>Impact Factor</th>
<th>Cite Score (2021)</th>
<th>Best Quartile</th>
<th>Total link strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Automation in Construction Sustainability</td>
<td>11</td>
<td>841</td>
<td>10.517</td>
<td>15</td>
<td>Q1</td>
<td>55</td>
</tr>
<tr>
<td>2</td>
<td>Sustainable Cities and Society</td>
<td>37</td>
<td>431</td>
<td>3.889</td>
<td>5.0</td>
<td>Q2</td>
<td>38</td>
</tr>
<tr>
<td>3</td>
<td>Journal of Building Engineering Energy and Buildings Buildings</td>
<td>9</td>
<td>301</td>
<td>10.696</td>
<td>14.4</td>
<td>Q1</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>Journal of Building Engineering</td>
<td>14</td>
<td>205</td>
<td>7.144</td>
<td>6.4</td>
<td>Q1</td>
<td>33</td>
</tr>
<tr>
<td>5</td>
<td>Energy and Buildings Buildings</td>
<td>16</td>
<td>726</td>
<td>7.201</td>
<td>11.5</td>
<td>Q1</td>
<td>44</td>
</tr>
<tr>
<td>6</td>
<td>Building and Environment</td>
<td>9</td>
<td>40</td>
<td>3.324</td>
<td>3.8</td>
<td>Q2</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>Applied Sciences Energy</td>
<td>8</td>
<td>155</td>
<td>7.093</td>
<td>10.7</td>
<td>Q1</td>
<td>11</td>
</tr>
<tr>
<td>8</td>
<td>Applied Energy</td>
<td>6</td>
<td>33</td>
<td>2.838</td>
<td>3.7</td>
<td>Q2</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>Journal of Cleaner Production Energies</td>
<td>6</td>
<td>172</td>
<td>11.446</td>
<td>20.4</td>
<td>Q1</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Journal of Cleaner Production</td>
<td>13</td>
<td>283</td>
<td>11.072</td>
<td>15.8</td>
<td>Q1</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>Materials</td>
<td>8</td>
<td>42</td>
<td>3.252</td>
<td>5.0</td>
<td>Q2</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>Construction and Building Materials</td>
<td>6</td>
<td>82</td>
<td>3.748</td>
<td>N/A</td>
<td>Q2</td>
<td>1</td>
</tr>
</tbody>
</table>

3.4 Analysis of scientific contribution: top institutions and countries

Institutional and regional participation in research is crucial as it helps unveil novel trends in a particular field of study. Also, it facilitates information flow and knowledge transfer, particularly from regions ahead of the curve in such research. Table 3 illustrates the top 10 institutions that apply DTs to the ongoing development of GB projects. As shown below, 6 (at 60%) of the represented institutions hailed from Asia, followed by 2 (at 20%) universities in Australia, while Europe and South America have one university apiece. Obviously, the dominance of Asian campuses could be attributed to the great premium placed on applied research regarding the automation of these technologies in GB development. Likewise, Australian universities were able to have produced notable research output on the subject matter in this study as they are said to witness rapid urban sprawl and infrastructural development. However, it is quite uncheering that Africa is not represented in this global wave of incorporating digital technologies into GB’s development.
Table 3: Analysis of top-10 institutional contributions on the application of advanced DT in GB

<table>
<thead>
<tr>
<th>S/N</th>
<th>Name of Institution</th>
<th>No of Citations</th>
<th>Average Citation</th>
<th>Total link strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Hong Kong Polytechnic University</td>
<td>1068</td>
<td>37</td>
<td>204</td>
</tr>
<tr>
<td>2</td>
<td>City University of Hong Kong</td>
<td>362</td>
<td>24</td>
<td>111</td>
</tr>
<tr>
<td>3</td>
<td>Hunan University</td>
<td>220</td>
<td>28</td>
<td>89</td>
</tr>
<tr>
<td>4</td>
<td>Universidade Federal Rio de Janeiro</td>
<td>270</td>
<td>25</td>
<td>57</td>
</tr>
<tr>
<td>5</td>
<td>Tongji University</td>
<td>243</td>
<td>41</td>
<td>54</td>
</tr>
<tr>
<td>6</td>
<td>National University of Singapore</td>
<td>239</td>
<td>34</td>
<td>44</td>
</tr>
<tr>
<td>7</td>
<td>University of Lisbon</td>
<td>338</td>
<td>56</td>
<td>44</td>
</tr>
<tr>
<td>8</td>
<td>Western Sydney University</td>
<td>95</td>
<td>16</td>
<td>43</td>
</tr>
<tr>
<td>9</td>
<td>University of New South Wales</td>
<td>177</td>
<td>13</td>
<td>35</td>
</tr>
<tr>
<td>10</td>
<td>Shanghai Jiao Tong University</td>
<td>239</td>
<td>30</td>
<td>22</td>
</tr>
</tbody>
</table>

4 Discussions

Since incorporating advanced digital technologies in GB is budding, some salient themes and thematic study areas are gaining momentum. The analysis of the selected studies unveiled the prominent and emerging applications of these technologies at various phases of GB development alongside those dealing with the resource efficiency of GB. Moreover, these technologies have been applied to the threefold aspects of sustainability (environmental, economic, and social) and were also briefly examined. Table 4 demystifies the succinct overview of these applications while a brief discussion on them is highlighted as follows:

4.1 Applications of DT in GB Lifecycle

Incorporating GB measures in every phase of construction projects is crucial in actualizing the ambitious goal of sustainability in the AEC industry. By extension, the integration of DT within each phase of GB development offers more strategic possibilities in this current Industry 4.0 era. In the strictest sense, implementing these DTs, chiefly at the project initiation/design stage, can be an ideal path to tackling likely construction-related issues and positively shape the rest of the entire building lifecycle. For instance, the potential inherent in machine learning in predicting future outcomes grants promising roles, especially for new GB projects.

An artificial neural network (ANN) was recently deployed as the chief ML algorithm to forecast the performance strength of innovative GB materials like hydrated-lime-activated rice husk ash (Onyelowe et al., 2021). Similarly, blockchain technology can be handy in the early preparation of ledger accounts as touching the construction of GB projects. Moreover, the fast-paced adoption of AI techniques could be beneficial for proper real-time data storage, monitoring and retrieval during the construction phase of GB. Moreover, sustainable material selection and new building components/elements are being developed via the BIM approach (Jayasinghe and Waldmann, 2020). A critical consideration of the result analysis revealed that these DTs had been mainly focused on the design and construction phases. However, aspects of operational phases are somewhat few, while those relating to GB retrofits and demolition and deconstruction cases have not been fully explored, thus calling for consideration.

4.2 Applications of DT in GB Resource Efficiency

Since the construction industry is regarded as a resource-consuming sector, the holistic utilization of the all-available GB-related resources alongside these cutting-edge DT in an efficient manner is very germane. It forms one of the critical goals of GB implementation. As shown in Table 4, an analysis of studies indicated that most of these DT are mainly deployed on achieving energy efficiency, and indeed, this could be so with the entire building lifecycle being energy dependent. In fact, embracing the AI
approach could optimise the conversion and management of energy used in existing GB. For example, Shahsavar et al. (2021) coupled AI techniques with Petri net modelling to develop a framework that generates biogas energy for GB. Likewise, this promising technology could help in material recycling and waste management as established in the study (Duan et al., 2021). This same scenario is typical for IoT technology as its application functions maximally in energy management, thus boosting interoperability among GB occupants. Recently, the green IoT (G-IoT) has been proposed as a novel technology to curb ecological hitches of buildings while acting as an enabler for green homes and smart cities (Yang et al., 2021). The vast application of BIM could be seen in its water-saving potential in GB retrofits. This is becoming more relevant as Liu, Zhang, et al. (2019) proposed a decision-making framework for water efficiency for the design and construction GBs. Within resource efficiency, ML often act as a data-driven optimization tool chiefly for conserving GB materials such as recycled concrete. From the discourse above, it is evident that these technologies are significant playmakers in enhancing resource efficiency, particularly in this period of complex modern GBs. Albeit, existing studies have not fully delved into how such technologies as blockchain, robotics, and augmented/virtual reality could be integrated within the context of resource efficiency optimization. Besides, another important query lies on how one or more of these DTs can be combined as their features and benefits differ from each other. Future studies can take this into account.

Table 4: Application of digital technologies in green building development in selected studies

<table>
<thead>
<tr>
<th>Subsets of DT</th>
<th>Phases of GB lifecycle</th>
<th>Resource Efficiency</th>
<th>Sustainability</th>
<th>Refs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GBD</td>
<td>GC</td>
<td>GBM</td>
<td>POE</td>
</tr>
<tr>
<td>AI</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>ML</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>IoT</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>BIM</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>RBT</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
4.3 Applications of DT in GB Sustainability

In general, the present-day GB implementation is meant to consider the three spheres of human development—social, environmental, and economical. On these wise these tools must consider these threefold sustainability aspects. ML models were applied by Pomponi et al. (2021) to evaluate the whole lifecycle of embodied energy in buildings. It can be seen that the dataset from such models can provide ampler decision support while ascertaining more confidence levels than traditional optimization techniques. Similarly, BIM has been proposed in some studies to consider these three elements of sustainability as illustrated by Filho et al. (2022) who integrated a BIM-based model with conducting sustainability evaluation of low-income GB and their accompanying materials.

In some cases, BIM is usually coupled with ML and Blockchain technology to produce more robust output in overall sustainability criteria (Liu, Jiang, et al., 2019). Most studies have considered environmental sustainability since the global focus is on carbon neutrality. Nonetheless, more searchlight should be given to social and economic aspects of sustainability. Also, most studies have not wholly earmarked the challenges that often confront using these tools. Although these tools have myriads of benefits, each of them has its own limitations. Thus, it is necessary to spot these issues when considering the wholesome aspect of sustainability.

5. Conclusion and Further Research

This study first gave an introductory background and overview of GB research alongside the necessity of advanced digital technologies in green building development. A bibliometric analysis was presented through different metrics, as highlighted in the previous section. From the analysis, it was discovered that most of these tools are still at their nascent stage of development, although BIM and AI are currently gaining ground in GB research. Notwithstanding, other technologies can be explored as well. Furthermore, developing economies and institutions, mainly from Africa, must implement these tools in their construction sector toward a sustainable and resilient built environment. Moreover, these applications can be incorporated into the course curricula of African institutions to have a good grasp and carry out applied research on DT in GB. Limitations of this study are evident in the following: (i) only one database was used to source relevant articles; (2) not all search queries within the subject matter’s spectrum were explored. (3) potential challenges and solutions to applying DTs in GB were not provided. Future research can investigate these areas and much more.

6. References


Adoption of Building Information Modelling (BIM) by Small and Medium UK Construction Enterprises (SMEs)

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ABSTRACT & KEYWORDS

Purpose of this paper
There is no unanimous agreement on a sole gain for adopting and implementing BIM (Building Information Modelling) will provide SMEs, which employed less than 250 people and perceptions of rewards have been seen to be impacted by the context of the individual. However, a general benefit can be inherent in its adoption except that all are focused predominantly on larger firms working on larger projects. There is less research conducted to establish a body of knowledge which allows SMEs to decide with greater certainty whether the adoption of BIM is suitable for their organisation due to the lack of current clarity on the issue.

Design/methodology/approach
This research investigates how BIM can be adopted by small and medium UK construction enterprise. It adopts an online-based questionnaire with both closed and open questions completed to fulfil the research objectives. The sample consists of 52 participants, working for SMEs within the construction industry.

Findings
The research demonstrates that occupation, experience, sector type, typical project size and organisation type all influenced perceptions of BIM, however these distinctions cause minor variances and the highest-ranked gain/benefit remain consistent throughout. The perceive challenges for BIM adoption for SMEs include Lack of awareness, cultural resistance to change, the initial need for upskilling, training and recruitment, lack of organisational structure to support BIM, interoperability issues and concerns relating to return on investment.

What is original/value of paper
The research concludes that BIM would improve most SMEs and it should be implemented in the long-term. However, in the current environment it has not achieve its potential benefits except where multiple stakeholders are willing and able to use the technology, it is evident the construction industry has not matured to this stage, particularly for SMEs.

Keyword: Building Information, Small and Medium Enterprise, Construction Industry.
1.0 INTRODUCTION.

Building Information Modelling (BIM) has not been universally adopted, though adoption is increasing (Mondrup et al, 2012). Eadie et al (2015) surveyed those at the leading edge of BIM adoption within the UK and found that 91.3% of those companies are using BIM, with only 8.7% adopting BIM on all their projects, demonstrating that even the leaders within the industry are not solely focused on BIM. Large organisations and SMEs have an ever-growing divide in BIM capabilities moving towards a situation where many smaller organisations are at serious threat of being left behind; ultimately this would lead to greater inefficiencies within the market as opposed to easing them (Construction Excellence, 2015; He et al, 2016). BIM is a vast technology and subject by nature which can be defined in a multitude of different ways due to its multi-faceted capabilities. According to Miettinen and Paavola (2014), BIM is a set of technologies and solutions aiming to enhance inter-organisational collaboration in the construction industry, to improve design, construction and maintenance practices. Forgues et al (2015) compliment that in their definition, labelling BIM as a form of disruptive innovation with the capability to mitigate a plethora of the negative factors which commonly adversely affect construction performance. It is deemed as an evolving multi-faceted phenomenon with an object-orientated 3D model of a structure to enable interoperability and information exchange (Miettinen & Paavola, 2014).

Research is relatively at an early stage when focusing on BIM adoption rates. Bernstein et al (2012) for example, found that global trends indicate that implementation levels are rising along with ever-increasing adoption rates, and a decreasing gap between the adoption percentages of multiple countries, concluding that BIM will be comprehensively used in diverse countries and utilisation ratio will continue to increase. This contradicts Alaka et al. (2019) position, stating that BIM adoption rates are very low which is compounded by a large gap between early adopters, late adopters and very late adopters. It is not a matter of developed countries demonstrating true BIM maturity while less developed economies and industries lag in delivering BIM. The issue is more complex than demonstrated by the United Kingdom (UK). UK figures show the highest disparity among all EU countries between knowledge of BIM and its actual implementation with figures reported at 94% awareness contrasted against a relatively meagre 39% implementation (NBS, 2014). Awareness of BIM does not seem to be the issue when understanding BIM adoption and implementation as figures from Europe demonstrate that 63% of EU respondents when questioned about their awareness and opinion of low BIM adoption stated that they believe this would have an impact on the EU economy; while 88% of them stated that standardisation would help smooth the gap (Alaka et al, 2019).

A Small and Medium Enterprise (SME) is characterised by its number of employees, enterprise turnover, asset size and capital requirement (Hsu & Cheng, 2011) and as those employing less than 10 (micro), 50 (small) and 250 (medium) people respectively (EC, 2003). Among this characterisation, NFB (2014) research among 135 companies reveals that 73% of SMEs never used BIM as opposed to 21% of larger organisations within the construction industry either for any of these function/tools, “3D drawings, clash detection tools, schedule integration tools or other BIM features.” These figures align and confirm the “BIM-Divide” situation which is not only present but continues to be amplified as time goes on. Hence, the research aims to establish a body of work which allows SMEs to decide with greater certainty whether BIM is suitable for their organisation due to the current lack of clarity on the conundrum.

2.0 LITERATURE REVIEW

2.1 Perception of BIM Adoption in Construction Industry

The conception and advancement of BIM is a by-product of the almost universal acknowledgement of the issues outlined by both Latham and Egan’s reports. Latham (1994) highlighted the disproportionate inefficiencies the construction industry suffers when juxtaposed against other industries of similar stature and communicated a need for a change in industry practices to increase efficiency and replace the bureaucratic, wasteful, adversarial atmosphere prevalent in most construction projects. These recommendations are similar to those promoted within the Egan report where partnering and collaborative working within the supply chain is an improvement in management and supervisory skills which were cited as being key to greater efficiencies (Egan, 1998). However, as
BIM and the industry are complex, its different functions have been utilised to varying degrees of success by differing parties (Forgues et al, 2015).

Clayton et al (2012) argue that BIM is used as a compendium of architectural theory which facilitates designers to act as architects as opposed to BIM being an individual and separate supplementary skill. Hardin (2009) views BIM outside the confines of enhancing the drawing process and advocates using BIM to bind the 3D geometry with time and resources to produce information which produces programmes which can easily identify clashes and forecasted timelines before the traditional approach of resolving such issues in real-time. Sheward (2012) notes that a traditional design approach is often constrained by the design team working on a project whereas contemporary BIM is a platform which enables the rationalisation and formalisation of design heuristics; consequently knowledge-based assistance is embedded throughout the design process.

Moving away from the traditional approach Opitz (2014) perceive BIM as an efficient document management system, as opposed to a system primarily utilised for design. Amin and Motamedi (2009) aligned with Hardin’s findings and detailed that standardised documentation of employer’s information requirements, execution plans and standards and protocols facilitate project teams being able to coordinate and share documentation more consistently than traditional processes. BIM should primarily be utilised to mitigate cultural constrictions associated to trust within construction and implore users to use a shared platform of transparent information to enhance collaboration between the traditionally adversarial parties involved in the construction process (Smith and Tardif, 2009). BIM is used as a vehicle to strive for uncompromisingly strong integrated practice (Broshar et al., 2006) to form an environment where communications are clear throughout the construction process. In the UK, the proliferation of BIM and possible demise of traditional quantification, with the concurrent rise of smart cities with exploitation of other innovative technology indicate that professional members practicing in the industry will need to reflect on developing products and services that can promote construction quality and productivity as well as their own professional development Seidu et al., (2020). According to Pittard (2011), BIM should be used to replace traditional operation and maintenance manuals advocating for the analysis of an intelligent “live” model, to replace reviewing outdated manuals. Whereas Dainty et al (2015) take a more pessimistic view and argue that BIM emphasis is often firmly on the digital model as a source of information and asserted that there is little recognition of BIM as a heterogeneous assemblage of technologies, processes and people, introduced into an already complicated landscape of projects, firms, contracts, professionals and technologies.

2.2 Stakeholder's Experience Adopting BIM in Construction

The study carried out by Beveridge et al (2015), indicate that around 26 separate contractors who had BIM revenues varying between $250 million and $2.5 billion and had been using BIM for more than three years with around half using it for six years or more. The top five advantages of BIM deduced from the study reveal that BIM adoption helps enhanced scheduling, communication both internally and throughout the supply chain, visualisation, coordination and clash detection. While the sample size is relatively small, the results are valuable as the respondents are highly skilled in the BIM field against an average organisation. Weygant (2011) supports the findings of Beveridge et al., however, they exemplify clash detection as the most influential benefit of BIM stating that unveiling of clashes at an early stage saves millions of unnecessary costs and countless hours when contrasted against traditional design methods.

Kharal et al (2014) study aligned with the work of Beveridge et al., with a better sample size of 102 respondents across multiple disciplines including consultants, engineers, main contractors, subcontractors and project managers. It is notable that although their sample contained multiple disciplines the key advantages highlighted were very similar; quality communication, enhanced visualisation, greater multidimensional coordination and more robust information were detailed as the dominant advantages. Further research from 2019 continues to confirm a broad yet convincing consensus regarding the benefits, or perhaps better phrased the perceived benefits of BIM within the construction industry. Georgiadou (2019) received 71 responses to a questionnaire specifically targeting BIM professionals and followed this research up with structured interviews and found that BIM is a product which is perceived to offer project quality assurance, on-time delivery, communication improvement,
visual representation, whole lifecycle value and notably the most frequently reported benefit of BIM was the communication benefits its implementation can accrue.

2.3 BIM Implementation in Construction SMEs

The perspective on BIM implementation and adoption for SMEs is highly underrepresented and poorly understood (Forgues et al, 2014). The technology gap between large companies and SMEs is large and continues to expand. Information and Communication Technology (ICT) has become a key component of infrastructure underpinning larger organisations throughout all business processes whereas smaller organisations are typically limited to traditional 2D drawings, emails and symbolic internet facilities (Harty et al, 2017). There are also sub-standard frameworks to help SMEs make an informed decision regarding BIM implementation, this is compounded by low levels of understanding of BIM and misplaced prejudices (Lam et al, 2017). Even if frameworks and understanding were improved a further challenge is an SME's relationship with innovation when contrasted against larger firms, it is acknowledged that the industry as a whole is risk-averse, however this aversion is intensified for SMEs (Sexton and Barrett, 2010). Johnson & Laepple (2003) add that the lack of initiative and training, the fragmented nature of the industry, varying market readiness across geographies and reluctance to change as reasons for low adoption and implementation.

According to Leon et al., (2015), SMEs have fewer resources to cope with the initial increased design time. Whilst Kouide and Paterson (2007) expands upon this notion and suggests that not only is this a resource issue, but the fact that the traditional 2D method of drawing would still be adequate also creates a resistance to the additional training, timing and software cost. This is particularly problematic for SMEs as their underdeveloped knowledge of BIM often results in the perception that BIM is a drawing and modelling tool when compared directly to the less expensive AutoCAD or an equivalent alternative, this disregards any further tool or benefit outside of drawing that BIM provides. The cost of installing BIM is not insignificant, particularly for a smaller business in a challenging industry and economy. At the lower end installation sits at around £10,000 and the leading end £70,000; therefore, the forecasted return on investment must be large, understood and achievable (BIM4SME, 2015).

There are skills shortages relating to BIM adoption. Hence, the need for training or sourcing of new staff (Loveday et al, 2019). NBS (2012) figures suggest that only 25% of SMEs within the UK industry have experienced producing 3D drawings, insinuating that their current capacity to use BIM would need to be supported by training and recruitment. Ghaffarianhoseini et al (2016) suggests that the initial costs associated with BIM training and new software are incompatible with the relative slow return on investment (ROI), in a traditionally risk-averse and cost-driven industry this becomes a very difficult obstacle for SMEs to overcome. SMEs are more likely to adopt reliable methods to ensure a strong ROI, regardless of the conceptual benefits of BIM (Forgues et al, 2015). Harty et al (2016) reaffirm that a slow return on investment contradicts the route SMEs tend to follow predominantly due to a tendency to refuse to look beyond the minimal set of tools to enhance their job performance. Kam (2013) noted that even if SMEs accepted BIM could produce a worthwhile ROI they face problems being able to measure it as a consequence of management executives often relying upon a subjective or anecdotal measure of performance. They further stated that if ROI concerns are a true barrier to BIM implementation, implementing BIM must be accompanied by improvements to measuring ROI through an objective scorecard approach. Without a systematic method of evaluation attempts to analyse the benefits of adoption and performance, following adoption become futile and induce short-sighted and ill-judged technological decisions.

Client's demand for BIM adoption by SMEs on their projects is low then there is less motivation to take what has been deemed a risk and change their traditional processes (Kouide and Paterson, 2007). Harty et al (2017) counter the position stating that there are strategic benefits SMEs can accrue through implementing BIM which include access to bigger markets, partnerships with larger companies, expansion to emerging niche markets, and the ability to compete using the same tools and skills of larger companies. Rostami et al., (2015) underline that reluctance to change is not only driven by a lack of client demand but is also due to resistance to change due to an intersection of established knowledge, experiences and behaviours which often resist new concept, changes require a substantial change in established mindsets and practices.
These demand-related issues are out of the control of the individual SME and require change driven by larger organisations and governments. External factors are also prevalent when analysing potential training requirements. Barnes and Davies (2014) concurred that professionals are trained and educated within the confines of their organisations; this is not conducive to an effective BIM environment as it is integral that collaborative working requires skill sets through cross-institutional cooperation between skilled individuals. The overall impact is that existing traditional boundaries between introverted firms must be expanded, such an exercise relies on a level of trust typical to the industry. Currently, it is not an uncommon practice for a specialist sub-contractor to use 3D models for their benefit without sharing the information modelled, which is in contrast to the culture that needs to be cultivated to give a greater opportunity for successful implementation.

Implementation and adoption of BIM is a complex process due to the lack of interoperability amongst the technology used between the various parties involved in the construction process (Georgiadou, 2019). A collaborative environment with a clear division of BIM roles and responsibilities combined with a thorough understanding of how to utilise the tool to ensure widespread benefits allocation is imperative to overcome this challenge, however creating this BIM environment takes time and skill (Holzer, 2007). Forgues et al., (2014) go a step further and suggest that to maximise the benefits, there is a need for a strategic approach at the organisational level, indicating that changes are required not only at the organisational level but at the industry level including a clear policy and guidance to deploy BIM as imperative (Forgues et al., 2014). Public policy may be required to counteract the impact of cultural resistance to change. These cultural forces are very strong within the industry, subsequently incentives such as: Government subsidising training costs to alleviate some of the initial hardships to negate resistance (Li et al, 2019), and creating a legal environment surrounding BIM to strengthen its adoption. Forgues et al (2014) agreed that incentives are required to encourage SMEs and prevent them from reverting to traditional project delivery systems whenever exposed to high potential risks.

Dainty et al., (2015) challenge the common technocratic optimism surrounding BIM and argue it is somewhat misplaced, the perception that once all firms have the relevant hardware and software, they will use BIM is highly unlikely to be accurate whilst Bach et al., (2013) underlines that transitioning between awareness and actual adoption is a large and poignantly difficult step and is constrained by the motivational access barrier. The suspicion around the actual desire to learn and implement technology, considering that the workforce is ageing and many who grew up "without" technology are still in the workplace. Though there are certainly challenges to BIM for SMEs, research has shown that there are some advantages to its adoption and tend to be more flexible which can be quickly exploited in any new business opportunities compared with larger firms (Rosenbusch, 2011). Due to the small stature of SMEs, it is worth noting that smaller firms do often lack the organisation slack or additional resources required to invest in embracing technological tools and processes while it is technically easier also has a higher inherent risk (Ritchie and Brindley, 2005).

3.0 Research Methodology

An online-based questionnaire is a fiscally prudent methodology used, which has the benefit of ease of completion, this produces a higher return rate than alternative methods (Fox et al, 2003). Data was collected through online questionnaires which allowed a mixture of qualitative and quantitative responses as required to meet the research objectives. Online questionnaire help mitigates the time issue, as large volumes of responses can quickly be obtained from large samples and there is no requirement to transfer information from a paper to an electronic data file (Harms et al, 2017). The online questionnaire consisted of 15 questions to ensure that all objectives can be addressed whilst also ensuring that the number of questions are not too many as to impact the response rate negatively.

Each question was created with a view to harnessing insight which provides data and information that helps achieve the research aim. This is achieved by consciously ensuring each question is geared towards at least one of the specific research objectives or giving an insight into the individual which would allow for the identification of trends. To fulfill the need of collecting quantitative and qualitative data a combination of both open and closed questions was included in the questionnaire. Qualitative data was obtained by including questions requiring open-ended written responses whereas quantitative data was obtained through closed questioning (Cryer, 2006). A Likert scale from 1-5 was used for some
of the closed questions to allow respondents to score statements dependent on their level of agreement or disagreement with the statement. This method of closed questioning was combined with simple yes or no questions and multiple choice.

There were 52 responses, from a sample size of 80 participants, representing 62.5% response rate. The survey collected both quantitative and qualitative data. In terms of qualitative data, the sample size was more than ample. Participants were selected through contacts working for SMEs within the construction industry. Participants were grouped by experience, project size, organisation type, sector and occupation to allow for a thorough analysis of trends.

![Figure 1: BIM Exposure](image1)

![Figure 2: Implementing BIM in short term.](image2)

![Figure 3: Implementing BIM in long term](image3)
Findings from the research demonstrates that overall, there is very low confidence that BIM is properly understood with participants describing their understanding of BIM, only 15% of participants responded with strong and 0% responded with very strong. The remainder were moderate to very weak; 8% selected very weak, 40% selected weak and 37% responded moderately. Indirect exposure to BIM was much higher than direct use, 56% of participants stated that they had worked on projects where BIM was being used whereas 44% said they had not, indicate that those within the residential and housebuilding sector have a slightly greater indirect exposure to BIM when contrasted against commercial at 60% against 54% respectively, see figure 1. Participants were unanimous when queried on their direct personal use of BIM, 96% stated that they had never used BIM during their time as a construction professional, with just 4% having had direct experience using the tool. This demonstrates that irrespective of occupation, job experience, sector or organisation type there is a real lack of current construction professionals who have experience using BIM. It is important to note that the majority of participants worked on projects smaller than £2,500,000 regularly, therefore you can infer from the data that most work for SMEs and the key takeaway is that most people working within SMEs have very limited to or no direct exposure to BIM.

The response on whether SMEs should adopt and implement BIM in the short term saw an equally split response from all participants. 2% strongly disagreed, 27% disagreed, 42% neither agreed nor disagreed, 27% agreed and 2% strongly agreed, see figure 2. The majority of participants held no opinion either way with the weaker and stronger responses being evenly split. This represents that overall, the general population are simply not sure about the best way to proceed. The participants generally showed a much greater propensity to agree with the proposal of SMEs adopting and implementing BIM when compared to the same question being framed in the short term. 63% of
respondents agreed which represents the majority, 23% neither agreed nor disagreed, 10% strongly agreed, 4% disagreed and none strongly disagreed, which aligned with Harty et al., (2017) findings that a perceived slow return on investment attributed to BIM contradicts the fervent immediacy which forms the basis of the majority of decisions made by SMEs, the responses become more positive when framed as long-term as opposed to short-term are a reflection of this industry behaviour, see figure 3. Short-term survival generally triumphs over striving for longer-term efficiencies. Kam (2013) indicates that SMEs in their current form generally have no scientific means to measure ROI for BIM, again, this negatively impacts BIM when reviewed as a short-term prospect as its cost-benefit is difficult to analyse regardless of the general acceptance that in the long-term it would be beneficial. Overall participants believed that collaboration and coordination between multi-disciplinary teams to be the greatest advantage of BIM, with 23% of overall selections attributed to this answer. This was followed by the visualisation of works accounting for 18% of selections. Real-time scheduling, clash detection, quality assurance and on-time delivery of projects scored relatively evenly at 12% for the former and 11% for the latter. Building simulation and virtual testing took a smaller 8%, with a reduction in contractual claims and improved overall sustainability taking small shares at 2% each see figure 4. Though the primary research did not distinguish which disadvantage or disadvantages did evoke the greatest concern indicated by participants was Cultural resistance to change from traditional methods at 17%, closely followed by 16% was the potential requirement for upskilling, training and recruiting, and the lack of organisational structure to support BIM at 15% with skills shortages within the industry at 14% see figure 5.

