ASOCSA

ASSOCIATION OF SCHOOLS OF CONSTRUCTION OF SOUTHERN AFRICA

JOURNAL OF CONSTRUCTION 2021

VOL 14 | ISSUE 02

ISSN 1994 - 7402

Journal of Construction

VOLUME 14 | ISSUE 2

CONTENTS

AIMS AND SCOPE

The Journal of Construction (JOC) is the official journal of the Association of Schools of Construction of Southern Africa. ASOCSA has committed itself to foster excellence in construction communication, scholarship, research, education and practice and the Journal provides this medium to achieve this commitment. There are four issues of refereed Journal of Constructions per year serving all stakeholders and participants in the Construction and Engineering sectors.

The Journal of Construction publishes quality papers written in a conversation style aiming to advance knowledge of practice and science of construction while providing a forum for the interchange of information and ideas on current issues. JOC aims to promote the interface between academia and industry, current and topical construction industry research and practical application by disseminating relevant in-depth research papers, reviews of projects and case studies, information on current research projects, comments on previous contributions, research, innovation, technical and practice notes and developments in construction education policies and strategies. Some issues might be themed by topic.

Topics in JOC include sustainable construction, educational and professional development, service delivery/customer service, information and communication technology, legislation and regulatory framework, safety, health, environment and quality management, construction industry development, international construction, risk management, housing, construction related design strategies; material, component and systems performance, process control; alternative and new technologies; organizational, management and resource issues; human factors; cost and life cycle issues; entrepreneurship; design, implementing, managing and practicing innovation; visualization, simulation, innovation, and strategies.

In order to maintain and ensure the highest quality in JOC, all papers undergo a rigorous system of blind peer review process by acknowledged international experts.

The Journal of Construction is committed to open access for academic work and is, therefore, an open access journal, which means that all articles are available on the internet to all users immediately from the date of publication. This allows for the reproduction of articles, free of charge, for non-commercial use only and with the appropriate citation information. All authors publishing in the Journal of Construction accept these as the terms of publication. Copyright of the content of all articles and reviews remains with the designated author/s of the article or review. Copyright of the layout and design of Journal of Construction articles and reviews remains with the Journal of Construction and cannot be used in other publications

Benefits of open access for authors, include:

- Free access for all users worldwide
- Authors retain copyright to their work
- Increased visibility and readership
- Rapid publication
- No spatial constraints

ADVISORY BOARD

A STRUCTURAL MODELLING ANALYSIS OF FACTORS INFLUENCING SUCCESSFUL PROJECT DELIVERY IN THE SOUTH AFRICAN PUBLIC SECTOR

Zakheeya Armoed[1] and Theo C. Haupt[2]

[1]Head of Department, Department of Construction Management and Quantity Surveying,
Faculty of Engineering and the Built Environment, Durban University of Technology,
Durban, Kwazulu-Natal, South Africa, 4001,
Phone (+27) 074 589 2244, E-mail: ZakheeyaA@dut.ac.za

[2]Supervisor, Associate Professor, Nelson Mandela University.
Email: pinnacle.haupt@gmail.com

ABSTRACT

PURPOSE

An empirical gap exists in South African literature on the key factors that influence successful project delivery of public sector construction and engineering projects. Prior research has focused primarily on select aspects of project delivery within a limited South African context [1][2][3]. This study provides an outline for gaining a deeper understanding of unexplored and unique influences that govern the public sector construction and engineering industry in South Africa. An empirical investigation of the above issues assists in refining the key influencing factors and in developing a proposed strategic infrastructure delivery management structural model for the successful delivery of public sector construction and engineering projects in South Africa [4].

DESIGN

The study employs methodological triangulation through semi-structured interviews and a scaled survey questionnaire to ascertain the views of the research participants experiences, opinions and factors that influence successful construction project delivery in the South African public sector environment. The research data collected from the triangulation methods were further analysed through empirical analysis and through the adoption of Structural Equation Modelling (SEM) to develop a proposed strategic infrastructure delivery management structural model[5][6][7][8][9].

FINDINGS

The research study findings contribute practically and theoretically to the prevailing body of knowledge and provides a foundation for policymakers and industry stakeholders to develop a ***Strategic Infrastructure Delivery Management Model*** for implementation by public sector institutions and key industry stakeholders.

RESEARCH LIMITATIONS

The research study will be limited to Kwazulu-Natal due to the Covid-19 pandemic. Furthermore, a quantitative research study will be conducted through the adoption of survey questionnaires amongst 750 construction and engineering sector stakeholders from organisations are registered with the Construction Industry Development Board, who represent their organisations' views and opinions.

VALUE

The research study contributes to the existing body of knowledge as it serve as a basis for further research into infrastructure delivery and management systems within developing countries and more specifically, the study provides the basis for research into the efficacy and appropriateness of infrastructure delivery management systems as a successful tool for infrastructure delivery management in the South African public sector environment [10][11].

Keywords: *Public Sector, Project Delivery, Statutory Framework, Legislation, Structural Equation Modelling*

INTRODUCTION

South Africa had previously been described as a nation plagued by racial inequality and a tempestuous past due to the segregationist policies and practices of the former Apartheid regime. As a united nation, the country embarked on a peaceful transition to democracy in 1994. South Africa is regarded both internally and globally as an exciting and progressive nation, with transformation policies, frameworks and strategies aimed at addressing and correcting the inequalities of the past[12][13][14].

The democratic government had implemented transformative strategic policies to encourage stability, enhance economic and socio-economic development and enable an environment for the international competitiveness of the South African public sector construction and engineering industry. However, public-sector infrastructure investment and socio-economic development have been on a significant decline since 2016[15][16][17]. Several challenges have emerged with the South African public sector construction and engineering industry and the country's transformative strategic policies. The public sector is regularly described as suffering from poor performance such as time and schedule overruns, quality defects, poor health and safety performance, fragmentation, poor communications, adversarial relationships and lack of coordination between the various project stakeholders. There has been a lack of research within the South African public sector context regarding the key operational strategies of responding to these challenges that pervade the sector. Prior to the implementation of any meaningful interventions or strategies for improvement to be developed, it is essential to gain an in-depth understanding of the nature and extent of current practices at the operational level in the South African public sector; and to acknowledge the foundational issues so that effective solutions may be implemented, as it is of national importance to understand critical theories behind current practices and the role of industry stakeholders, if the effective implementation of proposed strategies is to occur [15][12].

The construction and engineering industry is extremely project-centric, operating in an environment of great complexity and uncertainty, which is exacerbated by fragmentation in the supply chain processes; stakeholder influences; complex project characteristics and challenges such as the poor flow of information, conflicts and disputes; socio-economic factors and national and global dynamics[12]. Consequently, delays and disruptions have become endemic to the industry; with inapt strategies having resulted in further delays, disruptions, disputes and increased costs, with rising levels of dissatisfaction among clients and end-users. Studies by Hanson[18], Nkado and Mbachu[19] have found that clients are becoming dissatisfied with the outcome of construction and engineering projects as their expectations have not been met. Reasons posited have, apart from these issues, include lagging behind in technological advancement, the overall development of operational processes and not keeping abreast of societal and industry trends. The South African public sector construction and engineering industry utilise infrastructure development as vehicles to operationalise policy programmes and strategic objectives for project delivery. However, due to the labour-intensive nature of the public sector construction and engineering industry, it is critical that the optimum performance of its stakeholders is maintained for successful project delivery. Although great effort has been made by government institutions within the public sector to enhance the overall performance levels, disparagement continues to grow due to poor service delivery and the absence of a responsiveness system that satisfies the needs of the nation[20].

In recent years the public sector fails to comply with measures such as customer and stakeholder satisfaction, health and safety parameters, quality control and overall project sustainability. Therefore, this research study aims to investigate the challenges presumed to influence the overall project performance and development of the South African construction and engineering sector. This paper investigates how to improve overall construction and engineering project performance through understanding the nature and degree of challenges, systemic bottlenecks, uncertainties, legal frameworks, policies, and other factors that result in delays, disruptions and acceleration strategies. The study will further seek to develop modalities and interventions for improvement in construction project delivery within an industry that has been declared a national asset.

LITERATURE REVIEW

STATE CONTROLLED INEQUALITIES

The development of economic and socio-economic infrastructure in South Africa has a long and troubled history. During the 19th, 20th and 21st centuries, the development of infrastructure in South Africa was controlled by the state. The state owned, and operated infrastructures such as harbours, roads, airports, power stations, railway lines, water systems, and all communication networks. However, access to economic and social infrastructural services and government contracts was pre-determined along racial lines, with favour being granted to the minority white population and away from the majority black population. In the late 20th century, South Africa had experienced an economic crisis and an increased movement with the racial class struggle, which resulted in a grave threat to the level of success of construction and engineering sector companies. In 1994, South Africa had experienced a further change with the dawn of a new era under the new political rule of the ANC. In an effort to address the discriminatory and unfair practices, the Constitution of the Republic of South Africa (RSA, 1996) laid the foundation for the public procurement system. Many policies and legislative interventions were enacted, such as the Preferential Procurement Policy Framework Act, 5 of 2000 (PPPFA) (RSA, 2000). The Public Finance Management Act, 1 of 1999 (PFMA) (RSA, 1999) and the Broad-Based Black Economic Act, 53 of 2003 (B-BBEE) had been devised and implemented to generate increased participation by the black population in all aspects of the construction and related property industry[14][21][22].

POST-APARTHEID DEVELOPMENTS

The present-day construction and engineering industry in South Africa has shown to be a dynamic, multifaceted industry that is complex and risky due to its political transformation and the emergence of the inclusive nation in a post-apartheid era. The apartheid era was an era plagued by sanctions and racial policies which restrained the growth of the construction and engineering industry. As a result, the industry continuously experiences a gradual change and sense of complexity as the industry develops with the economy; in size, intricacy and sophistication[12], with the industry continuing to evolve, enhance and effectively overcome challenges posed by economic expansion. It is essential to a country's economic and societal development, both nationally and internationally, and appears in its national accounts: GDP, GNP, GNI and GFCF. The industry accounts for 2-6% of total employment in developing countries, with capital formation amounting to 7-13% of the GDP.

The Capital Expenditure (CAPEX) Report published in 2018 by Statistics SA stated that public sector institutions had recorded the largest CAPEX budget for 2018 at R111 billion compared to the allocated R127 billion in 2017. However, this was overshadowed by a 4% decline by municipalities, from R62 billion to R60 billion between 2017 and 2018, respectively. The CAPEX report further indicates that the national government budget for infrastructure had declined by 5%, which has become a trend in the South African public sector[12][14][15].

The country has made a resolute commitment to infrastructure development and transformation among the historically disadvantaged communities, where significant achievements have been made in terms of capital investment with a decrease in service backlogs that were inherited from apartheid [23]. However, recent years have seen an emergence of challenges such as infrastructure service delays and disruptions which is a common sight into the present-day construction industry. The management and successful completion of construction projects have faced many difficulties due to the intrinsic complexity, dynamics and uncertainty of construction projects regardless of the numerous interventions that have been employed. Despite South Africa's new economic policies and framework, unemployment still remains high, and productivity growth remains low, which is reflected through the GDP per capita growth[16][24][25].

THE CHALLENGES OF THE PUBLIC SECTOR

The construction and engineering sector is well known globally to face a constant array of challenges. However, developing countries have faced these difficulties and challenges at increased levels, which are present alongside the countries' socio-economic stresses, long-lasting resource shortages, institutional and operational weaknesses and the overall inability to handle key issues. Ofori[26] has highlighted that in recent years these challenges have become greater in scope and severity.

Challenges intrinsic to the South African public sector include; government policies, legislatures and frameworks; financial contributions by the government with uncertain economic environments; high unemployment levels; lack of skills capacity; a diverse and troubled socio-economic culture; new levels of inequality; poor stakeholder management; technological information inactivity and the overall dependence on engrained colonial codes of conduct and standards; a lack of sustainable development; stagnant industry developmental processes and force majeure events such as the Covid-19 pandemic; all of which affect project performance[16][17][27][30].

In the public sector, the construction and engineering industry faces ongoing construction project performance issues and challenges with respect to successful project delivery. These challenges are exacerbated by a general state of socio-economic stress, continued resource shortages, organisational weaknesses and an inability to deal with key issues due to continuously changing government priorities due to rapid globalisation as well as sociological, economic and political constraints[26][31][28][29]. Good levels of efficiency and successful delivery of projects often lead to the creation of socio-economic growth, wealth and improved standards of living for society. This level of efficiency by the South African construction and engineering sector may be viewed as the main criterion of project success[34][35].
However, the South African construction and engineering sector has experienced extensive project delays and disruptions, and in so doing has often exceeded the preliminary project duration times and cost budgets[26][32][33][36]. Once the key influencing factors for poor project delivery associated with the above challenges are addressed; the development or amendment of infrastructure delivery management systems can be actualised for the successful completion of construction and engineering projects[17][27][32][33].

RESEARCH METHODOLOGY

This paper forms part of a larger study, which adopted a mixed methodological approach. This research approach presented the best probability of collecting useful data to produce relevant evidence that assisted in answering the initial research question as concise as possible and in sanalysing data that produces findings that can be used to develop meaning and new knowledge. Exploratory semi-structured interviews and final survey questionnaires were employed to public sector engineering and construction industry professionals, to gather data, with the research question being central to the research study. A probability sampling technique was employed for the qualitative methodology, sutilising a random selection process. In the questionnaire sampling, a simple random stratified sampling method is one of the probability methods used in this research study, which allows for equal opportunity for the participants of the target population. Electronic mailing was used to disseminate and conduct the exploratory semi-structured interviews and main survey questionnaires amidst a global pandemic.

Key public sector industry professionals actively involved in the Kwazulu-Natal region were selected and invited to participate in the qualitative semi-structured interview. The selected individuals included heads of public sector departments, construction industry profesionals, consultants, senior managers and managers. A total of 50 invitations were sent out, with responses from 8 participants. Findings emanating from the exploratory semi-structured interviews informed the main quantitative questionnaire survey, which was adopted to further ascertain the views and opinions of industry stakeholders and professionals that are actively involved in the construction and engineering sector. Eight hundred fifty-three sorganisations registered at Grade 6 and above were identified on the Construction Industry Development Board database for the Kwazulu-Natal region. These are the grade of contractors who participate in large-scale public-sector infrastructure projects. One hundred and three sorganisations were identified as suspended and/or blacklisted on the database. Therefore only 750 questionnaire surveys were distributed to organisations, via email as well as by invitation through their registered associations. A total of 103 respondents participated in the questionnaire survey, with eight respondents presenting data that were missing or had presented irregularities. IBM SPSS Software was used sanalyse the data collected and identify missing data points. Cases that presented one missing data point were replaced with the mode of the other scores of the measurement scale. As a result, a total of 96 respondents were considered, which indicated a response rate of 13% with no missing data or irregularities present, highlighted in table 1. Extensive analysis and findings highlighted by the SPSS Software and Structural Equation Modelling are provided below in tables 2, 3 and 4, making sure to include confirmatory factor analysis, reliability, validity, model modification and model refinement.

Table 1: Profile of Respondents

PROFILE OF RESPONDEN TS		
Gender Composition		
Gender	*Frequency*	*Valid %*
Male	89	92.7
Female	7	7.3
Total	96	100.0
Age Composition		
Age Group	*Frequency*	*Valid %*
30 - 39	28	29.1
40 - 49	29	30.2
50 - 59	32	33.4
60 - 69	7	7.3
Total	96	100.0
Profession Composition		
Profession	*Frequency*	*Valid %*
Main Contractor	82	85.4
Project Manager	7	7.3
Engineer	7	7.3
Total	96	100.0
Professional Position Composition		
Professional Position	*Frequency*	*Valid %*
Chief Executive Officer	49	51.0
Senior Manager	21	21.9
Manager	19	19.8
Employee	7	7.3
Total	96	100.0
Professional Experience Composition		
Professional Experience	*Frequency*	*Valid %*
0 - 9	14	14.6
10 - 19	41	42.8
20 - 29	22	22.9
30 - 39	19	19.7
Total	96	100.0

PRESENTATION OF FINDINGS

Data from the exploratory semi-structured interviews and survey questionnaires highlighted the various influencing factors that impacted successful project delivery. The use of SPSS and SEM initially produced 6 key constructs and 38 factors. These were further reduced to 5 key constructs and 16 factors in the final structural model. Table 2 highlights the mean ratings, standard deviation and normality testing of the 38 factors of the 6 constructs that influenced successful construction and engineering project delivery in the South African public sector.

Table 2: Mean Rating and Ranking of Influencing Factors

Code	Influencing Factors	Rank	Code	Influencing Factors	Rank
PCHF5	Project Budget Size	1	PCF7	Sustainability	20
PCHF3	Project Size	2	PCF6	Information Technology	21
PCHF4	Project Complexity	3	PCF8	Industry Development	22
PCHF2	Project Scope	4	SEF8	Social Services	23
PSI2	Consultant Influence	5	SEF12	Transformation Policies	24
PSI3	Contractor Influence	6	PCF9	Force Majeure Events	25
PCF2	Financial Contributions	7	SFLF3	Equity Policies	26
PCHF1	Project Type	8	SEF4	Employment Rate	27
PCF5	Stakeholder Management	9	SEF9	Monetary Policies	28
SFLF5	Construction Contracts and Procurement Processes	10	SEF10	Investor Confidence	29
SFLF1	Political Policies	11	SEF11	Fiscal Policies	30
PSI1	Client Influence	12	NGD3	National Economic Trends	31
PCF4	Socioeconomic Culture	13	PSI4	Public Sector Officials Influence	32
PCF3	Skills Capacity	14	SEF6	Poverty and Inequality	33
PCF1	Government Policies Legislature and Frameworks	15	SEF1	Gross Domestic Product	34
SFLF4	Building Regulations	16	SEF2	Consumer Price Index	35
SEF7	Crime	17	SEF3	Gross Fixed Capital Formation	36
PCF3	Skills Shortage	18	NGD2	Global Economic Trends	37
SFLF2	Public Sector Policies and Management Systems	19	NGD1	Global Political Dynamics	38

The Kolmogorov-Smirnov and Shapiro-Wilk methods were applied to measure the levels of normality. Table 3 indicates that the data was significantly different from the normal distribution at 0.000. As a result, maximum likelihood estimation with robust standard errors and chi-square were employed in order to account for the non-normality of the dataset.

Table 3: Mean Rating, Standard Deviation and Normality Testing

	N	Mean	Std. Dev	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
				Stat	df	Sig.	Stat	df	Sig.
Project Stakeholder Influence									
Client Influence	96	7.531	2.850	.223	96	.000	.794	96	.000
Consultant Influence	96	8.322	2.129	.295	96	.000	.764	96	.000
Contractor Influence	96	8.270	2.751	.315	96	.000	.644	96	.000
Public Sector Officials Influence	96	6.000	3.012	.184	96	.000	.906	96	.000
Project Characteristics									
Project Type	96	7.968	1.997	.262	96	.000	.808	96	.000
Project Scope	96	8.479	1.628	.314	96	.000	.785	96	.000
Project Size	96	8.510	1.666	.272	96	.000	.796	96	.000
Project Complexity	96	8.479	1.753	.224	96	.000	.810	96	.000
Project Budget Size	96	9.135	1.342	.303	96	.000	.666	96	.000
Project Challenges									
Government Policies, Legislatures and Frameworks	96	7.416	1.658	.200	96	.000	.889	96	.000
Financial Contributions	96	8.041	2.275	.222	96	.000	.799	96	.000
Skills Capacity	96	7.427	2.279	.235	96	.000	.866	96	.000
Socio-Economic Culture	96	7.479	1.722	.155	96	.000	.899	96	.000
Stakeholder Management	96	7.895	2.438	.295	96	.000	.798	96	.000
Information Technology	96	6.947	1.700	.211	96	.000	.915	96	.000
Sustainability	96	6.968	1.497	.252	96	.000	.885	96	.000
Industry Development	96	6.843	1.778	.194	96	.000	.899	96	.000
Force Majeure	96	6.572	2.606	.127	96	.001	.903	96	.000
Socio-Economic Factors									
Gross Domestic Product	96	5.760	2.165	.214	96	.000	.854	96	.000
Consumer Price Index	96	5.750	1.685	.121	96	.001	.935	96	.000
Gross Fixed Capital Formation	96	5.677	1.599	.215	96	.000	.901	96	.000
Employment Rate	96	6.406	2.515	.226	96	.000	.893	96	.000
Skills Shortage	96	7.135	2.150	.127	96	.001	.923	96	.000
Poverty and Inequality	96	5.875	2.596	.155	96	.000	.920	96	.000
Crime	96	7.250	2.289	.212	96	.000	.891	96	.000
Social Services	96	6.666	2.039	.148	96	.000	.941	96	.000
Monetary Policies	96	6.354	2.214	.147	96	.000	.916	96	.000
Investor Confidence	96	6.354	2.470	.149	96	.000	.887	96	.000
Fiscal Policies	96	6.135	2.060	.163	96	.000	.921	96	.000
Transformation Policies	96	6.572	2.288	.137	96	.000	.925	96	.000
Statutory Frameworks and Legislation Factors									
Political Policies	96	7.718	1.878	.195	96	.000	.886	96	.000
Public Sector Policies and Management Systems	96	6.989	2.007	.182	96	.000	.926	96	.000
Equity Policies	96	6.437	2.160	.185	96	.000	.927	96	.000
Building Regulations	96	7.333	2.360	.177	96	.000	.883	96	.000
Construction Contracts and Procurement Processes	96	7.750	2.181	.206	96	.000	.863	96	.000
National and Global Dynamic Factors									
Global Political Dynamics	96	4.968	2.216	.164	96	.000	.897	96	.000
Global Economic Trends	96	5.114	1.929	.179	96	.000	.920	96	.000
National Economic Trends	96	6.135	2.781	.259	96	.000	.868	96	.000

Table 4 shows the overall reliability and the corrected item-total correlation statistics of the initial 6 constructs. The findings reflect the unidimensional and reliability of the 6 constructs and the refined 23 factor elements that were extracted using Exploratory Factor Analysis (EFA). The results illustrate that the corrected item-total correlation values were > 0.3, which indicates that the factor elements were adequate and good measures of the construct. Table 4 further indicates the Cronbach's reliability tests, with findings being greater than or relatively equal to the recommended 0.7, indicating a dataset that was both reliable and valid. The 6 constructs and 23 factor elements comprised the initial proposed model for Structural Equation Modelling as the key factors influencing the success of construction and engineering project delivery in the South African public sector.

Table 4: Exploratory Factor Analysis

Construct	Factor Elements	Corrected Item-Total Correlation	Cronbach's Alpha if item deleted
Project Stakeholder Influence	Client Influence	.854	**0.896**
	Consultant Influence	.744	
	Contractor Influence	.766	
	Public Sector Officials Influence	.752	
Project Characteristics	Project Type	.854	**0.748**
	Project Scope	.715	
	Project Size	.719	
	Project Budget Size	.892	
Project Challenges	Government Policies, Legislatures and Frameworks	.855	**0.850**
	Financial Contributions	.613	
	Socio-Economic Culture	.778	
	Stakeholder Management	.828	
	Information Technology	.512	
Socio-Economic Factors	Gross Domestic Product	.310	**0.698**
	Employment Rate	.719	
	Poverty and Inequality	.383	
	Crime	.558	
Statutory Frameworks and Legislation Factors	Equity Policies	.766	**0.911**
	Building Regulations	.854	
	Construction Contracts and Procurement Processes	.686	
National and Global Dynamic Factors	Global Political Dynamics	.679	**0.825**
	Global Economic Trends	.872	
	National Economic Trends	.571	

Structural equation modelling was used to develop a structural model to measure how well the collected data fitted the hypothesised conceptual model of the 6 constructs and 39 influencing factors. The path diagram in figure 1 depicts the various hypothesised relationships after the refinement of the hypothesized conceptual model to include five latent constructs. The final structural model had one independent and five intervening variables, with the intervening variables having 16 measuring variables. To measure the five dependent variables, a second-order factor analysis was conducted. According to[31] second-order factors are measured indirectly through the indicators of the first-order factors. Factor loadings were used to determine model parameters. The overall association between the 16 observed variables and five latent constructs was determined by employing standardised and unstandardised factor loadings. Standardised factor loadings > 0.50 were investigated as they indicated a reasonably good construct and convergent validity of the structural model[39]. Standardised regression weights were used to accept or reject the hypotheses from the structural model. According to[39][40], a hypothesis with a standardised regression weight < 0.1 should be rejected. The five hypothesised latent constructs of this research study were supported at the 95% level of significance.

Figure 1: The Final Structural Model

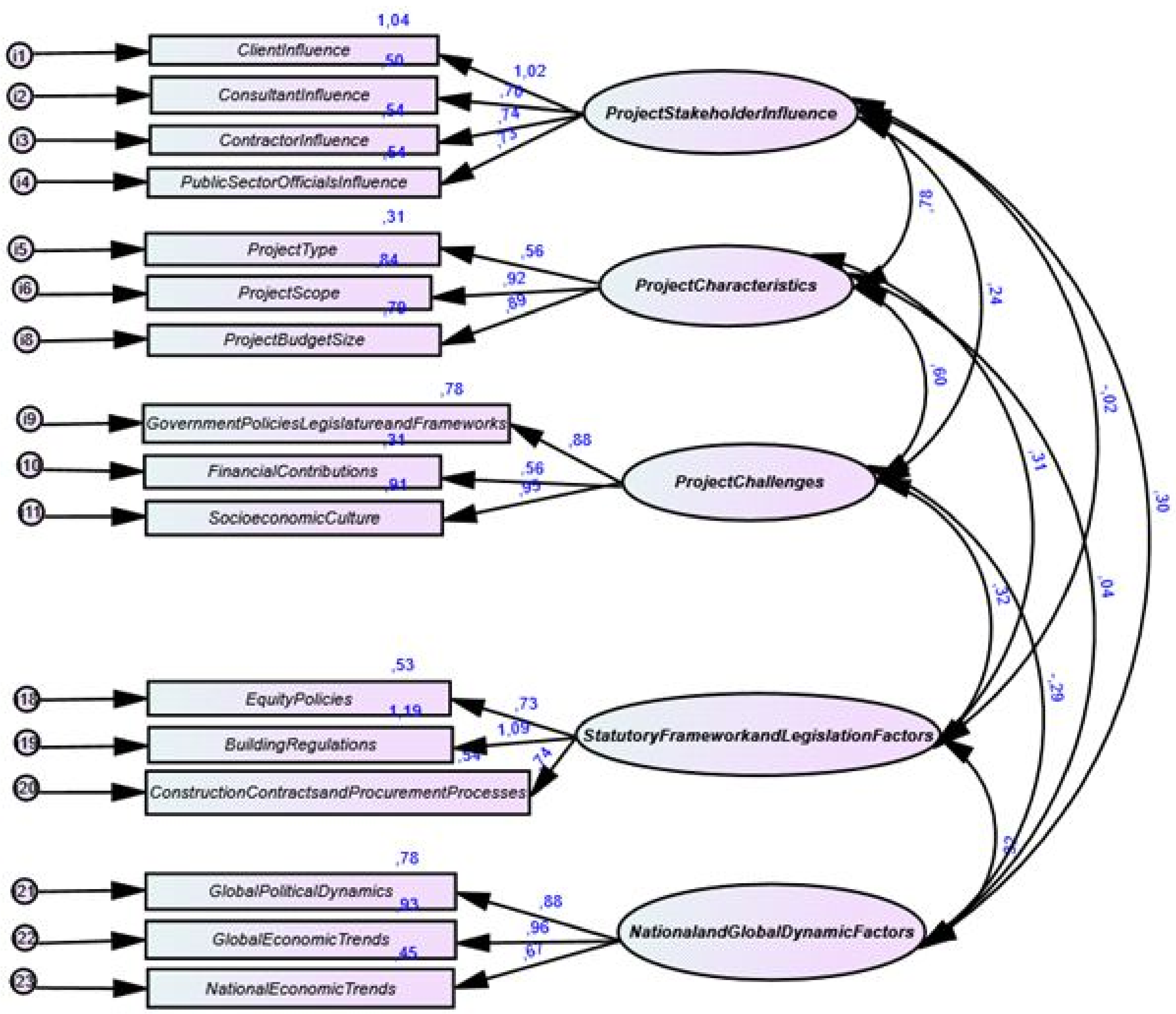


Table 6 highlights the standardised regression weights of the five latent constructs of the structural model that was > 0.1, with the highest value being Project Characteristics (1.136). The overall standardised regression weights were in the range between 0.745 and 1.136. The standard errors of the model do not present extremely small or large values. The hypothesised relationships of the five latent constructs present a CR value between 10.824 and 6.120 that positively support the hypothesised relationships. The research analysis results positively indicate that the participants of the research study considered the five latent constructs as essential factors that influenced project delays and disruptions in the construction and engineering sector.

Table 6: Structural Model Hypothesis Testing

Latent Constructs	Estimate	S.E.	C.R	p-Value	Conclusion
Project Stakeholder Influence	0.745	0.063	10.326	***	Cannot be rejected
Project Characteristics	1.136	0.196	6.120	***	Cannot be rejected
Project Challenges	0.997	0.119	9.060	***	Cannot be rejected
Statutory Frameworks and Legislation Factors	0.887	0.140	9.362	***	Cannot be rejected
National and Global Dynamic Factors	0.968	0.096	10.824	***	Cannot be rejected

As recommended by Anderson and Gerbing [41], Table 7 shows that the factor loading of each variable was > 0.50. The composite reliability index ranged from 0.843 to 0.897 for the five latent constructs signifying that the final structural model had attained composite reliability, adequacy and appropriateness. The average variance extracted value of the model measured the level of variance of a construct concerning the measurement error of the structural model. The constructs confirm that the model had achieved the average variance extracted value ranging from 0.651 to 0.752. The structural model had an internal reliability > 0.7, ranging between 0.819 to 0.911.

Table 7: Reliability and Validity of the Structural Model

	Observed Variable	Factor Loading	CR	AVE	Cronbach's Alpha
Project Stakeholder Influence	PSI1	0.929	0.881	0.654	0.896
	PSI2	0.785			
	PSI3	0.814			
	PSI4	0.806			
Project Characteristics	PCHF1	0.639	0.843	0.651	0.823
	PCHF2	0.899			
	PCHF5	0.888			
Project Challenges	PCF1	0.954	0.850	0.665	0.819
	PCF2	0.592			
	PCF4	0.876			
Statutory Framework and Legislation Factors	SFLF3	0.682	0.897	0.752	0.911
	SFLF4	0.792			
	SFLF5	0.653			
National and Global Dynamic Factors	NGD1	0.857	0.882	0.718	0.825
	NGD2	1.000			
	NGD3	0.658			

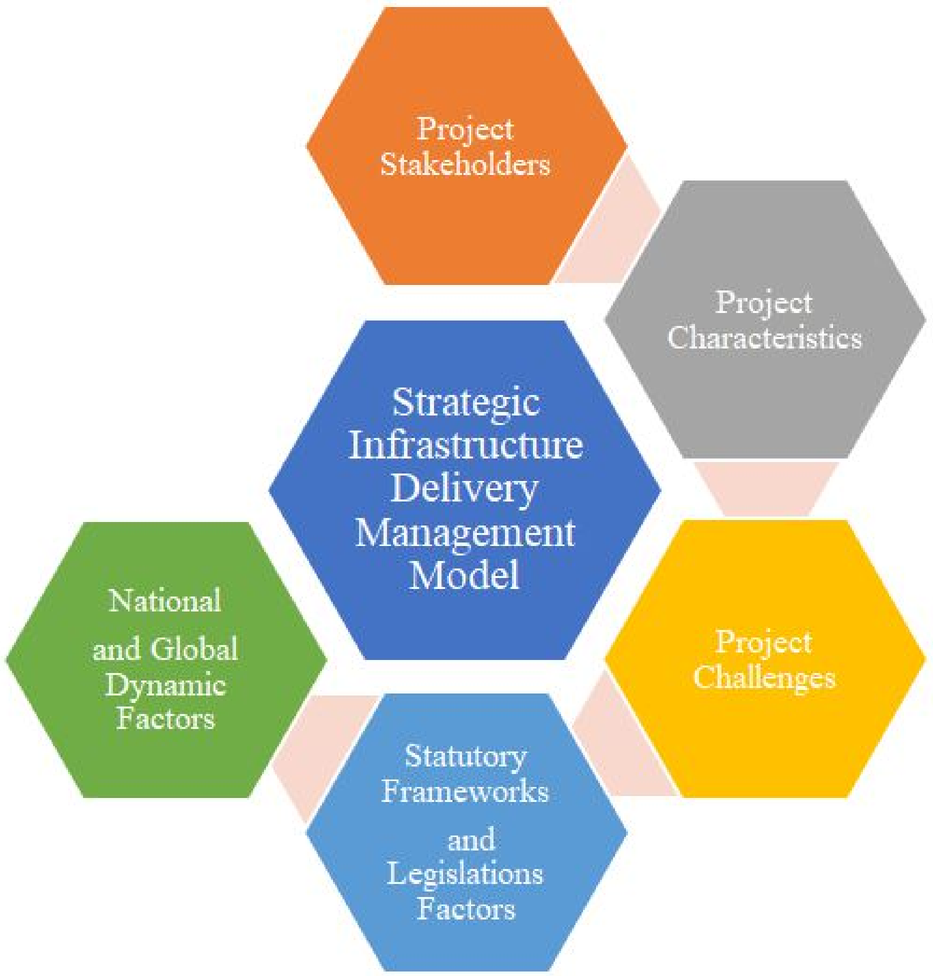
DISCUSSION

The research study sought to address the central question of *"How to enhance the successful delivery of public sector construction and engineering projects in Kwazulu-Natal?"* The various research questions and objectives arising from this central question was to identify and establish a strategic modality for successful construction and engineering project delivery that could be implemented within existing infrastructure delivery management systems within the South African public sector environment. As a result, the main objective was to identify and highlight the key factors that influenced successful construction and engineering project delivery. Based on findings from the exploratory semi structured pilot interview, key industry professionals indicated 6 essential factors that influence successful construction and engineering project delivery. These include, project stakeholder influence; project characteristics; project challenges; statutory frameworks and legislations; and national and global dynamics as essential factors. After extensive research analysis using Structural Equation Modeling, Confirmatory Factor Analysis, Reliability and Validity testing, based on findings from the final survey questionnaire; the conceptual model was refined to include five constructs with 16 associated factors. There were no factors excluded from construct one, namely project stakeholder influence and construct six: national and global economic trends. Two factors were excluded from construct two, namely project characteristics; six factors were excluded from construct three, namely project challenges. Two factors were excluded from factor five, namely statutory framework and legislation factors, with construct four: socio-economic factors being completely excluded.

The findings of this research study meaningfully contribute practically and theoretically to the prevailing body of knowledge in the area of successful construction and engineering project delivery in a uniquely South African context. The theoretical contributions of the research study lend itself towards the existent literature on the South African construction and engineering sector, the nature of the industry, which includes the characteristics, challenges, socio-economic factors, statutory and legislations implemented by the government and governing bodies, and the national and global trends that affect the industry over a period of time. Previous studies have highlighted the nature of the construction and engineering sector in developing countries and the factors that contribute to delays and disruptions. However, this research study focuses on the unique nature of the construction and engineering sector in South Africa and the prevalent factors that contribute to poor project delivery due to delays and disruptions in the South African public sector. The findings further serve as a basis for further research into infrastructure delivery and management systems in the context of developing countries. More specifically, it provides the basis for research into the efficacy and appropriateness of infrastructure delivery management systems as a successful tool for infrastructure delivery management in the South African public sector environment.

The practical implications of the study is the development of a strategic infrastructure delivery management model that considers the 5 key constructs that influence successful construction and engineering project delivery. These included; project stakeholder influence, project challenges, project characteristics, statutory framework and legislations and national and global economic trends. Based on the 5 key constructs, 16 associated factors presented itself which included project budget size, project scope, consultant influence, contractor influence, financial contributions, project type, construction contracts and procurement processes, client influence, socio-economic culture, government policies legislature and frameworks, building regulations, equity policies, national economic trends, public sector officials influence, global economic trends and global political dynamics; based on an extensive SEM analysis from leading industry stakeholders. The strategic model highlighted project budget size as the dominant factor influencing successful project delivery, with it being regarded as small and stretched across the scope of the project, with projects often exceeding the stipulated budgeted timeframe.

Figure 2: Proposed Strategic Infrastructure Delivery Management Model (Proposed SIDMM)



CONCLUSION AND RECOMMENDATIONS

This model is recommended to be adopted by public sector institutions and key industry stakeholders as a strategic tool in the effective planning, implementation and management of project stakeholders, project characteristics, project challenges, statutory frameworks and legislation, and national and global dynamics to successfully achieve satisfactory project delivery in the South African public sector environment. The research study further illustrated that these five constructs need to work cohesively with one another in order to achieve success. The strategic model shall serve as a strategic guide and be used in tandem by public sector institutions and key industry stakeholders to achieve synergy among the various project processes and delivery management systems to ensure successful project delivery.