5.0 Discussion of Findings

BIM is poorly understood within the construction industry and the pre-conceived notion that it is solely a modelling tool is far-reaching within the industry (Aubin, 2012). This was further evidenced by the research with the self-assessed levels of understanding of BIM, whereby the most selected answer was "weak". It is important to assess perceptions of BIM in terms of similarities and differences between larger firms and SMEs, particularly as there is evidence to suggest an ever-growing BIM divide (Construction Excellence, 2015). The reason it is important is, for BIM to be successful it requires understanding, competency and motivation from the multitude of relevant stakeholders. When assessing whether to adopt and implement BIM or indeed any technology or new process a firm will naturally attempt to analyse the potential benefits. As BIM is a relatively complex technology this is not as simple as many other potential business decisions, it is important to distinguish between the theoretical benefits of BIM and perceived benefits from an SME perspective as these distinctions could inform why the BIM divide continues to grow.

Enhanced collaboration and coordination and improved visualisation are reported benefits across a plethora of literature [Beveridge et al, 2015; Kharal et al, 2014 and Georgiadou, 2019]. These benefits were the top-ranked amongst the research participants, indicating there is universal acceptance among firms of all sizes that these outcomes of BIM implementation are highly sought after; which is unsurprising given the typically convoluted and inefficient flow of information during a construction project. Scheduling, clash detection, on-time delivery and quality assurance were also prominent conceptual advantages (Weygant, 2011; Georgiadou, 2019). Though these advantages were consistently revered amongst various sources of research work, they were only moderately valued by the sample population within the research, inferring SMEs are either not fully aware of the benefits or they simply deem collaboration and visualisation as more useful. There were conceptual advantages that this research uncovered what was not valued highly whatsoever. Simulation and virtual testing, improved sustainability and reduced contractual claims are benefits of BIM implementation [Akala et al., 2019; Ghaffarianhoseini et al., 2018, Kensek and Noble, 2014]. These advantages scored very poorly amongst SMEs within this research to the point it is evident that currently, SMEs do not deem these as benefits whatsoever; when giving due consideration to the costs associated to re-work, poor energy efficiency and contractual claims within the industry it is, on face-value, counter-intuitive to discover a solution to these issues are not sought after.

This is where conceptual and real-world scenarios collide within the industry, as whole poor sustainability for example is a great industry challenge, however individual SMEs are rarely given the
motivation to improve upon their sustainability; they are innately risk-averse due to the high penalty of failure to complete projects and prefer traditional methods due to the onerous litigious environment. Bach et al (2013) understood this concept when highlighting the difference between awareness and actual use and the discrepancy between having a conceptual advantage and an actual real-world benefit to an SME is a factor which makes this concept a reality. Through the data analysis, it is demonstrated that perceptions of benefits did not fluctuate greatly regardless of occupation, levels of experience, sector type, project size and organisation type and that perceived benefits remained more consistent than barriers. The barriers are relevant when understanding the perceptions of BIM. Without regurgitating the same information to a great degree it is important to note that the challenges associated with BIM from an SME perspective are mainly associated with cultural resistance to change, the potential requirement for upskilling, training and recruiting, the lack of organisational structure to support BIM and skills shortages within the construction industry, and as discussed the challenges most essential to address fluctuates dependent on occupation and levels of experience.

6.0 Conclusion

If there exist is an appetite for BIM is unclear, in the short term the prospect is not preferred as documented by the research. In the long-term, there is a greater appetite, though not by an overwhelming majority. The perceived benefits also need to be understood, the primary and secondary research indicate results which are relatively conclusive. Collaboration and coordination are deemed as great benefits across both primary and secondary research, with scheduling, clash detection, on-time delivery and quality assurance receiving moderate rankings within the primary research. Following desk research simulation and virtual testing, improved sustainability and reduced contractual claims were deemed to be important benefits. However, this was not evidenced by the primary research, all of which scored poorly. In summary, BIM is a poorly understood tool, which SMEs demonstrate as an unconvincing but adequately desired tool to adopt or implement in their project. Its value is primarily seen through its collaboration and co-ordination benefits, yet the benefits are marred by a cultural resistance to change, the potential requirement for upskilling, training and recruiting, the lack of organisational structure and skill shortages to support BIM.

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A systematic review of the adoption of wearable sensing devices for monitoring the health of construction workers

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ABSTRACT & KEYWORDS

Purpose
This study aimed at exploring the use of wearable sensing devices (WSD) for health monitoring of construction workers.

Research Methods
This study conducted a systematic review for data collection. Relevant databases were searched using keywords such as wearable sensing devices (WSDs), construction health and safety, and health monitoring in construction.

Findings
The results show that WSDs can help to identify several conditions that contribute to poor health, including heart disease, stroke, heat exhaustion, insomnia, blood pressure, pulse, and heatstroke. WSDs could help to reduce injuries and fatalities by monitoring workers’ health while they are performing physically demanding tasks. The most widely used WSDs in the construction industry are smartwatches, wristbands, smart hard hats, and smart safety vests.

Research limitations
This study is based on a systematic literature review that will serve as a foundation for further research.

Practical implications
This study makes recommendations for using WSDs to monitor construction workers’ health more effectively.

Value of paper
WSDs are one piece of digital technology that can help to monitor workers’ health in the construction industry.

Keywords Construction Health and Safety, Construction Industry, Construction Workers, Health Monitoring, Wearable Sensing Devices.
1 Introduction

Construction work is inherently dangerous since it involves working at heights, moving people, goods, and vehicles frequently, using power-driven machinery, plant, and equipment, as well as being exposed to a variety of hazardous substances (Helen, 2019). There are many different health problems that construction workers may encounter at work. For instance, musculoskeletal diseases (MSDs) are present in the workplace for construction workers due to repetitive motion, high force exertion, unpleasant body position, vibration, and contact force (Anagha & Annie, 2020). Additionally, a wide range of workers is impacted by several occupational health problems on construction sites, such as pneumoconiosis in tunnel builders and welders, low back pain in bricklayers, kidney problems caused by solvent exposure in painters and roofers, asbestosis in workers who demolish buildings, and heat stress in those who clean up hazardous waste (Yuan et al., 2018).

As a result, the focus has shifted away from the construction industry’s contribution to GDP, development, and employment opportunities in many countries due to its reputation as a hazardous, disagreeable, and unsafe industry (Conrad & Barker, 2010). Construction workers experience chronic illnesses as a result of inadequate medical care treatments in the industry. For example, musculoskeletal illnesses, cardiovascular diseases, metabolic diseases, and sleep disorders frequently precede fall-related injuries on construction sites. In addition, physical exhaustion has also been linked to several negative effects, such as decreased motivation and productivity, drowsiness, bad judgment, unsatisfactory performance, low job satisfaction, and a higher risk of accidents and injuries on construction sites (Hwang & Lee, 2017).

To maintain expected productivity without compromising worker health and safety, the construction industry must manage physical demands within an acceptable range. It is now possible to assess the physical demands of workers thanks to recent advancements in wearable sensing devices (WSDs) that contain biosensors (such as heart rate monitors and skin temperature sensors) (Hwang & Lee, 2017). WSDs have the potential to increase worker safety by effectively collecting data, analyzing it, and providing employees with real-time information regarding safety and health hazards (Nnaji, et al., 2021). In physically challenging and hazardous construction sites, the application of WSDs may provide a new avenue for managing occupational safety and health. The present proliferation of wearable technology equipped with biosensor systems has created numerous opportunities to continuously assess and comprehend the physical needs of construction workers (Awolusi, et al., 2019). As a result, this study aimed at exploring the adoption of wearable sensing devices (WSD) for monitoring the health of construction workers.

Research Method

To realize the objective of this study, which was to explore the adoption of wearable sensing devices (WSDs) for monitoring the health of construction workers. This study adopted systematic review methods similar to the study conducted by Awolusi, et al., (2018). The systematic review method allowed the researchers to explore the parameters that can be monitored using WSDs, the impacts of deploying WSDs, and the extent to which the WSDs can be used to monitor the real health of construction workers. Fig1 shows the main steps of the process used in this systematic review study, along with the inclusion and exclusion criteria for paper selection.
The review included publications from multiple databases, including Scopus, EBSCOHost, and Google Scholar. These databases were chosen because they provided a wider diversity, accuracy, and ease of retrieval for publications addressing wearable technologies in the construction industry. The researchers used keywords like wearable sensing devices (WSDs), construction health and safety, and the construction industry to search the relevant publications in the databases. The study’s final phase of literature research reviewed the titles and abstracts of the publications that were released between 2012 and 2022. The 85 published publications that the researchers discovered in the databases are shown in Fig 1. Following the screening process, 35 papers were found to be irrelevant and ignored. In addition, 25 papers from the publications were selected for this study after the researchers assessed an additional 50 papers. The publication names cited in this study are presented in Fig 2.
3 Research Findings

3.1 Background of Wearable Sensing Devices (WSDs)

Wearable Sensing Devices (WSDs) are defined as wearable gadgets used to monitor and gather real-time employee health data for analysis to assure the employees’ health and wellness (Fang & Tiwari, 2017). In addition, WSDs were defined by Liu & Poon (2021) as sensors that are either directly or indirectly put into the human body and cause motions to be produced while the worker performs activities. WSDs are frequently incorporated into clothing, eyewear, belts, watches, mobile devices, shoes, or even directly on the body. Due to its almost endless storage capacity and computing capabilities, cloud-based computing is used to store and analyze the vast amounts of data that WSDs collect (Mizani, 2017).

The uses of wearable technology in the field of healthcare, both current and future, are illustrated through several examples. Numerous aspects of our lives have changed due to the advancement of digital and mobile technology (Nagamine & Tokito, 2021). It is now feasible to deploy WSD due to advancements in sensor technology and short-range communication technologies like Bluetooth and ultrawideband radio (Awolusi, et al., 2018). WSD applications are used on numerous platforms, such as radio-frequency identification, magnetic fields, radar, ultra-wideband, ultrasonic, sonar, Blue-tooth, GPS, video and static cameras, electrocardiograms, and electromyography (Lee & Leeb, 2018). A collection of sensors, including galvanic skin response, accelerometers, gyroscopes, and magnetometers, make up a body sensor network (Awolusi, et al., 2018).

3.2 Application of Wearable Sensing Devices (WSDs) in the Construction Industry

Technology advancements have made it possible to create new wearable sensing devices that are more complicated and capable of conducting a variety of tasks, unlike typical wearable things. WSDs can increase worker health and safety by effectively gathering and analyzing data, which provides real-time knowledge about safety and health risks (Nnaji, et al., 2021). Recent advancements in wearable technology enable timely collection and conversion of safety and health data, which has the potential to improve health and safety performance by reducing harm risks. Many factors that affect health and safety have been researched in academic settings (Changbum, et al., 2019).

There has been extensive research on the applications of WSDs and their effects on construction health and safety (Changbum, et al., 2019). The adoption of WSD by workers on construction sites was examined by Choi et al. (2017). For instance, the authors investigated the workers’ intentions to adopt two WSDs to increase workplace health and safety. These WSDs included a smart vest with a built-in
GPS for tracking one's whereabouts and an activity tracker that resembled a wristband but had physiological sensors. The results shed light on the significance of many factors that aim to encourage construction workers to adopt wearable sensing devices at work (Choi, et al., 2017).

As a result, it is crucial to be fully aware of the underlying variables that influence the development of workplace safety technology (AL-Sahar, et al., 2021). For instance, WSDs would assist stakeholders and decision-makers in creating workable plans for the effective adoption and management of the implementation process (Othman, et al., 2017). In addition, an analysis of past and present research on the use of modern technologies in numerous disciplines reveals that several factors are required for the successful implementation of these technologies (AL-Sahar, et al., 2021). These variables include enterprise resource planning (ERP) systems, nanotechnology, green building technologies, 3D printing, building information Modeling (BIM), the Internet of Things, and WSDs which are still in the early phases of development (Nnaji & Awolusi, 2021).

WSDs have many benefits, but their effect on workers’ privacy is a problem, and if the data they acquire is managed improperly, it could harm site staff members' social confidence (Lee & Leeb, 2018). Additionally, because wearable technology development did not prioritize data security and encryption, the nature of wearable sensing devices' data collection and transmission to the receiver or base station has given rise to uncertainties (George, 2020). These difficulties can make users reluctant to embrace WSDs. Therefore, the adoption of wearable sensors increases the risk that suppliers will improperly protect workers' sensitive health information. As a result, past studies on the adoption of wearable technology have included perceived privacy risk as a crucial component in their theoretical models (Choi, et al., 2017).

However, these are not the only drawbacks of WSDs. WSDs benefit society in several ways (Awolusi, et al., 2020). Individuals can be monitored and located using these wearable sensing technologies, which can also be utilized to identify potentially dangerous situations that could be harmful to workers' health. Monitoring the physiological features of construction workers is also possible (Awolusi, et al., 2018). WSDs provide reliable health information that prevents disease transmission, fatalities, or collapses among persons working at heights in addition to the advantages mentioned above (Cheng, et al., 2012). Additionally, these tools make it possible to keep an eye on employees' mental health, prevent falls, determine their level of physical exhaustion or workload, and prevent musculoskeletal issues (Changbum, et al., 2019; Techera, et al., 2018). Because they make it easier to improve employees' health and eliminate ill health on construction sites, WSDs are a necessary resource (Alwasel, et al., 2011).

WSDs have been used in a wide variety of construction health and safety monitoring applications. These gadgets include proximity sensors, location trackers, physiological sensors, and environmental sensors (Changbum, et al., 2019). Construction workers frequently experience a variety of health difficulties as a result of their difficult and demanding work settings, which can hinder their ability to perform safely and effectively overall (Jochen, et al., 2010). Physiological data, including heart rate, breathing rate, body position, speed, and acceleration, can be automatically recorded and analyzed using a variety of sensors and systems, including the "Physiological Status Monitoring" system and GPS tracking device. Examples of widely used physiological sensors include electrocardiograms, electromyograms, electroencephalograms, skin temperature, blood pressure, tilt, breathing, and movement sensors (Lee & Leeb, 2018).

These sensors may collect a variety of data points that show the stress level and health of a construction worker, which enhances the workers' performance in terms of safety (Changbum, et al., 2019). WSDs with gyroscopes have been increasingly effective in human motion analysis, including improving balance and reducing falls (Awolusi, et al., 2019). However, data analysis algorithms might be created expressly to detect falls by analyzing motion and vital sign data (Wang, et al., 2017). The fundamental need for specialized materials, some of which may be hazardous to construction workers, raises additional health and safety considerations for employees in the workplace. WSDs must therefore ensure that workers are shielded from the potentially dangerous health risks present on building sites (Choi, et al., 2017).
While employees are engaged in their regular jobs, real-time health data, such as temperature, hazardous gases, airborne particles, and potentially lethal chemical spills, can be collected using WSD. The adoption and decision-making processes for health and safety technologies in the construction sector were highlighted in a recent study by Nnaji & Awolusi (2021), with technological reliability, efficacy, and durability being the most important considerations. According to Choi et al. (2017) on the variables influencing the adoption of workplace wearable technology, employees’ decisions to utilize smart vests and wristbands are influenced by the usefulness, impact they would have on society, and how much privacy risk, there is.

3.3 Incorporating Wearable Sensing Devices (WSDs) in the Construction Industry

Compared to workers in other industries, construction workers have a higher risk of occupational illnesses, accidents, and fatalities (Awolusi, et al., 2020). The majority of construction workers who pass away on the job every day could have gotten help before their conditions got worse or spread (Led, et al., 2015). On construction sites, worker disease is not effectively prevented by the usual technique of health monitoring. Construction workers can benefit from WSDs because they are utilized to give current health information to on-site staff. To reduce injuries and fatalities, managing workers’ health monitoring while they are performing physically demanding work is crucial (Marakhimov & Joo, 2017). The use of WSDs in the construction industry is crucial because it can identify several conditions that contribute to ill health, including heart disease, stroke, heat exhaustion, insomnia, blood pressure, pulse, and heatstroke (Choi, et al., 2017).

4 Conclusions

The use of WSDs to monitor the health of construction workers was examined in this study. The study’s results suggest that WSDs should be used to track the health of construction workers. These technologies have pushed the search for practical answers to unanticipated health issues at work. To address the issue of resistance to WSDs adoption for safety and health monitoring of construction workers, research has also been done to identify and evaluate the various WSDs available in the industry. The most widely used WSDs in the construction industry are smartwatches, wristbands, smart hard hats, safety vests and smart boots. There are a few limitations in this study, nevertheless, which open up possibilities for additional investigation. Future research should concentrate on incorporating the application of WSDs to monitor construction workers’ health using a real-world case on construction sites. Since this study was based on a systematic review to explore the adoption of WSDs for monitoring the health of construction workers.

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ABSTRACT & KEYWORDS

Purpose of this paper
While vibratory equipment is an inevitable input in the operational requirements of many domains, the construction industry included, it goes without saying that these are a constant occupational hazard and a threat to the health and well-being of specific work groups. Evidence abounds that exposure to vibration has debilitating effects on the human body, which depending on the extent of exposure and individual susceptibility, could lead to HAVS.

Design/methodology/approach
This study explored literature on HAVS in developing countries through examining 91 articles published between 2002 and 2022 from the Scopus database. VOSviewer version 1.6.18 was used to develop a co-occurrence network based on the bibliographic data obtained.

Findings
The study concluded that research on HAVS in developing countries is in its infancy, demonstrated through the scant data available. In fact, the disease is underdiagnosed and underreported. Notwithstanding from the above, in recent years the number of academic studies on HAVS in developing countries is on the rise.

Research limitations/implications
This study was focused on the prevalence of HAVS within the developing countries context, over the past twenty years.

Original/value of paper
This paper contributes to the knowledge corpus of HAVS in developing countries.

Key words: Hand-arm vibration syndrome (HAVS), vibration exposure, occupational health, bibliometric analysis, developing countries
1. INTRODUCTION

1.2 Basic Vibration Concepts

Vibration is a critical aspect of life, our eardrums vibrate so that we hear, light waves undergo vibration to be visible and vibration of our lungs enables us to breathe (Pavinthra, 2003). Likewise, vibration is critical to the functioning of most machines and engineered systems. Chaffin et al. (2006) defined vibration as the oscillatory motion of a structure or machine. Vibration, according to Pierzol & Piaz (2010: 1.1) refers to the “dynamic mechanical excitation that may cause a dynamic response of a physical system, usually a mechanical structure that is exposed to that excitation”. The theory of vibration therefore concerns itself with the study of oscillating bodies and any forces associated with them (Pavinthra, 2003).

Blake (2002) stated that a vibratory system comprises three components, namely;

- Potential energy in the form of a spring or elasticity
- Kinetic energy in the form of mass or inertia, and
- Damper, which is how energy is gradually lost.

According to Blake (2002) vibratory systems involve the transfer of energy between its potential and kinetic forms, alternately. While most human activities involve and to some extent rely on some form of vibration, it is without its disadvantages. In fact, vibration has some detrimental effects on both machines and humans Pavintra (2003), where in the former, it could cause machine failure and in the latter overexposure to vibrating systems may lead to diseases such as hand-arm vibration syndrome (HAVS) & Carpal Tunnel Syndrome (CTS). According to HSE Executive (2005), the daily exposure limit values for hand-transmitted vibration are $5\text{m/s}^2$ and an exposure action value of $2.5\text{m/s}^2$.

1.2 Occupational exposure

Occupational exposure is when individuals are exposed to different types of health problems relating to their work and work environment (Sharma et al., 2008). According to Olouch et al. (2017) almost half of the world’s population is exposed to occupational hazards, and between 68 and 157 million new cases of occupational diseases relating to exposure are recorded annually. Despite these high figures, it is asserted only a mere 5-10% of workers diagnosed with occupational diseases have adequate access to occupational health services in developing countries. Rotich and Kwasira (2015) buttress that assertion where they noted low compliance and regulation to health and safety statutory requirements in developing countries. According to Fidanci and Ozturk (2015), occupational diseases can be classified according to the exposure source, i.e.,

- Chemical source, e.g., gases and heavy metals
- Physical source, e.g., noise, vibration, and dust
- Biological source e.g., bacteria sourced, and virus sourced
- Psychological
- Based on ergonomic negligence e.g., accidents

This study will focus on HAVS, an occupational disease attributed to the physical source (vibration) category. Within the domain of occupational health and safety, especially within the developing world context, HAVS is one of the least diagnosed occupational hazards, especially given that the effects of HAVS are not noticeable immediately but rather after prolonged exposure (Palmer et al., 2002). Vibratory systems are an inevitable input in the operational requirements of many industries. Notwithstanding the above, it goes without saying that vibratory equipment are a constant occupational hazard and a threat to the health and well-being of specific work groups (Kurtul & Turk, 2019). Healthy individuals in a workspace tend to live longer, and contribute to increased productivity, efficiency, and cost effectiveness in the workspace (Howell et al., 2016; Olouch et al., 2017). In like manner, absence from sickness has huge economic costs. This much is corroborated by the UK’s Office of National
Statistics (2022) where an estimated 149.3 million working days were lost due to sickness in 2021 alone. A study by Webber (2022) estimated an economic cost of £781 per day lost. Using this as a guideline, the UK’s annual cost due to sickness in 2021 could be estimated at £12 billion. Occupational Care South Africa (OCSA) reported that the South African economy loses between R12 to R16 billion a year because of absent workers.

### 1.3 Hand-transmitted vibration

Hand-arm vibration (HAV) is when the hand is in contact with a vibrating surface or is a consequence of hand-transmitted vibration (HTV), i.e., when vibration enters the body through hands, largely through the use of power tools (Gardiner and Harrington, 2005). The repeated and regular exposure to HAV can result in permanent health impairments such as CTS & HAVS (Edwards et al. 2020; HSE, 2012; Shen & House, 2017). Available data confirms a positive association between increased vibration intensity and duration of exposure and HAVS manifestation (Heaver et al., 2011).

### 1.4 Hand Arm Vibration Syndrome (HAVS)

There has been a proliferation in the use of vibrating equipment across many sectors due to industrialization (Orelaja et al., 2019). Griffin (1990) alluded that, operators of vibrating equipment are susceptible to significant levels of shock and impaired health. Due to the serious health implications of regular usage of vibrating equipment by certain occupational groups, considerations for operator vibration exposure against the daily exposure limit values have become pivotal (Mihigo, 2010). Repeated and frequent usage of vibrating equipment can cause HAVS (HSE, 2014). Though completely avoidable, HAVS in its worst form could result in permanent disability. Needless to mention, HAVS, like all other occupational diseases, is completely preventable and the risk of exposure can be controlled (HSE, 2014; Fidanci and Ozturk, 2015). In support of this fact, Starr and Cox (2018) advised that ceasing the usage of vibrating equipment inhibits the progression of the symptoms. Henceforth, both legislators and manufacturers have made some efforts to reduce the risk of one contracting HAVS.

Hand-arm vibration syndrome, commonly known as HAVS is a prevalent chronic medical condition that affects, on average 50% of the workers exposed to the vibration (Bernard et al., 1998; DHHS (NIOSH) Publication No. 89-106, 1989). Despite this fact, it is a quite difficult to obtain accurate statistics on the number of people diagnosed with HAVS due to various reasons. Globally, it is estimated that over 8 million people are exposed to vibration (Mihigo, 2019). A report by Wilkinson (2019) stated that, in the UK, HAVS is the highest reported industrial illness. In that same report, Wilkinson reported that about 2 million people were at risk of contracting HAVS, with 300 000 people having the disease in its advanced stages in the UK. Between 2011 and 2020, according to (HSE, webpage), 8980 new cases of HAVS were recorded in the UK. In addition, of the 220 HAVS cases reported between 2017 and 2019 in the UK, 9% and 57% were attributed to the construction & mining sectors respectively. The US National Institute for Occupational Safety and Health (NIOSH) estimated 1.45 million US workers were exposed to hand-arm vibration in 1983, with about half of these likely to contract HAVS. However, as of 2016, this figure had increased by nearly 60% where in the US alone, almost 2.5 million people were exposed to HAV, with between 20 to 50% having a likelihood of HAVS manifestation (Acquisition Safety, 2016).

HAVS is a secondary form of Raynaud’s syndrome, which is a condition where vasospasms of the arteries cause intermittent restrictions in blood flow (Hughes-Riley and Dias, 2017). It is a disease which affects the fingers, hands, and arms due to prolonged HAV exposure. Its latency period, i.e., the time it takes for symptoms to manifest is variable (Heaver et al., 2011). HAVS is a group of disorders, which entail neurological, vascular, and musculoskeletal symptoms caused by repetitive trauma from vibration equipment (Gardiner et al., 2022; Rimell et al., 2008; Edwards and Holt, 2007). HAVS can easily be misdiagnosed (Cooke et al. 2022). Reportedly, in warmer ambient temperatures, neurological and musculoskeletal disorders are more common compared to the vascular symptoms (Su et al., 2011).
1.5 Risk Factors of Developing HAVS

The factors that influence HAVS include but are not limited to individual susceptibility, temperature, continuous or intermittent exposure and the extent of exposure (Gardiner et al., 2022). Critically, HAVS cannot be singly attributed to occupational hazards, but a person's lifestyle must also be taken into consideration, as social activities such as operating a lawn mower could lead to HAVS (Carra et al., 2019; Edwards and Holt, 2007). According to Kim et al. (2019), poor dietary choices and bad lifestyle choices such as smoking could enhance the probability of an individual developing HAVS. On the other hand, Ye et al. (2015) noted that the risk of developing HAVS is dependent on; tools' acceleration levels, duration of exposure, grip force required, structure of the work surface, working posture, climatic conditions, and individual susceptibility. On the other hand, Edwards et al. (2020) expanded on these factors to include individual worker susceptibility and the frequency, duration and amplitude of exposure.

Cold climatic conditions have been cited as increasing the risk of HAVS manifestation (Shen & House, 2017). According to Bilir (2016) some of the factors include, level of insulation, grip strength, body part affected by vibration source, maintenance / repair tools or instruments. Table 1 summarizes the HAVS risk factors into two, namely, occupational, and non-occupational.

<table>
<thead>
<tr>
<th>Occupational</th>
<th>Non-occupational</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of exposure</td>
<td>Individual susceptibility (genetic disposition)</td>
</tr>
<tr>
<td>Frequency of exposure</td>
<td>Individual’s lifestyle (e.g., smoking &amp; poor dietary choices)</td>
</tr>
<tr>
<td>Extent of /severity of exposure</td>
<td>Non-occupational exposure (e.g., using a lawn mower)</td>
</tr>
<tr>
<td>Tools acceleration</td>
<td></td>
</tr>
<tr>
<td>Grip force</td>
<td></td>
</tr>
<tr>
<td>Working posture</td>
<td></td>
</tr>
<tr>
<td>Structure of the work surface</td>
<td></td>
</tr>
<tr>
<td>Cold climatic conditions / temperature</td>
<td></td>
</tr>
<tr>
<td>Maintenance / repair tools or instruments.</td>
<td></td>
</tr>
<tr>
<td>Level of insulation</td>
<td></td>
</tr>
<tr>
<td>Body part affected by vibration source</td>
<td></td>
</tr>
</tbody>
</table>

1.6 Recognition of HAVS in developing countries

Generally, HAVS in developing countries is substantially under recognised, underdiagnosed and under reported. This much is demonstrated in part, by the meagre extant research on HAVS in Africa and the developing countries at large; with the mining industry dominating the scant research in this area (Nyantumbu et al., 2007). Ali (2018) corroborated this assertion where he noted that there is a shortage of data on hand arm vibration syndrome (HAVS) among exposed workers in developing countries, more specifically in the warmer regions. This fact is alarming, especially when, in recent years, the use of handheld equipment in developing countries has seen a surge with the rise in infrastructure development drives and industrialization (Futatsuka et al., 2005.) The drive towards increased infrastructure development, which has contributed to occupational exposure to vibration is in part, a response by governments to infrastructure’s contribution towards the national development plans (Mahamadu, Manu, Booth, Olomolaiye, Coker, Ibrahim & Lamond, 2018; Manu, Asiedu, Mahamadu, Olomolaiye, Booth, Manu, Ajayi & Agyekum, 2021). It is inevitable that, as a result of the widespread and increased use of vibrating equipment in developing countries, and if no corrective measures that reduce occupational exposure are put in place, there will be a rise in the number of people with HAVS.
Nyantumbu et al. (2007) studied the prevalence and severity of HAVS in 296 South African gold miners, of which 156 had occupational exposure to HTV and 140 no exposure. The results indicated that 15% (24) of gold miners exposed to HTV had symptoms of HVAS whereas only 5% (7) of the non-exposed group showed symptoms. The prevalence of HAVS symptoms in their study was very low and the reason for this was unclear. Another study of 365 vibration-exposed Congolese cassava and corn millers against 365 non-exposed civil workers by Mbutshu et al. (2014) found that 25.8% (94) cassava and corn millers reported musculoskeletal disorders and 98.7% of those reported chronic pain, against 5.2% (19) and 83% respectively for civil workers. Their study further revealed that those millers that had been exposed to vibration for longer durations (> 5 years) showed symptoms more that those with less exposure (< 5 years). Furthermore, a greater proportion of millers who worked longer (> 8 hours) had a higher incidence of hand arm musculoskeletal complaints when compared to those who worked shorter hours. A study of the Zambian National Labor Force Survey on occupational exposures conducted among 64,119 workers in 2009 showed that hand-arm vibration exposure accounted for 3% of the participants (Siziya, et al., 2013). Mahigo (2010) conducted a study that sought to establish daily exposures to HTV and WBV by construction workers at the University of Botswana. The study found that the construction workers were exposed to acceptable levels of vibration, i.e., the vibration levels were below the daily average exposure limit values. Hence the workers were at low risk of contracting HAVS. In a seminal study by Ali (2018) of the risk of exposure to hand-arm vibration among 110 oil workers in UAE, it was found that the prevalence of HAVS 13.6% (vibration white finger 0.9%, neurosensory symptoms 3.6%, and 9.1% musculoskeletal symptoms). Notably, in their study, the cases of HAVS increased significantly with age, increasing exposure categories and total years vibration exposure. There were no cases of vascular symptoms which they attributed to the warmer climatic conditions.