Finally, a Strategic Infrastructure Delivery Management Model is proposed for implementation by public sector institutions and key industry stakeholders by integrating advanced technological software programs that reflect the five essential constructs and associated factors identified through extensive structural equation modelling.

REFERENCES

[1] Rafat, K. F. and Riaz Ahmed. 2017. "Empirical Study on Causes of Project Delays." World Academy of Science, Engineering and Technology, International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering 11 (2017): 166-174.

[2] Mukuka, M.J., Aigbavboa, C.O. and Thwala, W.D., 2014, December. A Theoretical Review of the Causes and Effects of Construction Projects Cost and Schedule Overruns. In International Conference on Emerging Trends in Computer and Image Processing (ICETCIP'2014) (pp. 15-16).

[3] Aziz, R.F., 2013. Ranking of delay factors in construction projects after Egyptian revolution. Alexandria Engineering Journal, 52(3), pp.387-406.

[4] Miles, D. 2017. Article: "Research Methods and Strategies Workshop: A Taxonomy of Research Gaps: Identifying and Defining the Seven Research Gaps". 1. 1.

[5] Amade, B., Ubani, E.C., Omajeh, E.O.M., Anita, U. and Njoku, P., 2015. Critical Success factors for public sector construction project delivery: a case of Owerri, Imo State. International Journal of Research in Management, Science and Technology, 3(1), pp.11-21.

[6] Abdul-Rahman H., Hanid, M., and Yap, X. W. 2014. Does professional ethics affect quality of construction – a case in a developing economy? Total Quality Management & Business Excellence, 25:3-4, 235-248, DOI: 10.1080/14783363.2013.776764;

[7] Oloruntobi, D., M., 2013. Expected success factors for public sector projects in Nigeria: a stakeholder analysis. Organisation, technology and management in construction: An international journal, 5 (2), 842-859.;

[8] Ogundelea, O., and Somefunb, O., 2008. SDI: Prospects and Challenges for Federal State Developing Countries (Case of Nigeria). The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXXVII,31-37.

[9] Chan, A.P.C. and Ada, P.L. 2004. Key performance indicators for measuring construction success. "Benchmarking: An International Journal", 11(2), pp. 203-221.

[10] Asiedu, R.O., Frempong, N.K. and Alfen, H.W., 2017. Predicting likelihood of cost overrun in educational projects. Engineering, Construction and Architectural Management, 24(1), pp.21-39.

[11] Raisbeck, P. and Aibinu, A.A., 2010, September. Early-stage cost estimation and the relationship of architects to quantity surveyors. In Proceedings 26th Annual ARCOM Conference, Leeds, UK.

[12] Cottle, E., 2014. "Twenty years of transformation of the construction Sector in South Africa since the end of Apartheid", Bargaining Indicator: Labour Research Service. Durban: UKZN Press.

[13] Seekings, J., 2014. The social and political implications of demographic change in post-apartheid South Africa. The ANNALS of the American Academy of Political and Social Science, 652(1), pp.70-86.

[14] Mooya, M.M. 2007. The impact of property education on property research in South Africa: A review. RICS Research Paper Series, 7(6), pp. 9-32.

[15] South Africa (Republic). Statistics South Africa. 2019. General Household Survey 2018. Pretoria: Statistics South Africa

[16] Fourie, D. 2014. The role of Public Sector Enterprises in the South African Economy. School of Public Management and Administration University of Pretoria, Pretoria, South Africa. African Journal of Public Affairs.
[17] Du Plessis, C., 2002. Agenda 21 for sustainable construction in developing countries. CSIR Report BOU E, 204.
[18] Hanson, D., Mbachu, J. and Nkado, R. 2004. "Causes of client dissatisfaction in the South African building industry and ways of improvement: the contractors' perspectives."
[19] Mbachu, J., and Nkado, R. 2006. Conceptual framework for assessment of client needs and satisfaction in the building development process. Construction Management & Economics. 24. 31-44. 10.1080/01446190500126866.
[20] The Public Service Commission. 2007. Promoting Growth and Development through an Effective Public Service. State of The Public Service Report. Published in the Republic of South Africa by the Public Service Commission. Commission House, Pretoria, ISBN: 0-621-37022-3
[21] Bolton, P. 2006. Government procurement as a policy tool in South Africa. Journal of Public Procurement 6(3):193–217.
[22] Perkins, P, Fedderke, JW and Luiz, JM. 2005. 'An analysis of economic infrastructure investment in South Africa. South African Journal of Economics, 73(2): 211-228.
[23] Palmer, I., Graham, N., Swilling, M., Robinson, B., Eales, K., Fisher-Jeffes, L., Käsner, S.A. and Skeen, J., 2016. South Africa's Urban Infrastructure Challenge
[24] Construction Industry Development Board (CIDB). 2004. SA Construction Industry Status Report: Synthesis Review on the South African Construction Industry and its Development. Pretoria, South Africa: CIDB.
[25] Wells, J., and International Labour Organisation. 2001. Sectoral Activities Programme (ILO). The construction industry in the twenty-first century: its image, employment prospects and skill requirements: report for discussion at the Tripartite Meeting on the Construction Industry in the Twenty-first Century: Its Image, Employment Prospects and Skill Requirements, Geneva, 2001. International Labour Office, Geneva, Switzerland, 2001.
[26] Ofori, G., 2000a. Challenges of construction industries in developing countries: Lessons from various countries. In 2nd International Conference on Construction in Developing Countries: Challenges Facing the Construction Industry in Developing Countries, Gaborone, November (pp. 15-17). [27] Construction 21 Steering Committee, 1999
[28] Pongpeng, J. and Liston, J. 2003. Contractor ability criteria: a view from the Thai construction industry. Construction Management and Economics. 21, pp. 267–282.
[29] Chen, J.J 1998. The characteristics and current status of China's construction industry. Construction Management and Economics.16, 711-719.
[30] Hillebrandt, P.M. 2000. Economic Theory and the Construction Industry. 3rd Ed. Basingstoke: Macmillan.
[31] Windapo, A.O., and Cattell, K. 2013. The South African Construction Industry: Perceptions of Key Challenges Facing Its Performance, Development and Growth. Journal of Construction in Developing Countries, 18(2), 65–79, 2013.
[32] Sunjka, B.P. and Jacob, U. 2013. Significant causes and effects of project delays in the Niger delta region, Nigeria. SAIIE25 Proceedings: Stellenbosch, South Africa © 2013 SAIIE
[33] Sweis, G.J., Sweis, R., Rumman, M.A., Hussein, R.A., Dahiya, S.E., 2013. Cost overruns in public construction projects: the case of Jordan. J. Am. Sci. 9 (7), 134–141239 (Retrieved from http://www.jofamericanscience.org/journals/am-sci/am0907s/020_19897am0907s_134_141.pdf).
[34] Islam, M.S. and Trigunarsyah, B., 2017. Construction delays in developing countries: A review. KICEM Journal of Construction Engineering and Project Management, 7(1), pp.1-12.
[35] Chan, D.W. and Kumaraswamy, MM, 1997. A comparative study of causes of time overruns in Hong Kong construction projects. International Journal of project management, 15(1), pp.55-63.
[36] Oshungade, O.O., and Kruger, D.2016. A comparative study of causes and effects of project delays and disruptions in construction projects in the South African construction industry: City of Johannesburg as a case study (Doctoral dissertation, University of Johannesburg).
[37] Hisham, S.N.A. and Yahya, K., 2016. Causes and effects of delays in construction industry. Universiti Teknologi Malaysia.
[38] Kline, R. B. 2011. Methodology in the Social Sciences. Principles and practice of structural equation modeling (3rd ed.). Guilford Press
[39] Hair, J.F., Ringle, C.M. and Sarstedt, M., 2013. Partial least squares structural equation modeling: Rigorous applications, better results and higher acceptance. Long range planning, 46(1-2), pp.1-12.
[40] Lattin, J.; Carroll, J. D.; Green, P. E. 2011. Analysing multivariate data. Pacific Grove, CA: Brooks/Cole, Thomson Learning
[41] Anderson, J.C. and Gerbing, D.W., 1984. The effect of sampling error on convergence, improper solutions, and goodness-of-fit indices for maximum likelihood confirmatory factor analysis. Psychometrika, 49(2), pp.155-173.

ASSESSMENT OF HEALTH HAZARDS AND SAFETY PRACTICES ON CONSTRUCTION SITES IN LAGOS STATE, NIGERIA

Comfort Olubukola Iyiola and Modupe Cecilia Mewomo

Department Of Construction Management and Quantity Surveying
Durban University of Technology, Durban, South Africa
22176415@dut4life.ac.za, modupem@dut.ac.za

Submitted: 07 October 2021
Accepted: 31 January 2022

ABSTRACT

PURPOSE

The study investigated health hazards and safety practices on construction sites in Lagos state, Nigeria.

METHODOLOGY

A quantitative survey was adopted using questionnaires as research instruments for gathering relevant data from professionals in the study area. The data gathered were analysed using descriptive statistics.

FINDINGS

The findings revealed that exposure to dust (SI = 0.835), slips and trips (SI= 0.784), and noise from plants, machinery and other construction activities (SI = 0.742) were the frequent sources of health hazards that occur on construction sites. The study also found that organizational culture, environmental factors, workers behaviour and awareness factors were the major factors influencing health and safety practices on construction sites.

PRACTICAL IMPLICATIONS

The study concluded that safety prevention and control system, safety planning, safety commitment and safety education/training are notable strategies that can be used to reduce health hazards and improve safety practices on construction sites.

Keywords: *Construction sites, workplace, health hazards, safety practices*

INTRODUCTION

In Nigeria, the building sector is a significant element of the economy, and it is frequently seen as the engine of growth (Sarah, 2012). Every nation's economic and social growth is supported by the building sector. It is a major element of the economy in many nations, and it is frequently cited as a driving force behind Nigeria's economic progress. According to the National Bureau of Statistics, the construction industry accounted for an average of 3.46% of the national GDP in 2014 and contributed a total of 5.34% within the fourth quarter (Q4) in 2015. Despite their importance, construction sites have traditionally been seen as high-risk settings, with numerous deaths and health concerns. (Sarah, 2012). Employees on construction sites, according to Vitharana et al. (2013), are in danger of getting hurt, dying, or developing a variety of illnesses, although the amount of danger varies, depending on the events they engage in. Although building activity in Nigeria is increasing, attempts to ensure better health and safety procedures have achieved few benefits. Within the sector, there is lack of enforcement of safety rules (Ayinde and Damilare, 2018). In addition, construction workers are killed, wounded, and suffer from illness at a higher rate than employees in any other business (Orji et al., 2016). It is, nevertheless, distressing that, despite several efforts to improve the Nigerian construction industry's wellbeing and welfare condition, the number of accidents on construction sites continues to rise, both recorded and unreported. Furthermore, fatalities, permanent impairments, and serious injuries among construction workers have been on the increase because of significant accidents and bad working conditions (Olatunji and Bashorun, 2006). Meanwhile, investigations have revealed that the high number of accidents happening and being reported on Nigerian building sites is attributable to a lack of safety procedures (Diugwu et al., 2012; Okolie and Okoye, 2012; Idubor and Oisamoje, 2013; Ayinde and Damilare, 2018). Furthermore, legislation alone will not be enough to decrease the number of risks on construction sites unless craftsmen and management take proactive steps to incorporate safety rules and regulations into their daily operations through the implementation of a safety management program. According to Waziri et al. (2015), every human in life, whether employed or not, both at work and outside of work, has an inherent desire to be safe. As a result, safety on construction sites must be carefully taken into account in order to lower the risk of being wounded at work, and it is a factor that must be closely monitored on any construction site because the success of a construction project is determined not only by the quality of the building, but also by whether or not it meets safety performance goals. Therefore, it is necessary to provide and maintain adequate safety standards on construction sites. In view of this, the study investigated the various health hazards on construction sites, factors influencing ineffective health and safety practices and strategies to improve health and safety practices on construction sites.

LITERATURE REVIEW

HEALTH HAZARDS AND RISKS

A considerable literature exists on health hazards and safety practices on construction sites. According to Zainul et al. (2020), falls from height are the most common forms of accidents on construction sites that result in fatalities. Antonio et al. (2012) conducted a study on building accident analysis in Spain. The findings revealed that drops from great elevations are the most common type of accident on construction sites. Research on health hazards and risks on building sites was conducted by Vitharana et al. (2013). According to the study, health risks were classified as chronic and acute. Workers falling from heights and electric shocks were classified as acute health dangers, whereas exposure to hazardous substances was classified as chronic health hazard. Kaskutas et al. (2009) mentioned that, falls from height are the primary cause of death and illness on construction sites. According to Almen et al. (2012), falls from height on construction sites in the United States are the leading cause of accidents. In a similar vein, Rubio-Romero et al. (2013) found that falls from buildings account for roughly 40% of fatal incidents on construction sites and most of the falls are caused by temporary equipment on buildings built to function at height. Research on safety-critical events among small construction contractors was also conducted by Jackson et al. (2011). Trips and falls were found to be the most reported critical events, followed by puncture and laceration injuries, which generally included the use of tools. The other group included being caught on projecting items, being exposed to hazardous substances, and receiving electric shocks. Research on possible risks at building sites was also conducted by Ismail and Ab Ghani (2012). Scaffolds were discovered to be a form of a temporary structure that adds to the occurrence of accidents on building sites, according to the study. Halperin and McCann (2013) mentioned that scaffolding accidents can happen if scaffolds collapse or when workers fall from scaffolds. This is consistent with Chan et al. (2004) findings, who found that the most common reasons for scaffold staging accidents were lack of compliance, scaffolds, and physical movements such as mounting, walking, distraction, inadequate capabilities, and inappropriate use of personal protection equipment. Furthermore, Marcos (2009) discovered that one of the health dangers on construction sites is noise, which can lead to hearing loss (one of the adverse health effects). Geetha and Ambika (2015) agreed, stating that noise is one of the health hazards that may be found on building sites.

FACTORS INFLUENCING HEALTH HAZARDS AND SAFETY PRACTICES ON CONSTRUCTION SITES

Research on risks and safety concerns at building sites in Bangladesh was conducted by Islam and Roy (2019). The findings revealed that the major causes of construction site accidents were a lack of personal protection equipment, a lack of safety awareness, and inexperienced labor. Vitharana et al. (2013) also conducted a study on construction site safety procedures. According to the survey, the primary causes of poor safety practices on construction sites were a lack of understanding regarding site safety and a distaste for wearing personal protective equipment (PPE). Research by Aksorn and Hadikusumo (2008) looked at the important success variables that influence the effectiveness of safety programs in Thai construction projects. According to the study, management support is the most significant element affecting safety behaviors. Worker participation, a safety preventive and control system, a safety arrangement, and management commitment were also classified as key support factors. Herrero et al. (2006) agreed with the findings, stating that management plays a critical role in an efficient and successful safety program. Saeed (2017) researched construction project safety management.

According to the findings, high accident rates are caused by several factors which are not limited to; poor construction planning, a lack of safety in design, lack of safety program, inappropriate supervision, insufficient safety training, worker behavior, the inherent safety risk of construction, and a lack of awareness of safety laws. Inappropriate safety education and training, according to Lee and Jaafar (2012) and Fang et al. (2006), is a key factor impacting health and safety behaviors on construction sites. An effective safety program, according to the study, can only be achieved if all workers are provided frequent educational and training programs to increase their knowledge and abilities on workplace safety. Sarkam et al. (2015) investigated the elements that influence construction site safety performance. The study discovered that safety knowledge is the most significant element affecting construction site safety performance, whereas management commitment and time constraints have a favorable impact on safety performance. Oluoch (2012) conducted research in Kenya on factors impacting construction site safety. The usage of personal protective equipment (PPE), the contractor's safety policy, the expenses connected with safety measures, the enforcement of legal requirements, and safety training were all determined to be important in the research.

STRATEGIES TO IMPROVE HEALTH AND SAFETY PRACTICES ON CONSTRUCTION SITES

Alkilani et al. (2013) conducted research in Jordan on factors impacting construction site safety. According to the findings, a clear, comprehensive, and practical safety plan should be developed based on the organisation's safety policy. Furthermore, the findings revealed that, to increase construction site safety, safety measures such as hiring or contracting the services of a safety specialist must be in place. The author also believes that training construction employees on safety measures and providing personal protective equipment (PPE) is critical since it enhances site safety and there is a need to educate workers on safety procedures. Also, Sunindijo and Zou (2013) attributed safety assessments, safety briefings, safety regulation implementation, safety training, and safety information as strategies to enhance health and safety procedures on construction sites. Furthermore, the dissemination of safety information necessitates management commitment to establishing a reliable channel of communication amongst employees so that they may engage in collaborative problem-solving procedures that will improve site safety (Kines et al. 2010). In their study, Chan et al. (2010) found that the incentives element is one of the variables that encourage workers to follow safety laws on the job. Chan et al. (2010) further mentioned that incentives, are a psychological strategy that rewards workers for sticking to their daily routines on the job. Personnel difficulties has been identified as an issue influencing human elements in the workplace in some studies. Personnel considerations, according to Teo et al. (2005), include both management and supervisory attitudes toward safety, as well as employees' attitudes toward safety, which both have a substantial impact on site organization. According to Fang et al. (2006), a good safety program may be realized if all workers are provided frequent educational and training programs to increase their knowledge and skills about workplace safety.

According to Fang et al. (2006), a successful safety program requires employers to provide enough supervision in order to safeguard workers from occupational dangers. Fang et al. (2006) further mentioned that productive supervision, requires competent individuals to allocate work based on workers' skills, assess workers when they perform tasks safely, interact by listening and speaking, and setting a positive example by practicing the same safe practices. Herrero et al. (2006) mentioned that administration is critical to an efficient and effective safety program. Organisations must fully and actively translate ideas into safety actions, according to the study, which includes issuing a written comprehensive safety policy, allocating sufficient resources, promptly responding to safety ideas and criticism, attending safety training briefings, and visiting the workplace on a regular basis. Abudayyeh et al. (2006) also recommended that excellent communication among construction workers is necessary to decrease health risks and enhance safety procedures. According to the study, workers can bring reports of unsafe working practices and hazardous environments to management's attention when lines of communication between management and workers are opened, and organisation can communicate their concerns and safety initiatives to gain employees compliance and awareness.

METHODOLOGY

The study was performed in Ikeja, the capital city of Lagos State in Nigeria. The population comprised construction professionals on construction sites in the research region. However, builders and safety experts were selected as the sample frame for the study using the purposive sampling technique. A total of thirty (30) well-structured questionnaires were administered to the intended respondents. The purpose of the questionnaire was to collect information on the respondents. It also includes questions on the most common sources of hazards on construction sites, the variables that influence health and safety practices on construction sites, and potential strategies to enhance health and safety practices on construction sites in the research area. The data were analysed using descriptive and inferential statistics.