The relationship between cold climatic conditions and the prevalence of HAVS, especially vascular symptoms is contentious and conclusive within the corpus of extant literature. For instance, the first study of HAVS prevalence among Malaysian construction workers by Su et al. (2011) could not establish the reasons for the low HAVS prevalence in tropical areas. In that study, about 18% of the workers contracted HAVS, albeit with different sets of symptoms when compared to those in cold climatic conditions. Data obtained by Nyantumbu et al. (2007) noted that there seemed to be lower cases of HAVS within the South African gold miners, which they attributed partly to the warmer South African temperatures. On the contrary, in their study among tire shop workers in Kelantan, Malaysia, Qamraddim et al. (2021) found that HAVS is a significant problem among workers exposed to HAV in a warm environment.

2. Methodology

Bibliometric Analysis

The bibliometric analysis is a quantitative research method which was employed in this study. Bibliometrics is a scientific method where statistics for particular field publications from specific databases are undertaken. According to Zeleznik et al. (2017), bibliometrics is a critical determinant in establishing the extent of development in a certain field. Corroborating this, Pritchard (1969) noted that bibliometrics is a method which uses mathematical and statistical techniques to determine the knowledge base of a scientific area of study. Bibliometrics have been utilized in the evaluation of scientific output. For this research paper the search engine used to evaluate the literature on HAVS within the developing countries context was Scopus. The steps undertaken for data collection and analysis are as shown in Figure 1.
The search query included the following keywords, “hand arm vibration syndrome” AND (“HAVS prevalence” OR “vibration exposure” OR “legislation” on the topic (Title, Abstract, Keywords). In addition, the inclusion criteria were limited to peer-reviewed articles and conference proceedings published between 2002 and 2022 period. The results were filtered to cover only the developing countries. The criteria for determining countries considered as developing was in accordance with United Nation’s WESP (2022). 91 Articles were relevant to the study and were exported to VOSviewer (version 1.6.18) for analysis.

3. Results

Data was collected from 91 peer-reviewed articles. The 14 countries represented by the data, in order of the most publications included, Malaysia, India, China, Brazil, South Africa, Iran, Taiwan, Pakistan, Philippines, Saudi Arabia, Nigeria, Oman, Thailand and Viet Nam.
Figure 2: Clusters and their sub-components (co-occurrence network map showing the HAVS phenomenon within developing countries) (2005-2022)

Table 2: Clusters and their sub-components

<table>
<thead>
<tr>
<th>Cluster 1 (18 items)</th>
<th>Cluster 2 (13 items)</th>
<th>Cluster 3 (9 items)</th>
<th>Cluster 4 (8 items)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational risks &amp; disorders</td>
<td>Occupational Exposure</td>
<td>Vibration symptoms</td>
<td>Risk factors</td>
</tr>
<tr>
<td>Controlled study</td>
<td>Adverse event</td>
<td>Adult</td>
<td>Female</td>
</tr>
<tr>
<td>Ergonomics</td>
<td>Cross-sectional studies</td>
<td>Carpal tunnel syndrome</td>
<td>Forestry</td>
</tr>
<tr>
<td>Hand arm vibration</td>
<td>Cross sectional study</td>
<td>Finger</td>
<td>HAVS</td>
</tr>
<tr>
<td>Hand arm vibration syndrome</td>
<td>Hand</td>
<td>Grip strength</td>
<td>Middle aged</td>
</tr>
<tr>
<td>Hand transmitted vibration</td>
<td>Human</td>
<td>Hand arm vibration syndrome</td>
<td>Risk factor</td>
</tr>
<tr>
<td>Health risks</td>
<td>Humans</td>
<td>Major clinical study</td>
<td>Tropical climate</td>
</tr>
<tr>
<td>Human experiment</td>
<td>Occupational disease</td>
<td>Male</td>
<td>Young adult</td>
</tr>
<tr>
<td>Machine vibrations</td>
<td>Occupational exposure</td>
<td>Paraesthesia</td>
<td></td>
</tr>
<tr>
<td>Musculoskeletal disorders</td>
<td>Occupational health</td>
<td>Raynaud phenomenon</td>
<td></td>
</tr>
<tr>
<td>Occupational disorders</td>
<td>Prevalence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risk assessment</td>
<td>Vibration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tools</td>
<td>Vibration disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration analysis</td>
<td>Workplace</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration exposure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration measurement</td>
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</tbody>
</table>
To establish the extent of studies on HAVS and its prevalence thereof in the context of developing countries, the authors adopted the co-occurrence link of key terms. The co-occurrence network assisted the authors establish the body of knowledge in respect to HAVS through linking the key terms emanating from studies. The following VOSviewer 1.6.18 tools were applied: co-occurrence; unit of analysis: all keywords. The full counting option was selected during the analysis, and it yielded a total of 825 keywords, however, after the data set was eliminated to include words that were mentioned at least five times in the sample, 54 words met this criterion. The 54 keywords were subdivided into 4 clusters as shown in Figure 2 and Table 2.

4. Discussion

From the Scopus database, it appears that while studies on HAVS in developing countries can be traced to almost two decades ago Roshada et al. (2004), research in this area is still limited. Mahigo (2010) buttressed this observation by affirming that in most parts of the developing world, "vibration is one of the least recognized ergonomic hazards", which is evidenced by the few publications in the area. In recent years however, research in this area has gained prominence. This much is demonstrated by the proliferation of studies in the area, averaging eight articles within the past five years (2018-2022). The co-occurrence network map of key terms resulted in the generation of four clusters, viz.

Cluster 1 (red): The keywords (18) include aspects such as occupational diseases, machine vibrations and hand arm vibration syndrome. There is an increase in the drive towards industrialization within the developing countries context Mahamadu, et al. (2018) and Manu et al. (2021), thereby making vibration exposure inevitable (Futatsuka et al., 2005.) However, given the positive association between occupational exposure to vibrating equipment and HAVS manifestation (Orelaja et al., 2019; Griffin, 1990; HSE, 2014), it can be inferred that, in the absence of preventative and corrective measures, HAVS cases are on an incline in developing countries. While evidence abounds that studies on HAVS within these countries are limited, interest in this research area is gaining prominence (Mahigo, 2010). HAVS is an occupational disease (Ramakrishman et al., 2022; Jia et al. 2022; Fidanci and Ozturk, 2015), and sadly it is highly probable that some occupational diseases such as HAVS occur after leaving the job, thus making the proper diagnosis almost impossible (Palmer et al., 2002; Fidanci and Ozturk, 2015).

Cluster 2 (green): 13 key words including occupational exposure, vibration and human/s. Occupational exposure is one of the key challenges affecting working life (Fidanci and Ozturk, 2015). Extant scholarly articles confirm a link between occupational exposure to vibration and HAVS manifestation (Heaver et al., 2011; Edwards et al. 2020; HSE, 2012; Shen & House, 2017). Needless to mention, HAVS, like all other occupational diseases, is completely preventable and the risk of exposure can be controlled (HSE, 2014; Fidanci and Ozturk, 2015).

Cluster 3 (blue): 9 key words including adult, male, Raynaud phenomenon. Raynaud phenomenon is a vascular manifestation of HAVS (Cooke, 2022; Hughes-Riley and Dias, 2017). It is one of the common manifestations of HAVS and was previously referred to as vibration white finger (Pelmear, 1998).

Cluster 4 (yellow): 8 key words including risk factor, tropical climate and young adult. Certain studies have found an association between HAVS manifestation and tropical climatic conditions (Wei et al., 2021). Individual susceptibility, temperature, continuous or intermittent exposure and the extent of exposure Gardiner et al. (2022), operating a lawn mower Carra et al. (2019), Edwards and Holt (2007), poor dietary choices and bad lifestyle choices such as smoking Kim et al. (2019), tools’ acceleration levels, duration of exposure, grip force required, structure of the work surface, working posture, climatic conditions and individual susceptibility Ye et al. (2015), individual worker susceptibility and the frequency, duration and amplitude of exposure Edwards et al. (2020). Cold climatic conditions (Shen & House, 2017), level of insulation, grip strength, body part affected by vibration source, maintenance / repair tools or instruments ilir (2016) are all risk factors that contribute to HAVS.
Interestingly, some critical HAVS aspects that were identified in literature were not identified during the analysis, these included but were not limited to: control and management of HAVS, health surveillance, legislation in respect to vibration exposure and risk factors. This finding could serve as an affirmation that developing countries are indeed lagging behind in respect to research on HAVS.

5. Conclusion

Frequent exposure to vibration has debilitating effects on the human body, which depending on the extent of exposure and individual susceptibility, could lead to permanent disability. However, vibration is not getting the attention it deserves, especially in developing countries. Evidently, data on HAVS in developing countries is scant. In fact, the disease is underdiagnosed and underreported, thus impeding policy formulation and regularization. On a global perspective, a lot can be learnt from developed countries, as these have pioneered research on HAVS, with most of these countries having significant data and experiment results on the subject matter. In conclusion, there is need for better control of HAVS vibration occupational exposure in developing countries.

The study analyzed 91 articles from fourteen developing countries that were published from 2002 to 2022. Notably, research on HAVS in developing countries is on the rise. The Scopus database was used because of its enormous collection of abstracts and citation. This study made a significant contribution by providing insight into the current body of knowledge on HAVS in developing countries, and the trends of these studies were determined. Furthermore, bibliometric analysis enabled the identification of potential research directions. Potential areas for further research could entail conducting similar research, albeit for developing countries. Moreover, scientific and clinical studies that span years covering the prognosis of individuals with vibration exposure, their diagnosis and management & control of HAVS could be explored.

Acknowledgments
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E-Learning Challenges Faced by Construction Management Students in South African institutions during Covid-19 Pandemic

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ABSTRACT AND KEYWORDS

Purpose of this paper
E-learning has become necessary in education because it substituted physical contact-based teaching and became a learning tool during the Covid-19 pandemic. The education sector has emphasised the benefits of e-learning on student performance and given less attention to the challenges e-learning students face. These e-learning challenges must be well-addressed to have a minor influence on South African institutions’ student performance. Therefore, this study aims to evaluate the e-learning challenges faced by students during covid-19 and possible solutions that higher education institutions can implement to minimise these challenges.

Design/methodology/approach
This study seeks to adopt a scoping review method for reviewing published Journal articles in this study context. The authors used the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines to report the findings of this scoping review paper.

Findings
Despite providing ease and flexibility for lecturers and students, the online teaching and learning approach has drawbacks, especially for students. The key findings of this study are that students struggle with technical and technological issues and lack motivation and pedagogical skills. According to the paper’s conclusion, the shift to online learning has created a chance to learn from unusual circumstances and could be advantageous for most students in conjunction with technological advancements.

Research limitations/implications
The study was limited to students in South African higher education institutions.

What is the original/value of paper?
This study will add to the knowledge of innovative education in South African institutions for lecturers and construction students while positively impacting the construction industry.

KEYWORDS: e-learning, students challenges, higher education, covid-19, performance
1. INTRODUCTION

Coronavirus (Covid-19) poses tremendous challenges for educational development, the disease was discovered in December 2019, and it is defined as a communicable disease caused by a newly detected severe acute respiratory syndrome corona virus-2 (SARS-CoV-2) (WHO 2020). The outbreak began in Wuhan, China, and rapidly spread, affecting many countries worldwide, forcing all organisations to shift their operations to online mode (Zhu, Wei and Niu 2020). The government recognised or has proven that a large number of Covid-19 reported deaths and cases of infected people is increasing daily. Due to the terrifying circumstances brought on by the high number of reported deaths, all countries worldwide were forced to be on lockdown, and many South Africans believed that the world and their enterprises might end. (Hedding et al. 2020).

However, it has harmed teaching and learning as educational institutions across the country were forced to close for an undetermined period. Many countries have shifted from face-to-face learning to e-learning due to the pandemic. However, it has been discovered that the shift has a negative impact on student learning and performance (Huang et al. 2020). E-learning systems provide a leading platform for interactive learning anytime and from any location as long as users are connected to the system through the internet, e.g., learning management systems (LMS) are web-based software for distributing, tracking and managing courses over the internet, and you can access the system from a computer or a phone anytime (Keis et al. 2017). However, the substantial reliance on the usage of e-learning during the pandemic, not only for higher education institutions but also for students and lecturers, has become a challenge as they find it difficult to acquire and implement Information and communication technologies (ICT) skills used.

Most of the studies that researchers have conducted focused on revealing general challenges that prohibit the implementation of e-learning (Okereke et al. 2020; K. Elberkawi et al. 2022); there have been limited studies that focus on the e-learning challenges faced by students in South African institutions during the pandemic. The successful adoption of e-learning depends on overcoming users' challenges. Examining e-learning problems may help stakeholders, such as higher education institutions and policymakers, meet the demands of e-learning users, such as students and lecturers, to properly deploy e-learning. Given the importance of continuous learning in this difficult time, this study seeks to explore the challenges being faced by students in higher education institutions during the COVID-19 pandemic and suggest possible solutions.

2. LITERATURE REVIEW

This section examines the literature on e-learning challenges faced by students during the Covid-19 pandemic. Its users' adoption of an information system determines its success (Almaiah, Al-Khasawneh and Althunibat 2020). Numerous studies on the benefits of e-learning have been published. Lack of attention to aspects that impact user acceptability of e-learning may prove to be a challenge in e-learning. A study by (Khan et al. 2021) specifies students’ perception of e-learning during the covid-19 pandemic in India. The study's findings show that students have a good attitude toward e-learning and welcome this new learning approach. It also objectively highlighted the importance of e-learning during the COVID-19 pandemic. Indeed, e-learning has evolved as a new method of increasing the learning process, and social media may help to increase the learning output even further. According to many users, a study by (Gautam 2020; Mukhtar et al. 2020) also highlighted that online learning ensures that e-learning can be managed and that learners may easily access lecturers and instructional resources. Additionally, it reduced the effort, travel, and other costs associated with conventional learning.

Another body of literature that examines challenges in e-learning is in the context of challenges faced by universities and academics in specific cases. For instance (Islam, Beer and Slack 2015) explore e-learning challenges academics face in higher education. Here, the author reveals several challenges academics face using a literature review method, including learning styles and cultural challenges, pedagogical e-learning challenges, technological challenges, and time management challenges. The findings imply that these challenges must be addressed in the order in order to implement e-learning successfully.
(Kibuku, Ochieng and Wausi 2020) explores e-learning challenges faced by universities in Kenya and some of these challenges are in line with a review of studies on Covid-19 and e-learning: the challenges of students in tertiary institutions by (Aboagye, Yawson and Appiah 2021)

**METHODOLOGY**

This study used scoping review method to investigate e-learning challenges faced by students in higher education during the Covid-19 pandemic. Scoping review map a given field, summarising a range of evidence to convey the field's breadth and depth (Levac, Colquhoun & O'Brien, 2010). This study adopted a scoping review frame (Levac et al., 2010). In scoping reviews, guidelines are recommended to ease the scoping review reporting and transparency. Furthermore, a methodological framework for scoping reviews provides recommendations for clarity at each stage, which increases consistency. The following five steps are employed in this study.

1. Identifying the research question
2. Identifying relevant studies
3. Selecting the studies
4. Charting the data
5. Collating, summarising and reporting the results

In this study, the following inclusion criteria were used: peer-reviewed articles on e-learning challenges faced by students during Covid-19 in the context of South Africa, published in English. Exclusion criteria include book reviews, interviews, website information and non-English language studies. This scoping review focused on South Africa due to its advancement of digital learning during the pandemic.

3.1 Step one: Identifying the research questions

Identifying relevant research questions provides a roadmap for subsequent stages. The following research question was addressed in this scoping review.

1. What are the e-learning challenges students in South African Institutions faced during the Covid-19 pandemic? This analysis of the e-learning challenges forms the basis for the ongoing research that seeks to explore and suggest possible solutions to address some of these challenges.

3.2 Step two: Identifying relevant studies

Before identifying relevant studies, searching strategies were invented, which identified where to search, what terms to use, sources to search, and time and language, as recommended by (Levac, Colquhoun and O'Brien 2010). Publication dates were limited to a period ranging from 14 March 2020 to 31 December 2021. The beginning of 2020 marked the beginning of the impact of COVID-19 on the way construction education was delivered in the 2020 academic year.

The reviewed papers were obtained from various sources such as Google Scholar, Scopus, and Science Direct. The search was restricted by using the key terms in conjunction with "AND "to identify materials published between the years 2020.

3.3 Step three: Selecting relevant papers

A total of 1223 articles were retrieved, including 1123 from databases and 100 from Google Scholar searches. After removing the 520 duplicates, 703 remained for title screening. Sixty-six articles were chosen for further screening the abstract based on the inclusion and exclusion criteria. After the abstract screening and assessing the complete text, seven articles were considered relevant to be included in the data set for collating, summarising and reporting the results. A Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram was used to report the final number once the review had been done.

3.4 Step four: Charting the data

Seven articles included in this study were read several times to ascertain that all necessary information was included. According to (Levac, Colquhoun and O'Brien 2010), it is vital to develop a data charting
form and use it to extract the information from each study. In this study, the data we extracted was presented in the form of a table which includes: Authors, Aim, Topic focus, Research design, Population, Findings and DOI.

3.5 Step five: Collating, summarising, and reporting the results

In this phase, extracted collected data were analysed using a suggested inductive thematic synthesis approach and descriptive analysis (Cruzes and Dyba 2011). An organising matrix was made, and pertinent passages from each study's material were inserted to extract the data. And then compressed. The results from each study report were entered into NVivo (version 12), systematically coded and afterwards categorised into common themes according to the study's goals. Themes were developed after thoroughly analysing all the codes from all the chosen publications. Then, groups of themes were created. Each step of the framework for scoping review was adhered to achieve credibility. The research topic was resolved based on the information gleaned through a collaborative synthesis of the data.

Fig. 1: Flowchart of the study selection process
4. RESULTS & DISCUSSIONS

This section examines the review's findings, particularly the challenges of e-learning during the Covid-19 pandemic. The study of these challenges only focuses primarily on students who are found to be the most people affected by e-learning during the pandemic. A summary of yeh reviewed studies is provided in Appendix A. The concept and types of e-learning challenges serve as the foundation for this scoping review explored by the publication. Research themes and recommendations for future studies were also explored.

Of the 7 empirical studies included in this study, 80% (n = 5) used review methods, 20% (n = 2) used quantitative method see Figure .2. The majority of the selected studies were conducted with a focus on tertiary students (60%; n = 3), followed by university (20%; n = 2); both university and students (20%, n = 2) see Figure .3. The selected seven studies covered a wide range of e-learning challenges in higher education institutions. Some of them covered multiple aspects simultaneously (Table 1). Few topics focused on the concept of e-learning challenges faced by students during Covid-19 (n = 2), the process for embedding technology solutions in universities (n = 1) and few focused on the tools used in e-learning (n= 1). Most selected studies focused on challenges faced by universities and academics to support learning and teaching, including e-learning challenges faced by universities (n = 2) and universities and academics (n = 1). Few studies focused on students' experiences (n =2). Four main themes arose from the summary of the data. Themes are discussed in turn with supporting evidence from relevant studies. These themes are (i) Technical issues, (ii)Pedagogical Skills and Motivation, and (iii) Technology.

![Figure 2: Methods used in articles](image-url)
The study results confirm that e-learning challenges faced by students have been under research for years (Islam, Beer and Slack 2015). The reviewed studies adopted multi-methods comprising reports, literature reviews, case examples, and questionnaire surveys. The analysis adopted in the various studies included statistical analysis (descriptive statistics) and hybrid analysis. Most studies are based on statistical analysis and reviews. Furthermore, only a few studies were published in academic journals and conferences. This study identified four distinct challenges research themes: Technical, Pedagogical skills and motivation, Technology and case examples of e-learning challenges, as discussed below.

4.1 Technical issues

The use of Technology in higher education is a challenge. Compared to the desire for learning success and the extensive usage of e-learning technologies, technical support for students is limited. The strong desire is met with insufficient infrastructure and technical aid. (Barua et al. 2021) implementation of e-learning is particularly challenging in low-middle income countries. Lack of Technology, internet access, poor quality of internet services and infrastructure are barriers that impact both learners and faculty members.

Regarding challenges of implementation of e-learning, participants reported issues like the non-availability of available high-speed internet uniformly, which was an essential requirement of e-classes. (Aboagye, Yawson and Appiah 2020) indicated that accessibility of the internet, smartphones and laptops was one of the issues faced by students during Covid-19. The author further stated that this might be caused by different geographical locations used by the students. South Africa is a developing country; this issue significantly impacts students as the country has internet issues in other places.

4.2 Pedagogical Skills and Motivation

(Kibuku, Ochieng and Wausi 2020) The sessional paper proposed the following policy actions to address this challenge: compulsory ICT training for all students and lecturers, ensuring ICT competencies are acquired by all the end users, continuous training of students to maintain the ICT competencies and development and implementation of ICT education, also a Training Strategic Plan. (Aboagye, Yawson and Appiah 2020) stated that the unwillingness to adapt to the new way of learning may fail to implement online learning. Therefore, students need to be motivated as they are not ready for the new approach to learning. Digital skills are one of the requirements in e-learning students, and lecturers should be able to possess digital competence that is not limited to education but all spheres of life. (Adedoyin and Soykan 2020) states that students with low or lacking digital skills are liable to lack behind during online learning classes. Due to educational transformation during the pandemic, this paper proposes that libraries, departments and faculties need to work hand in hand to help the students fit for the course by providing classes for digital skills. (Barua et al. 2021) Among study participants in the author's study, (13.2%) reported a lack of self-motivation to attend e-classes. The author further stated that to motivate students, teachers should consider using animation, clear
organisation of materials, quizzes and explaining the importance of e-learning. Training sessions should be implemented to improve technological skills among students.

4.3 Technology

The delivery of e-learning depends on a flourishing ICT infrastructure which is far from satisfactory. South Africa is characterised by a significant digital divide between the urban and rural areas regarding ICT infrastructure and internet access which averages 69% (Kibuku, Ochieng and Wausi 2020). Technological challenges refer to development issues such as bugs, speed, errors, functions and features not correctly working or do not work according to what students require (Islam, Beer and Slack 2015). In reviewing e-learning literature, there are various criticisms of the quality of the e-learning systems currently being used. There are issues raised that include: usability problems and lousy performance. (Adedoyin and Soykan 2020) outlined that e-learning only depends on technological equipment, which is one of the challenges faced by the students, the author further states that students with outdated technological devices were facing difficulties in meeting up the requirements of e-learning platforms.

5. CONCLUSION

This research provides an overview of the e-learning challenges that students experienced during the covid-19 pandemic. The current scoping review revealed that after covid-19, most empirical studies focused on the benefits of e-learning during the pandemic. A few papers explored the concepts of e-learning challenges faced by students in higher education institutions. Having investigated, we identified and categorised challenges into themes and the points above view after reviewing seven articles in 2020. We recognise that students are being challenged not just by traditional Technology and self-regulation. Furthermore, students are impeded by competency and operational challenges while using e-learning resources. Such as a lack of e-learning training, lecturers are also worried about isolation issues such as loneliness in online lessons and maintaining a work-life balance when studying at home.
The authors present the issues and experience of conducting online medical teaching practices in China with the aim of communicating them to our peers in other countries or regions when examining the transition to e-learning during the COVID-19 pandemic and beyond.

To find out e-learning experience among medical undergraduates to help improve its format. 2. To assess students' perspectives regarding challenges and future scope of implementation of e-learning in medical education

E-learning in medical education: students' experience, challenges and perspectives: a cross-sectional study in India

A cross-sectional study was conducted among 537 undergraduate medical students in an Indian medical college using Google forms.

Data connectivity for e-classes was good/ average for 436 (81.2%) while poor data connectivity was reported by 101 (18.8%). Regarding online class participation, 285 (53.07%) students missed joining some classes due to network or other issues.

It is of great importance to investigate and improve online learning in the context of COVID-19

Challenges and coping strategies of online learning for college students in the context of COVID-19: A survey of Chinese universities

This study distributed online questionnaires to undergraduate and postgraduate students from 30 provinces or municipalities in China

A total of 645 questionnaires were received, of which 622 were valid and 23 were invalid.

Regarding the physical and mental health during online learning, most students had experienced eye strain (84%) and cervical stiff (79%), while anxiety is the most prominent mental issue (66% of occurrence).

This paper therefore aims to present a literature review of the challenges faced in the implementation and provision of e-Learning in universities in Kenya.

e-Learning Challenges Faced by Universities in Kenya: A Literature Review

The scoping review method was used to identify and analyse the literature of the e-Learning challenges

Universities in Kenya

The scoping review method was used to identify and analyse the literature of the e-Learning challenges. Some of the challenges revealed include: lack of adequate e-Learning policies, inadequate Information and
<table>
<thead>
<tr>
<th></th>
<th>Name</th>
<th>Challenges</th>
<th>Source</th>
<th>Literature Review</th>
<th>Challenges Faced by Academics in Higher Education</th>
<th>Academics in Higher Education</th>
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</thead>
<tbody>
<tr>
<td>5.</td>
<td>Olasile Babatunde and Emrah Soykan</td>
<td>challenges experienced during this pandemic are well explored and transformed to opportunities</td>
<td>Covid-19 pandemic and online learning: the challenges and opportunities</td>
<td>A literature review</td>
<td>To address digital competence as an emergency remote teaching problem, Ala-Mutka et al. (2008) suggested that educational institutions need not design a separate platform for learning digital skills, but it should be embedded in teaching and learning process of all subject</td>
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<td>6.</td>
<td>Nurul Islam, Martin Beer, Frances Slack</td>
<td>this paper identifies gaps in e-learning literature and calls for further works on this subject</td>
<td>E-Learning Challenges Faced by Academics in Higher Education</td>
<td>A literature review</td>
<td>The literature review has identified a gap in research existing in understanding the academics' perspective. There are many areas within this perspective that give cause for concern; they have been grouped as challenges facing higher education institutions. The five broad categories are: learning style and cultural challenges, pedagogical e-learning challenges, technological challenges, technical training challenges and time management challenges</td>
<td></td>
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<tr>
<td>7.</td>
<td>Emmanuel Aboagye, Joseph</td>
<td>The present study explores the challenges students in tertiary institutions have</td>
<td>COVID-19 and E-Learning: the current study was conducted using a sample (n = 141), an initial</td>
<td>The study revealed that accessibility is the most important challenge students</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. References


Gautam, P. 2020. Advantages and disadvantages of online learning. E-Learning Industry,


Keis, O., Grab, C., Schneider, A. and Ochsner, W. 2017. Online or face-to-face instruction? A qualitative study on the electrocardiogram course at the University of Ulm to examine why students choose a particular format. BMC Med Educ, 17 (1): 194. 15


The Utilization of Implementing Agents in Providing Infrastructure Management Capabilities in South African Municipalities: Emerging Lessons

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ABSTRACT & KEYWORDS

Purpose of this paper
The purpose of the study is to investigate the utilization of IA to provide IM capabilities in South African municipalities. This study aims to fill this research gap and explicit agreement design and explore some lessons from the perspective of maximizing the municipalities’ net benefits, to minimize asymmetric information on either of the GCC prescripts and MFMA and reduce its negative impacts.

Design/methodology/approach
This study employs principal agent economic theory and has adopted a case study method of investigation. The official representatives of the IA and the managers entrusted with infrastructure projects in the three case study municipalities, are at the forefront of the investigation. This ongoing study will further obtain qualitative data from the interviews with the stakeholders in the infrastructure delivery departments and enterprise programme management offices (EPMO) of the selected case study municipalities. The information gathered from interviews will be carefully documented. The study employs principal agent economic theory to evaluate and synchronize the prescripts that regulate the relationship between principals and agents, allowing them to make day-to-day decisions while guaranteeing that the agent operates in the principals' best interests. The fundamental issue in an agency partnership is constructing a contract that directs the engagement because neither party's efforts are always evident.

Findings
The information gathered from interviews will be carefully documented. Thematic analysis of interview results and critical variations between the General Conditions of Contract (GCC) and the Municipal Finance Management Act (MFMA) will be undertaken. Several studies (Páez-Pérez, and Sánchez-Silva, 2019; Glas, 2017, Khatleli, 2018; Patrucco, et al, 2019; Gong et. al., 2019) have indicated that quality can indeed be sacrificed, if the providers of infrastructure services are for-profit, and government departments lack comprehensive knowledge of General Conditions of Contract (GCC) for construction works to enable quality monitoring capabilities. The contract takes the center stage on construction projects as the most significant tool for guiding and influencing the behavior of the agent and contractor. According to (National Treasury, 2018; Mazele and Amoah, 2021) the perfect contract must create a precise balance between the incentives and sanctions imposed on the agent in order to ensure mutually beneficial optimal performance. Both the municipalities (principal) and the agent seem to understand value for money, avoiding cost overruns, and exercising due diligence in handling variation. On the contrary, there were no synergies about whose legislative precepts, whether GCC or MFMA, took precedence in administering infrastructure projects in municipalities.

Research limitations/implications (if applicable)
The limitation of this case study is the generalization of the findings.

Practical implications
The outcomes of this study have important consequences for the specific implementing agent contract design in terms of limiting asymmetric information and reducing its negative effects to meet all parties' value for money aim. There is a growing interest to utilise implementing agents in the local government sector, and the related practical implications towards increasing the IM capabilities in low-capacity municipalities. Therefore, it is recommended that there has to be an explicit agreement that synchronizes both GCC prescripts and MFMA legislative requirements.
Keywords: Implementing Agents, service delivery, engineering skills, GCC, MFMA, low-capacity municipalities

Introduction and Background to the Problem

The importance of government implementing agencies in expediting the construction of quality infrastructure and fostering cost-effective, integrated, long-term infrastructure planning and delivery has piqued interest around the world (Páez-Pérez, and Sánchez-Silva, 2019; Glas, 2017, Patrucco, et al, 2019). Similarly, for South African municipalities inadequate supply chain management processes obstruct infrastructure procurement and delivery, making it difficult to achieve value for money and high-quality service delivery (MFMA, 2005; National Treasury, 2018; Mazele & Amoah, 2021). The contribution of implementing agents in government procurement allows for greater flexibility in adapting to the diversity and variability of demand. The municipality's approach to procuring infrastructure management services from other government agencies has become a critical component of meeting the increased demand for resilient municipal service delivery. The principal, in this case, the low-capacity municipality, is forced to procure an agent with engineering skills and expertise to carry out infrastructure procurement, construction and monitoring responsibilities on its behalf. Consequently, the gap in literature has been an explicit agreement that minimize asymmetric information and stimulates the agent to work efficiently while also ensuring that the principal compensates the agent fairly for their efforts. This study aims to fill this research gap and explicit agreement design and explore some lessons from the perspective of maximizing the municipalities’ net benefits, to minimize asymmetric information on either of the GCC prescripts and MFMA and reduce its negative impacts.

Aims of the research

The study's main purpose is to determine how and why contracts for implementing agents for governmental entities might assist municipalities in managing their infrastructure.

Study Area

The Eastern Cape Province has been selected as the study area representative of the precise attributes of municipalities under enquiry. The embeddedness of case study design in answering how and why these category municipalities are experiencing the most infrastructure procurement challenges, makes it the proven choice for this study (Ridder, 2017). According to the Standard for Infrastructure Procurement and Delivery Management (SIPDM), the OR Tambo district municipalities in the Eastern Cape perform the lowest on infrastructure procurement scores and service delivery indicators (National Treasury, 2018). Furthermore, the local municipalities of Nyandeni, Mhlonlo, and Port St Johns in the OR Tambo district of the Eastern Cape Province of South Africa have been chosen as case studies because they had previously used implementing agency contract arrangements with other state organs. (Mazele and Amoah, 2021).
Theoretical Framework

The Principal Agency Theory

The study employs principal agent economic theory to evaluate and synchronize the prescripts that regulate the relationship between principals and agents, allowing them to make day-to-day decisions while guaranteeing that the agent operates in the principals’ best interests (Gong et. al., 2019). The fundamental issue in an agency partnership is constructing a contract that directs the engagement because neither party’s efforts are always evident (Páez-Pérez, and Sánchez-Silva, 2019; Glas, 2017, Patrucco, et al, 2019).

In any government acquisition, asymmetric information may occur, which, Gong et. al., (2019) believe is at the basis of principal agent theory. Several studies (Páez-Pérez, and Sánchez-Silva, 2019; Glas, 2017, Khatleli, 2018; Patrucco, et al, 2019; Gong et. al., 2019) have indicated that quality can indeed be sacrificed, if the providers of infrastructure services are for-profit, and government departments lack comprehensive knowledge of General Conditions of Contract (GCC) for construction works to enable quality monitoring capabilities (SAICE, 2019). Páez-Pérez, and Sánchez-Silva (2019) maintains that asymmetric information results in imperfect supervisory measures. Therefore, the contract takes the center stage on construction projects as the most significant tool for guiding and influencing the behavior of the agent and contractor. According to (National Treasury, 2018; Mazele and Amoah, 2021) the perfect contract must create a precise balance between the incentives and sanctions imposed on the agent in order to ensure mutually beneficial optimal performance.

4.2 Research Methodology

Qualitative research can be conducted in different ways. In the discipline of construction management, case study is one of the most often utilized qualitative research methodologies; nonetheless, case study design and implementation remain a complex and disputed problem among researchers (Ridder, 2017; Saunders et, al., 2019). The case study technique was utilized to identify research subjects in this study, with preset features (Creswell, 2014). Case study as a research technique has developed as a natural choice for researchers who want to analyze real-life occurrences on a small scale or compare a small number of municipalities in this case. While the case study method has been criticized for appearing to lack rigor Rashi (2019), the utilization of multiple case studies to analyze a single phenomenon, as well as an emphasis on a well-structured study design was found essential for the study. Saunders et, al., (2019) deemed interviews essential for case study research because of their richness. Interviews were a crucial part of this study since they allowed respondents to discuss their own practices. Open-ended interviews were held with all the official representatives of the IA and the managers entrusted with infrastructure projects in the three case study municipalities.
Table 5. Background and Experience levels of the Respondents.

<table>
<thead>
<tr>
<th>Case Study Municipalities</th>
<th>Highest Qualifications and Professional Registration (Municipal EPMO/ Technical Managers)</th>
<th>Municipal Technical Managers Years’ experience</th>
<th>Highest Qualifications and Professional Registration (Implementing Agent Representatives)</th>
<th>Implementing Agent Representatives Years’ experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nyandeni Local Municipality</td>
<td>B Tech 9</td>
<td></td>
<td>MSc Engineering, Pr Eng 26</td>
<td></td>
</tr>
<tr>
<td>Mhlontlo Local Municipality</td>
<td>Diploma in Civil Engineering 7</td>
<td></td>
<td>BEng (Civil), BEng (Hons) (Structural) 22</td>
<td></td>
</tr>
<tr>
<td>Port St Johns Local Municipality</td>
<td>Civil Engineering Technician 6</td>
<td></td>
<td>BEng (Civil), Pr Eng 18</td>
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</tbody>
</table>

Results of the Study

There were important observations made on the implementing agent's contract after conducting interviews with the infrastructure delivery departments and enterprise programme management offices (EPMO) of the selected case study municipalities. Both the municipalities (principal) and the agent seem to understand value for money, avoiding cost overruns, and exercising due diligence in handling variation. On the contrary, there were no synergies about whose legislative prescripts, whether GCC or MFMA, took precedence in administering infrastructure projects in municipalities.

Covid-19 was unexpected a few months ago, but because it is still present today, it is evident that parties should begin working together to identify ways to mitigate the situation and agree on the best course of action for the benefit of both parties. The municipality's position on covid claims was noteworthy, that contractors may only claim direct costs, otherwise, processing generic covid claims would be considered wasteful expenditure under the MFMA. Whereas, in their adjudication of covid claims guided by the GCC, the agent believed the contractors were eligible for reimbursement of full costs, thereby invalidating the MFMA's prescripts. In adjudicating the claims, implement agents are of the opinion that contractors are entitled to an extension of time claim even if the supply chain contract expiry dates have past because access to the site was restricted or non-existent during covid. The municipalities (principal) maintained that would have been in contravention of the MFMA if the agents were to consider only the GCC in their deliberations for the extension of time claims. Both the agent and the principal agree that projects should not be left unfinished; either an extension of time has been allowed, or penalties have been imposed if projects are not completed on time.

Recommendations

Following the completion of this research, several findings were reached. Working on construction projects and, more specifically, building contracts, agents occasionally run into conflicting prescripts, and legal departments are usually the last resort for resolving claims to be processed. The outcomes of this study have important consequences for the specific implementing agent contract design in terms
of limiting asymmetric information and reducing its negative effects to meet all parties' value for money aims.

References


Eliciting Key Enablers of Development and Sustainability of Small and Medium-sized Contractors: A case of Namibia

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ABSTRACT AND KEYWORDS

Purpose of this paper
This study sought to establish the key enablers of development and sustainability of small and medium-sized contractors (SMCs) in Namibia.

Design/methodology/approach
The study adopted industrywide semi-structured interviews with twenty-two (22) construction stakeholders who were purposively selected. Data were analysed using thematic and frequency analysis.

Findings
The findings revealed five (5) key enablers of SMC development and sustainability which include an enabling construction business environment, training of SMCs, provision of adequate and affordable capital finance, consistent work opportunities and collaborative support of public and private institutions.

Research limitations/implications
The small sample size employed precludes the study from being generalised to other settings without caution.

Practical implications
The findings of the current study could assist policymakers and other relevant stakeholders to formulate and implement apt policies and programmes that adequately respond to the developmental needs of SMCs in Namibia and similar contexts.

Originality/value of paper
The study findings could be adapted to re-engineer policies and contractor development programmes (CDPs) that enhance development and sustainability of SMCs in Namibia. Further, there is dearth of literature on key enablers of development and sustainability of SMCs in the Namibian context.

Keywords: Key enablers, SMC development and sustainability, Namibia
1. INTRODUCTION

Small and medium-sized contractors (SMCs) have been viewed as the driving force of sustainable infrastructure development in developing countries (Lello and Mtendamema, 2018; Amoah and Shakantu, 2019; Bikitsha and Amoah, 2020). Also, the contribution of SMCs to employment creation and gross domestic product worldwide is well documented (Small, Medium and Micro Enterprise Sector-SEDA, 2019; Organisation for Economic Cooperation and Development-OECD, 2019; Anugwo and Shakantu, 2020). For instance, OECD pointed out that SMCs constitute 99% of businesses in its member states, with 67% of the employable population being in the SMC sector (p.3).

Arguably, there is no universal definition of an SMC since this is often contextualised (Lello and Mtendamema, 2018; Offei, Kissi and Nani, 2019; Bikitsha and Amoah, 2020). However, the common yardstick used to define an SMC as mentioned by the cited scholars include number of full-time employees, sales turnover, income turnover, technical and managerial capabilities, and physical assets. Thus, the current study adopted the definition enshrined in the National Policy on Micro, Small and Medium Enterprises in Namibia (2016: p.11) which views an SMC as an enterprise with full-time employees ranging from 11 to 100 and or an annual turnover spanning from three hundred and one Namibia dollars (N$300 001) to ten million Namibia dollars (N$10 000 000).

Despite the observable contributions of SMCs in various jurisdictions, these firms encounter a myriad of teething challenges that impede their meaningful development and sustainability as highlighted by vast scholars (Iyagba and Mafimidiwo, 2016; Hove, 2016; Asante, Kissi and Badu, 2017; Akinsiku and Oyediran, 2020). In the context of the current study, development refers to improved performance in terms of the number of employees, annual turnover, technical and managerial capabilities, physical assets, and capital outlay (Saga, Masurek and Montfort, 2015; Arther-Aidoo, Aigbavboa and Thwala, 2018; Lello and Mtendamema 2018; Diabate, Sibiri, Wang and Yu, 2019). On the other hand, sustainability is viewed in the current study as the SMC’s survival instinct or adaptability capacity as advanced by Watts, Cope and Hulme (1998: p.103). Therefore, inadequate financing (Hove, 2016; Amamege, 2019), technical and managerial ineptness (Aigbavboa and Thwala, 2014; Kulemeka, Kululanga and Morton, 2015, Tayeh, Alaloul and Muaisen, 2019), lack of strategic planning (Anugwo, Shakantu, Saidu and Adamu, 2017; Anugwo and Shakantu, 2020) and insufficient technological prowess (OECD, 2019) were observed as predominant challenges encountered by SMCs globally.

Notably, the phenomenon has been incessant for a couple of decades as evidenced in previous studies from varied countries like Ghana (Eyiah, 2001, Eyiah and Cook, 2003; Laryea, 2010), Swaziland (Thwala and Mvubu, 2009) and South Africa (Thwala and Phaladi, 2009; Martin and Root, 2012; Mofokeng and Thwala, 2013) where SMCs continue to experience sustainability challenges. As a result, most SMCs discontinue businesses within five (5) years of their existence (Anugwo and Shakantu, 2016; Adediran and Windapo, 2017; Atanga, 2019). In a way, this inadvertently perpetuate unsustainable infrastructure development in developing countries, as observed by Akinsiku and Oyediran (2020) in the Nigeria context. Going by the argument of the proponents of Africapitalism ideology who advance that sustainable economic development is largely attainable by developing domesticated solutions (Idemudia, Amaeshi and Okupe, 2018; Idemudia and Amaeshi, 2019), SMCs are strategic drivers of sustainable infrastructure development in developing countries, hence strong need support.

In proffering solutions to the ongoing predicament, extant literature shows that concerted efforts were made by governments, researchers, and practitioners as early as 1980 to stimulate development of SMCs. This is evidenced by the work of scholars like Ofiri (1980a; 1991; 1996; 2002; 2015), Adams (1995; 1996; 1997; 1998; 2002) and Martin and Root (1996). Ofiri observed in the early 1980s that finance and technical issues predominantly retarded growth of SMCs, which intrigued the then stakeholders to pay their focus on addressing finance through various strategies while ignoring other critical factors. Consequently, the efforts failed to yield expected results thereby intriguing Ofiri to make a clarion call to develop a comprehensive approach in a bid to address the plight of SMCs. Since then, Ofiri argued that addressing a single factor like finance would be inadequate, since SMCs’ survival and growth are thwarted by a myriad of factors. In a later study, Ofiri (1991) pinpointed that comprehensive contractor development programmes (CDPs) in developing countries should be country specific, coupled with specific, measurable, realistic, and time-bound (SMART) objectives, as well as effecting monitoring, evaluation, and timely review of such programmes. This is corroborated by Adams who reviewed CDPs in Nigeria (Adams, 1995; 1996;1997) and discovered that previous programmes
had put emphasis on finance and provision of work supply while paying little attention to the training of SMCs. According to Adams, this culminated in high failure rate of SMCs in Nigeria. In a study that assessed the relative importance of training against other factors, Adams (2002) observed that training was ranked among the top critical measures required to transform SMCs. Based on the findings, Adams recommended that training should be a prerequisite of other interventions. This argument stems from the fact that providing finance and work opportunities to SMCs without firstly equip them with the requisite skills to diligently execute the work would not accentuate their growth. In fact, most of them were reportedly squandered the money and abandoned projects or upper subcontracted projects to larger foreign companies as noted about two decades ago by Reeves (2002: p.417) in the Japanese construction industry.

Even though most governments took heed of the clarion call made by early researchers in terms of training, financing, and work provision (Adams, 1996;1997;1998; Dlungwana and Rwelamila, 2004, Duke and John, 2010), only few countries like Singapore (Ofori and Lean, 2001) displayed significant success. Contrarily, majority of developing countries experienced little success, particularly in Africa (Dapaah, Thwala and Musonda, 2017; Anugwo and Shakantu, 2020; Wentzel, Fapohunda and Haldenwang, 2022). Dapaah, Thwala and Musonda who assessed the impact of contractor development programmes (CDPs) on SMCs in the South African context, discovered that, despite the numerous CDPs implemented by the South African government, most SMCs did not develop as expected due to low outreach of the programmes and discontinuity of further support to supplement initial programmes. This is consistent with previous studies (Thwala and Phaladi, 2009; Martin and Root, 2012; Mofokeng and Thwala, 2013) that observed underperformance of CDPs. However, some scholars (Huda et al., 2018, Mamman et al., 2019; Bikitsha and Amoah, 2020; Santoso and Permana, 2021) lamented the absence of an enabling business environment in most developing countries which they claim to be key to the successful development and sustainability of SMCs. In addition, firm owner’s entrepreneurial culture was also noted as pivotal in determining the growth trajectory of an SMC (Weber, Genest and Connell, 2015; Adel and Habib, 2026 and Dvoulety, Srhoj and Pantea, 2021). Besides, some scholars opined that both public and private institutions need to collaborate to stimulate development and sustainability of SMCs across the globe (Asante, Kissi and Badu, 2018; Songling et al., 2018; OECD, 2019; Alkahtani, Nordin and Khani, 2020, Kawimbe, 2020; Pu et al., 2021).

Therefore, in view of the incessant low survival rate of SMCs in developing countries, the current study advance that it is critical to establish the key enablers of development and sustainability of SMCs in a bid to develop a comprehensive framework to drive and sustain these firms since they are widely regarded as propellers of sustainable socio-economic development.

2. METHODOLOGY

The current study employed semi-structured interviews. An interview guide comprising open ended questions was developed to gather diverse views from different categories of participants. The participants consisted of six (6) owners of SME contracting firms, Director of Capital Projects Management at Ministry of Works and Transport, General Manager of the Construction Industries Federation (CIF) of Namibia, two (2) consultants from Microfinance Institutions (MFIs), Head of Architecture and Spatial Planning at Namibia University of Science and Technology, Instructor at Windhoek Vocational Training Centre, register professional consultants comprising four (4) quantity surveyors, three (3) architects and three (3) civil engineers.

Thus, a total of twenty-two (22) purposively selected participants were considered for the study as indicated on Table 1. The interviews were one on one, with some conducted face to face, while others were done telephonically and through Zoom meetings. Multiple strategies were employed in collecting data because some participants could only be accessed remotely due to their busy schedules, location and or covid-19 restrictions, while others preferred physical meetings due to poor online communication infrastructure. Covid-19 protocols prescribed by World Health Organisation (WHO) and augmented by Ministry of Health and Social Services in Namibia were adhered to during face-to-face interviews. These included hands sanitization, social distancing which was about three (3) metres and face masking. Further, a soft copy document of informed consent form was emailed to each participant prior to interviews. The study minimised exchange of hardcopy documents to protect participants and researchers against Covid-19 transmission. The interview protocol involved a brief explanation of the
aim of the study, request for the participant’s consent and a pledge by the researcher to comply to ethical issues. Each interview session took an average of thirty (30) minutes which was fair and reasonable to minimise fatigue of participants. The study sought to establish the key enablers of development and sustainability of SMCs in Namibia. The main research question was on which key enablers drive development and sustainability of SMCs in Namibia. Follow up questions were also probed where it deemed necessary. The data collected through face to face and telephonic interviews were recorded using Smart Phone- Galaxy A10S, while Zoom interviews were recorded in the laptop. Recorded data were then downloaded and saved in one folder in the laptop and sent to a specialist transcriber. Thereafter, the study checked transcripts for accuracy, and then analysed using thematic analysis and frequency analysis.

<table>
<thead>
<tr>
<th>Category</th>
<th>Designation</th>
<th>Total Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>SME Contractors</td>
<td>Owners</td>
<td>6</td>
</tr>
<tr>
<td>Ministry of Works and Transport</td>
<td>Director - Capital Projects</td>
<td>1</td>
</tr>
<tr>
<td>Construction Industries Federation of Namibia</td>
<td>General Manager</td>
<td>1</td>
</tr>
<tr>
<td>Namibia University of Science and Technology</td>
<td>HoD- Architecture and Spatial Planning</td>
<td>1</td>
</tr>
<tr>
<td>Windhoek Vocational Centre</td>
<td>Instructor- Joinery and Carpentry</td>
<td>1</td>
</tr>
<tr>
<td>Microfinance institutions</td>
<td>Consultants</td>
<td>2</td>
</tr>
<tr>
<td>Registered Consultants</td>
<td>Professional Quantity Surveyors</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Architects</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Civil Engineers</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Study Participants</strong></td>
<td></td>
<td><strong>22</strong></td>
</tr>
</tbody>
</table>

3. RESULTS AND DISCUSSION

From the interviews, six (6) major themes emerged namely training, access to adequate and affordable finance, creating enabling business environment, collaborative support of public and private institutions, consistent work supply and firm owner’s entrepreneurial culture. To protect the identity of participants, coding system was employed for each participant, using P1 to P22.

**Major Theme 1: Training**

Seventy-three percent (73%) of the participants (P1, P2, P4, P5, P6, P10, P11, P13, P14, P15, P16, P17, P18, P19, P20, P22) viewed skills training as the major driver of development of SMCs. The participants pointed out that training would fill the skills gap in the construction industry P1 said:

“I think SMCs need training in different areas”. [P1]

P1 further explained that, besides apt policies and access to adequate finance, SMCs require upskilling to understand the entire construction business.

Likewise, P4 noted skills as critical in addition to financial support. P4 said:

“Finance support and skills to the SMCs”.[P4]

Also, P5 concurred with P4 by sharing that:
“I think the other key driver is skills… and skills development”. [P5]

Further, P6 also noted skills as one of the critical factor. P6 said:

“Yah for me is just skill and finance”[P6]

Again, P7 reported the previous interventions by government where it offered work opportunities and finance to contractors failed due to lack of training. P7 stated:

“Training is very critical… the government even tried to put … an association of contractors, there was an association of contractors… it did not succeed properly because of that aspect of training”. [P7]

Clearly, most owners of contracting firms mentioned skill development as one of the key drivers of SMC development. This view was supported by most construction professional consultants’ views. For instance, P13 who is a quantity surveyor said:

“There should be workshop… and it should be free of charge. I think also in terms of their employees they should also employ qualified, the qualified foreman, qualified engineers and quantity surveyors. Currently that is where they are lacking”. [P13]

Likewise, P14 shared that SMCs should have:

“Adequate qualified person on site to execute the projects… pull also the VTC into plan”. [P14]

Further, P15 mentioned that education is the key factor that SMCs should embrace before embarking on construction business. P15 expressed that:

“Education should be our key driver…”.[P15]

Similarly, P20 mentioned the need for the owners of contracting firms to possess basic construction knowledge that would be enhanced through further training. P20 shared:

“Once you registered, I think these guys should be trained. I think training should be important and that is the thing about the training that we should be doing, should not be training someone from scratch…, their knowledge should be at a certain level and then you just bridge a gap”. [P20]

On the other hand, P22 mentioned the role of government as critical in offering training facilities to SMCs. P21 opined:

“I think the government should encourage them and then give training facility that you going to be a contractor, come and understand the contract that you are signing”. [P21]

The views of P15, P20 and P22 are consistent with the sentiments by P10, who shared that:

“... anyone can become a contractor, but you expect that would obviously anticipate that they would have to have some kind of training prior to establishing a business”. [P10]

Generally, the predominant training needs cited by participants include technical skills, financial management skills, administrative skills, project management skills, marketing skills and cost estimation and tendering skills.

The results are consistent with existing literature. Literature is replete with the need to train SMCs to stimulate their development and sustainability (Mofokeng and Thwala, 2013; Rwelamila and Ogunlana, 2015; Dapaah, Thwala and Musonda, 2017; Amoah and Shakantu, 2019; Bikitscha and Amoah, 2020). The cited scholars highlighted that training is a strategic driver to improve the performance of SMCs. Where training was effectively conducted, like in Singapore (Ofori and Lean, 2001), SMCs demonstrated remarkable growth, with some have grown to the level of competing internationally.
Major Theme 2: Access to adequate and affordable finance

Forty-five percent (45%) of the participants indicated that access to adequate finance is among the major factors required to promote SMCs’ development (P1, P3, P4, P5, P6, P10, P13, P14, P16, P17, P19). For instance, P1 said:

“The government had good intentions initially when they came up SME bank. It had good intent before someone came up and messed it up for themselves because of greedy. But I think if such a facility is helping small and medium organisations or companies, I think they will help very much...”. [P1]

In concurrence, P4 shared:

“I think is only finance support. Finance support and skills to the SMCs. The government need to support the SMCs...”. [P4]

Similarly, P6 who expressed that money is required in many aspects which include securing qualified labour force, construction materials, insurance, performance guarantees, plant and equipment. P6 stated:

“Yaah, for me is just... finance. Proper labour... your materials, insurance, your performance guarantees, plant and equipment, you have to have that money...”. [P6]

Basically, start-up capital has been overly considered by participants as the main challenge among most SME contractors.

These findings are consistent with extant literature on SME financing (Ovat, 2016; Olusegun and Akinbode, 2016; Hove, 2016). Ovat mentioned that adequate financing is key for the survival of SMCs. This is supported by Anigbogu et al. (2014) who averred that inadequate finance retards the development of SMCs.

In proffering solutions to financial catastrophe, participants mentioned three strategies namely establishment of dedicated financial institution, tailormade SMCs’ financial support and timely payment of certificates by clients.

In supporting the idea of a dedicated financial institution, P5 said:

“Okay, I think first of all, we need to bring back SME bank...”. [P5]

Similarly, P13 stated:

“... if we can make finance available to them, example- the SME bank...”. [P13]

Likewise, P19 also expressed that:

“I think we need a dedicated financial institution. I know we have the Development Bank of Namibia... but what I have seen as much as it is a bank that is dedicated to infrastructure or development or projects, I think we need maybe a shift in terms of the mindset in the way they approach development projects...Because they normally approach it like a commercial bank, but yet corporate finance and project finance are totally different”. [P19]

The suggestion of a dedicated bank for contractors has been proffered by early researchers (Ofori, 1980a, Larcher, 1999; Larcher and Miles, 2000 due to the persistent reluctance of commercial banks to finance SMCs. However, where governments implemented dedicated banks like in Nigeria (Duke and John, 2010) and Ghana (Eyiah and Cook, 2003), the success rate was marginal. This was largely frustrated by SMCs’ incompetency and unethical conducts like getting money and thereafter deliberately abandon the project as alluded to by Eyiah and Cook. Nonetheless, this does not discount the nobility of the dedicated bank as Eyiah and Cook later argued that lessons could be drawn from previous failures to improve future interventions.

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Regarding tailor-made financial support, participants suggested the need to model financial support which is flexible and affordable. For instance, P21 stated:

“...tailor made loan system that accommodates them in their small way with lenient terms ... low interest rates. I think this will go a long way in helping these guys”. [P21]

Similarly, P18 and P19 added that such a customised funding could be in form of project-based finance. P18 stated:

“... maybe enforce the idea of project-based finance or project base loaning. Development Bank they would then give you funding based on a tender you got, okay and then the tenders basically use as a surety”. [P18]

On the other hand, P19 mentioned that:

“We need to learn from other institutions how infrastructure or banks fund SMCs... how they support them especially when it comes to securing performance guarantees... how they can bridge that gap to make sure that a contractor who is capable in terms of delivery but is failing in terms of financing how they can support that...”. [19]

The findings are corroborated by a plethora of studies (Gbandi and Amissah, 2014; Eferakeya, 2014, Hove, 2016). Hove who elicited financial challenges faced by emerging contractors in South Africa, found that lack of collateral is among the predominant factors that need to be relaxed. This is supported by Eferekeya who posited that banks need to relax their lending conditions. Further, Ovat (2019) argued that commercial banks need to be catalytic in financing SMCs by significantly reducing lending rates. Additionally, Nyumba, Munganda, Musienga and Masinde (2010) in a study in Kenya observed that high interests impoverish SMCs by eroding potential profits and working capital. Thus, it is critical that financial institutions relax their conditions and develop a lending scheme that is adequate and affordable to SMCs.

Pertaining to the timely payment by clients, several participants indicated that this is a critical factor for improving SMCs’ cashflow. In referring to SMCs, P18 stated:

“They need be paid promptly”. [P18]

Likewise, P16 averred that payment should be guaranteed to SME contractors upon completing the works. P16 said:

“...a guaranteed time, to say okay I am going to do my work, the moment I submit my claim I get the money and after so many days, ... because we cannot expect the contractors to plan everything, and then at the end of the other line where the money issues are concerned, people will take their time to pay, ...even the banks these days they are taking their time, they hardly finance the project. Be it DBN or... they are taking their time to pay...”. [P16]

The results are in line with observations by vast scholars (Offei, Kissi and Nani, 2019; Amoah and shakantu, 2019; Bikitscha and Amoah, 2020) who pointed out that payment delays remain unabated, especially on government projects. Arguably, prompt payments are rare on construction projects as noted by Xie, Zheng, Zhang and Li (2019). Xie et al. stated that “payment is the lifeblood of construction projects” (p.1). These scholars further submitted that, despite that most contracts stipulate a period within which the client ought to settle payment for work done by the contractor, payment delays consistent characterise construction projects. As mentioned by Perera and Dewagoda (2021: p.236), this adversely impact SMCs’ working capital. Thus, it is agreeable that shortening payment period would accelerate the flow of funds, thus easing the contractor’s financial burden.

Major Theme 3: Enabling construction business environment

Fifty-five percent (55%) of the participants indicated that the Namibian construction industry is not regulated, hence free entry to anyone who wishes to start a construction company regardless of basic
understanding about construction business. Also, participants revealed that contractors are not graded or categorised, thus compete for any public project regardless of experience. This was noted as problematic and attributable to high failure rate of SMCs. As such, all the participants advocated for the creation of an enabling construction business environment. For instance, P6 stated:

“I think we need to regulate the industry. Is very important that we regulate the industry. Most of the government programs in terms of SMC development is well intended but regulation thereof is absent and that is the reason why we have failed as a nation. Let us say we have failed so much miserably because anyone could just become a contractor…”.[P6]

This is supported by P10 who stated:

“I do think that in an economic environment we find ourselves, there should be also greater focus on supporting our local contractors, whether they are large size or smaller contractors, that will ultimately help them to grow and hopefully a sustainable future provided that there is the right legislative environment in place”.[P10]

Further, P14 expressed:

“…we have… to regulate the construction industry… We have different people from different industries entering the construction industry without even having the knowhow or how to actually do and carry out this construction processes and I mean looking at it here it is more than 30 years now and we still have the same issues which has been raised 5 years ago, 10 years ago where the SMCs getting projects and they are not executing them as per industry standards”.[P14]

Also, P15 shared that:

“What I noted now is that there has not been extensive development in SMCs because the industry is not regulated, everyone becomes a contractor without skills”.[P15]

Likewise, P18 said:

“…But I think we do need some sort of a statutory body that actually controls the SMCs or the SMCs or contractors in general…It was at the moment you know if I am a builder today I go bankrupt I close that CC I open other company operate under a different name there is no real track record you know that you can monitor to see if there is actually credible contractors out there you know”.[P18]

Therefore, the results showed urgent need to create the enabling construction business environment by formulating a legislative and regulatory framework that provides for the establishment of the regulatory body, registration of contractors, and grading of contractors.