RESULT OF FINDINGS

GENERAL INFORMATION OF RESPONDENTS

The general information about the respondents in the sampled construction sites is presented in Table 1. The result of the profession of respondents showed that builders have the highest frequency, 23 (76.7%) on construction sites. The result also shows that 5(16.7%) of the firms have been in operation for at least 5 years, 6(20%) of the firms have been operating for over 5 years i.e. between 6-10 years, a total of 16 (53.3%) operating for over 10 years while only 3(10%) of the firms have been around and operating for over 15 years between 16-20 years. This showed that a large percentage of firms were incorporated in the last ten (10) years and operating within Lagos. As regards employees' length of service with their firms, Table 1 shows that 10(48.9%) had been working in the same organization for about 5 years, only 8(40.0%) had spent between 6 and 10 years in the same firm, 9 (9.6%) had spent between 11 and 15 years, 2(1.5%) had spent between 16 and 20 years, while 1(3.3%) had spent over 20 years. This showed that a large percentage of the firm's employees changed their employment with a firm within 5 years

Table 1: Demographic Attributes of Respondents

Year of firms establishment	Frequency (n)	Percentage (%)
0-5 years	5	16.7
6-10 years	6	20.0
11-20 years	16	53.3
above 20 years	3	10.0
Designation in the firm		
Builder	23	76.7
Health and Safety Professional	7	23.3
Length of service		
less than 5 years	10	48.9
6-10 years	8	40.0
11-15 years	9	9.6
16-20years	2	1.5
above 20 years	1	3.3
Academic qualification		
OND/HND	12	10.0
B.Sc/B.Tech	13	40.0
PGD	3	6.70
M.Sc./M.Tech	2	43.3

Table 2 above shows the rate at which hazards occur on construction sites in the study area. The result revealed that hazards occur very often (M = 1.43, SD = 0.504) while a limited number of the respondents claimed hazards occur rarely on construction sites (M = 1.07, SD = 0.254). Based on this, it can be said that hazard occurs very often on construction sites.

Table 2: The Rate at which Hazards Occur on Construction Sites

How often do hazards occur on construction sites	Mean	SD
Very Often	1.43	0.504
Often	1.27	0.450
Rarely	1.07	0.254

FREQUENT SOURCES OF HEALTH HAZARDS THAT OCCUR ON CONSTRUCTION SITE

Table 3 shows the respondents' response on the frequent sources of health hazards that occur on construction sites. Exposure to dust with (M = 1.77, SD = 0.835), Slips and trips (M = 4.22, SD = 1.230), and Noise from plants, machineries and other construction activities (M = 4.10, SD = 1.189) were rated the highest severe hazards on construction sites. While the least frequent sources of health hazards are; electrocution (M = 2.93), exposure to chemical substances (M = 2.90), fire hazards (M = 2.77), materials falling from construction equipment (M = 2.73) and site machinery falling on excavation area (M = 2.70). It is noteworthy to know that regardless of the relative ranking of the assessed variables, they all contribute to accidents on construction sites.

Table 3: Frequent Sources of Health Hazards that Occur on Construction Site

Frequent sources of health hazards	Mean	SD	Rank
Exposure to dust	4.30	1.784	1
Slips and Trips	4.22	1.230	2
Noise from plants, machineries, and other construction activities	4.10	1.189	3
Lifting of heavy equipment	3.93	1.135	4
Exposure to sun	3.63	1.165	5
Misuse and improper maintenance of equipment	3.57	1.431	6
Refusal to abide by safety rules	3.57	1.221	7
Vibration of tools	3.43	1.213	8
Manual handling of heavy loads	3.40	1.119	9
Inappropriate use of safety gadgets	3.33	0.845	10
Structural Collapse	3.30	1.285	11
Falling from heights	3.10	1.015	12
Accidents from vehicles and plants	3.07	0.548	13
Electrocution	2.93	0.504	14
Exposure to chemical substances	2.90	0.583	15
Fire Hazards	2.77	0.794	16
Materials falling from construction equipment	2.73	0.621	17
Site machinery falling on excavation area	2.70	0.466	18

FACTORS INFLUENCING HEALTH AND SAFETY PRACTICES

This section categorized the factors influencing health and safety practices on construction sites. Twenty six variables was identified for this section. The variables were analysed using factor analysis in order to reduce the number of variable into groups. A Kaiser-Meyer-Olkin (KMO) value of 0.644 which is above the acceptable limit of 0.5 (Field, 2009) ascertained the sample adequacy for the analysis as shown in Table 4. To further ascertain the suitability of the Principal Component Analysis for data analysis, the Kaiser-Meyer-Olkin (KMO) measure of sample adequacy and Bartlett's Test of Sphericity was performed. The Bartlett's test of sphericity was statistically significant at 0.000 which is lower than the benchmark of 0.05 for suitability of data as postulated by Pallant (2010). The KMO measure of sampling adequacy is also 0.644 which is above the minimum benchmark of 0.6 (Pallant, 2010). The information is therefore considered to fulfill all of the standards.

Table 4: KMO and Barlett's Test of Sample Adequacy

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.644
Bartlett's Test of Sphericity	Approx. Chi-Square	739.073
	df	325
	Sig.	.000

TOTAL VARIANCE EXPLAINED FOR FACTORS INFLUENCING HEALTH AND SAFETY PRACTICES

In order to identify the number of components to retain and to make output easier to interpret, only components with eigenvalues greater than 0.5 and factors with communalities greater than 0.5 were retained (Kaiser, 1960; Pallant, 2010; Oladokun and Ajayi, 2018). This explains why some variables were not loaded in the table. Table 5 revealed that four groups of components were extracted and they cumulatively accounted for 43.48% of total variance explained. The result also shows the percentage of variance explained by each component. First component explains 24.54% of the total variance while others explains 11.94%, 6.86%, and 6.36% respectively. This implied that the factors can be grouped into four categories.

Table 5: Total Variance Explained

Component	Initial Eigenvalues			xzracti.ond321 Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.380	24.538	24.538	6.380	24.538	24.538	3.670	14.117	14.117
2	3.103	11.936	36.474	3.103	11.936	36.474	3.347	12.872	26.989
3	1.784	6.863	43.337	1.784	6.863	43.337	2.176	8.370	35.359
4	1.655	6.364	49.701	1.655	6.364	49.701	2.112	8.122	43.481
5	1.447	5.566	55.268						
6	1.377	5.294	60.562						
7	1.095	4.213	64.775						
8	.985	3.790	68.564						
9	.918	3.531	72.095						
10	.864	3.322	75.417						
11	.771	2.965	78.382						
12	.722	2.778	81.160						
13	.653	2.511	83.671						
14	.591	2.273	85.945						
15	.563	2.166	88.110						
16	.478	1.839	89.950						
17	.447	1.721	91.671						
18	.397	1.528	93.199						
19	.351	1.350	94.549						
20	.315	1.210	95.758						
21	.287	1.103	96.862						
22	.259	.994	97.856						
23	.192	.740	98.596						
24	.153	.588	99.183						
25	.132	.507	99.690						
26	.080	.310	100.000						

PRINCIPAL FACTOR EXTRACTION FOR FACTOR INFLUENCING HEALTH AND SAFETY PRACTICES

In order to identify the category of factors under each factor loadings, Table 6 (pattern matrix) presents the pattern of distribution of variables that makes up each components. The factors that loaded highly in components one to four were assigned unique names as shown in Table 6. Factors loaded into component one were named Organisational culture factors loaded in component two were named environmental factors, factors loaded in component three were attributed to workers' behaviour, and factors loaded in component four were named awareness/knowledge factors.

Table 6: Table showing the Principal Factor Extraction

Component Factors	Description	Factor Loading 1	2	3	4
Organisational Culture	Poor organization leadership	.693			
	Lack of workers commitment	.648			
	Lack of planning and inspection of project	.799			
	Inadequate evaluation of safety programm	.699			
	Poor quality control systems	.805			
	Lack of emergency response plan	.507			
	Inadequate safety policy and standards	.712			
	Lack of personal protective equipment	.542			
	Lack of site safety officers	.612			
Environmental factors	Lackof conducive work environment		.795		
	Tight work areas		.509		
	Work overload		.726		
	Overtime work		.794		
	Multiple operations		.815		
	Incomplete structural connection		.692		
	Crews working in close proximity		.910		
Workers Behaviour	Inappropriate workers attitude			.612	
	Technical or human error			.509	
	Low compliance to safety rules			.615	
	Insufficient communication among worker			.729	
	Poor relationship among colleagues			.579	
	Incompetence of workers			.684	
	Noncompliance with instructions			.849	
Awareness/knowledge Fa	Lack of knowledge and information on saf				.528
	Lack of safety training and education				.687
	Lack of safety experience				.749

STRATEGIES TO IMPROVE HEALTH AND SAFETY PRACTICES

This section also categorized the strategies that can be used to improve health and safety practices on construction sites. Twenty six variables was also identified for this section. The variables were analysed using factor analysis in order to reduce the number of variable into groups. A Kaiser-Meyer-Olkin (KMO) value of 0.581 which is above the acceptable limit of 0.5 (Field, 2009) ascertained the sample adequacy for the analysis. To further ascertain the suitability of the Principal Component Analysis for data analysis, the Kaiser-Meyer-Olkin (KMO) measure of sample adequacy and Bartlett's Test of Sphericity was performed as shown in Table 7. The Bartlett's test of sphericity was statistically significant at 0.000 which is lower than the benchmark of 0.05 for suitability of data as postulated by Pallant (2010). The KMO measure of sampling adequacy is also 0.581 which is above the minimum benchmark of 0.6 (Pallant, 2010). The information is therefore considered to fulfill all of the standards.

Table 7: KMO and Barlett's Test of Sample Adequacy

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.581
Bartlett's Test of Sphericity	Approx. Chi-Square	1313.0730
	df	325
	Sig.	.000

TOTAL VARIANCE EXPLAINED FOR STRATEGIES TO IMPROVE HEALTH AND SAFETY PRACTICES

In order to identify the number of components to retain and to make output easier to interpret, only components with eigenvalues greater than 0.5 and factors with communalities greater than 0.5 were retained. This explains why some variables were not loaded in the table. Table 8 revealed that four groups of components were extracted and they cumulatively accounted for 78.95% of total variance explained. The result also shows the percentage of variance explained by each component. First component explains 37.60% of the total variance while others explains 28.62%, 7.60%, and 5.12% respectively. This implied that the strategies can be grouped into four groups.

Table 8: Total Variance Explained Strategies for Strategies to Improve Health and Safety Practices

Compo-nent	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.776	37.600	37.600	9.776	37.600	37.600	8.759	33.690	33.690
2	7.442	28.623	66.223	7.442	28.623	66.223	6.812	26.200	59.890
3	1.977	7.604	73.826	1.977	7.604	73.826	2.900	11.152	71.042
4	1.331	5.120	78.947	1.331	5.120	78.947	2.055	7.905	78.947
5	.925	3.556	82.503						
6	.820	3.154	85.656						
7	.757	2.910	88.566						
8	.551	2.121	90.687						
9	.488	1.877	92.564						
10	.407	1.567	94.130						
11	.278	1.070	95.200						
12	.246	.948	96.148						
13	.195	.750	96.898						
14	.157	.603	97.501						
15	.146	.560	98.061						
16	.125	.481	98.541						
17	.104	.399	98.940						
18	.083	.318	99.258						
19	.059	.226	99.484						
20	.050	.194	99.678						
21	.035	.135	99.813						
22	.019	.074	99.887						
23	.014	.054	99.941						
24	.008	.030	99.971						
25	.006	.022	99.992						
26	.002	.008	100.000						

PRINCIPAL FACTOR EXTRACTION FOR STRATEGIES TO IMPROVE HEALTH AND SAFETY PRACTICES

In order to identify the category of strategies under each factor loadings, Table 9 (pattern matrix) presents the pattern of distribution of variables that makes up each components. The factors that loaded highly in components one to four were assigned unique names as shown in Table 9. Factors loaded into component one were named safety prevention and control system, factors loaded in component two were named safety planning, factors loaded in component three were named safety commitment, factors loaded in component four were named safety education/training.

Table 9: Table showing the Principal Factor Extraction

		Components			
		1	2	3	4
Safety prevention and control system	Adequate commitment by management	.816			
	Provision of tidy environment	.807			
	Suitable supervision	.803			
	Planned and organized site	.693			
	Efficient enforcement system	.717			
	Adequate resource allocation	.649			
	Provision of health and safety committe	.830			
	Regular safety meetings	.920			
	Provision of personal protective equipm	.571			
Safety Planning	Regular safety inspections		.926		
	Effective communicatioamong workers		.790		
	Implementing health and safety policy		.853		
	Emergency response planning		.866		
	Reducing labour turnover rates		.879		
	Allocation of authority and responsibilit		.673		
Safety commitment	Teamwork			.760	
	Clear andreasonable objective			.909	
	Personal motivation			.851	
	Right safety attitudes from workers			.742	
	Good governance practices			.709	
	Equipment and maintenance			.695	
	Management support			.867	
Safety Education/Training	Raising health andsafety awareness campaign				.929
	Regular education on health and safety practices				.844
	Availability of safety manual				.704
	Conducting safety training				.506

DISCUSSION OF FINDINGS

The research identified the most common causes of health risks on construction sites. From the result, it was discovered that exposure to dust, slips and accidents, and noise from plants, machineries, and other building activities were major health hazards on construction sites in the research region. This findings are also in support of the findings of Williams et al. (2019) and Eze et al. (2020). This may be due to the constant demolition operations that take place on construction sites, as well as vehicle movement from one location to another. The conclusion is that inhaling dust over an extended period might cause respiratory problems. Dust can also cause stomach discomfort if breathed, as well as skin and eye irritation from abrasion. As a result, eye protection should be used to keep dust out of the eyes. When physically handling blocks or bulk chips, standard construction safety equipment, including safety helmets, safety boots, protective toe caps, and abrasion-resistant gloves, should be used. This has a bigger influence on the performance of the workforce. These findings agree with David and Gary (2011), Jackson et al. (2011) and Geetha and Ambika (2015). The study also found organizational factors, environmental factors, workers' behaviour and safety awareness factors. This study corroborate the findings of Ismail and Ab Ghani, (2012) who found personal awareness and communication as the most influential factors affecting safety practices on construction sites. Agyekum et al. (2018) also attributed factors influencing health and safety practices to insufficient communication of safety programmes, lack of workers' awareness, poor personal attitudes towards safety and ineffective laws and lack of enforcement. The findings of Sarkam, et al. (2015), and Saeed (2017) also mentioned that inadequate safety policy and standards, organizational leadership, and a lack of knowledge and information on safety policy are also important variables impacting health and safety practices on construction sites. In view of this, management's should be committed to doing everything possible to prevent injuries and to maintain a safe and healthy environment, health and safety programs such as training, correct work procedures, joint health and safety committees, workplace inspection, employee orientation, reporting and investigating accidents, health and safety promotion, medical and first aid, health and safety rules, also the individual's responsibility towards health and safety risk should be considered. Management must also guarantee that personal protective equipment is provided, that workers are given health and safety information, that health and safety data are collected and analyzed, and that people are instructed to adopt safe work practices. The study also discovered that increasing health and safety awareness campaigns, regular education on health and safety practices, and the provision of personal protective equipment (PPE) on construction sites in the study area are the major factors that could improve health hazards and safety practices. This agrees with the findings of Fang et al. (2004), Herrero et al. (2006) and Kines et al. (2010) who opined that raising health and safety awareness campaigns, regular education on health and safety practices and provision of personal protective equipment (PPE) will reduce the rate at which health hazards occur on construction sites. This study categorised all these strategies for improving health and safety practices on construction sites into; safety prevention and control system, safety planning, safety commitment, and safety education/training. According to Bottani et al. (2009), while safety management programs have been shown to increase safety performance on construction sites, the majority of projects do not implement such systems. Cheng et al. (2018) further affirmed that lack of commitment to safety management programs on construction sites results in a reduction in worker safety awareness. Competent safety professionals should be held responsible for establishing and implementing the needed preventative measures for such safety management programs to be effective (Olutuase, 2014).

CONCLUSIONS AND RECOMMENDATIONS

Health hazards and safety practices on construction sites in Lagos State, Nigeria was investigated. The result concluded that hazards occur very often on construction sites in the study area. The result also claimed that exposure to dust, slips and accidents, and noise from plants, machineries, and other building activities were the most common sources of risks on construction sites in the study area. It was also concluded that organizational culture, environmental factors, workers behaviour and awareness factors were the major factors influencing health and safety practices on construction sites. Furthermore, the study found that safety prevention and control system, safety planning, safety commitment and safety education/training are strategies that can be used to improve health and safety practices on construction sites. The findings of this study are expected to contribute significantly to the implementation of health and safety rules and regulations on construction sites and minimise health risks. This study contributed to knowledge by providing information on health dangers and safety procedures, as well as some of the elements that influence health and safety practices, and also provided suggestions on how to improve their implementation.