The resultants are supported by vast studies in various countries. It is evident that most countries have since established independent regulatory bodies to oversee development of their local construction industries. For instance, South Africa (CIDB, 2018; Bikitsa and Amoah, 2020), Ghana (Amoah and Shakantu, 2019), Tanzania (Lello and Mtendamena, 2018) and Nigeria (Ogbu and Asuquo, 2019) have in the past decade put in place a regulatory framework to guide development of indigenous contractors. As presented by Bikitsa and Amoah, a regulatory framework creates an enabling business environment within which SMC could thrive and grow. This is further supported Mamman et al. (2019) who emphasised the need to align SME policies to peculiarities within a given context to stimulate growth and sustainability of such organisations. Notably, both internal and external business environments largely influence development and growth of the firm (Huda, Rini, Siswoyo and Azizah, 2018; Santos and Permana, 2021), thus validate the vitality of creating a conducive business environment for SMCs to survive and grow.

Major Theme 4: Consistent work supply

Thirty-two percent (32%) of the participants (P1, P2, P3, P11, P15, P16, P17, P18) mentioned provision of work opportunities as one of the key drivers of SMC development. For instance, P1 suggested that government should reserve certain procurement threshold to SMCs. P1 stated:
“...the best thing is the government must have a deliberate policy that might be skewed towards nationalism or nationalising everything, where they say every tender below 5 million, we will give it to this size of the company...”.[P1]

On the other hand, P2 raised the importance of equitable distribution of work:

“...the distribution equality is also needed to be addressed in terms of tender distribution among the SMCs in different categories".[P2]

These sentiments are supported by P3 who briefly stated:

“Fair opportunities for all of us".[P3]

In addition, P10 mentioned the need for continuity of work supply:

“I think u need to have some continuity in terms of workflow, work provided for the sector, which makes is more sensible for the SMC to invest into the business...”.[P10]

Clearly, this continuity could be made possible by government interventions through measures like preferential procurement as mentioned by several participants (P11, P15, P16, P17, P19). P15 stated that such a measure would eliminate competition from large contractors particularly on small projects. P15 said:

“...the current situation where they are competing with the bigger firms should not be entertained because... we cannot produce local contractors if we do not give them opportunities to perform on smaller scale projects".[P15]

For example, P11 mentioned that the City of Windhoek prepares a vendor list annually for maintenance work predominated by SMCs. P11 stated:

“...I know the city of Windhoek, I think ... they have a sort of standing, sort of put out as expression of interest for small contractors to be on the...vendor list of whatever they call it and then how and they have small works they can ...procure from there...".[P11]

These findings resonate with extant literature. Previous findings by UNCHS (1996) suggested policies on contractor development should include those that promote consistent work supply among SMCs. It is evident that Singaporean SMCs grew tremendously due to the aggressive support received from the Singaporean government which included consistent work opportunities (Ofori, 2001). Rationally, work supply should be at the epicenter of any contractor development programme (CDP). This is well documented by researchers who studied on CDPs in developing countries, especially in South Africa (Mofokeng and Thwala, 2013; Adediran and Windapo, 2017; Bikitsa and Amoah, 2020) where the government introduced deliberate programmes that fostered provision of work opportunities to emerging contractors that involved road construction, housing development and general maintenance. Moreover, most countries worldwide developed policies that reserved certain type of work and procurement thresholds to SMCs (Amoah and Shakantu, 2019; OCED, 2019; Akinsiku and Oyediran, 2020). However, in a study that reviewed impact of CDPs in South Africa, Dapaah, Thwala and Musonda (2017) observed lack of consistency in the provision of work and other critical interventions like mentorship programmes.

Major Theme 5: Public and private sector collaborative support

One hundred percent (100%) of the participants acknowledged that both public and private institutions play a critical role in advancing SME contractors' development. These institutions include financial institutions, training institutions, material suppliers, construction professional consultants, contractors' association, international development agencies, private clients. However, enhance effective contractor development, participants suggested a coordinated approach to programmes offered by both public institutions and private institutions.
P1 stated:

“The best think I would propose is an institution that only deals with SMC needs, then that institution links to others like to suppliers and as well as to people that need to procure service, like a central body where you have the data base for SMCs, their level expertise and their needs, like an independent body on its own, I don’t know whether it can be funded by government or by SMCs themselves...”[P1]

Likewise, P2 agreed by saying:

“We need an SMC institution”.[P2]

Further, P6 suggested key stakeholders that need to collaborate include DBN, the Ministry of Works, GIPF, Ministry of Trade and Industrialisation and SME Development, Polytechnic and Namibian Training Authorities (NTA) and Namibia University of Science and Technology (NUST).

Similarly, P7 stated that:

“...government can come up with one unified organisation where they will even make efforts to channel finance, through that one unit in government and finance which will go along with the training...”.[P7]

On the other hand, P14 posited that the government and CIF should coordinate effectively unlike the current status:

“I think there is like a lack of coordination or cohesion between these two entities, the government and the regulator which are the CIF”. [P14]

Also, P17 who is a registered architect suggested that the Namibia Institute of Architects (NIA) should initiate workshops in collaboration with the Construction Industry Federation (CIF) of Namibia to capacitate SME contractors, while P11 who proposed collaboration between government and training institutions like universities and VTCs. P11 stated:

“...one would possibly have to look at sort of partnership approach between government that could structure certain initiatives... in sort of learning institutions that could offer...training opportunities that are really tailored...for financial management or whatever aspect needs to be improved ...”.[P11]

These findings are supported by vast studies. A previous study by Larcher (1999) raised similar concerns regarding fragmentation of interventions from distinct institutions. Since then, researchers and policymakers have consistently agitated for the collaboration of all relevant stakeholders in both public and private sectors to meaningfully develop SME contractors (Lello and Mtendamema, 2018; Idemudia, Amaeshi and Okupe, 2018; Idemudia and Amaeshi, 2019; OCED, 2019). While government remains instrumental in creating an enabling environment through formulation of apt policies coupled with legal and regulatory framework (Dar et al., 2017; Amoah and Amoah, 2018, Bhorat et al., 2018; Mamman et al., 2019), developing SMCs without private sectors players is daunting. Instead of leaving the burden solely on government, Amaeshi and Okupe, and Idemudia and Amaeshi opined that the private sector should aggressively drive the development agenda by supporting and mentoring small businesses. Further, there has been increasing call for the formal financial institutions like commercial and merchant banks to relax conditions avail affordable and adequate funding to SMCs (Ghandi and Amissah, 2014; Imafidon and Itoy, 2014; Taiwo, Falohun and Agwu, 2016; Ovat, 2016). In view of the current laxity in development, a robust approach encompassing all critical players is of paramount importance. A summary of the identified key enablers on Table 2.

However, while literature shows that firm owner’s entrepreneurial culture fundamentally influences growth of firms (Weber, Geneste and Connell, 2015; Lello and Mtendamema, 2018), the study findings were not explicit on that aspect, hence needs further investigation.
Table 2: Key enablers of SMC development and sustainability

<table>
<thead>
<tr>
<th>Enabler of Development</th>
<th>SME contractor Participants</th>
<th>Percentage Frequency</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative public and private institutional support</td>
<td>All</td>
<td>100%</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>• Public institutions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Private institutions i.e. financial institutions, training institutions, professional consultants, contractors associations, material suppliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• International development agencies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training</td>
<td>P1, P2, P4, P5, P6, P10, P11, P13, P14, P15, P16, P17, P18, P19, P20, P22</td>
<td>73%</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>• Technical skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Financial management</td>
<td></td>
<td></td>
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<td></td>
<td>• Administrative skills</td>
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<td></td>
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<td></td>
<td>• Project management skills</td>
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<td></td>
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<tr>
<td></td>
<td>• Marketing strategies</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Cost estimation and pricing skills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creating conducive business environment</td>
<td>P5, P6, P7, P10, P11, P14, P15, P16, P18, P20, P21, P22</td>
<td>55%</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>• Establishment of regulatory body</td>
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<td></td>
<td>• Registration of contractors</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• Grading of contractors</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Monitoring, evaluation, and upgradation of contractors</td>
<td></td>
<td></td>
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<tr>
<td>Access to adequate and affordable finance</td>
<td>P1, P3, P4, P5, P6, P10, P13, P14, P16, P19</td>
<td>45%</td>
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<tr>
<td></td>
<td>• Dedicated financial institution</td>
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<tr>
<td></td>
<td>• Tailor-made financial support from banks</td>
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</tr>
<tr>
<td></td>
<td>• Timely payment by clients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>consistent work opportunities</td>
<td>P1, P3, P11, P15, P16, P17</td>
<td>27%</td>
<td>5</td>
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</table>

4. CONCLUSIONS AND RECOMMENDATIONS

This study sought to establish key enablers of development and sustainability of SMCs. Based on the findings, it is concluded that the key enablers of development and sustainability of contractors include collaborative public and private institutions’ support, training, enabling construction business environment, access to adequate and affordable financing and consistent work supply. The study advances that funding should be tailormade to reflect low cost of capital and adequate for the project (s) being executed by the SMC. Further, consistent work supply is critical in stimulating growth of SMC since inconsistent work supply retards growth and or leads to premature closure of SMC business. Besides, it envisaged that these factors ought to be integrated for effective development of SMCs.

Consequently, the study recommends the inclusion of the five (5) identified key enablers in the development of a framework which catalyses development and sustainability of SMCs in Namibia.

5. REFERENCES


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Digital technologies for enabling Construction 4.0 in the South African context

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ABSTRACT AND KEYWORDS

Purpose of this paper
The paper reports the preliminary results from a study on how to leverage digital technologies to enable Construction 4.0, which is inherently tied to improved construction project performance.

Design/methodology/approach
A scoping review methodology was used to compile the paper. Scoping review was chosen because the researchers are identifying knowledge gaps and to clarify concepts on a subject matter. Relevant Construction 4.0 literature was extracted from Google Scholar, EBSCO, Science Direct and Emerald.

Findings
There is evidence of improved construction project performance in the construction sector by leveraging on digital technologies. These findings thus reinforced the need to empirically test the available digital technologies in South Africa on whether they are best suited to enable a transformation, which will promote favourable project delivery outcomes.

Research limitations/implications (if applicable)
The findings of a preliminary review of the related literature showed a lack of case studies to authenticate, how digital technologies can enable Construction 4.0, especially for small contractors busy with small projects.

Practical implications (if applicable)
The changes recommended from practice as a result of this paper are that 3D Printing can be used as a key driver of enabling Construction 4.0 in South Africa. The research will serve as a basis for other studies on the subject.

Originality/value of paper
3D Printing is proposed as the primary physical digital technology identified from the existing Construction 4.0 models to drive change in South Africa. The use of Construction 4.0 leads to positive project performance related to cost, the environment and time.

Keywords: Construction 4.0, Digitisation, Transformation, Project Delivery
1. INTRODUCTION

The construction industry is forecast to expand along with the increased complexity. The sophistication of construction projects has placed more pressure on construction companies to maintain their viability and grow in the modern market. The aim of the research is on leveraging digital technologies to enable Construction 4.0 to ensure companies are able to collect data, establish trends and make better decisions. In South Africa, the construction industry is one of the most significant sectors in terms of influence over the gross domestic product (GDP) of the economy (Matete, Emuze, and Smallwood, 2016). At the beginning of 2020, the South African construction sector accounted for 2.7% of the national GDP, employing an estimated 1.3 million workers (8.3% of the country’s total employed workforce at the time). These figures were estimated off the back of a brutal 2014-2019 for this major driver of socio-economic development and a key employment multiplier.

Construction projects are complex, high-risk, and time-consuming undertakings that are usually commissioned and delivered by participants with varying cultural differences, backgrounds, political systems, and languages (Sibiya, Aigbavboa and Thwala, 2018). In addition, digital progress has transformed all industries, ushering in a new technological era known as the Fourth Industrial Revolution (4IR). This new technological era is satisfying consumer demand for better ways of doing things. Innovation has improved companies’ productivity and sustainability and redefined the skills and competencies needed to thrive (World Economic Forum, 2020).

Numerous innovative construction technologies available on the market aim to complement job functions and improve the performance of construction companies. However, in line with the diffusion of innovation theory, these technologies have not been adopted in the construction sector of many developing economies, such as South Africa, and low productivity continues to affect them. Previous research suggests that there are opportunities for the digital environment to transform the construction industry and make it more productive. Construction projects are unique, and they tend to assume a greater dimension of complexity as they increase in size. A project's success is primarily dependent upon the iron triangle of cost, time, and quality (Ali et al., 2010; Arcila, 2012). Oke et al. (2016) stated that managing time in the procurement, engineering and construction of projects is a key competing factor among innovative firms. It is believed that customers who consider time as a valuable performance indicator and resource will be keen on timely delivery of their projects and sometimes, their demand influence contractors to improve their time performance. Walker and Shen (2015) found that the time performance of construction projects is directly proportional to design team performance. Cheng et al. (2011) recognized some factors which usually affect the performance in the construction industry. Such factors were highlighted as construction methods, time management capabilities, and material depletion.

Industry 4.0 gave rise to the term Construction 4.0. Construction 4.0 is modelled after the concept of Industry 4.0; the idea of Construction 4.0 is shaped by a confluence of trends and technologies (both digital and physical) that promise to reshape the way the built environment assets are designed and constructed. Construction 4.0 may be defined more specifically as an innovative construction management technique, driven by Industry 4.0 technologies, that allows for the creation of a smart construction site. Construction 4.0 can also be implemented as a process of implementing cyber-physical systems (CPS) to encourage the digitizing of the construction industry with the intention of achieving optimum performance in the sector. It can be explained as a combination of cyber-physical technologies that supports a smart construction site, digital modelling (such as digital twin – a digital replica of potential and actual physical assets, processes, people, places, systems, and devices), simulation, and virtualization. So far, it is unclear which specific Construction 4.0 model is applicable to the South African construction sector. In enabling Construction 4.0 in South Africa, digital technologies would assist to solve the problem of excessive schedule overruns on projects which often translates to cost overruns and poor-quality issues on projects. It is therefore imperative, that a process model be developed that can guide how best to leverage digital technologies to enable Construction 4.0 in the South African context.

Over the past decade, South Africa has experienced a significant decline in economic growth (McKinsey, 2019). According to Faure (2017), this decline is a result of relatively high inflation and rising
public and external debt. Given the deterioration in the country’s macroeconomic fundamentals, Standard and Poor’s 500 (S&P’s) and Fitch have just downgraded the sovereign debt in foreign currency to speculative grade. It is hoped that increased digitisation and a faster pace of technology implementation could provide a major boost to the economic prosperity of the nation (McKinsey, 2019).

A recent study by the McKinsey Global Institute (2019) analysed the performance of seventy-one (71) developing economies over the last fifty years (50) years and identified eighteen (18) outperformers that had sustained rapid GDP growth over decades. Those countries provide valuable lessons for South Africa. They have driven a pro-growth agenda of productivity, income, and demand. As a core element of that agenda, they have fostered productive companies and highly competitive industries. By leveraging technology to improve productivity and innovation, South Africa could have the potential to adopt strategies used by these identified economies. Thus, the objective of this review paper is to highlight the need for a process model that will identify which of the digital tools can be the key driver of enabling Construction 4.0. The focus is on the key driver of physical technology and how it can initiate a transformation of construction processes to collect data, establish trends and make better business decisions.

2. PROBLEM FORMULATION

2.1 Scoping Review

In this section, a breakdown of the literature was reviewed, and the literature led to the identification of knowledge gaps that includes a lack of adoption of digital technologies for enabling Construction 4.0. The literature reviewed was important to further identify publications related to the use of digital technologies to enable Construction 4.0 in South Africa.

The main keywords that were used in this paper were: Construction 4.0, Digitization, Transformation, Project Delivery, and South Africa. Quite a number of scholarly databases were explored, such as Google Scholar, EBSCO, Science Direct and Emerald. These databases were chosen because of the high quality of research articles and journals available. About forty-two (42) published papers were searched, comprising conference papers and journal articles. The number was later refined based on appropriate titles and abstracts. The four key words provided in the abstract being Construction 4.0, Digitisation, Transformation and Project Delivery where utilised as stand-alone search items, whereby thirty-two (32) papers were of interest. In order to make it a point that the titles and abstract actually fit this survey all the papers retrieved were manually explored and analysed. Therefore, a conclusion of this study’s investigation was that research on the “digital technologies for enabling construction 4.0 in the South African context” has been increasing as indicated. The most relevant papers were read and analysed further.

This allowed the identification of trends and key areas that were covered by many papers, namely: ‘Barriers to use of digital technologies, Appraisal of stakeholders’ willingness to adopt construction 4.0 technologies for construction projects, Digital technology transformation, The use of 3D printing for enabling construction 4.0 and Construction 4.0 Models’, which represented the research scope within the ‘construction 4.0’ topic. The papers were classified according to the years. This classification shows that most of the research on Construction 4.0 was done in 2020 (14 papers) followed by 2021 (8 papers) and lastly in 2018 (10 ten papers). This is an indication that research on the usage of digital technologies to enable construction 4.0 has been increasing over the years and there is more exposure and understating around this space.

The continued exploration and findings around Construction 4.0 is a key mitigation strategy to avoid the underutilisation of the technologies. The methodology followed is based on a scoping literature review. Munn et al (2016) describe a scoping literature review as useful for examining emerging evidence when it is still unclear what other, more specific questions can be posed and valuably addressed by a more precise systematic review. The purpose for conducting a scoping review is to identify the types of available evidence in a given field, to examine how research is conducted on a certain topic or field, to clarify key concepts/ definitions in the literature, to identify key characteristics or factors related to a concept, as a precursor to a systematic review and to identify and analyse knowledge gaps. Hence, the scoping review was the method best suited to identifying how to best
leverage existing digital technologies to enable Construction 4.0 as there are numerous concepts on attaining Construction 4.0 and there exists various knowledge gaps in this field.

2.2 Opportunities offered by digital technologies to enable Construction 4.0

There are various notable projects in South Africa that have been in the public domain due to severe project delays such as the notorious Eskom projects (Medupi and Kusile power stations) (Tshidavhu & Khatleli, 2020). A megaproject is defined as a project that costs $1 billion or more (Flyvbjerg, 2014). In practice, cost and schedule overruns are generally an ongoing problem in megaprojects implementation (Aljohani et al., 2017).

Megaprojects are expensive and include many risk factors that can cause delays or failures during the project’s execution (Ma et al., 2017). The construction industry is infamous for its slowness to adapt, and traditional practices remain the most-used project delivery methods (Fulford and Standing, 2014; Ahiaga-Dagbui et al., 2015). Howell and Higgins (1990), cited by Windapo (2021) hold a theory that organisations in the construction industry must be leaders in the identification, evaluation, and adoption of the latest technological innovations if they are to remain relevant and competitive. However, many companies do not fully adopt these innovative technologies.

The numerous innovative construction technologies available on the market aim to complement job functions and improve the performance of construction companies. However, in line with the diffusion of innovation theory, these technologies have not been adopted in the construction sector of many developing economies, such as Nigeria, and low productivity continues to affect them. In the case of South Africa also a developing nation, the same barriers to the adoption of digital technologies are also prevalent.

Windapo (2021) states that previous research suggests that there are opportunities for the digital environment to transform the construction industry towards Construction 4.0 and make it more productive. Oke et al (2018) note that there are several barriers to adopting digital technologies. There is limited knowledge of how they could improve the productivity of projects and transform the construction industry. Windapo (2021) indicates that digital innovative technologies, which may offer new opportunities to resolve issues of poor productivity and performance in the construction industry include 3D scanning, building information modelling (BIM), 3D printing, augmented/virtual reality, drone technology, the Internet of Things, big data analytics, machine learning and blockchain technology.

MacDougall (2014) supports this by stating that with the advent of the 4IR and the resulting framework, the construction sector also has the opportunity to leapfrog to more efficient production, business models, and value chains. Such a transformation is possible through the convergence of existing and emerging technologies that form part of industry 4.0 (Oesterreich and Teutenberg, 2016). This transformation has been widely accepted to be the blueprint for the Construction 4.0 framework. However, due to numerous infrastructure and digital challenges in developing nations it is unclear which of these digital technologies can best provide a template for successful conversion and transformation of the construction sector to Construction 4.0.

Gartner (2017) elaborates that the Construction 4.0 Framework uses CPS as a core driver and links it with the concept of a Digital Ecosystem where “A digital ecosystem is an independent group of enterprises, people and/or things that share standardized digital platforms for a mutually beneficial purpose, such as commercial gain, innovation and common interest. Sawhney et al (2018) provide a Construction 4.0 framework based on a confluence of trends and technologies (both digital and physical technologies) where they envision that the Construction 4.0 framework can fundamentally change the way that assets are designed, and constructed, and operated. Sawhney (2020) also states that with the pervasive use of BIM, lean principles, digital technologies, and offsite construction, the industry is at the cusp of a transformation driven by Construction 4.0. This is supported by Osunsami et al (2020) who concluded that there is a strong willingness of the construction professionals to adopt simulation technologies despite the possibility of fully integrating the technologies into the construction industry being low. The strong willingness to adopt Construction 4.0 is based on data collected from respondents which showed that 5 out of the 18 technologies representing construction 4.0 have a standard deviation over one which means that there is variability in data and the willingness level of the respondent to
adopt construction 4.0. The variability of data was further revealed in the mean ranking of the construction 4.0 technologies. On the first component (Smart construction site) it is shown that the drone was rated with the highest mean score of 4.40 this implies that the construction professionals are ready to adopt drones for construction projects. This finding could be tied to the situation that drones are used to monitor construction project (Niselow, 2018). The use of drones has recorded significant benefits for the department of infrastructure through better monitoring of construction projects within the country (Dlamini, 2018). Other technologies with a high mean score (above 3.5) that construction professionals are willing to adopt are; prefabrication, RFID, Internet of things and automation. The willingness of the construction professionals to adopt construction 4.0 technologies like RFID and prefabrication could be related to their level of awareness of such technologies (Sardroud, 2012; Boafo et al., 2016).

In the presented Construction 4.0 framework, construction projects are separated into two components, the Design Component (Digital Layer), and the Construction Component (Physical Layer), both of which are interconnected centrally to the Digital Tools (BIM, Digital Twin, Cloud Based Data Environment etc.) which feed data to both layers. The gap is what are the guidelines that are to be followed when connecting the Digital Layer, the Physical Layer and Digital Tools. Lastly, not all digital tools will be essential for a successful implementation in South Africa. This understanding and also noting socio-economic and economic challenges around the conversion of the sector from traditional to digital requires that an in-depth approach be made to the available technologies to determine which of those can smoothen the transition. Once a is identified a clear process model may be necessary to provide a pathway to Construction 4.0.

3. RATIONALE

The construction industry has failed to embrace the opportunities afforded by technology and advances in data available to enhance the efficiency and performance of the sector. This is endorsed by Penzes (2018), by stating that throughout the world, the construction industry has long been challenged to improve its efficiency, and productivity, and to embrace the opportunities presented by emerging technologies. Despite numerous historical attempts to initiate and effect meaningful change, the industry suffers from fragmentation and inefficiencies in the process, information flows, and collaborative working. Therefore, the study is aimed at identifying the key driver of digital technology to provide a pathway on how to best enable Construction 4.0 in the South African context.

4. FINDINGS AND DISCUSSION

In reviewing the available literature using a scoping review method, it was found that there is a strong willingness from the construction industry to adopt Construction 4.0. However, the barriers to adoption are several as listed in Table 1. These barriers were identified from the literature upon having undertaken a scoping review. Thematic analysis was used to analyse non-numerical data as presented in Table 1.
<table>
<thead>
<tr>
<th>Barriers</th>
<th>Descriptions</th>
<th>Sources and/or Key references</th>
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<tbody>
<tr>
<td>Implementation challenges</td>
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<tr>
<td>1. High implementation costs</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 17, 19, 20</td>
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<td>2. Low investments in Research and Development</td>
<td>2, 3, 6, 5, 7, 9, 10, 12, 13, 15, 16, 17, 18, 19, 20</td>
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<td>(R&amp;D)</td>
<td>20</td>
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<td>3. Need for enhanced skills</td>
<td>1, 2, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 17</td>
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<td>4. Longitudinal fragmentation</td>
<td>3, 4, 5, 6, 7, 8, 9, 11, 12, 14, 15, 20</td>
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<td>5. Lack of standards</td>
<td>1, 2, 3, 4, 5, 8, 9, 11, 10, 11, 12, 14, 17, 19, 20</td>
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<td>6. Data security, data protection and cybersecurity</td>
<td>1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 16, 19</td>
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<td>7. Legal and Contractual uncertainty</td>
<td>1, 2, 4, 5, 7, 8, 9, 10, 11, 12, 14, 19</td>
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<td>8. Regulatory compliance</td>
<td>1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 19, 20</td>
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<td>9. Fragmented industry structure</td>
<td>1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 19, 20</td>
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<tr>
<td>10. Historically poor adoption rates in the industry</td>
<td>1, 2, 3, 4, 5, 11, 15, 16, 17, 19, 20</td>
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<td>11. Added-hurdles imposed by custom-made, once-off projects</td>
<td>1, 2, 3, 4, 5, 8, 9, 11, 12, 18, 19</td>
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<td>12. Existing weak information transparency and transmission</td>
<td>1, 2, 3, 4, 5, 11, 13, 14, 17, 18, 19</td>
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<tr>
<td>13. Political and social acceptance</td>
<td>1, 2, 3, 4, 5, 7, 8, 9, 11, 13, 17</td>
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<tr>
<td>14 Complexity of digital technologies</td>
<td>2, 3, 4, 5, 10, 11, 15, 18, 20</td>
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<tr>
<td>15. Challenges posed by systemic innovation</td>
<td>4, 5, 9, 11, 13, 14, 18, 19</td>
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<tr>
<td>16. Unclear value proposition</td>
<td>6, 7, 14, 15, 17, 18, 19, 20</td>
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<td>17. Education and training</td>
<td>12, 14, 19, 20</td>
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<td>18. Interoperability</td>
<td>2, 16, 18, 19</td>
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<td>19. Insufficient/erratic power supply</td>
<td>6, 7, 14, 18, 19</td>
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</table>
20. Lack of accessibility 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 19
21. Increasing complexity of data structures 1, 2, 3, 4, 5, 8, 9, 11, 14
22. Resistance by consultant team 1, 2, 3, 10, 11, 16, 17, 19
23. Diverse nature of systems 2, 3, 4, 5, 6, 9, 10, 11, 14

References in Table 1 above are as follows; 1 = El Jazzar et al (2020); 2 = Sawhney et al (2020); 3 = Osunsami et al (2018); 4 – Hossain et al (2019); 5 = Oesterreich et al (2016); 6 = Cooper et al (2018); 7 = Dallasega et al (2018); 8 – Alaloul et al (2018); 9 Klinic et al (2019); 10 = Munoz-La-Rivera et al (2020); 11 = Prieto (2021); 12 = Ibrahim et al (2019); 13 = Craveiro et al (2019); 14 = Oke et al (2018); 15 = Chowdhury et al (2019); 16 = Aigbavboa et al (2018); 17 = Taher (2021); 18 = Forcael et al (2020); 19 = Windapo (2021); 20 Osunsami et al (2020).

From the above findings, it can be argued that there is a need to identify a suitable key driver of digital technology to ensure the barriers identified and supported by the listed literature in Table 1 above are greatly minimised to enable Construction 4.0 which will result in the sector having enhanced business and project performance. It is pertinent to note that in relation to the implementation guidelines related to Construction 4.0 models as listed in Table 2, there are key barriers as highlighted in Table 23.1. This is supported by the high ranking of three barriers, which include the lack of standards on how to implement (15 papers), legal and contractual uncertainty (11 papers) and regulatory compliance (11 papers). These barriers lead to the same repetitive chronic challenges in the sector. El Jazzar et al (2020) support this by mentioning that the challenges associated with moving construction toward a process-thinking industry, the lack of global standards and a framework for implementation are roadblocks. This highlights the need to identify a suitable key driver digital technology that can act as a key driver of transforming the sector towards Construction 4.0 in South Africa, which will result in the transformation of construction business processes and establish trends and make better business decisions.

Osunsami et al (2020) support this idea by concluding that there is a high level of willingness to adopt Construction 4.0 in South Africa. However, the possibility of integrating construction 4.0 principles into the construction industry is low. The basis of the research is that from the Construction 4.0 models, a key driver of digital technology housed within the physical layer (construction processes) has to be identified which leverages existing digital technologies (Digital Twin, BIM etc.) housed in the digital layer. There are a number of digital technologies such as robotics, and cyber-physical systems (CPS) that encourage a smart construction site. These digital technologies are still rated as not important by the construction stakeholders.

This is associated with little awareness of the technologies for construction work, the nature of the construction industry and poor understanding of modern technologies. There is a proposal that big data and cloud computing needs to be put in place to enable Construction 4.0. Our research seeks to also challenge this by recommending that big data and cloud computing should be applied as an open-source on which the robots on-site can download their own project-specific information for easy decision making. However, these digital technologies and tools still need to be led by a key driver of digital technology that is on the physical layer of the CPS ecosystem on which it can be supported by digital technologies on construction site. Taking the South African context into account and also referencing back to the identified barriers there is no key driver digital technology identified that interacts with the digital layer and the physical layer, which is what is currently missing to ensure there is a transformation from traditional to the digitisation of construction processes. There are existing frameworks that could aid in this regard as presented in Table 2, however not all the digital technologies will be applicable but only those that will need to work in sync and support the key driver digital technology identified.
4.1 A need for a key driver of digital technology to enable Construction 4.0

The importance of why the construction sector needs to transform from traditional construction to Construction 4.0 has been well established (El Jazzar et al., 2020, Sawhney et al., 2020, Prieto, 2021, Ibrahim et al., 2019, Craveiro et al., 2019 and Munoz-La-Rivera et al., 2020). The idea of Construction 4.0 developed from the need of the construction sector to overcome the existing horizontal, vertical, and longitudinal fragmentation. Ibrahim et al. (2019) state that technology is moving fast with 4IR, and the construction industry is facing more futuristic and complex design, material diversity, green building, and smart homes, which makes it necessary for the construction players to transform conventional practices into digital technology. Craveiro et al. (2019) support this by stating that this transformation, will enable construction companies to improve productivity, reduce project delays and cost overruns, manage complexity, and enhance safety, quality and resource efficiency. The transformation of the sector is crucial as several emerging economies have achieved strong growth by leveraging technology to improve productivity and innovation, South Africa has the opportunity to emulate these economies (McKinsey; 2019).