REFERENCES

1. Abudayyeh, O., Fredericks, T.K., Butt, S.E. and Shaar, A. (2006). An Investigation of Management's Commitment to Construction Safety. International Journal of Project Management, 24, 167-174.
2. Aksorn, T. and Hadikusomo, B.H.W. (2008). Critical Success Factors Influencing Safety Program Performance in Thai Construction Projects. Safety Science, 26, 709-727.
3. Alkilani, S.Z., Jupp, J. and Sawhney, A. (2013). Issues of Construction Health and Safety in Developing Countries: A Case of Jordan Australasian. Journal of Construction Economics and Buildings, 13(3), 141-156.
4. Almen, L., Larsson, T.J. and Thunqvist, E.L. (2012). The Influence of the Designer on the Risk of Falling from Heights and of Exposure to Excessive Workloads on Two Construction Sites. Journal of Safety Science, 16(6), 1-7.
5. Antonio, L.A., Juan, C.R. and Gribb, A. (2012). Analysis of Construction Accidents in Spain. Journal of Safety Research, 43(5-6), 281-388.
6. Ayinde, O.O. and Damilare, O.E. (2018). Appraisal of Safety Practices on Construction Sites in Ibadan, Oyo State, Nigeria. International Journal of Advances in Scientific Research and Engineering, 10(4), 56-62.
7. Agyekum, K., Simons, B. and Botchway, S.Y. (2018). Factors Influencing the Performance of Safety Programmes in the Ghanaian Construction Industry. Acta Structilia, 25(2), 39-68.
8. Bottani, E., Monica, L. & Vignali, G. 2009. Safety management systems: Performance differences between Adopters and Non-Adopters. Safety Science, 47(2009), pp. 155-162.
9. Chan, D., Chan, A.P. and Choi, T.N. (2010). An Empirical Survey of the Benefits of Implementing the Pay for Safety Scheme (PFSS). Journal of Safety Research, 41(5), 433-443.
10. Cheng, S.L., Micheal, F.L., Hamidi, H. and Abdullah, S.M. (2018). The Relationship between Management Practices and Safety. Journal of Cognitive Sciences and Human Development, 4(1), 15-27.
11. Chia, F.C., Tin, C.C. and Hsin, I.T. (2004). Accident Patterns and Prevention Measures for Fatal Occupational Falls in Construction Industry. Journal of Applied Ergonomics, 36, 391-400.
12. David, J.E. and Gary, D.H. (2011). Slips, Trips, Fall and Other Risks; When Accessing, Egressing or Working Upon Workplace Transport. The Off-Highway Plant and Equipment Research Centre (OPERC).
13. Diugwu, I.A., Baba, D.L. and Egila, A.E. (2012). Effective Regulation and Level of Awareness. An Expose of the Nigeria's Construction Industry, Journal of Safety Science and Technology, 2, 140-146.
14. Eze, E., Sofolahan, O. and Siunoje, L. (2020). Health and Safety Management on Construction Projects: The View of Construction Tradespeople. CSID Journal of Infrastructure Development, 3(2), 152.
15. Fang, D.P., Xie, F., Hunag, X.Y. and Li, H. (2004). Factor Analysis Based Studies on Construction Workplace Safety Management in China. International Journal of Project Management, 22(1), 43-49.
16. Fang, D.P., Chen, Y., Wong, L. (2006). Safety Climate in Construction Industry: A Case Study in Hong Kong, Journal of Construction Engineering and Management, 132(6), 573-584.
17. Field, A. (2009). Discovering Statistics Using SPSS. Introducing Statistical Method (3rd ed.). Thousand Oaks, CA: Sage.
18. Geetha, M. and Ambika, D. (2015). Study on Impact of Noise Pollution at Construction Job Sites. International Journal of Latest Trends in Engineering and Technology, 5(1), 46-49.
19. Herrero, S.G., Saldana, M.G.M., Campo, M.A.M., Ritzel, D.O. (2006). A Model for the Improvement of Occupational Safety Management. Journal of SH and E Research, 3(3), 1-21.
20. Idubor, E.E. and Oisamoje, M.D. (2013). An Exploration of Health and Safety Management Issues in Nigeria's Effort to Industrialize. European Science Journal, 9, 154-169.
21. Ismail, H.B. and Ab Ghani, K.D. (2012). Potential Hazards at the Construction Workplace Due to Temporary Structures. Ist National Conference on Environment Behaviour Studies, Faculty of Architecture, Planning and Surveying, Universiti Teknologi, MARA, Shah Alam, Selengor, Malaysia, Department of Civil Engineering.
22. Islam, M.S. and Roy, C. (2019). Hazards and Safety Issues at Construction Sites in Bangladesh. MOJ Civil Engineering Journal, 5(2), 52-56.
23. Jackson, T. S., Artis, S., Hung, Y. and Kim, H.N. (2011). Safety-Critical Incidents among Small Construction Contractors: A Prospective Case Study. The Open Occupational Health and Safety Journal, 3, 39-47.
24. Kaiser, H.F., 1960. The Application of Electronic Computer to Factor Analysis. Education and Psychology Measurement, 20, 141–157.
25. Kaskutas, V., Dale, M.A., Nolan, J., Patterson, D., Lipscomb, J.H. and Evansoff, B. (2019). Fall Hazard Control Observation on Residential Construction Sites. American Journal of Industrial Medicine, 52(6), 491-512.
26. Kines, P., Andersen, L.P., Spangerburg, S., Mikkelsen, K.L. and Dyreborg, J. (2010). Improving Construction Site Safety through Leader-Based Verbal Safety Communication. Journal of Safety Research, 21(3), 399-406.
27. Lee, C.K. and Jaafar, Y. (2012). Prioritization of Factors Influencing Safety Performance on Construction Sites: A Study Based on Grade Seven (G7) Main Contractors Perspectives. International Proceedings of Economics Development and Research, 57(2), 6-12.
28. Marcos, D.F.B., Samuel, Q., Noelia, C. and Jose, A.B. (2009). Noise Exposure of Workers of the Construction Sector. Journal of Applied Acoustics, 70, 753-760.
29. Oladokun, S.O. and Ajayi, C.A. (2019). Assessing Users' Perception of Facilities Management Services in a Public University: A Case Study Approach. Journal of Facility Management and Research, 2(2), 62-73.
30. Olatunji, O.A. and Bashorun, F. (2006). Evaluating Health and Safety Performance of Nigerian Construction Sites. CIB World Building Congress, 11, 76.
31. Olutuase, S.O. (2014). A Study of Safety Management in the Nigerian Construction Industry. IOSR Journal of Business and Management, 16(3), 1-10. https://doi.org/10.9790/487X-16350110
32. Okolie, K.C., and Okoye, P.U. (2012). Assessment of National Culture Dimensions and Construction Health and Safety Climate in Nigeria. Science Journal of Environmental Engineering Research, 12, 1-6.
33. Orji, S.E., Nwachukwu, L.N. and Enebe, E.C. (2016). Hazards in Buildings Construction Sites and Safety Precautions in Enugu Metropolis, Enugu State, Nigeria. Imperial Journal of Interdisciplinary Research, 2.
34. Pallant, J., 2010. SPSS Survival Manual, 4th Edition. Australia.Allen & Unwin Book.
35. Rubio-Romeero, J.C., Gamez, M. and Carrillo, C.J. (2013). Analysis of the Safety Conditions of Scaffolding on Construction Sites. Journal of Safety Science, 55, 160-164.
36. Saeed, Y.S. (2017). Safety Management in Construction Projects. Journal of University of Duhok, Pure and Engineering Sciences, 20(1), 546-560.
37. Sarah, P. (2012), Health and Safety Risk Management on Construction Sites in Tanzania: The Practice of Risk Assessment, Communication and Control. Unpublished M.Sc Thesis.
38. Sarkam, S.F., Shaharuddin, L.S., Masdek, N.R.N.M., Yaacob, N.J.A. and Musramaini, M. (2015). Factors Influencing Safety Performance at Construction sites. Journal of Academic Research in Business and Social Sciences, 8(9), 1057-1068.
39. Sunindijo, R.Y. and Zou, P.X.W. (2013). Conceptualizing Safety Management in Construction Projects. Journal of Construction Engineering and Management, 139(9), 1144-1153.
40. Tam, C.M., Zeng, S.X. and Deng, Z.M. (2004). Identifying Elements of Poor Construction Safety Management in China, Safety Sciences, 42, 569-586.
41. Teo, E.A.L., Ling, F.Y.Y and Chong, A.F.W. (2005). Framework for Project Managers to Manage Construction Safety. International Journal of Project Management, 23(4), 329-341.
42. Vitharana, V.H.P., Subashi De Silva, G.H.M.J. and Sudhira, De Silva (2015). Health Hazards, Risk and Safety Practices in Construction Sites. Engineers, 68(3), 35-44.
43. Waziri, B.S., Hamma-Adama, M. and Kadai, B. (2015). Exploring Health and Safety Practices on Some Nigerian Construction Sites. In Laryea, S. and Leiringer, R. (Eds), Procs 6th West Africa Built Environment Research (WABER) Conference, 10-12 August 2015, Accra, Ghana, 491-502.
44. Williams, O.S., Hamid, R.A. and Misnan, M.S. (2019). Causes of Building Construction Related Accident in the South-Western States of Nigeria. International Journal of Built Environment and Sustainability, 6(1), 14-22.
45. Zainul, N.Z.M., Salleh, M.A.M., Hasmori, M.F. and Abas, N.H. (2020). Effects of Accident Due to Fall from Height at Construction Sites in Malaysia. IOP Conference Series: Earth and Environmental Science, 498, 1-7.

TERTIARY STUDENTS' CAREER CHOICES IN CONSTRUCTION DISCIPLINES: ARE THE PREDICTORS THE SAME FOR MEN AND WOMEN?

Mariam Akinlolu[1] and Theo C. Haupt[2]

[1]Department of Construction Management and Quantity Surveying, Mangosuthu University of Technology, Durban, South Africa

[2]Faculty of Engineering, Mangosuthu University of Technology, Durban, South Africa

ABSTRACT

PURPOSE

This study examines the gender differences in the perception of students as it relates of factors that determine their choices to undertake a career in construction.

METHODOLOGY

The study used a close-ended questionnaire in a survey of university students enrolled in construction-related programs in South Africa. A survey of 229 conveniently sampled undergraduate students, enrolled in construction-related programs was conducted. The Mann-Whitney U test was used to test for significant differences between the gender groups concerning the nine constructs.

FINDINGS

Results from the questionnaire survey revealed that outcome expectations, perceived barriers, goal representations, social supports and gender stereotypes had the most influence on the career choice of men and women. Three of the nine predictor constructs (social supports, perceived barriers, and gender stereotypes) were found to have significant differences between men and women.

PRACTICAL IMPLICATIONS

Findings of the current study have meaningful implication for practice in career choice and development in male-dominated environments and occupations.

Keywords: *Career Choice, Construction, Gender, SCCT, Women*

INTRODUCTION

Issues regarding gender equality and accommodation of peculiar gender needs are lacking in South Africa[1,2,3]. A lack of understanding of girls and women's career choice and development is a significant obstacle to attracting women into the construction industry. Although the construction industry has sought to find solutions to the problem of under-representation of women, progress seems to be very slow and erratic. Despite the existence of a significant range of studies on gender and career choice and development in construction[4, 5,6 ,7], limited progress has been to develop interventions and strategies that can be applied to the women and minorities in the construction industry[8,9].

Although there have been numerous studies on the experiences of women in the construction industry [2, 3, 5, 10,11,12], few studies have attempted to view their experiences from a theoretical perspective to give larger meaning to their career choices and development. The lack of empirical research in this area suggests that more in-depth exploration of this problem is required.
Gender has been identified to play a significant role in determining educational and career choice [13,14] . By viewing gender as a socially constructed aspect of the experience, it may be emphasized that it is a major sociocultural agent that helps shape career choices[13,15]. Findings from a previous study suggested that men and women have different perceptions of the factors that influence their career decisions in male-dominated professions such as construction, as these professions have been resistant to the participation of women[16]. Gender differences may have an impact on the career decisions of people and their perceptions of career-related barriers. While scholars have begun seeking the role culture and society plays on the career decisions of women and their development at the workplace, fewer studies have focused on inter-group differences[17]. Likewise, although numerous researchers have suggested a convergence of major career development theories[18,19, 20] most recognize that this has still not been achieved.

This study applied the Social Cognitive Career Theory (SCCT) as it relates to the career decisions of students in construction programs. The SCCT conceptualised by Lent et al. and derived from Bandura's social cognitive theory, argues that a person is not entirely controlled by their environments, nor are they able to apply complete free will[20]. Instead, a person's behaviour and thoughts influence the environment and are likewise influenced by personal factors and the social environment[21,22]. SCCT elaborates exclusively on the educational interest formation, career development, performance, and persistence of individuals in their career endeavors. Processes whereby the educational and professional interest of individuals are developed; the influence of interests and other socio-cognitive mechanisms on career choices and the attainment of different levels of career performance and persistence are outlined in the SCCT[20,23]. SCCT focuses on the role of cognitive factors such as self-concept, self-efficacy, goal representations, interests, outcomes and expectations in the career development of an individual and how these factors interact with internal and individual variables such as gender, ethnicity, belief systems and social supports to influence the career behaviour of adolescents[24, 25,26]. Biological, situational and contextual factors such as gender are moderators of the formulation of choice goals and have a significant influence on career development[23,26].

Self-efficacy has been found to play a crucial role in the career choices of individuals[22, 27]. Self-efficacy belief which is the core construct SCCT and typically influences a person's academic and professional aspirations is influenced by learning experiences[25]. In the context of SCCT, outcome expectations are anticipations of possible consequences from chosen actions and work-related behaviour[26,28]. Goal representations are achievement-related choices[29]. All these factors in combination with background factors and personal inputs such as gender, race and ethnicity are the most prevailing predictors of career decision making as they are also suggested to influence learning experiences[22,28]. From the SCCT perspective, learning experiences are verbal encouragements, supports and modelling from significant others, used to maximise the performance accomplishment of a person[30]. Interests are hypothesized to result in actual engagement in activities which lead to performance outcomes[26].

Consistent with the SCCT model of career choice, this study predicts that each of the selected variables will have differential impact on the career behaviour of women and men in construction. This study further expands the SCCT by capturing barriers to the participation in the construction profession. It is predicted that such choices are, in many cases, influenced by societal barriers and supports received by an individual and by the individual's judgment for the probability of success of these career options. This study attempts to link contextual factors such as barriers, for example, work-life conflict, sexual harassment, glass ceiling, and the gender wage gap; opportunity structures, support structures, gender role stereotypes, and gender from a student's career choice perspective.

MATERIALS AND METHODS

The study implemented a descriptive survey design, adopting a quantitative research approach. For a proper understanding of the nature of the data, descriptive statistics in the form of central measures of tendency such as percentages, means and standard deviations were used to analyse the data. The study conveniently selected two public universities in the KwaZulu-Natal province of South Africa to participate in the study. The two universities were conveniently chosen because of their proximity to the researcher. Undergraduate students enrolled in construction-related programmes such as construction management, land surveying, building, civil engineering, quantity surveying and architecture were chosen as the sample frame. The target population for the survey was 461 which is the number of students enrolled in construction related programmes in the two universities and was used for data collection. A total of 229 responses were received, representing 49.6% of the population. While there is a rule of thumb for an acceptable response rate, numerous studies have suggested a response rate of 50% is generally adequate[31,32]. Questionnaires were developed and administered to the students electronically using Google forms.
To conform to the accepted ethical research standards, the study ensured that appropriate ethical considerations were made in the conduct of this research. The participants were contacted, and consent was obtained through an informed consent form distributed to all participants with all the research information. Implications of their participation in the study were clearly stated. Further, gatekeeper's permission was obtained from the participating universities before the survey of the students. Anonymity and confidentiality of the participants were ensured by not identifying the questionnaires with a particular participant and ensuring that the data collected was only for this study.

Following the result of the normality test, which revealed a non-normal distribution of data, a non- parametric test was deemed suitable to test for significant differences among the gender and SES groups concerning the study constructs. A Cronbach's alpha of 0.887 was obtained for the gender stereotypes scale, indicating adequate reliability since its value is >0.700 which is universally accepted as the benchmark for acceptable reliability.

The study adopted the Mann-Whitney U test to the significant differences between the gender groups. Mann-Whitney U test is the non-parametric version of the parametric t-test used to assess independent samples. Unlike the t-test, which compares the means of two different groups, the Mann-Whitney U test compares the median of the two different groups on a continuous measure and converts the scores obtained to ranks. It then determines whether significant differences exist between the two groups[33,34] . The values to consider after the Mann-Whitney- U test are the Z value and the significance value, which is represented as the Asymp.Sig (2 tailed). A Sig. value of 0.05 or smaller ($p \leq 0.05$) indicates a significant difference between groups.

RESULTS

DEMOGRAPHIC STATISTICS

Table 1 shows the demographic distribution of the respondents. There were 116 men (50.7%) in the sample. First year students had the largest number of participants with 94 students (41%), followed by 2nd year students at 87 (38%). This rate of participation is possible because it is well-known that universally the 1st year cohort of students at South African Universities is usually larger than in the later years or more advanced levels of study.
Most respondents were enrolled in the discipline of Construction Management (n= 110; 48%), which also accounted for the largest number of participants because both of the participating universities offering the programme. Architecture had the lowest number of students (n=1; 0.4%) in the sample because only one of the universities offered the programme and typically had smaller numbers of students compared to the other disciplines and programmes.

A cross-tabulation of the demographic statistics was conducted to establish the distribution of the demographic statistics. Men accounted for between 43% and 67% of each year of study. Of the men, 40 were in the 1st year (34.5%), 44 (37.9%) were in the 2nd year, while 20 (17.2%) and 12 (10.3%) were in the 3rd and 4th year, respectively. Of the women, 54 (47.8%) were in the 1st year, 43 (38.1%) were in the 2nd year, while 10 (8.8%) and 6 (5.3%) were in the 3rd and 4th year of study, respectively. The distribution of women across the years of study was almost like the men. The ratio of gender distribution across the different years of study was 50.7% for men. Therefore, in terms of gender distribution across years of study, the sample is a fair representation of the population of interest.

Table 1. Demographic Distribution

Year of Study	Frequency	Percent
1st year	94	41.0
2nd year	87	38.0
3rd year	30	13.1
4th year	18	7.9
Total	**229**	**100.00%**
Programme of Study		
Construction Management	110	48.0
Land Surveying	4	1.7
Quantity Surveying	50	21.8
Civil Engineering	17	7.4
Building	47	20.5
Architecture	1	0.4
Total	**229**	**100.00%**

STUDENT'S PERCEPTION OF CAREER CHOICE PREDICTORS

Table 2 presents the normality test and descriptive results for the factors and predictors of career choice in construction. The assessment of the influence of the predictors on student's career choices revealed that the item *"I would like to perform well at my job"* with a mean score of 4.62 had the most influence on student's career choices. The statistics showed that the item *"Because of my gender, I will earn a lower salary than my counterparts for similar work"* had the lowest mean score (1.89), indicating least influence on the career choice of students.

As shown in Table 3, It was further revealed that outcome expectations (mean score =57.10), perceived barriers (mean score = 40.46), goal representations (mean score= 29.16), social supports (mean score=23.12) and gender stereotypes (mean score =21.92) had the most influence on career choice. The mean scores obtained revealed learning experiences as the career choice predictor with the least influence.

Kolmogorov-Smirnov Z and Shapiro-Wilk were adopted for the normality tests of the elements. The Shapiro-Wilk test and Kolmogorov-Smirnov test makes comparisons between the scores obtained from a sample to normally distributed score sets with the same mean and standard deviation. The tests assess the normality of the distribution of scores. A non-significant test result, namely the test significance is greater than 0.05, means that the difference is insignificantly different from a normal distribution, therefore indicating normality. Numerous studies have asserted that the Shapiro-Wilk test is the most effective test for normality compared to other tests[35].
As shown in Table 2, the Kolmogorov-Smirnov Z and Shapiro-Wilk tests indicated a non-normal distribution at 0.000 for all the variables.