In transforming the local construction industry to Construction 4.0, the use of digital technologies is paramount. However, in the review of preliminary literature, debates around theories, methodologies and approaches on how best to transition from conventional to digital construction persist. One of the differences identified is which of the available digital technologies would best make this transition happen especially in the physical layer of the CPS ecosystem. There are three models widely discussed in the field of Construction 4.0, these three models are coherently different from each other. The comparison of the three models is shown in Table 2, also shown are the number of digital technologies within each model.

<table>
<thead>
<tr>
<th>Table 2. Available Construction 4.0 models</th>
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<tbody>
<tr>
<td><strong>Model Type</strong></td>
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<tr>
<td><strong>Digital Technologies</strong></td>
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The three models outlined in Table 2 will inform a process model to be developed using implementation science in South Africa. The process model to be developed aims to provide an eco-system on which the local industry can leverage digital technologies in the enablement of Construction 4.0.

A possible key driver of digital technology is 3D Printing (3DP). In the assessment of all the barriers identified, 3DP as its regarded as a digital tool housed within the physical layer of the CPS ecosystem. 3DP has the potential to interact with and interface with both the digital layer and physical layers of the CPS ecosystem. Most, importantly 3DP in the construction industry helps save time, effort, and material compared to traditional construction methods, thereby, ensuring that small contractors busy with small projects will experience increased profit margins and overall business growth. Freire *et al.* (2020)
support the above by stating that the demand for cost-effective solutions in the construction industry led to the development of 3DP technology, as a possible constructive solution in the scope of the so-called Industry 4.0. It has been shown to be feasible in several areas, due to its low cost, speed, geometric freedom and being an environmentally friendly solution.

Alzarrad et al (2019) state that the advent of 3D printing technology may very well be remembered as one of the most important technological advances of the early twenty-first century. The technology is being used in numerous different industries to produce various parts and components for generally lower costs while achieving better quality. This is either achieved by 3DP the parts themselves or the moulds that would eventually be used to make the parts. However, the construction industry has been slow in adopting this technology for many reasons, many of which still need to be investigated so a way can be found around them. As the approach of the study was focused on the identification of the barriers to implementation, the pathway to utilise 3DP as a key driver of digital technology to enable Construction 4.0 is realistic and attainable if a process model was to be developed. This process model would be providing guidance to small contractors on how they can utilise 3DP technology to digitise their construction processes by also leveraging on available digital technologies should the need arise.

The industry is experiencing low productivity with minimum technological innovations for a number of decades. In recent times, various automation technologies including 3DP have received increasing interest in construction. Hossain et al (2020) state that 3DP in construction is found to be very promising to automate the construction processes and has the potential of saving laborious work, material waste, construction time, and risky operations for humans. It has been found that 3DP can reduce a significant number of labours which can solve the labour shortage problem, especially for countries where construction is heavily dependent on immigrant workers. In contrast, 3DP might not be favourable for the countries where construction is one of the main workforces and labour is less expensive. Moreover, 3DP will also require people with special skills related to this new technology.

This, therefore, ensures that this digital technology is worth researching as a key driver of enabling Construction 4.0. Furthermore, for the transformation of the South African construction industry from traditional to digitisation, Freire et al (2020) provide further inputs on the possible benefits, by pointing out the advantages and future possibilities of 3DP in construction. It is an emerging technology with a great potential for evolution, namely in terms of materials for printing, size and finishing, or even in terms of simultaneous printing of mortar and insulation materials. However, it is currently limited to the lack of legislation and certification. The lack of legislative compliance as the analysis of data has shown in the research, can be regarded as a direct result of there not being a clear and concise pathway or process model that shows the necessary actions that are to be performed in the implementation of 3DP technology during construction for the benefit of enabling Construction 4.0 by leveraging on digital technologies housed within the digital layer of CPS ecosystem.

5. CONCLUSIONS AND RECOMMENDATIONS

The implementation of digital technologies to enable Construction 4.0 is a necessity to achieve optimum efficiency. The paper highlighted the barriers involved when attempting to use digital technologies for enabling Construction 4.0. Based on the literature findings, the study concludes that due to the lack of regulatory compliance, legal and contractual compliance, a lack of standards and adequate infrastructure, a key driver is to be identified. There is little guidance or technical know-how on how to best implement the available digital technologies to enable Construction 4.0 in South Africa.

The data analysed from the findings highlighted specific key barriers to the enablement of Construction 4.0. The key barriers which are highlighted are the lack of standards on how to implement Construction 4.0, legal and contractual uncertainty and regulatory compliance. Over and above these barriers to implementation, there is no clear specific digital tool which has been put forward as the key driver for the enablement of Construction 4.0. It can therefore, be concluded that there is a need for identification of a key driver digital technology to enable Construction 4.0 which will provide the basis for enhanced project and business performance.

The research recommends that 3DP be investigated as a key driver of digital technology due to its positioning in the CPS ecosystem. Construction processes under the physical layer of the CPS
ecosystem are of key importance as it is mainly those processes that require a transformation from traditional to digitisation to reap the benefits of a fully digitised and smart construction site. The adoption of this digitisation will enable Construction 4.0. A fully digitised construction site, at its centre, is a key driver digital tool housed in the physical layer of the CPS ecosystem that aims to improve construction processes by leveraging on other digital technologies housed within the digital layer of the CPS ecosystem thereby resulting in increased project performance and improved business decisions by small contractors. 3DP is proposed as this digital tool at the centre of the CPS ecosystem. 3DP can be positioned as the missing link in creating an interface between the digital and physical layers to enable Construction 4.0 in the local sector.

It is further recommended that 3DP as a key driver digital technology utilised for enabling Construction 4.0 be investigated further and a process model be developed which will improve assist to improve business processes. 3DP, by leveraging digital technologies in collecting project and product data, establishing trends and assisting the sector in making better infrastructure and investment decisions has the potential to transform the sector for the better. Therefore, the formulation of a process model will provide guidance to small contractors in how to utilise 3DP technology to digitise their construction processes by also leveraging on available digital technologies, whilst also embedding specific local certifying and quality requirements from bodies such as the Council for Scientific and Industrial Research (CSIR), South African National Standards (SANS) and Agreement SA and lastly, qualifying legislative and administrative requirements from industry-specific Acts such as the National Building Regulations (NBR). It is recommended that further research be undertaken on 3DP as a key driver of digital technology within the CPS ecosystem.

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The influence of different personality types relating to the Quantity Surveyor within a design team to facilitate effective communication in the Construction Industry

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ABSTRACT AND KEYWORDS

Purpose of this paper
To manage a construction project efficiently, the entire project team must overcome communication barriers by communicating effectively and accurately. The aim of this study is to investigate the communication methods, forms, channels, and personality type indicators used by the quantity surveyor as part of a design team to achieve the shared project objective. These objectives are achieved through communicating their interactions and collaboration, resulting in the team enhancing its innovation, problem-solving, decision making, support, and work performance.

Design/methodology/approach
A literature review was conducted to identify the communication methods and barriers that exist within a construction design team, because all aspects of work are affected to some extent by communication in the construction industry. Qualitative and quantitative data were obtained through web-based questionnaires undertaken by thirty-two industry professionals in South Africa. The findings indicate that the communication barriers relate to consistency, timeliness, accuracy, frequency, length, and exclusion of communication by the other design team members.

Findings
The study concludes that the communication barriers include the lack of questioning, expression, listening skills, perception differences, as well as jumping to conclusions, and having a general lack of knowledge when communicating with other design team members. Therefore, writing, listening, reading, response time, tone, risk response strategy, method, channels, timeliness, and format accuracy of communication should be addressed among the design team members and the quantity surveyor to ensure effective communication.

Research limitations/implications
It is recommended to undertake a case study to investigate the communication barriers of a small design team, in contrast to a large design team. The communication channels, format, and methods could then be researched and compared comprehensively.

What is original/value of paper
This study identified key barriers design team members face when communicating. Furthermore, the process to determine the personality type of the stakeholders within the design team is discussed by explaining the process and purpose of a personality assessment.

Keywords: Quantity surveyor, design team, communication, personality assessment.
1. INTRODUCTION

The focus of this research paper is on communication with regard to the design team's personality assessment during the different phases of a construction project. To manage a construction project efficiently, the whole team must overcome communication barriers by communicating effectively and accurately. In this study, additional focus is placed on the personality type indicators and communication method used by the quantity surveyor. Burke (2014: 174) defines a project team as individuals who work closely together to achieve the shared project objective. This is achieved by communicating their interaction and collaboration, resulting in the team enhancing its innovation, problem-solving, decision making, support, and work performance. Effective communication is determined by the communication preferences of the personality types within the design team.

This paper examines how communication relating to personality types plays an essential part in the organization of a design team in the construction industry, focusing on the quantity surveyor's profession and communication methods. Firstly, it covers the background and defines communication while creating a link to the personality types of the quantity surveyor within the construction industry. This then transfers into covering the important forms and types of communication relating to the identified personality types in the construction industry. Based on the personality types, communication methods will also be discussed to overcome the communication barriers that exist.

This paper is based on the communication process barriers that exist relating to the diversity of individual personality types of the quantity surveyor within the design team of a construction project. Effective communication with regard to the personality types will ensure that any project can be managed professionally (Kichuk & Wiesner, 1998: 197). Communication is the conveyance of information, ideas, thoughts, and feelings using words or other suitable methods and forms. In the project management framework, it is defined as the trading of knowledge, skills, and experience (Clearly, 2008: 63).

Freeman (2016: 73) states that to understand communication, the need for effective communication arises. Effective communication is to give instructions, solve problems, and ensure that all the relevant professionals involved with the project are supplied with the latest information that is needed. The professionals working through the project office holds key positions to maintain all the project’s lines of communication. Most of the professionals’ working time is dedicated to a form of communication; be it meetings, typing of emails, report reading, or having a conversation with the project professionals (Burke, 2014: 280).

In accordance with the above-mentioned, Zulch (2016: 178) suggests that the range of professionals that exists within the construction industry must integrate their knowledge and skills with those of the other members of the design team. Working together on projects requires effective and well-timed communication focusing on professionals that include the architect, project manager, quantity surveyor, and engineer. These professionals need to form part of the communication process to ensure the project is a success. Efficient communication needs to be implemented from the very start of the project until the finish (Sommerville, Craig & Carney, 2004: 3).

Quenk (2013: 3-29) explains that to convey information better, a personality assessment using the Myers-Briggs Type Indicator (MBTI) is used. The personality assessment is based on the theory of Swiss psychiatrist Carl Jung, namely that humans experience the world using four principal psychological functions – sensation, intuition, feeling, and thinking – and that most of the time one of these four functions is dominant within a person (Myers, 1998). The key issues relating to communication barriers can be addressed by conducting a personality assessment and recommending the communication methods for effective communication.

2. AN OVERVIEW OF THE COMMUNICATION PROCESS AND THE COMMUNICATION BARRIERS THAT EXIST WITHIN THE DESIGN TEAM

To understand the process of communication, the flow, types, and forms will be determined and explained. Fisk and Reynolds (2010: 36) state that the importance of communication and information management is to determine the different lines of communication at the beginning of a construction project, while Chen and Kamara (2008: 30) explain that two-way communication lines represent the movement of information upwards. The movement of internal communication can be vertical, horizontal,
diagonal, and across the organizational structure of the design team. Posea (2012: 201) agrees that horizontal communication is present on the same hierarchic level to supply information regarding the activities of the lower levels, while diagonal communication is present on different hierarchic levels (Alexander, 2015: online; Posea, 2012: 201; Smit & Cronje, 2002: 371-372).

According to Dainty, Moore and Murray (2006: 5-6), project managers need communication skills to interact and convey information effectively to individuals, groups and organizations. Skulmoski and Hartman (2009: 242-243) and Zulch (2014: 677-680) are of the opinion that explaining, questioning, listening, reflecting, writing competency, presentation skills, self-disclosure, and humour are part of a project manager’s communication skills. The above-mentioned communication skills are needed to overcome the communication barriers that exist within the design team.

The relevant communication skills need to be applied to meet the requirements of effective communication. According to Heldman (2003: 33), communication skills are the most significant skills a project manager possesses. In accordance with the above, Heldman, PMBoK (cited in Burke & Barron, 2007: 346) defines effective communication as simply ensuring that the correct person receives the correct information at the correct time. Therefore, it is vital to determine and understand the flow, types, and forms that are considered ineffective construction project communication.

Effective project communication is based on the clarity of the message being conveyed as well as the role. Valuable time must be spent during the early stages of the project to agree on the flow, types, and forms of communication while being clear. The project communicator must form part of the project from the outset, but if not, communication starts further through the lifecycle. Time must be spent to ensure a mutual understanding of the communication role to avoid additional time delays (Pilkington, 2013: 1).

Toor and Ogunlana (2005: 154) states that a common assumption in the construction industry is that a project is deemed successful if the project is completed on time, within the agreed budget, and to a certain set quality, also referred to as the golden triangle. Other evidence suggests that the construction industry needs to pay special attention to critical success factors, besides the ‘golden triangle’, if it is to survive the challenges posed by globalization.

Seven main determinant factors of project communication quality were determined by previous studies (Bond-Barnard, Steyn & Fletcher, 2014: 5-12; Daim et al., 2012; Müller, 2003; Turner & Müller, 2004: 329-333). These factors include communication channels, communications plans, audience, content, frequency of interaction, technology, and communication type. Therefore, the communication process is of supreme importance to the construction industry.

2.2 COMMUNICATION BARRIERS

2.2.1 Reasons for Communication Barriers

According to Stanton (2009: 4-5) factors causing communication barriers are perception differences, jumping to conclusions, stereotyping, lack of knowledge in the area, lack of interest, self-expression difficulties, and emotions. All these factors relate to a person’s personality type. By determining the relevant personality type the factors can be managed to ensure the barriers are overcome. Rougvie (1991: 17) states that human communication interaction has misunderstandings and communication barriers. It is necessary to recognize the existence of the communication barriers that influence effective communication to enable improvement of the whole communication process (Brown, 2001: 11). Now that the reasons for the existence of communication barriers are known, the different types of barriers can be discussed to enable the personality assessment to help manage or resolve these barriers that exist.

2.2.2 Types of communication barriers

Interaction frequency is the timing and number of design team members’ communications (Turner & Müller, 2004: 328-333). A guide by the Project Management Institute (PMI) (2013: 287-295) states that well-timed communication is a prerequisite for achieving the project objectives. In accordance with the above, Turner and Müller (2004: 329-333) and Webber (2008: 71-81) state that communication quality is improved by frequent communication and trust. The lack of well-timed communication is a common cause of failing construction projects.
According to Chaturvedi and Chaturvedi (2011: 181-193) and Zulch (2014: 677-680), the construction project manager should apply the correct communication method, when needed, to the satisfaction of the members of the design team to avoid miscommunication. Henderson (2004: 474) regards the satisfaction of design team members as crucial to productivity, due to the lack of productivity resulting in the loss of valuable time and cost. Turner and Müller (2005: 58) further states that the relationship between the design team members plays an important role with regard to the satisfaction and productivity of the team.

If the team is not satisfied, the execution of works could result in disaster due to relationships lacking communication. The barriers that exist can be prevented by applying the correct communication methods. The application of the different methods is dependent on the personality type of the person applying them (Carvalho, 2008: 27-31).

3. AN OVERVIEW OF THE DIFFERENT PERSONALITY TYPES THAT FACILITATE EFFECTIVE COMMUNICATION WITHIN THE DESIGN TEAM

3.1 The purpose, process, and outcome of a personality assessment

According to Hogan, Barrettt and Hogan (2007: 1), the area within the study of psychology is referred to as a persons’ personality and that is based on human nature. This creates the urge to attempt to determine and understand personality. The urge is driven with two main goals in mind; firstly, to predict the behaviour of people, and secondly, to understand why people act in a certain way. People act in a certain way due to individualities or characteristics that are present in their psychological profile or personality (Chamorro- Premuzic & Ahmetoglu, 2012: 19).

Now that the term ‘personality’ is defined, the personality assessment can be discussed. Weiner et al. (2017:15) are of the opinion that the procedures for identifying similarities and differences between people are referred to as a personality assessment. The specialist approach to determine the personality type assumes that the observable changeability in behaviour from one individual to another results from differences referred to as underlying personal characteristics. The assessment defines these characteristics and relates them to socially significant aspects of behaviour (Palcroft & Lopez, 2009: 66- 68). Hogan et al. (2007: 3) agree with the above-mentioned by stating that the characteristics of personality assessments include measures such as emotional states, motivations, attitudes, and interpersonal relations. According to Palcroft and Lopez (2009: 67), the common approaches to determine the personality assessment include the interview, rating scales, self-reports, personality inventories, projective techniques, and behavioural observation.

Weiner et al. (2017: 17) agree with Hogan et al. (2007) by stating that the personality assessment is done through interviews, collateral reports, rating scales, and historical documents providing information about a person’s previous experiences, background, and life circumstances. Bradley and Hebert (1997: 42) state that the purposes of a personality assessment are to provide a way to categorize different characteristics. The categorization will enable the person to determine how people might react to certain situations. Weiner et al. (2017: 16) state that the main purpose of these tests is for self-reflection and understanding, but other uses include job placement, interaction, and teamwork improvement. Kumar (2016: 19) enhances the above-mentioned by stating that the process of a personality assessment is undertaken to provide a measurable description based on the differences between people in relation to their cognition and behaviour.

3.2 The process, purpose, and outcome of the Myers-Briggs personality type indicator

The chosen personality assessment for this study is the Myers-Briggs Type Indicator® (MBTI®). The main purpose of the MBTI is to make use of the psychological types that are defined by Jung (1934) in an understandable and useful manner to ensure better project communication (Quenk, 2013: 3-19). Katherine and her daughter Isabel Myers were captivated by the theory based on psychological types by Jung (Carlyn, 1977: 576. They recognized the real-world applications of the theory. They began researching and developing the MBTI to utilize, help, and understand individual personality differences to enable individuals to select occupations best suited to their personality types (Quenk, 2013: 8). The MBTI identifies individuals as having one of sixteen personality types. The result is that respondents will be able to understand and explore their personality type in respect of their likes, dislikes, strengths,
weaknesses, possible career preferences, and compatibility with other people (Myers-Briggs, 2020: 12).

Gordon (2000: 7) states that the purpose of the MBTI is to identify characteristics correctly by sorting individual respondents into the categories based on their behaviour. Carlyn (1977: 581) further states that the mental functions and attitudes are the basic elements of the Jung/Myers theory. This is done by representing all items in a forced-choice layout. Requiring the individual respondent to choose between two mental functions or attitudes identifies the naturally preferred characteristics (Quenk, 2013: 3-19).

Myers-Briggs (2020: 12) explains that the MBTI questionnaire consists of four different scales: Extraversion-Introversion, Sensing-Intuition, Thinking-Feeling, and Judging-Perceiving. Gordon (2000: 5) further explains that four main preference scales make up the whole personality type. Thus, there are sixteen personality type variables present in the MBTI, some being more common than others. The basic preferences of an individual are identified when taking the MBTI. According to Myers-Briggs (2020: 16), all 16 personality types are equal and have value. Especially when working in group situations, the recognition and understanding of strengths and weaknesses prove helpful. The recognition of different personality types allows better assignment of tasks, thus enabling the team to work together and achieve their goals (Kuder, 1968; Campbell & Hansen, 1981; Barrett, Sorensen & Hartung, 1985).

Previously discussed the process and purpose of a personality type assessment related to the study of psychology to determine the similarities and differences between people who function together in a design team. The literature indicates that the specialist approach taken to do a personality assessment is the Myers-Briggs Type Indicator (MBTI). From the purpose, process, and outcomes of the MBTI emerged 16 personality type variables that possess unique qualities relating to a personality that could be linked to the stakeholders of a design team.

4. RESEARCH METHODOLOGY

A qualitative and quantitative mixed-method research approach using a survey was used in this study. The use of a simple random sampling method was applied to select 80 registered construction professionals in construction management, project management, quantity surveying, engineering, and architectural professions. A web-based questionnaire was distributed electronically using contact details from the various professional Councils' registers obtained online. The 32 completed and useable questionnaires received back were analysed using an Excel spreadsheet and then analysed statistically.

5. PRESENTATION AND ANALYSIS OF FINDINGS

Semi-structured questionnaires were sent out to industry professionals registered at the SACQSP as well as the ASAQS. A web-based research questionnaire was sent via e-mail to participants enabling the collection of qualitative and quantitative data required. A total number of eighty (80) questionnaires were sent to various participants and thirty-two (32) were completed; the total response rate was thus only 40%, due to industry fatigue, the Covid-19 pandemic, and the limited capacity of the built environment due to government regulations at the time of data collection.

5.1 Demographic information

The first six questions of the questionnaire were aimed at retrieving demographical information about the respondents’ gender, age, location, language, employment status, and level of education. The empirical results and analysis indicated that 32 respondents completed the web-based questionnaire, from which 18 were quantity surveyors between the ages of 26 and 35, with an Honours Degree level of education and are employed full-time. The main language of communication was English, as preferred in the written format during the planning and execution phases of the project cycle.

5.2 Communication methods and barrier information

An assumption for this study was made on the basis that all the respondents experience some form of communication barrier with a member of the design team.
5.2.1 Communication frequency among participants

An indication of effective communication could be drawn if the respondents communicate regularly. This question was included in the study to determine the frequency of communication between project participants in the design team. Twenty-six (26) communicated daily, six (6) weekly; and one (1) monthly. The respondents’ frequency of communication relates to the formation of communication barriers, as nonfrequent communication could delay the project and daily communication is required for team members to function effectively.

5.2.2 Typical form of communication

The form of communication relates to the communication barriers that are formed when communication takes place between members of the design team and the quantity surveyor. Twenty-six (26) communicated in written format, including the use of e-mails, messages, letters, documents, and twelve (12) communicated verbally, which include calls, face-to-face discussions, and presentations as the most typical communication form when communicating with other members of the design team. The respondents preferred written forms of communication. The reason for their preference is discussed in the following question. Different forms of communication are preferred by different personality types, resulting in communication barriers between the different members of the design team.

The research question based on how the personality types within the design team influence different communication methods and types to ensure effective communication is linked to this study, as further data analysis indicated that 26 respondents preferred written forms of communication. The influence of the personality type thus indicates that introverted personality types prefer written communication and some extroverted personality types explained that they communicated verbally, but ensured the information conveyed was noted in some form of written communication.

5.2.3 Reasons for the above-mentioned form of communication

The responses of the participants who preferred written forms of communication stated that this form of communication was easy to track due to the utilization of communication records when disputes arose. This also enabled the communicator to ensure the correct information had been conveyed. A communication record is also required for project documentation such as change orders and site instructions. A back-up of the communication details is available when in written form, since verbal communication often results in one person’s account of an event disagreeing with that of another person, with no proof available. Written communication provides the required proof and should be kept as an additional resource, should the need arise.

It is of the utmost importance to have everything that is communicated in writing. This enables the tracing of communication channels and information conveyance while providing proof of communication. If the design team is spread across numerous countries, the time difference is taken into account in written communication. Verbal communication is done in real-time and requires the participants to be present when the information is conveyed. Written communication is sent and received at the convenience of the participant. Thus, time differences as well as location differences are considered; therefore, the ease of referring to written communication.

The responses of the 12 participants who preferred verbal forms of communication showed that this form of communication is generally for office use or the conveyance of urgent information. Nonetheless, verbal communication is the fastest way to convey information as well as derive an answer, as communication is in real-time. The conveyance of verbal information must be correlated by also using written communication to ensure the information has been implemented correctly. The interpretation of written information could be problematic, as face-to-face communication enables the participants to ask questions and avoid misunderstandings.

Therefore, verbal communication takes place first, followed by written communication to ensure that a record of what was communicated verbally is available. In some cases, design teams are in different locations, and verbal communication is not used, to allow all members of the design team to communicate and decrease the cost of communication. The main reason why written communication is preferred is that disputes could arise due to misunderstandings and communication barriers due to
misinterpretations when communicating verbally. A paper trail or back-up is necessary to serve as evidence that the information was communicated correctly.

5.2.4 A lack of individual communication skills

Rougvie (1991: 17) states that human communication interaction has misunderstandings and communication barriers. It is necessary to recognise the existence of the communication barriers that influence effective communication in order improve the entire communication process (Brown, 2001: 11). For the communication process to be effective, certain skills are required by all project team members. The skills must be applied correctly to ensure that the communication process is a success. Some members lack certain communication skills; thus, it is essential to be aware of the skills most of the design team lack to ensure that these skills are developed, as they create communication barriers.

![Lack of individual communication skills in Quantity Surveyors]

Figure 1 illustrates that twelve (12) respondents lack the skill to question what is being communicated to them; seven (7) lack the ability to explain certain topics or terms and are not active listeners. Six (6) respondents are not fully competent on a certain level of writing and prefer not to present project information to other members of the design team. Three (3) respondents struggle to provide feedback and reflect on the information communicated to them. These issues relate to the forming of communication barriers between the members of the design team and the quantity surveyor due to these skills not being developed.

5.2.5 Experiences when communicating project information to other industry professionals

The communication process is essential to convey project information among the industry professionals. According to Stanton (2009: 4-5), factors causing communication barriers are differences in perception, jumping to conclusions, stereotyping, lack of knowledge in the area, lack of interest, self-expression difficulties, and emotions. All these factors relate to a person’s personality type. By determining the relevant personality type, the factors can be managed to ensure the barriers are overcome.

The respondents were asked what they experienced when communicating with the other members of the design team, as some of these differences create communication barriers or alter the communication method used when conveying information. The experiences included in the questionnaire were perception differences, jumping to conclusions, a lack of knowledge, a lack of interest, and self-expression difficulties. Nineteen (19) respondents experience perception differences; nine (9) often jump to a conclusion before the information is conveyed; six (6) has a general lack of
knowledge, while three (3) have a lack of interest and one (1) lacks self-expression when communicating. The perception differences are a barrier to the communication process, as the professionals in a design team complete tasks based on their perception of the information conveyed.

The research question based on how the communication barrier can be eliminated when the personality types within the design team are known, is linked to this study, as the communication barriers need to be identified based on the experience of the design team members when communicating with other professional members of the design team.

5.2.6 Areas of improvement for other design team members

The responses from five (5) respondents indicated that the writing style used when communication in a written format must be of a formal standard without slang, acronyms, or spelling errors. A professional tone should be applied, as the tone could influence how the information conveyed is perceived. Three (3) respondents indicated that active listening skills should be applied when information is being conveyed. Furthermore, valuable information should be read carefully to ensure that the information being conveyed is understood correctly. Adequate response time should be allowed for written communication, while verbal communication should be used to ensure that written communication is responded to urgently. Site communications are verbal; therefore, notes must be taken as the instruction in the site instruction book is written down. Thereafter, all known and important information should be communicated to the project team, especially information discussed outside a design meeting that will have a cost impact on the project. Two (2) respondents stated that the exclusion of design team members when communicating should be improved. Changes could be small but could affect the excluded members’ work. If excluded, additional time and cost could be required. All members form part of the communication channel.

Six (6) respondents stated that important information should be communicated from the top to the lowest priority, as the respondents might only read the first sentence and decide the information was not as important. Lengthy correspondence is time-consuming and ineffective. Only three (3) stated that clear explanation skills are required to communicate effectively. Communication should be to the point, clear and accurate. Unnecessary information should not be included to lengthen messages.

Furthermore, one respondent indicated that communication by certain design team members could result in the formation of perceptions. These perceptions include that the information is unimportant, incorrect, or could be ignored, as the member does not play an important role. The respondent indicated that an architect may be viewed as an idealist by the design team members. The conveyance of information should be regarded as a professional manner.

5.2.7 Crucial communication elements

The communication elements industry professionals deem crucial for the successful completion of a construction project were open for interpretation by the respondents. Table 1 illustrates the responses collected:
Table 1: Crucial communication elements required for successful project completion

<table>
<thead>
<tr>
<th>Communication elements considered to be crucial:</th>
<th>Reason or implication:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Consistency in methods, channels, and format.</td>
<td>1.1 Consistency ensures that the information is conveyed to the correct members in the correct format through the correct method.</td>
</tr>
<tr>
<td>2. Clear upfront communication when conveying important information.</td>
<td>2.1 The conveyance of important information should be clear and stated first.</td>
</tr>
<tr>
<td>3. Timeliness of the correct information.</td>
<td>3.1 On-time communication is of utmost importance as the design team members must function under time-pressure.</td>
</tr>
<tr>
<td>4. Correct communication channels preferred by stakeholders.</td>
<td>4.1 The communication channels set out by the project manager must be utilized to ensure all participants receive the correct information.</td>
</tr>
<tr>
<td>5. Method of communication.</td>
<td>5.1 Written communication ensures sufficient evidence, but may require additional response time. Verbal communication is preferred in certain instances, followed by written confirmations.</td>
</tr>
<tr>
<td>6. Early communication to avoid cost overruns and delays.</td>
<td>6.1 Timely communication is of the utmost importance to ensure the correct information is applied as changes occur.</td>
</tr>
<tr>
<td>7. Constant contact between the design team members.</td>
<td>7.1 The design team members should be in constant contact as the need arises. The lack of communication results in additional time and cost needed as information if not conveyed on time.</td>
</tr>
<tr>
<td>8. Clarity of instructions or requests given when communicating.</td>
<td>8.1 Instructions and requests should be clear and accurate for the respondents. Unclear instructions or requests could result in rework, additional time, and costs.</td>
</tr>
<tr>
<td>9. Allow for adequate response time after the information has been conveyed.</td>
<td>9.1 Allowance should be made for response time, as the information requires processing and interpretation. Industry professionals often work on more than one project at a time.</td>
</tr>
</tbody>
</table>

Table 1 indicates that there are several crucial communication elements, including consistency, clarity, timeliness in the conveyance and response of information, correct channels, method, and accuracy of instructions and information. Lastly, the stakeholders should be in constant contact regarding the development of the project to ensure no information is lost.