Table 2. Perception of Career Choice Predictors

		Mean	Std. Dv.	Rank		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
						Stat	df	Sig.	Stat	Df	Sig.
	I have confidence in my ability to identify resources, limitations, and personal characteristics that might influence my career choices.	3.97	.982	**30**		.292	229	.00	.793	229	.000
	I am confident about being able to collect information about training and employment opportunities for myself and manage them effectively.	4.05	.923	**26**		.222	229	.00	.832	229	.000
Self-Efficacy	I am confident about being able to develop lists of priorities on the effective actions to successfully manage my own personal professional development	4.02	.908	**28**	**7**	.253	229	.00	.826	229	.00
	I am confident about being able to plan the steps needed to realize a project related to my profession	4.02	1.02	**28**		.277	229	.00	.805	229	.00
	I am confident about being able to address any difficulties related to my career	4.01	1.06	**29**		.231	229	.00	.820	229	.00
	I expect to earn a good and satisfactory salary	4.37	.862	**11**		.304	229	.00	.697	229	.00
	I expect to get experience and get better jobs in future	4.45	1.007	**6**		.357	229	.00	.616	229	.00
	I expect to get promoted and get regular salary increases	4.23	.961	**19**		.281	229	.00	.755	229	.00
	I expect to work in a decent and satisfying work environment	4.33	.933	**14**		.315	229	.00	.713	229	.00
	I expect to have a stable and secure job	4.32	1.018	**15**		.315	229	.00	.698	229	.00
Outcome Expectations	I expect to have a stable career and guaranteed employment	4.29	1.007	**17**	**1**	.300	229	.00	.697	229	.00
	I expect to have a positive image and contribute to the society	4.39	.947	**9**		.329	229	.00	.648	229	.00
	I expect to have a satisfying lifestyle	4.34	.949	**12**		.302	229	.00	.704	229	.00
	I expect to have a happy future	4.45	.870	**6**		.337	229	.00	.657	229	.00
	I expect to feel productive and have a sense of purpose and worth	4.44	.919	**7**		.340	229	.00	.618	229	.00
	I expect to achieve my career goals	4.49	.989	**4**		.387	229	.00	.560	229	.00
	I expect to be successful in my career	4.50	.958	**3**		.386	229	.00	.568	229	.00
	I expect to learn new skills and be able to use these skills and talents in my job	4.53	.929	**2**		.393	229	.00	.549	229	.00
	I will obtain technical/functional skills in my chosen career	4.17	.965	**20**		.281	229	.00	.741	229	.00
	I will have opportunities for training and development in my chosen career	4.08	.984	**25**		.289	229	.00	.776	229	.00
	I will have the opportunities for interesting work in my chosen my career	4.09	1.009	**24**		.273	229	.00	.772	229	.00
Goal Representations	My chosen career will allow me to meet my financial obligations	4.12	1.0179	**21**	**3**	.287	229	.00	.753	229	.00
	I will be successful in my chosen career	4.33	.952	**13**		.306	229	.00	.695	229	.00
	I will occupy leadership positions in my chosen career	4.09	.992	**23**		.233	229	.00	.799	229	.00
	My chosen career will make my family, friends and society have a good and positive opinion of me	4.30	1.000	**16**		.325	229	.00	.707	229	.00

Table 2. Perception of Career Choice Predictors Cont.

		Mean	Std. Dv.	Rank		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
						Stat	df	Sig.	Stat	Df	Sig.
Social Supports	I receive support from both my parents	3.17	1.480	**43**	4	.191	229	.00	.863	229	.00
	I receive support from my teachers	3.21	1.158	**40**		.202	229	.00	.908	229	.00
	I receive support from my family members	3.64	1.178	**33**		.231	229	.00	.874	229	.00
	I receive support from my peers (e.g. friends, colleagues)	3.50	1.137	**34**		.237	229	.00	.875	229	.00
	I receive support from my father	2.86	1.663	**49**		.223	229	.000	.809	229	.00
	I receive support from my mother	3.90	1.435	**31**		.306	229	.00	.738	229	.00
	I receive support from my significant other (e.g. husband, wife, partner)	2.83	1.369	**50**		.159	229	.00	.889	229	.00
Learning Experiences	I receive positive feedback and encouragement, especially from influential people in my life such as my parents and teachers	4.04	.999	**27**	9	.234	229	.00	.812	229	.00
	I learn through observing others perform tasks related to my own career	4.01	1.002	**2**		.268	229	.00	.808	229	.00
	I experience feelings of anxiety, nervousness and fear of failure when performing tasks and activities related to my career	3.67	1.117	**32**		.218	229	.00	.882	229	.00
	I successfully complete tasks and activities related to my career	4.10	.970	**22**		.271	229	.00	.784	229	.00
Interests	I enjoy performing tasks and activities related to my choice of profession	4.24	.901	**18**	6	.275	229	.00	.726	229	.00
	I would like to make a lot of money	4.48	.846	**5**		.361	229	.00	.641	229	.00
	I would like to receive recognition in the society	4.17	1.061	**20**		.271	229	.00	.743	229	.00
	I would like to perform well at my job.	4.62	.832	**1**		.421	229	.00	.491	229	.00
	I enjoy thinking and solving problems	4.38	.883	**10**		.318	229	.00	.691	229	.00
	I like highly challenging activities and taking risk	4.12	1.039	**21**		.255	229	.00	.777	229	.00
Perceived Barriers	Discriminatory attitudes	2.51	1.289	**57**	2	.169	229	.00	.881	229	.00
	Work-life conflict	2.65	1.112	**56**		.179	229	.00	.909	229	.00
	Wage gap	3.03	1.088	**46**		.198	229	.00	.914	229	.00
	Masculine workplace culture	2.95	1.043	**48**		.237	229	.00	.898	229	.00
	Lack of access to opportunities	3.14	1.358	**45**		.155	229	.00	.897	229	.00
	Poor working conditions	2.95	1.323	**48**		.165	229	.00	.899	229	.00
	Long working hours	3.18	1.119	**42**		.227	229	.00	.899	229	.00
	Challenges in career progression	3.21	1.117	**40**		.197	229	.00	.908	229	.00
	Gender stereotypes	2.86	1.337	**49**		.146	229	.00	.899	229	.00
	Glass ceiling (Invisible barrier to career advancement)	2.79	1.107	**51**		.233	229	.00	.898	229	.00
	Lack of knowledge and career information	2.73	1.286	**53**		.151	229	.00	.900	229	.00
	Lack of role models in my chosen career	2.73	1.237	**53**		.170	229	.00	.904	229	.00
	Lack of education and training	2.78	1.340	**52**		.173	229	.00	.892	229	.00
	Lack of opportunities in my chosen career	3.00	1.370	**47**		.159	229	.00	.892	229	.00

Table 2. Perception of Career Choice Predictors Cont.

		Mean	Std. Dv.	Rank		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
						Stat	df	Sig.	Stat	Df	Sig.
Gender Stereotypes	Because of my gender, people will believe I possess lesser abilities in my work	2.70	1.373	**54**	5	.205	229	.00	.882	229	.00
	Because of my gender, I will have to work twice as hard as my counterparts	2.68	1.376	**55**		.196	229	.00	.881	229	.00
	Because of my gender, I will have to occupy a junior position at work	2.18	1.207	**60**		.224	229	.00	.834	229	.00
	Because of my gender, I will be expected to do administrative work	2.21	1.252	**59**		.243	229	.00	.831	229	.00
	Because of my gender, I will be expected to have a lesser status in the society	2.13	1.239	**62**		.241	229	.00	.811	229	.00
	Because of my gender, I will be expected to possess domestic skills rather than technical skills	2.18	1.291	**60**		.248		.00	.794	229	.00
	Because of my gender, I will be expected to have a low level of education	1.93	1.203	**64**		.290	229	.00	.757	229	.00
	Because of my gender, I will be expected to choose a career different from the one I prefer	2.14	1.614	**61**		.254	229	.00	.687	229	.00
	Because of my gender, people will believe I will perform badly in mathematics and science subjects	1.96	1.215	**63**		.266	229	.00	.761	229	.00
	Because of my gender, I will earn a lower salary than my counterparts for similar work	1.90	1.179	**65**		.293	229	.00	.754	229	.00
Access to Opportunity Structures	I have access to information on organizations and jobs in my chosen career	3.48	.989	**36**	8	.223	229	.00	.888	229	.00
	I have attended various career orientation programs	3.15	1.138	**44**		.195	229	.00	.911	229	.00
	I have initiated conversations with knowledgeable individuals in my career area	3.36	1.152	**39**		.240	229	.00	.895	229	.00
	I have access to information on the labour market and general job opportunities in my career area	3.18	1.068	**42**		.210	229	.00	.905	229	.00
	I have access to information on specific areas of career interest	3.39	1.075	**38**		.239	229	.00	.894	229	.00

DIFFERENCES IN GENDER CATEGORIES SUBJECTED TO THE MANN-WHITNEY U TEST

To test for significant differences between men and women, with regards to the influence of self-efficacy, outcome expectations, social supports, goal representations, learning experiences, interests, perceived barriers, gender stereotypes and access to opportunity structures on career choice, the Mann-Whitney U test was conducted. Table 3 shows the mean scores for the career choice predictors, their rank orders for men group, women group and men and women combined. The Z-value and the Sig. value obtained from the Mann-Whitney U- test were also presented. The assessment of the career choice predictors revealed that outcome expectations (mean score =57.10), perceived barriers (mean score = 40.46), goal representations (mean score= 29.16), social supports (mean score=23.12) and gender stereotypes (mean score =21.92) had the most influence on career choice for both men and women. The mean scores obtained separately for men and women showed that both groups considered outcome expectations to have the most influence on career choice and learning experiences with the least influence.To test for the significant differences in the influence of the career choice predictors between men and women, the Mann-Whitney U test was conducted. Table 3 shows that significant differences were found for social supports (Z value =-1.653, p=0.041), perceived barriers (z value =-1.805, p = 0.042) and gender stereotypes (z value = 4.000, p= 0.000) as the Sig. values were less than the cut-off value of 0.05.

Table 3: Test Statistics for Gender and Career choice predictors

	Men		Women		Overall		Mann -Whitney U	
	MIS	Rank	MIS	Rank	MIS	Rank	Z-value	Sig.
Self-Efficacy	20.51	**7**	19.64	**7**	20.08	**7**	-1.380	0.168
Outcome Expectations	57.75	**1**	56.44	**1**	57.10	**1**	-0.296	0.767
Goal Representations	30.13	**3**	28.26	**3**	29.16	**3**	-1.824	0.068
Social Supports	23.27	**5**	22.96	**5**	23.12	**4**	-1.653	0.041
Learning experiences	15.84	**9**	15.81	**9**	15.82	**9**	0.559	0.576
Interests	22.14	**6**	21.62	**6**	21.89	**6**	-0.626	0.531
Perceived Barriers	33.68	**2**	41.25	**2**	40.46	**2**	-1.805	0.042
Gender Stereotypes	24.03	**4**	27.07	**4**	21.92	**5**	4.000	0.000
Access to Opportunity Structures	16.70	**8**	16.28	**8**	16.49	**8**	-0.763	0.446

DISCUSSION

The survey results presented the evaluation of the factors that predict student's career choices in construction. The findings revealed that the career choices of the respondents were mostly influenced by the interest in performing well, expectations of learning new skills and being able to use these skills and talents in their job, expectations to be successful in their career, expectations to achieve their career goals and the interest to make a lot of money. These findings are consistent with previous studies that expectations of achieving a certain outcome are a significant component of the career choice process of young adults and university students and is a strong predictor of their post-university pathways[36]. The study found outcome expectations, perceived barriers, goal representations, social supports and gender stereotypes had the most influence on student's career choices in the construction industry.

The Mann- Whitney U test revealed a statistically significant difference in the influence of social supports, perceived barriers, and gender stereotypes on the career choices among men and women, therefore the hypothesis that in the context of the South African construction industry, the aforementioned predictors differently influence the career choices of men and women was substantiated. The men in this study perceived social supports as being of greater influence compared to women, while the women perceived gender stereotypes and perceived barriers as being of greater influence. There are similarities in the present study and those described by[37], confirming that men and women perceive different levels of support from their social environment with regards to their career choices. Consistent with the findings for this study, numerous studies have examined gender differences in the effect of perceived social support on the career choice process of men and women studying STEM subjects and found that girls received less encouragement and support from their social networks[37,38,39,40].

Studies have been conducted to examine the stereotypical beliefs on career choice in male-dominated occupations and have hypothesized that the under-representation of women in the construction industry is because of gender-stereotyping of careers[41,42]. Previous research provides evidence that men and women differ in their perception of gender stereotypes[19,21]. There is a higher likelihood for female students than male students to choose careers traditional to their gender. Evidence from literature examining gender stereotyping and the differences in career choice behaviour[37]. Studies have examined gender differences in the barriers to career choices among undergraduate students in traditionally male occupations and have found female students to perceive more barriers than did their male counterparts[43, 44]. Gender disparities exist in the barriers experienced by students in choosing a construction career[41]. Studies conducted to examine the barriers to participation in construction suggest that women compared to men experience barriers such as discrimination, harassment, lack of role models, wage gap etc., which hinder their entry and participation in the industry[45,46].

CONCLUSIONS

The aim of the study was to identify the key factors that influence the career choices in construction industry related disciplines for men and women in the South Africa and determine whether there are gender differences in the factors that influence career choices in construction. Although the issue of career choices in construction exist in South Africa and numerous studies have focused on factors affecting career choices and their influences, very few studies have attempted to consider predictors of career choices from a theoretical perspective and empirical analysis. The study applied the Socio-Cognitive Career Theory (SCCT) to understand the career choices and of students in construction-related disciplines. Therefore, the current study extended the evaluation of career choice predictors to include the SCCT constructs and to incorporate person and contextual variables such as gender, gender stereotypes, perceived barriers, and access to opportunity structures.

Outcome expectations was found to be the most salient predictor with regards to predicting a career choice in construction. Guidance from experienced and satisfied individuals should be provided to students seeking to make career decisions to help them establish clearer perceptions of their career expectations with regards to the physical, social, and self-evaluative outcomes. This is particularly relevant for women who may be interested in undertaking non-tradition careers such as construction given that differences in their socialization process may have diminished their consideration and motivation to pursue these careers. Further implications can be drawn from the study findings in relation to the proposal of Lent et al. [20] for mentorship and training programs for the support of minority groups such as women who may be interested in pursuing non-traditional professions. Addressing the issue of gender role stereotypes and the socialization process within some non-traditional environments could serve to empower women to pursue non-traditional professions more confidently and with a better understanding of the barriers to participation.

Although this study sampled students in the KwaZulu-Natal province of South Africa, a generalization of the findings to the entire South African population needs caution. Further, because the sample in this study was one of convenience, some limitations apply. Since the present sample may be described as unique due to the inclusion of only undergraduate students enrolled in construction-related programmes at two universities, it is uncertain whether these results may not adequately represent the population of interest and be generalized to a general sample of students in other universities.

REFERENCES

1. Alves, S., & English, J. (2018) “Female students' preparedness for a male-dominated workplace”, Journal of Engineering, Design and Technology.
2. Chileshe, N., & Haupt, T. C. (2010) “An empirical analysis of factors impacting career decisions in South African construction industry”, Journal of Engineering, Design and Technology.
3. Vainikolo, K. (2017) “Women's Career Paths in the Construction Industry in New Zealand”, Auckland University of Technology.
4. Ahuja, V., & Kumari, S. (2012) “Issues and challenges for women in construction industry: global as well as Indian perspective”, Proceedings of the 18th Annual Convention and Seminar on Training Skill Upgradation and Competence Development in Building Industry, New Delhi.
5. English, J., & Hay, P. (2015) “Black South African women in construction: cues for success”, Journal of Engineering, Design and Technology.
6. Madikizela, K., & Haupt, T. (2010)” Influences on women's choices of careers in construction: A South African study”.
7. Powell, A., Bagilhole, B., & Dainty, A. (2009) “How women engineers do and undo gender: Consequences for gender equality”, Gender, work & organization, 16(4), 411-428.
8. Brown, D. (2002) Career choice and development. John Wiley & Sons.
9. Moore, J. D. (2006) Women in construction management: Creating a theory of career choice and development. Colorado State University.
10. Enshassi, A., & Mohammaden, A. (2012) “Occupational Deaths and Injuries in The Construction Industry”, Occupational Deaths and Injuries in The Construction Industry.
11. Madikizela, K. (2008) An analysis of the factors influencing the choices of careers in construction by South African women, Cape Peninsula University of Technology.
12. Rosa, J. E., Hon, C. K., Xia, B., & Lamari, F. (2017) “Challenges, success factors and strategies for women's career development in the Australian construction industry”, Construction economics and building, 17(3), 27.
13. Andres, L., Adamuti-Trache, M., Yoon, E.-S., Pidgeon, M., Thomsen, J. (2007) Educational Expectations, Parental Social Class, Gender, And Postsecondary Attainment: A 10- Year Perspective. 39, 135-163.
14. Buchmann, C. & Dalton, B. J. (2002) Interpersonal Influences And Educational Aspirations In 12 Countries: The Importance Of Institutional Context. 99-122.
15. Pio, E., Syed, J., Saifuddin, S. M., Dyke, L. S. & Rasouli, M. J. (2013) Gender And Careers: A Study Of Persistence In Engineering Education In Bangladesh.
16. Wynn, A. T. & Correll, S. J. (2017) Gendered Perceptions Of Cultural And Skill Alignment In Technology Companies. 6, 45.
17. Holvino, E. (2010) Intersections: The Simultaneity Of Race, Gender And Class In Organization Studies.Gender, Work & Organization, 17, 248-277.
18. Eccles, J. (1984) “Sex Differences In Achievement Patterns”, Nebraska Symposium On Motivation, University Of Nebraska Press.
19. Eccles, J., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L. & Midgley, C. (1985) Self- Perceptions, Task Perceptions, Socializing Influences, And The Decision To Enroll In Mathematics. Women And Mathematics: Balancing The Equation, 95-121.
20. Lent, R. W., Brown, S. D., & Hackett, G. (1994) “Toward a unifying social cognitive theory of career and academic interest, choice, and performance”, Journal of vocational behavior, 45(1), 79-122.
21. Bandura, A. J. (1989) Human agency in social cognitive theory. 44(9), 1175.
22. Charity-Leeke, P. (2012) Women in engineering: A phenomenological analysis of sociocultural contextual meaning of gender roles, Cleveland State University.
23. Ali, S. R., & McWhirter, E. (2006) Rural Appalachian youth's vocational/educational postsecondary aspirations: Applying social cognitive career theory. 33(2), 87-111.
24. Ali, S. R., & Saunders, J. L. (2006) College expectations of rural Appalachian youth: An exploration of social cognitive career theory factors. 55(1), 38-51.
25. Saifuddin, S. M., Dyke, L. S., & Rasouli, M. (2013) “Gender and careers: a study of persistence in engineering education in Bangladesh”, Gender in Management: An International Journal.
26. Kelly, M. E. (2009) Social cognitive career theory as applied to the school-to-work transition.
27. Hackett, G., & Betz, N. E. (1981) A self-efficacy approach to the career development of women. 18(3), 326-339.
28. Lent, R. W., Do Céu Taveira, M., Pinto, J. C., Silva, A. D., Blanco, Á., Faria, S. & Gonçalves, A. M. J. (2014) Social Cognitive Predictors Of Well-Being In African College Students. 84, 266- 272.
29. Lent, R. W. & Brown, S. D. (2006) Integrating Person And Situation Perspectives On Work Satisfaction: A Social-Cognitive View. 69, 236-247.
30. Flores, L. Y., Ramos, K., & Kanagui, M. (2010) “Applying the cultural formulation approach to career counseling with Latinas/os”, Journal of Career Development, 37(1), 411-422.
31. Hair, J. F., Anderson, R. E., Babin, B. J. & Black, W. C. (2010) Multivariate Data Analysis: A Global Perspective (Vol. 7). Upper Saddle River, Nj: Pearson.
32. Babbie, E. J. A. C. L. 2013. The Practice Of Social Research (International Edition).
33. Neutens, J. & Rubinson, L. (2001) Research Techniques For The Health Sciences. 3. Painos. San Francisco: Benjamin Cummings. Usa.
34. Pallant, J. (2020) Spss Survival Manual: A Step By Step Guide To Data Analysis Using Ibm Spss, Routledge.
35. Razali, N. M., & Wah, Y. B. (2011) “Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-darling tests”, Journal of statistical modeling and analytics, 2(1), 21-33.
36. Foud, N. & Smith, P. (1996) A Test Of Social Cognitive Model For Middle School Students: Maths And Science. Journal Of Counseling Psychology, 43, 338-346.
37. Serra, P., Soler, S., Camacho-Miñano, M. J., Rey-Cao, A. I. & Vilanova, A. J. (2019) Gendered Career Choices: Paths Towards Studying A Degree In Physical Activity And Sport Science. 10, 1986.
38. Buday, S. K., Stake, J. E. & Peterson, Z. D. (2012) Gender And The Choice Of A Science Career: The Impact Of Social Support And Possible Selves. 66, 197-209.
39. Rogers, M. E., Creed, P. A. & Glendon, A. I. (2008) The Role Of Personality In Adolescent Career Planning And Exploration: A Social Cognitive Perspective. 73, 132-142.
40. Sáinz, M., Meneses, J., López, B.-S. & Fàbregues, S. J. (2016) Gender Stereotypes And Attitudes Towards Information And Communication Technology Professionals In A Sample Of Spanish Secondary Students. 74, 154-168.
41. Ginige, K., Amaratunga, R. & Haigh, R. (2007) Gender Stereotypes: A Barrier For Career Development Of Women In Construction.
42. Mendez, L. M. R. & Crawford, K. M. (2002) Gender-Role Stereotyping And Career Aspirations: A Comparison Of Gifted Early Adolescent Boys And Girls. 13, 96-107.
43. Byars-Winston, A., Estrada, Y., Howard, C., Davis, D. & Zalapa, J. J. J. O. C. P. 2010. Influence Of Social Cognitive And Ethnic Variables On Academic Goals Of Underrepresented Students In Science And Engineering: A Multiple-Groups Analysis. 57, 205.
44. Peña-Calvo, J. V., Inda-Caro, M., Rodríguez-Menéndez, C. & Fernández-García, C. M. (2016) Perceived Supports And Barriers For Career Development For Second-Year Stem Students. 105, 341-365.
45. Adeyemi, A. Y., Ojo, S. O., Aina, O. O. & Olanipekun, E. A. (2006) Empirical Evidence Of Women Under-Representation In The Construction Industry In Nigeria.
46. Jimoh, R. A., Oyewobi, L. O., Adamu, A. N. & Bajere, P. A. (2016) “Women Professionals' Participation In The Nigerian Construction Industry: Finding Voice For The Voiceless”, Organization, Technology And Management In Construction: An International Journal, 8, 1429-1436.