The research question based on what personality types facilitate the best communication method between the quantity surveyor and the members of the design team to save valuable time and cost is linked to this study, as the data analysis indicated that the respondents view certain communication elements such as consistency, clarity, timeliness in the conveyance and response of information, correct channels, method, and accuracy of instructions and information as crucial to save valuable time and cost.

5.3 Personality assessment analysis

The personality assessment is based on the MBTI to determine the personality type of the respondents.

5.3.1 Completion rate of a personality assessment

Bradley and Hebert (1997: 42) state that the purpose of a personality assessment is to provide a way to categorize different characteristics. The categorization will enable a person to determine how people might react to certain situations. The completion of a personality assessment enables the respondent to determine what their key characteristics and preferences are, enabling the respondent to improve the required communication skills. Sixteen (16) respondents have previously participated in a personality assessment and none of them has undertaken a personality assessment before. Therefore, it can be concluded that, although 50% of the respondents have completed a personality assessment, they have not improved their lack of communication skills based on their personality assessment.
5.3.3 Personality types based on the Myers-Briggs type assessment

Weiner et al. (2017: 16) state that the main purpose of these tests is for self-reflection and understanding, but other uses include job placement, interactions, and teamwork improvement. The MBTI identifies individuals as having one of 16 personality types, the respondent’s responses were recorded in Table 2, along with the gender and professional capacity.

Table 2: Classification of MBTI assessment according to gender and professional capacity

<table>
<thead>
<tr>
<th>The MBTI result:</th>
<th>Number of respondents:</th>
<th>Gender:</th>
<th>Professional Capacity:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>ISTJ - INSPECTOR</td>
<td>3</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>ISFJ - PROTECTOR</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>INFJ - ADVOCATE</td>
<td>13</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>INFP - MEDIATOR</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>INTP - THINKER</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>ESTJ - DIRECTOR</td>
<td>1</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>ESFP - PERFORMER</td>
<td>1</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>ESFJ - CAREGIVER</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>ENFP - CHAMPION</td>
<td>2</td>
<td>1</td>
<td>1</td>
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<td>ENFJ - GIVER</td>
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<td>ENTP - DEBATER</td>
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<td></td>
<td>The total number of respondents:</td>
<td>32</td>
<td>20</td>
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Table 2 illustrates that from thirty-two (32) respondents, three (3) respondents are classified as ISTJ Inspectors; two (2) as ISFJ Protectors; thirteen (13) as INFJ Advocates; one (1) as an INFP mediator; four (4) as INTP Thinkers; one (1) as an ESTJ Director; one (1) as an ESFJ Performer; three (3) as ESFJ Caregivers; two (2) as ENFP Champions; one (1) as an ENFJ Giver, and one (1) as an ENTP Debater. This question indicates that most respondents classify as Advocates, discussed in section 4. The allocation of male and female respondents indicates that the diversity in gender-based personality types could be further researched and discussed under further research areas. The research question based on how the personality types within the design team influence different communication methods and types to ensure effective communication is also linked to the study, as the different personality types identified in this study proved that the dominating indicator is Introvert; twenty-one (21) from thirty-two (32) respondents indicated that they are introverts, while only eleven (11) respondents indicated the main indicator as Extravert.

6. CONCLUSIONS AND RECOMMENDATIONS

According to the empirical results and analysis, as well as the personality assessment indicated in Table 2, the respondents are introverted and prefer the communication format to be written. Even though verbal communication may be used when the response time is limited, written confirmation is still required. Frequent communication during the planning and execution phases of the project cycle is of the utmost importance, as well as the consistent, clear, and accurate conveyance of information for the quantity surveyor to communicate effectively.

Furthermore, the empirical findings indicate that the quantity surveyors’ communication barriers include a lack of questioning, expression, and listening skills when communicating with other design team members. The quantity surveying respondents considered the communication barriers of the other design team members to be differences of perception, jumping to conclusions, and having a general
lack of knowledge of the information that is being conveyed. Therefore, writing, listening, reading, response time, tone, risk response strategy, method, channels, timeliness, and format accuracy of communication should be addressed between the design team members and the quantity surveyor to ensure effective communication.

6.1 Recommendations

To minimize the communication barriers arising between the quantity surveyor and the design team members, the application of innovative communication strategies among design team members is required. Design team members should improve their writing, listening, and reading skills, as the conveyance of information affects the communicator as well as the communicatee. They should consider collaborating with communication consultants to set communication guidelines for written communication.

The response time should always be taken into consideration when the method and form of communication are selected. The design team members have office hours and work simultaneously on numerous projects. Verbal communication should always be followed by a written confirmation of what was communicated.

The tone used when communicating should be formal and professional. It is advised that respondents not reply hastily to written communication such as e-mails when overcome with emotions. It is advised to reply only if an emotion is not present in what is being conveyed. Some industry professionals consider matters to be personal and not professional. This should be avoided by ensuring the correct tone of communication is used.

Communication channels are determined by the project manager; the correct channel should always be utilized to ensure all members of the design team are included when important information is being conveyed. The exclusion of a team member in the communication channel could result in miscommunication or disputes. Therefore, it is recommended that open communication channels between the design team members exist that include all participants.

Lastly, the format and accuracy of information conveyance, scope changes, change requests and site instructions have a set format to ensure all the necessary details are included when the information is being conveyed. Accurate information requires a structured format to ensure that the communication process is efficient. The correct communication channels and format may be utilized while inaccurate information is being conveyed.

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Leveraging IoT to Mitigate Information Management & Communication Lapses on Construction Sites

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ABSTRACT & KEYWORDS

Purpose of this paper
This paper explores IoT leveraging by construction project management professionals for information management and communication lapses mitigation.

Design/methodology/approach
An integrative review of a purposive sample of literature exploring implications around leveraging IoT for enhanced information management and communication for construction project management professionals in South Africa.

Findings
Findings indicates the capacity and pervasiveness of IoT in the global and local construction industry extends to the enhancement in capturing, management, and communication of ubiquitous construction site data in real-time. Literature also shows that CSM shortcomings related to information management & communication can be improved through innovative exploitation of available IoT technologies as supposed to reinvention of technologies from other sectors.

Research limitations/implications
The current study is a theoretical study, limited to relevant extant literature and therefore needing subsequent empirical studies, as a next step.

Practical implications
Inherent limitations to this first theoretical study provide a basis for evaluating the current conjectures. The findings obviously paint an initial picture in a relevant gap area highlighting the need for empirical studies.

What is original/value of paper
The study explored a nascent technology that is at the forefront of digital innovation in construction project management. The study offers a comprehensive view on IoT leveraging for information management and communication enhancement during construction project execution. Furthermore, the study identifies the need for a framework to explore areas of CSM where IoT can also be leveraged beyond health & safety.

Keywords: IoT, Construction site, Information Management and Communication, Limitations, Construction Digitisation
1. Introduction
The construction industry is at the cusp of a new era where technology applications and tools are transforming design, planning, and execution methodologies (Blanco et al., 2017; Osunsanmi et al., 2020). Management limitations on construction management processes are being eliminated with the provision of advanced software, construction focused hardware, and analytics capabilities (Ram et al., 2019). Nevertheless, the increasing complexity and value of projects are constantly putting construction contractors under immense pressure to reduce costs overruns, improve timeline and efficiency (Agarwal et al., 2020; Hossain and Nadeem, 2019). Digital technologies emerging from technological advancement amid the 4th industrial revolution have caused disruption across all sectors. Digital innovation within construction project management has evolved to computer aided information and communication technologies, as well as digitised data management systems (Reyes Veras et al., 2018; Safa and Hill, 2019). Current trends in proliferation include the development and infusion of integration and collaborative technologies such as Building Information Modelling (BIM), the Internet of Things (IoT), cloud computing and project management software (Elia et al., 2020; Ibem and Laryea, 2014). Hence, technological development within construction is no longer the enablement of model-based information but more complex and integrated data management systems (Agarwal et al., 2016; Chen and Lu, 2019; Ibem and Laryea, 2014). More so now that the global Covid-19 pandemic has forced industry players to abruptly adopt digital strategies in their project delivery methods, the role of technology has become even more important (Booyens and Van Beek, 2020; Harinarain and Naicker, 2019; Mahajan, 2021).

Digitisation of construction execution processes means doing away with manual and paper-based management of construction site activities. It is a data-driven solution that enables improved construction execution practices (Sawhney et al., 2020). A paradigmatic shift towards real-time sharing of information for guaranteed transparency and collaboration, progress fast tracking and quality control for better and more reliable outcomes (Kähkönen and Rannisto, 2015). IoT implementation is one digital strategy that can facilitate in reducing complexity and uncertainty by offering project managers the ability to monitor and modify on-site operations and enhance information exchange to increase productivity and efficiency. The deployment of IoT could be pivotal in transforming the construction industry to enable new functionalities along the entire project value chain (World Economic Forum, May 2016). The WEF (2016) suggest that emerging and developing countries must identify how they can benefit from technological advances already being applied in developed countries. As such, this paper seeks to review how construction project site management professionals can leverage IoT for effective information management and communication. It will highlight tools required in leveraging IoT for enhanced CSM information management and communication. Furthermore, the paper will review challenges currently hindering wide adoption of IoT to aid project management professionals in strengthening their strategies when implementing IoT beyond health and safety.

2. Preliminary Review of Literature
2.1. The internet of things (IoT)
IoT leveraging potential within the construction industry can be rated across phases and functions (Alaloul et al., 2020). Moreover, it can be characterised into four main aspects: digital access; digital data; automation; and connectivity. Digital access describes the possibilities enabled by information and communication (ICT) systems in accessing the internet and enterprise resource planning (ERP) systems. Digital data entails the electronic capture and analysing of data to generate insights regarding processes in the construction project value chain for informed decision making and efficiency improvement. Automation classifies autonomous, machine learning and artificially intelligent systems. Lastly, connectivity characterises the opportunities to integrate and synchronise previously isolated activities and systems (Schober, 2016).

For an environment that is increasingly complex and ephemeral, real-time on-site data capture through IoT can radically improve cost savings, connectivity, greater flexibility, and adaptability (Martinez et al., 2020). Furthermore, in the wake of digital transformation across the project life cycle, it can be argued that a construction process-orientated development of cyber-physical working methods ensure optimal workflow definition, creating basis for standardisation and efficiency improvement. Additionally, real-time capture of on-site processes’ data through IoT would outline comparison between intended and actual progress. Thus, enabling substantive forecasts of time and cost during the progression of the construction phase (Atayero et al., 2016; Gubbi et al., 2013; van Wyk and Kajimo-Shakantu, 2019).
This would add value in controlling construction progress both to the client and contractor through remote supervision, more detailed documentation, and improved budget security.

The internet of things (IoT) is an integrated framework of innovative applications sharing information across organisational platforms through connected sensors and actuators (Gubbi et al., 2013). Kobusińska et al., (2018) describes IoT as a dynamic and ubiquitous network of interconnected agile devices and sensors embedded to enable scalability, flexibility, and ubiquity in multimedia data processing, storage, access, as well as communications. These devices extract data from social environments and wireless networks provide connection between “things”. The promise of IoT lies in the cyber-physical systems with the capability to record, generate and process information previously performed with human shortcomings (Chen et al., 2021).

IoT in construction encompasses the use of wearable or site embedded internet-connected sensors and actuators. These devices enable the collection of certain data regarding activity, performance, and conditions of the construction site (Gamil et al., 2020; Oke and Arowoiya, 2021). Internet connectivity allows the transmission of this data to dashboards where it is utilised for real-time monitoring of certain construction site aspects.

Thus, integrating and translating data into real-time decision-making insights to enhance performance of construction processes. Ergo, IoT has lucrative implications for construction site management in health and safety (safety monitoring), productivity (task management), resource management (asset tracking and monitoring) as well as cost and time saving (site monitoring) (Dilakshan et al., 2021; Dogan and Akcamete Gungor, 2020; Louis and Dunston, 2018). IoT is replacing legacy operational models in their entirety. It is no longer a mere tool to assist in carrying out tasks but a technology that permeates every part of construction execution process (Agarwal et al., 2016). However, several studies focusing on digital technologies within the south African construction industry have highlighted lack in adoption (see (Oke and Arowoiya, 2021; Ozumba and Shakantu, 2014, 2017), recent literature addressing IoT praxes within the industry indicates its proliferation (Aghimien et al., 2019; Arowoiya et al., 2020; Ikuabe et al., 2020; Oke and Arowoiya, 2021; Osunsanmi et al., 2020; van Wyk and Kajimo-Shakantu, 2019).

Information management and communication refers to the manner in which information discovered is handled and essentially conveyed to relevant parties (Miao, 2022). It is a term coined by merging the concepts of information management and information communication. The term encompasses the general harnessing of information from information resources to enable utilisation by the right parties for process efficiency improvement (Serema and Mooko, 2014). This aspect concerns how information discovered is organised, accessed and how users can interact with the information (Safapour et al., 2020).

Essentially, it describes the entire information life cycle from capturing of operational information for delivery through various channels to the various organisational stakeholders. "The main purpose of communication is to inform or share facts, ideas and opinions for desired actions between sender and receiver" (Lee and Kim, 2018). Fundamentally, communication plays a major role in transferring project specific data and enabling information visualisation (Miao, 2022). Conversely, suboptimal information management with regards to information communication in construction site management leads to delays in the progression of works, defects and at times project failures (Alsafouri and Ayer, 2018; Safapour et al., 2020). Information management and communication as relating to importing timely, accurate information and timely transfer of data affects all other aspects of CSM such as Health and Safety and site material management among others (Dai et al., 2021).

Construction site management (CSM) is an aspect of site management that encompasses the everyday administration, control and management of resources needed to reduce inefficiencies and optimise outputs in the execution of construction activities (Ozumba et al., 2019; SACPCMP, 2019). CSM depends in part on process variability, flexibility, and the coalescence of resource transforming activities to generate finished outputs. In their findings, confirmed that increased exploitation of technology on construction sites could enhance CSM processes. They noted that prevalent digital tools may also serve as potential mitigation against management shortcomings. IoT tools have capabilities to minimize dependence on periodic information of onsite status from the various stakeholders by offering ubiquitous information and insights of onsite status (Dilakshan et al., 2021; Ikuabe et al., 2020; Wang et al., 2016). Moreover, they enable control and proactive circumvention over site activities and resources (Lee et al., 2018).
3. Research Design for the Study

An integrative literature review technique was used to study how project management professionals can leverage IoT for enhanced information management and communication (Saunders et al., 2016). Subsequent to the literature review, the study identifies strategies in leveraging IoT for IM&C. However, there are challenges that hinder optimal implementation of IoT on construction projects. These challenges are also identified. For the purpose of this paper various sources of literature including journal papers, conference proceedings and industry publications on the topic were consulted. A review of 36 articles was carried out and the findings are discussed in the section that follows.

In examining the evolution of each research concept within the global and local construction industry over the past ten years, the precise purpose of each search result is previewed to establish how it informs this study. Initially, each concept was studied in its broader context to understand what it is and its constructs. Thereafter, each study was summarised outlining the arguments and deductions made. Lastly, studies were compared and contrasted then grouped thematically. Literature questions were used to ensure that all aspects of the research that needs to be addressed through literature is addressed. To improve the transparency in the review process, sources used comprised of online data bases available through the Wits university library, open Sources: ResearchGate; Google Scholar. Search words included: digital transformation in construction; 4th IR technologies in construction; construction data management; IoT; IoT in construction; IM&C lapses: construction site management shortcomings.

4. Research Findings

4.1. CSM IM&C shortcomings

CSM IM&C shortcomings are those management lapses resulting from limitations of site management in overseeing the construction site management process that affect how information is managed and communicated (Love et al., 2014). Shortcomings emanate from “limitations in the human capacity to ally, direct, track, monitor and control the activities of operatives and movement and utilisation of resources on site” (Ozumba et al., 2019). Crescenzi and Gagliardi, (2018) argue that effective mitigation of such lapses requires technological innovation adoption. This point is also opined by (Ozumba and Shakantu, 2020) who suggest that technology-based process enhancement where technology is infused in construction sites is a need for the effective alleviation of such lapses.

Ismail et al., (2018) envisaged that with the proliferation of innovative technologies within the construction industry, comes significant increase in the volume of data generated in construction projects. Moreover, technological advancements pre- covid-19 was underpinned by the availability of information and data exchange among project stakeholders. Thus, owing to the industry’s dynamics and data availability, information management and communication suffers from critical lapses (Xu, 2021). Major shortcomings with regards to IM&C relates to the heterogeneity in information assemblage, and lack of validation as regards information exchange and repository (Ayodele and Kajimo-Shakantu, 2021).

Furthermore, Ayodele and Kajima-Shakantu (2020) argue that challenges in data management arise where inconsistency in the method of information generation affects the effective sharing of such data across platforms. This relays to the challenge of interoperability and incompatibility within databases (WEF, 2017). Other shortcomings with regard to IM&C relate to the lack of clarity in data sets due to poor information quality (Sermet and Demir, 2019), ad hoc information collection, unstructured methods of collecting information (Che Ibrahim et al., 2018; Dallaqua et al., 2021).

Furthermore, there is complexity in matching information sources resulting from the collection and storage of information using different data bases and repositories (Martinez-Rojas et al., 2018). Moreover, there is still a lack of coherence in the way information is captured, managed, and communicated, making it difficult for project stakeholders to access such information (Ayodele and Kajimo-Shakantu, 2021). Other IM&C shortcomings are due to the resistance to migrate to more digitally adept methods, lack of uniformity in construction execution, information and data integrity, manual capture of information where data collected is altered making it inaccurate, corrupted, and incomplete (Ahmed et al., 2018; Che Ibrahim et al., 2018; Chen et al., 2021; Dallaqua et al., 2021).
While extant literature highlights major shortcomings relating to IM&C, it is also important to review challenges to effective IM&C specific to the South African construction industry. As iterated in the previous section, human limitations on management performance with regard to IM&C in CSM factors how process enhancement is effected to avoid negative effects of variability (Ozumba et al., 2019). Lapses in IM&C are prominent across construction sites in South Africa due to the low-quality information and its communication during construction execution (van Wyk and Kajimo-Shakantu, 2019a). Furthermore, these challenges could be linked to the lack of real-time capacity on construction sites for monitoring, physical representation with regards to information communication, as well as the overall lack of digital convergence (Ozumba and Shakantu, 2020).

Safapour et al., (2020) suggest that insufficient experience from construction site management impedes the transfer of data and information among project team members at the right time. Consequently, this leads to the decrease of internal communication. This was the case in the study by Ayodele and Kajimo-Shakantu (2021) where they discovered that the lack of expertise relates to the willingness to share information. Diversity in information formats and ad hoc methods of information capture were also discovered as challenges affecting IM&C (Ayodele and Kajimo-Shakantu, 2021; Oke et al., 2018a). Similarly, there is a lack in concise information communication where information collected is not reported comprehensively and in detail (Ikuabe et al., 2020). This links to the context where construction execution information collected is not properly managed due to human limitations in the handling capabilities of such data (Ozumba et al., 2019; Ozumba and Shakantu, 2017) (Ozumba et al, 2019).

Furthermore, there is also a notion that project stakeholders are not exposed to the modules that would improve their expertise with regards to data capture, storage, processing, visualisation, and reporting (Ayodele and Kajimo-Shakantu, 2021). Likewise, there is still the issue of cost considerations based on perception of inherent benefits in employing technological strategies that would enhance IM&C processes (Aghimien et al., 2019). This extends to the difficulty in the collection of information in more structured ways which hinders the level of compatibility with information management systems.

Kim et al., (2013) note in their study on “on-site construction management using mobile computing technology” the difficulty among construction project stakeholders in collecting and sharing data in real time due to paper-based construction procurement activities. Ibem and Laryea, (2014) suggest that this is because paper-based methods lack capability in capturing, storing, processing, and presenting heterogeneous project information being generated in modern day construction procurement activities. It has become evident that as construction sites are getting denser and increasingly complex, paper-based procurement activities are becoming rudimentary.

Furthermore, simplifying the “integration of complex physical machinery and devices with networked sensors and software” transform the construction industry profoundly and irrevocably (Alaloul et al., 2018; Kudriaishov et al., 2016). IoT, mobile and cloud applications, and advanced analytics enable equipment and assets in capturing critical performance parameters (Kalirajan and Babu, 2019; Sivagnana and Babu, 2019). These systems can assist in monitoring productivity and reliability. Moreover, value can be derived from communicated information through advanced analytics to improve efficiency, timelines, and risk management.

Research shows IoT applications within the construction industry as enabling the capturing and analysis of unparalleled volumes of data (Kobusińska et al., 2018; Tryfon-Bojarska and Winska, 2019), contributing to enlarging current data environments for future big data and analytics (Sawhney et al., 2020). Thus, leveraging IoT presents opportunities to improve construction and operational efficiencies as well as economy (Ghosh et al., 2020). On the other hand, Madakam and Uchiya, (2019) argue that through real-time and high-speed reporting, IoT is anticipated as providing enhanced construction processes control and optimisation. Key IoT technologies making wave within the global construction industry include bricklaying robots, smart helmets, RFID sensors, GPS systems, and drones (Dogan and Akcamete Gungor, 2020).

Currently, the wider application of IoT within the construction industry is on reliable and real-time health and safety monitoring (Jin et al., 2020; Kanan et al., 2018; Mneyneh et al., 2019); automated visual management of construction activities (Burger, 2019; Kim et al., 2013; Louis and Dunston, 2018); as well as material and resource management (Arowoiya et al., 2020; Ghosh et al., 2020; Lieberman et al., 2017). Likewise, the scope of IoT capability is yet to be, through research, extended to data...
management capabilities to address process need areas as well as advancing big data and analytics within construction.

Successful leveraging of IoT processes for data capture requires a dramatic change in internal planning, procurement, and construction processes. (Agaral et al., (2020) recommends four principles for project owners and contractors in exploiting a digital technology for information management.

- Firstly, they recommend transparency and risk sharing in contracts noting that contracts should explicitly outline responsibilities allowing for equitable risk sharing and rewards. Consequently, to transition to digital information management, project owners and developers need to mandate adoption of digital technologies in contracts.
- Secondly, they recommend return-on-investment alignment where positive effects on cost, schedule, and risk optimisation are measured and communicated to build a compelling case for said technology use. Clients should measure and incentivise digital adoption across their projects while project managers should build their abilities to become digitally adept. It is suggested that midsize projects should be used to develop these capabilities.
- Thirdly, new solutions should be simple and intuitive. Interfaces should be site-personnel friendly and compatible with existing ERP solutions to eliminate spending on upgrading existing platforms. Contractors should ensure that project teams are equipped with the authority and budget to pilot new technologies.
- Lastly, change management is imperative as the importance of change towards active data management systems need to be communicated. Lack of investment in change management could lead to organisational failures similar to those encountered by those that resisted change during previous waves of technology disruptions.

The institute of Interdisciplinary Construction Process Management at the Vienna University of Technology (TU Vien) identify five areas where action is needed in leveraging IoT for SCM data capture (Goger and Bisenberger, 2020). These entails restructuring internal processes in organisational structures; consideration of contractual amendments; ensuring interoperability of software solutions; analysis of suitable processes of construction project procurement; and investment in research and development (R&D).

Current knowledge on digital technology alignment extends that IoT capabilities are developed by eliciting incremental and radical learning as two modes of organisational learning focusing on both individuals and the organisation as a whole (Dremel et al., 2020). IoT capabilities relating to electronic data management systems (DMS/CDEs) enable simpler and faster data access, less documentation errors due to the improved quality of documentation, as well as improved efficiency in information related tasks.

Kärkkäinen et al., (2019) suggest that developing a digital information management system on construction sites can contribute to optimising productivity, quality, and safety. In substantiating their claim, they argue that on-site progress reports are often subjective and only minimal operational disruptions are recorded in site meetings. In testing their hypothesis – “if information needs are mapped and categorized, methods for collecting, refining and delivering just the right information at the right time and for the right stakeholders can be constructed” – they develop a situation picture framework. This framework focuses on how information flow could be designed in a holistic manner to increase perception, comprehension, and projection of a digital strategy. Their concept indicates workflow data levels accessibility focusing on operational information needed and how to acquire, store, refine, and distribute it for enhancing on-site production processes as well as cross project planning.

Furthermore, IoT enables equipment and assets to communicate with one another and deliver critical performance parameters to a central data platform for digital capture which can be measured and processed (Woodhead et al., 2018). Web-based adaptive instrumentation and monitoring systems have capabilities to capture and store field-sensor data, construction progress data, workforce, and vehicle movement. In turn, variances and potential risks onsite can be detected from statistical analysis of such data. More importantly in very dense project sites where there are too many activities happening concurrently (Louis and Dunston, 2018).
5. Discussions and Recommendations

Data is at the heart of the entire project delivery process. Harnessing the right data can enable construction companies to devise strategies that prevent scope variances and cost overruns (Dremel et al., 2020). The power of properly harnessed data is fundamental to change in productivity and efficiency improvement. To improve efficiency, control, and project bottom line, there is a need to implement technological solutions that provide real-time capture and processing of construction execution processes' data. This would assist informed decision-making in project control, estimating costs and enterprise management (Ram et al., 2019). However, due to the manual management of construction execution processes and deliverables in developing countries such as South Africa (Safa and Hill, 2019; Agarwal et al., 2020), project monitoring often consists of mainly post hoc documenting leading to late detection of deviations from budget and scope (Kärkkäinen et al., 2019).

This late awareness impedes the implementation of timely mitigation measures resulting mostly in severe financial and reputational consequences (Batarseh, 2018; Schuh et al., 2017). The lack of real-time remote access to site-based project information give rise to incidents leading to time delays, cost overruns, and loss of material for the contractor (Osunsanmi et al., 2020). Martínez-Caro et al., (2020) argue that amid the 4th IR, it is fundamental to anchor organisational visions, aspirations, missions, and strategies in knowledge creation and data driven technologies. Consequently, the introduction of real-time project monitoring that can enable immediate action to bring projects back on track (Reyes Veras et al., 2018).

Therefore, in the context of the South African construction industry, there is a need to provide real-time data that can enable construction project managers to make informed decisions that will improve controls, efficiencies and contribute positively to the outcome for each project. Thus, addressing lapse in aspects of site management such as information management and communication (IM&C). The application of predictive analysis and machine learning to structured and unstructured data in construction execution optimises decision-making on areas such as workloads, resource management and strategies for maximising efficiency. With increased complexity, scope, scale and rapidity of projects, human limitations on CSM become more prominent. Several human limitations in manual management of on-site activities have been addressed in literature. These include Lack of coordination of on-site activities, improved processes and strategic technology adoption, lack of technology adoption as a reason for poor CSM. Noting that project requirements determine project milestones and consequently, the alternatives, the real-time digital collection, management and communication of project data through IoT could ensure enhanced definition and understanding of project control systems (Sun et al., 2020). This would lead to better uncertainty reduction and improved operational efficiency through operational intelligence (OI). Consequently, this could result in more efficient project planning, monitoring, and controlling. Thus, reshaping the status quo of the South African construction industry.

6. Conclusion

The capacity and pervasiveness of IoT in the global construction industry extends to the enhancement of collection, management, and communication of ubiquitous construction site data in real-time. Literature also shows that CSM shortcomings related to information management & communication can be improved through innovative exploitation of available IoT technologies as supposed to reinvention of technologies from other sectors. Nevertheless, there is acute lack of effort in actualising real-time information management and communication within CSM to cover lapses in various areas of CSM where increasing human resources has been ineffective. Specifically, when IoT is applied to complex heterogenous construction project planning, scheduling, and controlling processes to drive better CSM operational intelligence). Technological advancement pertaining to the construction industry (weather natural or forced by the Covid-19 pandemic) is redefining construction data discovery. IoT has enabled real-time cyber-physical systems to generate and communicate heterogenous data sets from numerous construction activities.

As noted, the effects of industry 4.0 and the accompanying ground-breaking technologies are unavoidable even to the conservative and bureaucratic South African construction industry. Therefore, developing digital approaches to leveraging project site data seems imperative. The intended outcome of the study was to heighten awareness of the vast potential of IoT through highlighting the benefits
discovered in attempting to conceptualise a real-time information management and communication framework. Thus, advancing knowledge areas, understanding and practice among South African construction project management professionals and academics regarding leveraging IoT for multiple process need mitigation in CSM.

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An audience analysis on financial feasibility studies in construction

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ABSTRACT AND KEYWORDS

Purpose of this paper
The aim of this study is to understand the needs and priorities of real estate developers in terms of financial feasibility studies.

Design/methodology/approach
An interpretivist view lends the opportunity to investigate the issue through a qualitative methodology. Semi–structured, in–depth interviews with 23 real estate developers were conducted, followed by the audience analysis to better understand the needs and priorities of the real estate developers in terms of financial feasibility studies.

Findings
From the analysis simplicity is key. The formatting of the report is vital, and the audience is not necessarily financially inclined. The audience has very specific aspects that they would like to look at that should always form part of the summary page.

Research limitations/implications
The sample size of this study is small and limited to South Africa. Thus, a greater sample size that stretches cross borders could provide more clarity and allow generalisability.

Practical implications
Understanding the audience better in terms of what their needs and priorities are, can lead to better compiled and communicated financial feasibility studies in the industry. This in turn may improve the readability of these reports and the understandability of it that leads to better investment decisions. This also grants the opportunity for quantity surveyors to produce improved and more professional reports.

What is original/value of paper.
An audience analysis was done on the audience (real estate developers) on financial feasibility studies, giving a clear indication on how the report should be formatted and what information it should display.

Keywords: Audience analysis; Communication; Construction industry; Real estate developers; Quantity Surveyors
1. INTRODUCTION

In the construction industry, the quantity surveyor prepares and manages construction budgets and this is often extended to financial feasibility studies (Maritz and Siglé, 2016; Ashworth, Hogg and Higgs, 2013). This translates into advising clients of the optimal expenditure of capital (Ismail, Droegemuller, Beazley and Owen, 2016; Cruywagen and Llale, 2017; The Association of South African Quantity Surveyors, 2020). It is important to note the distinction between overall feasibility studies and financial feasibility studies (Costello and Preller, 2010). An overall feasibility study encompasses various aspects including technical feasibility, legal feasibility, operational feasibility, scheduling feasibility and the financial feasibility (Mukherjee and Roy, 2017). The final phase of the study is to evaluate if a proposed project would adhere the financial requirements of the developer. It provides clarity on whether the investment will generate enough cash flow to counter the debt service and provide an acceptable return to the investors (Costello and Preller, 2010). The financial feasibility (Willemse, 2019) is also referred to as the economic feasibility (Mukherjee and Roy, 2017). For the purpose of this study, the term feasibility/ies will be used to refer to financial feasibility studies.

Therefore, developers receive the communication on financial feasibility from the quantity surveyors. While financial feasibility studies have been identified as a “critical success factor” of construction projects that can cause projects to fail if not executed or communicated correctly (Mudi, 2016; Mukherjee and Roy, 2017), it is essential to delve deeper into the communication aspect. Research do indicate that the aforementioned feasibilities are not executed or communicated well and do require enhancement (Hyari and Kandil, 2009).

Drawing from the above, communication skills are vital to the quantity surveying profession (Dada and Jagboro, 2012). Defining communication is thus required. McQuail and Windahl (1993) combined three definitions of communication from three groups of authors: (Osgood, Suci and Tannenbaum, 1957; Gerbner, 1967; Theodorson and Theodorson, 1969). McQuail and Windahl (1993) then defined communication as:

“In general terms, communication implies a sender, a channel, a message, a receiver, a relationship between sender and receiver, an effect, a context in which communication occurs and a range of things to which ‘messages’ refer.”

This definition bears a reminder that the receiver, the developer in this case, is just as important in the communication process as the communicator. The developer therefore becomes the audience of the communicator. This is where this study is grounded, in analysing the audience of financial feasibility studies.

3. LITERATURE REVIEW

The message in this case is a document that presents financial information, therefore understanding the core elements of an effective and quality financial document for communication is necessary. The readability of the document becomes central. Readability is affected by four main categories: content, style, format and features of organisation (Gray and Leary cited in (DuBay, 2004))

Ruesch, Bateson, Pinsker and Combs (2017) states that communication does not refer to verbal or explicit transmission of messages alone. Furthermore, Shaikh (2007) investigated typefaces as an element of a message, and the impact it has on how the document is perceived. Lexico (2020), the online version of the Oxford Dictionary, defines typeface as a particular design of type. Shaikh (2007) found that the typeface and its perceived appropriateness for a document affects the overall tone of the document and the probability of the viewer to take action based on the document (message), and whether or not the viewer prefers the document. Additionally, Hochhauser (2000) elucidates that the effective communication of a document can be assessed in terms of text factors, headings, subheadings, formatting, and readability tests. There are several guidelines for adequate document design (Hochhauser, 2000), set out hereunder:

- Sentences should be short, simple and direct
- Words comprising more than three syllables must be avoided
- Headings should be simple and placed close to the text
- Readability analysis must be performed
- The print style should be easy readable
- Justified left margins while the right margins remain ragged
- Use upper- and lower-case letters
• Work ought to be familiar to the reader
• Plain Language must be utilised

As such, some core elements that contribute to an effective message in the context of a document have been identified. Matveeva, Moosally and Willerton (2017) researched Plain Language with the aim to reinstate the use of Plain Language in the professional industry. Matveeva et al. (2017) explain that Plain Language produces guidelines for language use and design frameworks for easily comprehensible documents. The guidelines and principles for Plain Language requires an audience analysis to be done (Matveeva et al., 2017).

3.1 Guidelines for adequate financial communication

The Society of Investment Professionals in Germany (DVFA, 2007) compiled a structure of “principles for effective financial communication”. The three aspects for effective financial communication include transparency, target group orientation, and continuity.

Palmieri, Perrin and Whitehouse (2018) explored the pragmatics of financial communication. They found that previous knowledge, level of language skills, and text design play a role in comprehending financial documentation. In the context of the current study, the text design is an element of the ‘message’, and the level of knowledge and language skills are elements of the ‘receiver/audience’. They examined the extent to which the three contextual elements affected the capability to comprehend financial communication. They concluded that the skills required to successfully interpret financial documentation varies with the format of the text presentation. This means, the simpler the text format and design, the less skill is required to successfully interpret and use the information given. The ‘message’ is thus the element that can be adjusted in order to achieve higher efficiency and comprehensibility. Therefore, it is essential to understand the skill levels of the audience.

Studies done on financial feasibilities (Abou-Zeid, Bushraa and Ezzat, 2007; Mackenzie and Cusworth, 2007; Hyari and Kandil, 2009; Shen, Tam, Tam and Ji, 2010; Stefánsdóttir, 2015; Sudhana, 2016; Mukherjee and Roy, 2017; Anees, Hussain, Khan and Abbas, 2018; Syed Alwee, Salehudin, Mohamed Sabli, Isnaini Janipha and Maisham, 2019; Mohammed, Naji and Ali, 2019; Huxham, 2010; Ramawela, 2017; Willemse, 2019), did not execute and audience analysis nor focussed on any of the communication aspects. An audience analysis entails finding the needs and priorities of the audience. According to Dyer (1986), the first step before doing the report should be an audience analysis. An audience analysis includes determining who will receive the report and determining audience characteristics. These characteristics include operational, objective and personal characteristics (Dyer, 1986).

4. RESEARCH METHODOLOGY

An interpretivism view was followed with an inductive approach. In depth semi-structured interviews were held with a total of 23 developers lending this study to a qualitative methodology. The population criteria for the developers are private sector developers in South Africa. Developers in the private sector are driven by commercial success while aiming for financial feasibility and benefits, whereas the public sector is motivated by success in development while aiming for social benefits (Rwelamila and Ogunlana, 2015).

A total of 46 developers were contacted, where 23 were interviewed as part of this study, ending with a success rate of 50%. The developer side of the industry is dominated by males, as only one female formed part of this sample group. As indicated in Figure 1, most of the developers interviewed were originally quantity surveyors or construction managers. However, it is clear that developers can have many different backgrounds that does not necessarily originate from a financial background or experience.
The real estate developer field is fed by other professions, as it is more an entrepreneurial role (Ramawela, 2017; Kgaka, 2018). The initial profession of the other participants includes accountants, bankers, engineers, architect, town planner, lawyer and a building inspector and valuator. It is noteworthy to mention that none of the participants started their careers by studying property development.

The objective characteristics were determined by asking the following questions:

- Tell me about your career as a developer.
- What is your role in the company?
- What type of projects do you prefer to develop?
- What did you do before you become a developer?

The operational characteristics were determined by asking:

- What do you expect from a feasibility study? / What do you want to see in a feasibility?
- What is the first section you page to?

5. FINDINGS AND DISCUSSION

The interviews yielded in-depth feedback and each interviewee is referenced (D01-D23). The data indicated that there are definite preferred formatting from the audience. The preferred formatting as stipulated by the developers are simple 4–5 pages (D02), with spreadsheet and tables (D02, D12, D14, D15, D23), broken down into the main components (land, fees, development cost, construction cost, vat calculations) (D03) while in chronological sequence (D05, D16, D17). However, detailed backing is required (D05, D11, D13, D15, D16, D17, D18, D20, D22), should any queries arise. They also indicated they want to see an easy-to-read report (D09) with graphs (D09, D12, D14) and pie charts to give one a sense of how the money is being divided (D11, D22).

One developer specific said: “It's got to look nice. It's got to have all the bells and whistles and it's got to have all the information that allows you to get a decision.” (D11) Furthermore, there needs to be a summary page (D12, D16, D19, D22) and one participant even stated they want nothing more than a one pager (D19). This indicates that all the important information should be summarised in one page that is easy to read and understand. The next question that arise, is what are these important aspects that should form part of the summary page?

The participants were asked to elaborate on their most important touch points in the feasibilities and what the first items are that they would look at, when presented to them. The data presented the following:
From the above findings, a clear and simple summary page can be developed that includes all the important elements to support the needs of the audience, while the main need is to make an informed investment decision. There needs to be clear and simple communication. Further to the summary page items, the interviewees elaborated on other elements that must form part of the feasibility study, although not necessarily on the summary page. These elements are:

- Totals for sub-contractors (D16)
- Tenant installation allowances (D05)
- Cash flow (D12, D20, D22)
- Clarity on assumptions (D04, D11)
- Sensitivity analysis (D20)
- Value engineering suggestions (D04, D07)

From the analysis it is clear that simplicity is key. The formatting is vital to the audience, as they are not necessarily financially inclined. Communication guidelines for document design and the needs of the audience has to be incorporated. If the report is simple enough for someone that is a first time developer with no financial background to understand, then anyone should be able to understand it. That should be the goal. Further, the analysis presented the elements that the audience require and therefore elucidated on the actual expectations of the real estate developers in terms of the financial feasibility document and communication. The in-depth data collected formed a comprehensive list of expectations that. This comprehensive list can contribute to a comprehensive feasibility that serves the general audience better.

6. CONCLUSIONS AND RECOMMENDATIONS

Understanding who the audience is and what they need from the report gives direction to how the reports should be compiled and communicated. It is clear that the financial feasibilities, when prepared, should follow clear communication guidelines and should not merely be a bunch of numbers on a spreadsheet. There are many requirements and expectations from the audience that should be taken into account. These requirements can form the basis of a set framework that should be followed when the financial feasibility reports are compiled. The audience can then be served with a well communicated report that has increased comprehensibility and success. For future research, an evaluation of feasibilities should be done in terms of the audience analysis to determine the acceptability thereof. An evaluation tool can be developed based on the needs of the audience as well as a framework to follow when compiling feasibilities.

7. REFERENCES


Deconstructing Female Recruitment and Retention Insufficiencies

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ABSTRACT & KEYWORDS

Purpose of this paper
This paper is a critical review of the solutions to increase female recruitment and retention despite existing gender equity-oriented policies.

Design/methodology/approach
The Social exchange theory (SET) and Job embeddedness theory (JET) are used to contextualise plausible solutions to female recruitment and retention in construction. A systematic literature review was used to identify relevant articles discussing the underrepresentation of females in the construction industry.

Findings
The results from the review identified intrinsic and extrinsic job satisfaction as key drivers for mitigating female underrepresentation in Construction Management related fields.

Research limitations/implications (if applicable)
From the lenses of JET and SET, the construction sector must prioritise overall employee job satisfaction for females. Various factors of job satisfaction, including remuneration and leave models, health and safety issues, and other gender equality issues must be achieved by organisations.

What is original/value of paper
The paper introduces the application of relevant theories to the less explored aspects of the feminine footprint of the construction industry, thereby providing a sound basis for deeper empirical research.

Keywords: Recruitment; Retention; Social Innovation; Job embeddedness; Job satisfaction
1. INTRODUCTION

The construction industry continues to experience a shortage of skilled labour globally (Sanni-Anibire, Mohamad Zin and Olatunji, 2020). Forecasts indicate that the lack of employing and retaining a skilled construction workforce will negatively affect the construction sector if left unattended on a global scale (Perrenoud, Bigelow and Perkins, 2020). Amid this shortage lies a solution that could increase the skills pool within the construction – the untapped female talent pool that currently exists within construction-related disciplines (Morello, Issa and Franz, 2018). The shortage causes are due to the following reasons: worsening skills shortage and an ageing workforce (Kim, Chang, and Castro-Lacouture, 2020). One of the most discussed characteristics of the construction sector globally is mainly male-dominated. Therefore, practices, processes, roles and norms are oriented to maintain highly gendered work structures that deter females (Galea & Chappell, 2021). Female underrepresentation in construction is a global issue and has been a long-standing battle with female retention and recruitment bottlenecks (Lewis & Shan, 2020). An unwelcoming industry exhibiting gender bias from male co-workers, work-family imbalance, wage gap, glass ceiling and sexual harassment characterises the sector as a boy's club (Morello, Issa and Franz, 2018; Regis, Alberte, Dos Santos Lima and Freitas, 2019; Rivera et al., 2021). Construction activities are inherently dangerous, leaving construction workers prone to various hazards and stressors detrimental to physical and mental health and overall well-being (Wu et al., 2018). Long working hours, excessive workloads, and the hazardous nature of construction work tend to cause sleep deprivation, depression, and musculoskeletal and cardiovascular diseases regardless of gender (Tucker, 2021). However, it is argued that women are more likely to experience high injury and fatality risks, thus requiring unique health and safety needs than males (Mariam, Olalusi and Haupt, 2020).

Furthermore, work environments such as inadequate Jobsite sanitation deter women from entering the workforce (Morello, Issa and Franz, 2018). Women working in the construction sector face a variety of operational and environmental concerns, the majority of which are due to poor physical working conditions (Mariam, Olalusi and Haupt, 2020). Therefore, the construction industry is perceived as masculine, hostile, challenging, and dangerous (Galea et al., 2015). According to Morello, Issa and Franz (2018), encouraging more females to pursue careers in construction-related fields could minimise the labour shortage, thereby contributing to the overall success of the construction sector. Therefore, this paper aims to identify drivers for improving recruitment and retention in the construction sector.

Social exchange (JET) and Job exchange (JET) are two theoretical perspectives used in this article to contextualise the necessary pull factors for recruiting and retaining a significantly untapped reservoir of skilled CM female talent.

2. LITERATURE REVIEW

The construction sector is diverse and consists of professionals recruited from various degree programs such as architecture, construction management and engineering. Many engineering fields and trade training programs ranging from electrical to welding to carpentry also form part of the sector (Morello, Issa and Franz, 2018). The construction sector's pivotal role lies in providing infrastructure for other industries to operate, making it the engine of economic growth and infrastructural development (Hamid, Singh and Mazlan, 2013). The increasing shortage of skilled labour in the construction sector due to an exodus of an ageing skilled workforce (Sanni-Anibire, Mohamad Zin and Olatunji, 2020) stands to produce negative consequences for socio-economic development (Perrenoud, Bigelow and Perkins, 2020). Inadequacies in hiring and retaining skilled workers also threaten the sector's growth (Choi, Shane and Chih, 2022). If left unaddressed, they will worsen across developed and developing economies (Brown, 2019). Subsequent implications of the skilled labour shortage include project delays and rising project costs. A promising outlook cited by Lewis and Shan (2020) is that by 2026, the CM field is predicted to grow by 11 percent, resulting in 44,800 new jobs for the well informed and competent. According to the US Department of Labor, eight hundred thousand workers will be required by 2024 to complete all building projects on the horizon (Wagner & Kulwiec, 2022). Countries within
the European Union (EU) also face labour shortages that are expected to increase due to a declining population and an ageing workforce (Brucker Juricic, Galic & Marenjak, 2021). With so many workers with decades of experience leaving the sector, the question we should be asking is are being adequately replaced (Brown, 2019). Males have long dominated the construction industry globally (Aboagye-nimo, 2018). Recent figures from the Department for Education in the UK show that the number of new construction apprenticeships in January 2019 fell to 950, down from 1,216 in 2018 (Brown, 2019). Despite the establishment of formal rules by corporations to address the issue, underrepresentation exists. In Australia’s construction sector, female representation decreased from 17 percent in 2006 to 12 percent in 2016 (Galea et al., 2020). Of the total employed South African population in 2017, 44 percent were women, and only 10 – 13 percent of these women were employed in the construction industry (Akinsiku & Ajala, 2018; Statistics South Africa, 2017).

Developing markets like Malaysia, Colombia, and Indonesia are also particularly affected by a shortage of skilled construction workers (Brown, 2019). Skills are the necessary competencies that can be expertly applied in a particular context for a particular purpose (Rata, 2019). Akomah, Ahinaquah and Mustapha (2020) mention that skilled labour plays a vital role in the success of every construction project and stands tall in the advent of sophistication and technology in building construction project delivery. A skilled workforce is considered one of the critical factors of production in construction projects (Mohammadi, Tavakolan and Koshravi, 2018). Since on-site construction activities rely primarily on a skilled workforce, any shortage negatively impacts the construction industry (Akomah, Ahinaquah and Mustapha, 2020; Hassan et al., 2018; Won, Hwang and Chng, 2021). Therefore, adequate measures must be implemented to solve existing recruitment and retention inadequacies in the construction sector, with gender equality as a driver. A significant measure exists in increasing inclusivity and diversity and growing skills without discrimination, including attracting and retaining workers from underrepresented groups (Wright & Conley, 2020). Underrepresented persons fall within a certain race, gender or ethnicity. They are often caused by discriminatory recruitment practices that discourage their selection or make the working environment unbearable for their retention (Liani et al., 2021). Many researchers have investigated various issues relating to impediments to the development of skilled labourers and the causes of skilled labour shortages in construction. Many scholars have written about the factors that deter women from the construction sector. Norberg and Johansson (2021) argue that female participation in the construction sector remains necessary to fill the labour shortage. Their study also identifies the ample opportunities for females in the construction industry.

Further analysis indicates experiences of gender-biased attitudes, discrimination, and unrealistic demands as deterrents to female career progression in the sector (Norberg & Johansson, 2021). Female professionals in the construction sector must demonstrate their technical talents and ability to fit into the workplace's expected conduct. Women faced the following pressures; the need to be as good as their male co-workers, fit into an acceptable behaviour and be psychologically strong on-site (Norberg & Johansson, 2021).

Gender bias and unequal treatment, such as pay-gap and glass ceiling, deter females from entering or progressing their careers in the construction sector. The gender wage gap is a global issue with numerous severe socio-economic effects in developed and developing nations (Jafari et al., 2020). It is commonly characterised as an organisation’s workforce having an unequal salary or income distribution based on gender (Espi, Francis and Valodia, 2019). A study conducted in Addis Ababa found variations in the average salary of male and female employees, where males are compensated higher than females when it comes to overtime (Macabodbod, Cerna and Abas, 2017). The glass ceiling is an impenetrable barrier that inhibits eligible persons from progressing and realising their full potential within their organisations (Kisi, 2019). It disproportionately affects women, preventing them from progressing in their jobs by preventing them from rising within their industries due to a lack of internal promotions (Regis et al., 2019). Gender
bias encapsulates the unwelcoming nature of the construction sector for women (Oyewobi et al., 2019). It is the cause of the leaky pipeline phenomenon, where a continual loss of female talent from the construction sector occurs (Pritchard & Miles, 2018).

Morello et al. (2018) mention the hostile working environment as a factor that causes female attrition in the construction sector. Manesh, Choi and Shrestha (2020) attribute the underrepresentation of females in construction professions to the industry’s history of being conflict dominated and full of discrimination against women. Historically the construction sector has been a male-dominated field where men have always been the majority while women have been the minority (Naoum et al., 2020). The masculine culture has shaped and maintained highly gendered work structures, practices, processes, roles, norms, and even language (both formal and informal). These factors disadvantage and exclude women from the construction workplace at all levels, except in administrative and support roles, where female representation tends to be concentrated (George & Loosemore, 2019). Women in the construction industry struggle mostly with sexist attitudes, behaviours and perceptions in the workplace. Barriers include discriminatory attitudes, gender stereotypes, wage gap, glass ceiling, lack of access to opportunities, challenges in career progression and male-dominant workplace culture. Work-life conflict, poor working conditions, long work hours, lack of knowledge and career information, lack of role models, sexual harassment, lack of education and training and lack of opportunities contribute to the lack of female recruitment and retention (Akinlolu & Haupt, 2021). An additional concern surrounding the construction sector is the inflexible working practices which often lead to work-life imbalance. Previous research indicated that females continue to take responsibility for household tasks and child upbringing despite spending many hours working outside the house. In such instances, job satisfaction may decrease with increased stress due to conflicting work-family roles (Oyewobi et al., 2019). Employees usually decide to leave organisations due to volunteer turnover caused by contrasting administrative policies and the unwelcoming behaviour of senior management (Jiang et al., 2012; Rehman, 2012). Managerial staff are not provided training opportunities and do not even have clearly defined organisational rules that managers have.

Consequently, junior staff remain unsatisfied and thus often decide to leave their organisation (Ahmad et al., 2017). Absenteeism, low morale, workplace conflict, low participation and general discontent, decreased productivity and efficiency, poor safety, and poor quality are all recognised adverse organisational outcomes (Andersen et al., 2015). The untransformed structure of South Africa’s construction sector and the continuous underrepresentation of females have been a significant source of concern for years. One of the barriers is the negative perceptions that female graduates have of CM related sectors (Moraba & Babatunde, 2019).

While interrogating the causes of female underrepresentation in construction and measures that can be undertaken in recruiting and retaining them, determining the benefits of including women remains imperative. Prior research indicates that increasing gender diversity proves beneficial for better financial outcomes, stakeholder engagement and efficient communication (Pritchard & Miles, 2018). Furthermore, since women tend to demonstrate lower tolerance for risk, their participation on audit and compliance committees decreases an organisation’s risk position, increasing the likelihood of better returns (Hickey & Cui, 2020). The following section presents the theoretical perspective used to contextualise the important factors requiring much consideration.

3 THEORETICAL PERSPECTIVE

The theoretical framework of this study is informed by two theories: the Social exchange theory (SET) and the Job embeddedness theory (JET). The argument presented is that both SET and JET are critical in achieving job satisfaction, creating the necessary conditions to deconstruct male dominance, thereby maximising female retention and gender equality. Job satisfaction is a critical aspect in guaranteeing employee productivity and career longevity, and it continues to be a proxy for employees’ physiological, psychological, and emotional well-being (Bektaş, 2017). The relationship between an organisation and its employee must be positively symbiotic and reciprocal. Often employees leave their organisation due to a lack of satisfaction which arises from the unwelcoming behaviour of colleagues, such as those in
senior management, and contrasting administrative policies (Webber & Rogers, 2018). The lack of job satisfaction may also stem from a lack of training opportunities, giving employees a feeling of stagnation in their career progression or development (De Vito et al., 2018). Human beings have fundamental needs that must be met (Norazmi et al., 2019). Within the workplace, one of the requirements is job satisfaction. Job satisfaction is a crucial subject that has piqued the interest of both business leaders and academics (Sanjeev, 2017). It has become a crucial issue for governmental, business, and non-profit organisations needing much attention (Bektas, 2017).

For this reason, managers are placing a premium on the notion of employment satisfaction (Thiagaraj & Thangaswamy, 2017). Within an organisation, employees who are content with their jobs are more likely to have a positive attitude towards accomplishing tasks with confidence and enthusiasm (Amin, 2021). Employee satisfaction benefits organisations because contented employees are less likely to quit their jobs, perform better, suffer less burnout, and demonstrate less absenteeism and tardiness (Al-Asadi et al., 2020).

Moreover, when employees are satisfied with their jobs, commitment to the organisation is heightened; The capacity of workers to be loyal and identify with the organisation prioritisling of duties and obligations is characterised as employee commitment, which is defined as the total of these feelings of job satisfaction (Ocen, Francis & Angundaru, 2017). A high level of work satisfaction reduces expenses, increases employee engagement, and improves performance (Antony, 2018). Managers are increasingly focusing on this to guarantee that their organisations' human resources stay effective and efficient in service delivery. In organisations, service delivery efficacy and efficiency are achieved if employees are satisfied with their jobs and have a sense of belonging within their organisation.

3.1 Social Exchange Theory

Initially, the social exchange theory was primarily utilised to depict how individuals interact in their attitudes and behaviours (Yin, 2018). Aju and Beddewela (2020) give recognition SET as the cornerstone of employee-organisation relationships. According to Cortez and Johnston (2020), SET refers to the extent of any social form of exchange, including tangible/intangible and material/non-material goods exchanged between individuals. The basic premise of SET is that human relations are formed based on subjective cost-benefit analysis. People tend to repeat actions rewarded in the past, and the more often a particular behaviour has been rewarded, the more likely it will be repeated (Chernyak-Hai & Rabenu, 2018). A reward is a form of affording value to employees' performance, which results in higher levels of employee loyalty and faithfulness, thereby increasing employee retention (Hadi & Ahmed, 2018; Bos-Nehles & Meijerink, 2018). SET social relationships are based on the trust that goodwill gestures will be reciprocated (Chernyak-Hai & Rabenu, 2018). Yin (2018) further explains that when it comes to social exchange, an individual is first bound to evaluate the possible rewards they can by interacting with others. Employees, therefore, tend to produce a high degree of confidence in an organisation if they pledge to provide incentives, respect, fairness, and other components, which improve their motivation to work hard (Jin & Rainey, 2020). However, the social exchange does not occur if two parties in a relationship do not get a good reward.

3.2 Job Embeddedness theory

Job embeddedness (JE) is a comprehensive set of psychological, social, and economic factors that affect employee retention (Ahmad et al., 2019). JET, like SET, was developed to explain why people stay in their jobs (Holtom & Darabi, 2018; Treuren, 2019) and is divided into on-the-job embeddedness and off-the-job embeddedness (Fasbender, Van der Heijden and Grimshaw, 2019). On-the-job embeddedness refers to the employee's connection to the company. Off-the-job embeddedness refers to the employee's connection to the community (Steindórsdóttir, Nerstad and Magnúsdóttir, 2021). Previous research has found that on-the-job and off-the-job embeddedness have distinct effects on employee behaviour and attitudes (Porter et al., 2019). The three aspects of job embeddedness are links, fit, and sacrifice (Coetzet et al., 2018). Formal or informal relationships between a person, institutions, or other persons are referred to as links (Rafiq et al., 2019). According to JE, an employee
has social, psychological, and financial links that encompass co-workers and non-work acquaintances, groups, such as one's working team, family, friends, and social clubs (Shimoda, 2017). The more linkages between a person and the web there are, and the more crucial those relationships are, the more a worker is connected to the job, the supervisor, and organisational structures like teams. The use of JET has led to findings that employees who are more integrated or embedded are less likely to demonstrate absenteeism or participate in detrimental work behaviours (Holtom & Darabi, 2018).

4 METHODOLOGY

A systematic review was the preferred methodology to explore the causes and plausible solutions to increase female recruitment and retention in the construction sector. Content analysis was used as the framework for data collection and analysis, which involved a detailed review of abstracts, introductions, methodologies, and findings of full-paper studies. Job embeddedness and social exchange theories were critically reviewed alongside factors causing female recruitment and retention in the construction sector. Relevant publications such as articles, conference proceedings, and book chapters dating from 2017 to 2022 were identified using the connected paper's website (see figure 1). Science Direct, Google Scholar, Emerald Insight, Springer, Wiley, and Elsevier; 66 studies were retrieved. The search terms originated from the main topic of the study involving female retention, recruitment and attrition in CM related work fields and JET and SET theories. The following two research questions aided in the development of search terms.

• What factors deter females from the construction sector?
• How can recruitment and retention be maximised among females?

The nature of literature included in this study dealt with women's experience in construction. Articles not available in English were excluded due to difficulty accessing their content. Articles published later than 2017 were also excluded to retain five-year relevance in determining up-to-date progress made regarding female talent retention in the construction sector. Selection criteria 1) the gendered experience of women had to be central to the article, 2) elements of Job embeddedness and social exchange or a lack thereof had to be present within the article. Based on the criteria above, the initial search resulted in n=21 articles dealing with female involvement in construction. Furthermore, relevant citations from the 21 selected articles included in the sample underwent a snowballing technique, increasing the articles used in this study to n=41. In addition articles on Social exchange and Job embeddedness and Job satisfaction were included (n=14).

Figure 1: Articles generated for study (Source: iConnectedpapers.com)
4 Results and Discussion

RQ1 What factors deter females from the construction sector?

The literature uncovers factors contributing to high attrition rates of females in the construction sector globally in the USA, countries within the European Union, developing countries in Sub-Saharan Africa and Asia and Australia. Akinlolu and Haupt (2021) outlined that the construction sector's male-dominance and oriented nature is the overarching deterrent preventing women from pursuing or perpetuating their careers in the sector. The male dominance produces gender bias toward females, which includes acts of sexual harassment, gender stereotypes, gender pay gap, lack of access to opportunities, and challenges in career progression contributing to the glass ceiling phenomena. The gender pay gap is the most significant deterrent to female entry into the construction industry in the south African context. The lack of direction provided in pursuing a CM-related career path is also a significant deterrent, coupled with a lack of adequate mentorship or coaching (Navarro-Astor Román-Onsalo & Infante-Perea, 2017).

RQ2 What can be done to improve female recruitment and retention?

The argument presented for increasing female talent recruitment and retention in the construction sector is to mitigate the factors that cause female attrition. Female recruitment should be addressed simultaneously with retention. However, retention should be prioritised. Addressing the leaky pipeline by achieving job satisfaction among the female talent pool will reflect an industry considerate of gender equality. This would result in an attractive industry that is bound to attract new female talent. In South Africa's case, mentorship from the onset of pursuing a career in construction should be afforded to females. Secondly, gender-pay gap issues must be addressed to reflect equality within organisations.

5 Conclusion

This paper aimed to identify drivers for improving the recruitment and retention of females in the construction sector using a systematic literature review. JET and SET were used to understand the factors required for maximising female retention in the construction industry. The general male-dominant nature of the construction sector proves unwelcoming to female talent and must be addressed if the sector is to curb its increasing labour shortage. The argument presented is that the leaky pipeline, which describes the loss of female talent due to the unwelcoming nature of the construction industry, must be addressed. Gender diversity in construction produces an environment that allows for the input of women in the design and construction of facilities. Female perspectives are needed when infrastructure is catered for women, e.g. construction of female prisons and hospitals that require female input. Hindrances in female retention and recruitment in CM related fields include long-working hours, work-life imbalance, male dominance, sexual harassment, lewd jokes, the glass ceiling, and the gender wage gap. The findings highlight the need for more studies, bearing in mind the key limitation of the current study, which is that the findings are limited to existing literature. This study focused on female recruitment and retention. Moreover, it is essential to note that the interpretations of the causes of recruitment and retention barriers among females are country-specific and may prove specific across various organisations. Further studies could therefore include retention and recruitment issues from the experiences of males and females in construction and consider clearly defined context-specific case studies or surveys of organisations.

6 References


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