THE FOURTH INDUSTRIAL REVOLUTION: OPPORTUNITIES AND CHALLENGES FOR CONSTRUCTION HEALTH AND SAFETY (H&S) IN ZIMBABWE

Benviolent Chigara and John Smallwood

Department of Construction Management, Nelson Mandela University, Port Elizabeth, South Africa
benviolent@gmail.com

ABSTRACT

PURPOSE

Industry 4.0 is fast changing the way in which work, and production processes are organised in most sectors. Nevertheless, the impact of Industry 4.0 on workers' health and safety (H&S) has not been sufficiently explored in Zimbabwe. This study aims to investigate the potential impact of Industry 4.0 technologies on construction H&S.

DESIGN

A quantitative survey design was adopted which entailed the distribution of 45 questionnaires to construction professionals in construction and consultant firms in Harare, whereafter a response rate of 46.7% was achieved. The data was analysed through computing descriptive statistics.

FINDINGS

The salient findings are that Industry 4.0 can positively impact H&S through enhancing real-time data gathering, real-time monitoring of the work environment, hazard identification and risk assessments, accident investigation, and communication and awareness. However, the application of Industry 4.0 in H&S in Zimbabwe remains sub-optimal, and it is perceived that the technologies will result in job losses and introduce new H&S risks.

VALUE

Through identifying the opportunities and challenges presented by Industry 4.0, construction stakeholders are provided with valuable information necessary to inform decision making relative to the integration of Industry 4.0 in construction H&S management.

Keywords: *Digital Technologies, Health, Industry 4.0, Safety, Zimbabwe.*

INTRODUCTION

Industry 4.0 is fast changing the way in which work, and production processes are organised to improve productivity and enhance cost-efficiency. Industry 4.0 has a background in the German manufacturing sector wherein the use of adaptable and responsive machinery was adopted to propel manufacturers to meet ever-changing demand more efficiently[1]. In the manufacturing sector, Industry 4.0 transformed traditional production process through digitalisation of manufacturing systems[2] and creating smart and interconnected industrial value systems through the integration of cyber-physical systems into production[3]. Due to its notable benefits in the manufacturing, automotive, and mining sectors, Industry 4.0 has been gradually embraced by the construction sector. In the construction industry, Industry 4.0 technologies can contribute to cost savings, time savings, on-time delivery or projects, improved quality, improved collaboration and communication, improved customer relationship, and enhanced H&S[4]. It is increasingly evident that the future of construction depends on its ability to adopt technology in its various practices[5].

Industry 4.0 technologies and concepts can influence several aspects of construction practice. However, this study focussed on its potential impact on H&S performance. This is in recognition of the poor H&S record exhibited by the construction industry in Zimbabwe and elsewhere. The National Social Security Authority (NSSA) statistics reveal that the construction sector has a higher-than-average risk of occupational injury. Construction workers in developing countries have a six-fold risk of fatal accidents compared to workers in other sectors[7]. However, the risk of occupational injuries or fatalities is not limited to developing countries. In Great Britain, the construction sector accounts for approximately one-third of all fatal injuries to workers[6]. The consequent socio-economic burden of workplace injuries, disease, and fatalities calls for more action to improve H&S. With Industry 4.0 gradually shaping construction production space, construction stakeholders should explore the opportunities that Industry 4.0 and its underlying technologies and concepts offer to improve H&S. Although at first glance the disruptive technologies seem to increase risk and job losses, they may also enable organisations to make work environments healthy, safe, and socially enjoyable[8]. Evidence from recent studies suggests that the construction industry is gradually adopting Industry 4.0 technologies and concepts in H&S management[9] to improve performance[10; 11; 12]. An emerging body of research argues that H&S cannot resist advances in technology[13]. The corona virus disease (COVID-19) further highlights the need for technology application in construction H&S management[14]

Despite the abundant potential of Industry 4.0 technologies to enhance construction H&S management, research investigating the role of Industry 4.0 to improve H&S management remains limited[11]. To contribute to this body of knowledge, this study aims to investigate the perceptions of construction professionals in Zimbabwe with regards to the potential impact of Industry 4.0 technologies on construction H&S. The specific research objectives are: (1) to determine the level of application of Industry 4.0 technologies and concepts in construction and H&S management in Zimbabwe, and (2) to investigate the potential benefits and challenges / adverse effects of Industry 4.0 technologies and concepts for construction H&S. Through identifying the opportunities and challenges presented by Industry 4.0, construction stakeholders are provided with valuable information necessary to inform decision making regarding the adoption of Industry 4.0 as a strategy to improve H&S in the construction industry.

THE REVIEW OF RELATED LITERATURE

The section discusses the state of construction H&S in Zimbabwe and the interface between Industry 4.0 and construction H&S management.

OVERVIEW OF CONSTRUCTION H&S STATUS IN ZIMBABWE

The construction industry has an undesirable H&S record. Studies conducted in Zimbabwe reveal that the organisation and implementation of construction H&S is poor / sub-optimal[15,16]. The NSSA H&S statistics for the period 2011 to 2015 show that the average incidence rate (IR) (6.0 per 1 000 insured workers) for the construction sector is above the all-sector average IR (5.2 per 1000 insured workers)[17]. The leading types of accidents contributing to non-fatal injuries are: contact with objects (28%); fall of material objects (14.4%); fall of persons (13.9%); overexertion when lifting, pushing, or pulling heavy objects (10.7%); road traffic accidents (9.8%), and caught in or between objects (8.7%)[18]. The primary drivers of the H&S problem include poor compliance with H&S provisions[18], unsafe work practices, inadequate inspections, inadequate hazards identification and risk assessment, inadequate H&S planning, inadequate H&S training, and inadequate design hazard identification, which contribute to the occurrence of injuries, fatalities, and disease[19]. However, work-related injuries curtail the working life of workers by several years, shorten life expectancy, increase temporary and permanent work disability, and premature death or retirement[20]. This calls for more action to improve the H&S situation. Previous interventions by the government and construction practitioners to do so did not yield the required results Reyes et al[21] suggest that new interventions which look beyond the traditional approaches are required. Emerging studies recommend the construction industry leverage the recent developments in Industry 4.0 technologies to achieve better H&S results[11]. The following section discusses the interface between Industry 4.0 and construction H&S.

INDUSTRY 4.0 TECHNOLOGIES AND APPLICATION TO CONSTRUCTION H&S MANAGEMENT

Industry 4.0 is a new paradigm of production and one that leads to faster and more precise decision-making[3]. It seeks to make production more efficient, flexible, and to the required quality standards[22] through the integration of digital systems of production with analysis and communication of all data generated within an intelligent environment[1]. Automation and computerisation can increase efficiency and effectiveness of production systems thereby increasing firms' competitiveness[22]. Although its primary focus is to enhance productivity, efficiency, profitability, and quality improvement[11], the technological transformation associated with Industry 4.0 may also enable modern organisations to make work areas healthy, safe, flexible, and socially enjoyable[8]. Conversely, technologies can change the way humans and machines interact resulting in new demands to make work safe, healthy, and secure[23]. To understand how Industry 4.0 influences H&S, the study is informed by a previously developed framework of Industry 4.0 technologies and concepts[4]. This framework consists of three clusters of technology, namely, smart factory, simulation and modelling, and digitalisation and virtualisation, and fourteen (14) technologies / concepts.

Table 1: The influence (positive) of Industry 4.0 technologies and concepts on construction H&S

Industry 4.0 technologies	Potential positive impact on H&S
A. Smart factory / The smart workplace	
Internet of Things (IoTs) Global Positioning System (GPS)	IoTs and sensors enable monitoring of workers and the work environment, collection, and dissemination of information [13, 24], and evaluation of hazards [25] in real time. Through detecting potential collision and unsafe site locations [24, 26], GPSs and sensors can reduce / prevent accidents involving equipment and workers on site [27].
Cyber-physical systems (CPSs)	CPSs allow for planning, real-time monitoring of the equipment, provision of early warning of risks detected, and enhanced communication and coordination between multiple parties [28]. Enhanced collision detection at work using RFID technologies [10].
Modularisation / Prefabrication	Transfers risk to a safe environment through offsite construction thereby reducing on-site activities [6].
Additive manufacturing (AM)	By increasing the degree of automation, AM can reduce the physical workload and workers' exposure to on-site hazards [2, 29].
Robotics	Allows monotonous tasks that burden employees and cause stress to be identified and performed by robots [23, 26]. Exoskeletons can help workers performing manual tasks regarding postures and mechanical stress [12]. Drones / UAVs are useful for monitoring, inspection, maintenance, and transporting / applying materials [26].
B. Simulation and modelling	
Building Information Modelling (BIM)	During the planning and design phase, BIM enables site layout and logistics planning, and early (design) hazard identification and mitigation before physical work begins [6]. BIM can also be used during the operative phase where 'as-built models' are used to assist property owners, operators, and contractors to consider hazards and reduce the risk to workers and members [6].
3D & 4D visualisation	The 3D visual medium enables virtual visualisation of the project and allows project stakeholders to detect potential problems and contribute to the planning process [6]. 4D CAD can facilitate detection of congestion, design-related hazards, and obstruction of space [10].
Augmented and Virtual Realities (AR & VR)	AR allows designers and workers to have an early appreciation of how a complete site would look like thereby facilitating early hazard identification before work begins on site [6]. AR / VR facilitate training of working using a simulated project environment [10].
Simulation tools and models	Simulated models during the design stage allow project stakeholders to visualise critical stages of construction, and identification of any residual risks [6]. Simulation assists the project team to identify hazards during the design stage [30].
C. Digitisation and virtualisation	
Digitisation	Makes work possible anywhere anytime; enhances capacity to collect information in real time thereby ensuring real time response before risk emerges[25] and enhances digitised management of H&S reports [13].
Mobile computing	Mobile technology makes communication easier for on time decision and remedial action, and digital mobile technologies promote flexibility and improved work-life balance [31].
Cloud computing	Stores data for decision-making [32]. Data analysis can be implemented in the cloud [11].
Social media	Facilitates communication, collaboration, and sharing crucial H&S information [4].
Big data	Enhances analysis and interpretation of vast amounts of sensor data to determine which information is relevant to protect worker safety, health, and wellbeing, and inform decision making for risk-informed actions [26]. Facilitates the collection, storing, and analysis of large amounts of data [10].

Table 1 shows that Industry 4.0 has major potential to influence H&S throughout the project lifecycle. In summary, Industry 4.0 can improve H&S performance through improved information gathering, monitoring of workers, enhanced early hazard identification, enhanced training, and reduced work-related injuries arising from performing tasks manually and collision of workers-on-foot and equipment. Although the foregoing depicts Industry 4.0 as a valuable resource for H&S, it is based mainly on the viewpoint of construction professionals from developed countries. Understanding the perspectives of construction professionals from developing countries regarding the expected benefits and challenges of the technologies is important to inform context specific interventions. Accordingly, this study sought to expand the boundaries of knowledge on the subject by investigating the perceptions of construction professionals in Zimbabwe regarding the expected benefits and challenges of adopting Industry 4.0 for workers' H&S.

RESEARCH METHOD

A quantitative research approach was adopted, which entailed the distribution of structured questionnaires to architects, construction H&S managers / officers, construction managers, construction project managers, engineers, and quantity surveyors in Harare. A survey design was selected because it is a dominant research approach in construction management research[33] that provides a quantitative analysis of attitudes and opinions of a population based on studying a sample of that population[34]. The study was conducted in Harare because the city hosts a large pool of contractor and consultants' head-offices in Zimbabwe[19]. The 2021 database of contractors and construction professionals in Harare shows that 57 contractors in categories A to C (medium to large), and 21 quantity surveying, 50 architectural, and 45 engineering firms are registered by the Construction Industry Federation of Zimbabwe (CIFOZ), Zimbabwe Institute of Quantity Surveyors (ZIQS), Institute of Architects Zimbabwe (IAZ), and Zimbabwe Association of Consulting Engineers (ZACE) respectively.

POPULATION AND SAMPLING

In line with the exploratory nature of the study, a combination of purposive and snowball sampling was adopted to select construction professionals based on their (a) engagement on active project(s), (b) involvement / experience in H&S management, and / or exposure to / use / knowledge of Industry 4.0 technologies[35]. Using these criteria, contact details obtained from the professional association database, and chain referrals, forty-five (45) questionnaires were distributed to architects, construction H&S managers / officers, construction managers, construction project managers, engineers, H&S officers, and quantity surveyors from construction and consultant firms in Harare to participate in the survey. The sample size, though small, conforms with past studies. During a study investigating H&S practices in the Malawian construction industry[36], the authors distributed thirty (30) questionnaires to architects, clients, contractors, engineers, and project managers, and twenty-one (21) responses were received.

QUESTION DESIGN AND ADMINISTRATION

The questionnaires were distributed to construction professionals in Harare via emails and drop-off and pick up methods. The questionnaire was divided into two sections. In Section A, respondents were asked to provide their demographic data such as gender, current designation, highest educational qualification, and work experience. Section B comprised four (4) closed-ended questions and one (1) open-ended question. A five-point Likert scale (varying from 1 = not at all to 5 = extensive / major) was used to solicit respondents' perceptions regarding (a) their knowledge of selected technologies of Industry 4.0; (b) the application of selected technologies to H&S, and (c) the potential benefits and challenges of adopting Industry 4.0 for H&S. The study is informed by extant literature regarding the use of a five-point Likert type scale because it has the ability to maintain response categories meaningful to respondents[37]. Through the review of literature, Industry 4.0 enabling technologies and their benefits were explored and included as elements of the questionnaire. Table 1 provides a summary of the technologies and their potential contribution / benefits to H&S. The research instrument was accompanied by an introductory letter requesting construction professionals to participate in the survey, and articulating the objectives of the study, and participants' right to participate or withdraw from the study.

DATA ANALYSIS

The collected data was analysed using the Statistical Package for Social Sciences (SPSS) software (v. 24) to compute frequencies, and a measure of central tendency in the form of mean scores (MSs) to facilitate ranking of the variables. Extant literature [38] recommends the use of a midpoint score of 3.00 $[(1 + 2 + 3 + 4 + 5) / 5 = 3)]$ as a benchmark where factors / elements / variables with MSs > 3.00 are considered significant. The standard deviation was used to facilitate rank differentiation where two or more factors had the same MS[39].

The Cronbach's alpha coefficient was calculated to assess internal consistency reliability of the Likert-type scales used in the questionnaire[40]. The Cronbach's alpha reliability coefficient normally ranges between 0.0 and 1.0, and a co-efficient closer to 1.0 indicates greater internal consistency of the items in the scale[40].

Responses from the open-ended questionnaire were analysed using content analysis, which entailed identifying and coding of themes that appear in text passages[41]. Specifically, the analysis process involved organising the data, breaking the data into manageable units, coding the data, synthesising and searching for patterns/themes[42].

RESEARCH FINDINGS

SAMPLE STRATUM AND RESPONSE RATE

A total of 45 questionnaires were emailed to construction professionals and 21 responses were received, representing a response rate of 46.7%. Due to the small sample, the results may be regarded as indicative. However, previous studies suggest that the respondents to studies are likely to be the more committed practitioners, and practitioners that are familiar and / or interested in the subject area, which reinforces the validity of the findings[43]. As proffered during study[44], meaningful findings can be obtained if quality data are obtainable from a smaller sample drawn using well-developed selection criteria. Notably, small samples have previously been reported in construction management research. During a related study in Malaysia[45], 45 questionnaires were distributed to different target groups in the construction industry and 14 responses were received and analysed.

Table 2 presents the demographic profile of the respondents. With regards to gender, most respondents (90.5%) were males and 9.5% were females. The respondents' educational background shows that 76.2% of the respondents had a Bachelors' degree, followed by 14.3% with Masters, and 9.5% with a diploma. The respondents' work experience in the construction industry shows that 38.1% of the respondents had between 6 to 10 years of work experience, followed by 28.6 % who had 0 to 5 years, and 23.8% who had 11 to 15 years.

Table 2: Demographic profile of the respondents

Characteristic	Description	Frequency	Percent (%)
Gender	Male	19	90.5
	Female	2	9.5
	Total	**21**	**100**
Educational background	Bachelors' degree	16	76.2
	Master's degree	3	14.3
	National diploma	2	9.5
	Total	**21**	**100**
Organisation	Architects	2	9.5
	Contractors	8	42.9
	Engineers	3	14.3
	Project managers	4	19.0
	Quantity surveyors	3	14.3
	Total	**21**	**100**
Designation	Architect	2	9.5
	Construction / Project Manager	7	33.3
	Engineer / Site Agent	3	14.3
	Quantity Surveyor	7	33.3
	H&S Officer	2	9.5
	Total	**21**	**100**
Number of years working in the construction industry	0-5 years	6	28.6
	6-10 years	8	38.1
	11-15 years	5	23.8
	16 years+	2	14.3
	Total	**21**	**100**

The demographic characteristics of the respondents, namely, level of education, work experience, and designation suggest that the study benefitted from knowledgeable and experienced respondents with the capacity to comprehend the issues included in the questionnaire thereby enhancing the quality of the responses and reliability of the research findings.

RELIABILITY OF THE SCALES

Table 3 presents the results of the reliability test. Given that the Cronbach's alpha values for reliability are more than the lower limit threshold of 0.70[46], it suggests that individual items of the scale are measuring the same construct and the instrument is reliable.

Table 3: Test of reliability

Construct	No. of items	Cronbach's alpha
Level of knowledge of Industry 4.0 technologies	15	0.852
Application of Industry 4.0 technologies in the construction industry	8	0.888
Application of Industry 4.0 technologies in construction H&S	17	0.877
Perceived benefits of Industry 4.0 technologies for H&S	17	0.923

KNOWLEDGE OF INDUSTRY 4.0 TECHNOLOGIES / CONCEPTS

Table 4 shows the respondents' self-rating of their level of knowledge of Industry 4.0 technologies and concepts in terms of percentage responses to a scale of 1 (not at all) to 5 (extensive), and a MS ranging between 1.00 and 5.00, the midpoint score being 3.00.

Table 4: Respondents' self-rating of their level of knowledge of fifteen Industry 4.0 technologies

Industry 4.0 technology / concept	Response (%)						MS	SD	Rank
	Unsure	Not at all				Extensive			
		1	2	3	4	5			
Modularisation / prefabrication	4.8	9.5	0.0	33.3	33.3	19.0	3.38	1.360	1
Product-Lifecyle-management	0.0	0.0	28.6	33.3	19.0	19.0	3.29	1.102	2
Automation	0.0	9.5	19.0	14.3	52.4	4.8	3.24	1.136	3
Digitisation	4.8	0.0	23.8	38.1	9.5	23.8	3.19	1.327	4
Internet of Things	4.8	14.3	14.3	33.3	23.8	9.5	2.85	1.352	5
Building Information Modelling	4.8	0.0	42.9	28.6	19.0	4.8	2.71	1.102	6
Human Computer Interaction	0.0	9.5	38.1	33.3	14.3	4.8	2.67	1.017	7
Cloud computing	14.3	9.5	19.0	23.8	23.8	9.5	2.62	1.564	8
Additive Manufacturing (AM)	8.5	9.5	23.8	33.3	19.0	4.8	2.57	1.326	9
Simulation and Modelling	4.8	9.5	33.3	38.1	9.5	4.8	2.52	1.123	10
Robotics	9.5	9.5	28.6	38.1	9.5	4.8	2.48	1.248	11
Mobile computing	28.6	4.8	0.0	52.4	4.8	9.5	2.29	1.678	12
Big data	19.0	14.3	23.8	28.6	14.3	0.0	2.05	1.359	13
Cyber-physical systems (CPSs)	19.0	19.0	14.3	42.9	4.8	0.0	1.95	1.284	14
Augmented / Virtual Reality	19.0	23.8	14.3	33.3	9.5	0.0	1.90	1.338	15
Composite M S							**2.65**	**0.732**	

Note: MS = Mean Score, SD = Standard deviation

The composite MS of 2.65 indicates that the construction professionals' composite self-rating is below average to average / average.

8 / 15 (53.3%) MSs are > 2.60 ≤ 3.40, which indicates the self-rating is below average to average / average - modularisation / prefabrication, product-lifecycle-management, automation, digitisation, Internet of Things, Building Information Modelling, human computer interaction, and cloud computing. The technologies ranked 9th to 15th have MSs > 1.80 ≤ 2.60, which indicates the self-rating is between not at all to below average / below average - cloud computing, additive manufacturing, simulation and modelling, robotics, mobile computing, big data, cyber-physical systems, and augmented / virtual reality (AR / VR). Although the findings correlate with those of previous studies, which show that modularisation has been in the construction industry for quite some time while other technologies such as AR / VR are still being adopted[32], limited knowledge of Industry 4.0 technologies among construction professionals can act as barrier to the adoption of these technologies for H&S management. As highlighted during previous studies[47,48], lack of knowledge regarding Industry 4.0 technologies and the corresponding benefits is identified as a hindrance to the adoption of the technologies.

APPLICATION OF INDUSTRY 4.0 TECHNOLOGIES IN CONSTRUCTION INDUSTRY

Table 5 presents the extent to which Industry 4.0 technologies are applied to construction industry practices 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.

Table 5: Extent to which Industry 4.0 technologies / concepts are applied to eight construction industry practices

Practice	Response (%)						MS	SD	Rank
	Unsure	Not at all				Major			
		1	2	3	4	5			
Cost management	0.0	0.0	9.5	33.3	42.9	14.3	3.62	0.865	1
Project schedule management	0.0	4.8	14.3	42.9	23.8	14.3	3.29	1.056	2
Construction site management	0.0	9.5	33.3	14.3	23.8	19.0	3.10	1.338	3
Resources and asset management	0.0	4.8	38.1	47.6	4.8	4.8	2.67	0.856	4
H&S management	0.0	4.8	52.4	19.0	19.0	4.8	2.67	1.017	5
Productivity management	9.5	9.5	33.3	28.6	14.3	4.8	2.43	1.287	6
Quality management	0.0	23.8	33.3	33.3	9.5	0.0	2.29	0.956	7
Environmental management	9.5	19.0	38.1	19.0	14.3	0.0	2.10	1.179	8
Composite Mean							**2.77**	**0.810**	

Given that cost management has a MS of 3.62 (> 3.40 ≤ 4.20), the respondents deem that Industry 4.0 technologies / concepts are applied to cost management between a moderate to a near major / near major extent. Given that the MSs for project schedule management, construction site management, resources and asset management, and H&S management are > 2.60 ≤ 3.40, the respondents deem that the Industry 4.0 technologies / concepts are applied to these practices between a minor to moderate / moderate extent. Given that the MSs for productivity management, quality management, and environmental management are > 1.80 ≤ 2.60, the respondents deem that the industry 4.0 technologies / concepts are applied to these practices between not at all to a minor / minor extent.

Overall, the composite MS of 2.77 indicates that the respondents deem the application of Industry 4.0 technologies / concepts to practices is between a minor to be moderate / moderate extent. Nonetheless, the results corroborate those of past studies, which show that the construction industry lags other industries in terms of technology adoptions, implementation, and diffusion[9,31] despite the potential benefits of increasing automation and digitisation in the construction process and its activities.

APPLICATION OF INDUSTRY 4.0 TECHNOLOGIES TO CONSTRUCTION H&S IN ZIMBABWE

Table 6 indicates the extent to which seventeen (17) Industry 4.0 technologies / concepts are applied to construction H&S management in terms of percentage responses to a scale of 1 (not at all) and 5 (major), and MSs between 1.00 and 5.00.

Table 6: Extent to which seventeen Industry 4.0 technologies and concepts are applied to construction H&S management

Industry 4.0 technology / concept	Response (%)						MS	SD	Cluster Rank	Overall Rank
	Unsure	Not at all				Major				
		1	2	3	4	5				
Smart Factory										
Modularisation / Prefabrication	4.8	0.0	61.9	14.3	9.5	9.5	2.52	1.167	1	3
Product-Lifecyle-management	0.0	14.3	42.9	28.6	9.5	4.8	2.45	1.030	2	4
Automation	9.5	19.0	42.9	23.8	0.0	4.8	2.00	1.140	3	7
Additive Manufacturing	19.0	33.3	9.5	19.0	19.0	0.0	1.86	1.030	4	8
Internet of Things (IoTs)	14.3	23.8	33.3	19.0	9.5	0.0	1.86	1.195	5	9
Radio frequency identification	9.5	33.3	33.3	19.0	4.8	0.0	1.76	1.044	6	10
Human-computer interaction	23.8	19.0	33.3	14.3	9.5	0.0	1.67	1.278	7	12
Cyber-physical systems	28.6	23.8	28.6	19.0	0.0	0.0	1.38	1.117	8	14
Robots / Exoskeletons	14.3	57.1	28.6	0.0	0.0	0.0	1.14	0.655	9	17
Simulation and Modelling										
Building Information Modelling	23.8	19.0	23.8	28.6	4.8	0.0	1.71	1.271	1	11
Augmented / Virtual Reality	28.6	28.6	33.3	4.8	0.0	4.8	1.33	1.238	2	15
Simulation tools / models	33.3	28.6	19.0	14.3	4.8	0.0	1.29	1.231	3	16
Digitisation and Virtualisation										
Social media	0.0	5.3	10.5	31.6	36.8	15.8	3.44	1.073	1	1
Mobile computing	4.8	4.8	19.0	23.8	28.6	19.0	3.24	1.375	2	2
Digitisation	16.7	16.7	16.7	38.9	11.1	0.0	2.11	1.323	3	5
Cloud computing	21.1	10.5	31.6	15.8	15.8	5.3	2.10	1.524	4	6
Big data	38.1	9.5	23.8	28.6	0.0	0.0	1.43	1.287	5	13
Composite mean							**2.64**	**0.741**		

It is notable that only 2 / 17 (11.7%) technologies / concepts have MSs > 3.00, which indicates the extent to which the two Industry 4.0 technologies and concepts are applied is major as opposed to minor.

Smart factory / workplace
The technologies / concepts ranked 1st to 6th have MSs > 1.80 ≤ 2.60, which indicates that respondents deem the extent of application of these technologies and concepts in H&S management to be between not at all to a minor / minor extent – modularisation / prefabrication, product life cycle management (PLM), automation, Internet of Things (IoTs), and additive manufacturing (AM) / 3D printing. The remaining technologies and concepts ranked 7th to 12th have MSs ≥ 1.00 < 1.80, which indicates that respondents deem the selected Industry 4.0 technologies / concepts to be applied to H&S management between not at all to a minor extent.

Simulation and modelling
The technologies / concepts in this cluster have MSs ≥ 1.00 < 1.80, which indicates that respondents deem the selected Industry 4.0 technologies / concepts to be applied to H&S management between not at all to a minor extent - BIM, AR / VR, and simulation tools / models. Although BIM is considered central to construction[4], the results of this study suggest that its adoption for general construction practice and H&S specific tasks is limited.

Digitisation and virtualisation
Social media ranked 1st has a MS > 3.40 ≤ 4.20, which indicates that respondents deem that it is applied between a moderate and a near major / near major extent to H&S management. Mobile computing ranked 2nd has a MS > 2.60 ≤ 3.40, which indicates that respondents deem that it is applied between a minor to a moderate / moderate extent in H&S management. Digitisation, and cloud computing have MSs > 1.80 ≤ 2.60, which indicates that respondents deem that they are applied to H&S management between not at all to a minor / minor extent. Big data has a MS ≥ 1.00 ≤ 1.80, which indicates that it is applied to H&S management between not at all to a minor extent.

Overall, the results confirm that Industry 4.0 technologies are not sufficiently applied for H&S management in the construction industry in Zimbabwe. The results in this section corroborate those presented in Table 4, which show that there is a low uptake of Industry 4.0 technologies in the construction practices and specifically for H&S management (MS = 2.76). Although some past studies[9, 41] indicate that the construction industry steadily adopted Industry 4.0 technologies to enhance H&S, the results of the current study corroborate the findings of some previous studies, which show that integration of H&S management and Industry 4.0 is still a relatively new phenomenon[11] and effectiveness of such integration is affected by the inability of firms to productively exploit data generated by Industry 4.0 technologies to the benefit of workers' H&S[12]. Conversely, the results reveal an important gap to effectively improve construction H&S. A recent study conducted in Zimbabwe[14] observed that lack of technology integration in H&S adversely affected the effective delivery of H&S during the COVID-19 pandemic.

POTENTIAL H&S BENEFITS OF INDUSTRY 4.0 TECHNOLOGIES

Table 7 indicates the potential benefits of integrating Industry 4.0 technologies into H&S management 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.

Table 7: Benefits of integrating Industry 4.0 technologies into H&S management

Benefit	Response (%)						MS	SD	Rank
	Unsure	Not at all				Major			
		1	2	3	4	5			
Real-time gathering of H&S information	0.0	4.8	0.0	9.5	33.3	52.4	4.29	1.007	1
Real-time monitoring of workers, plant and equipment and the work environment	0.0	0.0	4.8	19.0	23.8	52.4	4.24	0.944	2
Enhanced HIRAs	0.0	0.0	9.5	14.3	19.0	57.1	4.23	1.044	3
Improved accident investigation	0.0	4.8	9.5	0.0	33.3	52.4	4.19	1.167	4
Reduction of work -related incidents and accidents	0.0	0.0	4.8	23.8	23.8	47.6	4.14	0.964	5
Improved H&S awareness and communication	0.0	0.0	9.5	19.0	23.8	47.6	4.10	1.044	6
Enhanced coordination between multiple parties	0.0	0.0	4.8	23.8	28.6	42.9	4.10	0.944	7
Improves H&S training	0.0	0.0	0.0	28.6	38.1	33.3	4.05	0.805	8
Provision of early warning relative to H&S risks and disasters	0.0	0.0	14.3	19.0	23.8	42.9	4.05	1.117	9
Improved site layout and logistics planning	0.0	4.8	4.8	23.8	14.3	52.4	4.05	1.203	10
Promotion of safe construction methods (e.g., pre-fabrication)	4.8	0.0	4.8	19.0	19.0	52.4	4.05	1.322	11
Improved H&S planning	4.8	0.0	14.3	9.5	9.5	61.9	4.05	1.465	12
Separation of workers from dangerous physical and environmental hazards	4.8	0.0	0.0	14.3	47.6	33.3	4.00	1.140	13
Reduced risk of machine-worker collisions	4.8	0.0	4.8	33.3	28.6	28.6	3.67	1.238	14
Improved cognitive abilities of H&S trainees	4.8	0.0	14.3	23.8	23.8	33.3	3.62	1.359	15
Reduced workers' exposure to physical and monotonous work	0.0	4.8	14.3	28.6	33.3	19.0	3.48	1.123	16
Improved monitoring of environmental thermal changes	14.3	0.0	0.0	28.6	23.8	33.3	3.48	1.662	17
Flexibility of work tasks	4.8	0.0	23.8	28.6	28.6	14.3	3.19	1.250	18
Composite MS							**3.95**	**0.7775**	

Given that the composite MS for all the benefits is 3.95, the results suggest that respondents deem that Industry 4.0 technologies / concepts will benefit H&S between a moderate to a near major extent / near major extent.

The benefits ranked 1st to 3rd have MSs > 4.20 ≤ 5.00, which indicates that respondents deem the benefits of integrating Industry 4.0 technologies to contribute to the realisation of these benefits to between a near major to major / major extent - real-time gathering of H&S information, real-time monitoring of workers, equipment, and the work environment, and enhanced HIRAs. The results suggest that integrating these Industry 4.0 technologies into H&S management will promote real-time decision making thereby reducing the risk of injuries to workers.

The benefits ranked 4th to 21st have MSs > 3.40 ≤ 4.20, which indicates that respondents deem the integration of Industry 4.0 technologies into construction H&S management will contribute to the realisation of these benefits between a moderate to a near major / near major extent. The top five benefits in this cluster are 'reduction of work-related incidents and accidents', improved accident investigation, enhanced communication and coordination between multiple parties, improved health and safety awareness, and early warning relative to H&S risks and disasters.

The results indicate that Industry 4.0 technologies have the potential to influence H&S through specific areas. The top five application areas that demonstrate potential to benefit H&S through Industry 4.0 technologies are information management, site monitoring of workers and construction environment, hazard identification and risk assessment, accident investigation, and communication and awareness. Through influencing these key elements of H&S management, Industry 4.0 technologies can contribute to a reduction of accidents, and subsequently, improve H&S performance. The results corroborate the findings of previous studies which established that Industry 4.0 technologies can contribute to reducing accident rates through increased monitoring and measurement of the working environment[10], enabling the removal of workers from hazardous working situations, offering opportunities for more effective H&S training, advanced HIRA, communication, and H&S inspections[31], collision prevention, and monitoring extreme weather conditions[49]. In summary, the study corroborates the findings of earlier studies which identified that technology application is an effective way to further construction H&S management[48].

THE EFFECTS OF ADOPTING INDUSTRY 4.0 FOR CONSTRUCTION H&S MANAGEMENT

The respondents were asked to state, through an open-ended question, the challenges / adverse effects that may arise from the integration of Industry 4.0 technologies in construction H&S management. Three main issues emerged from the analysis of the responses, namely, potential loss of employment, increasing cost of H&S, and H&S concerns / risks. This was succinctly captured by one respondent who stated that "Industry 4.0 technologies may lead to high level of unemployment in the construction sector, misuse of technologies, and subsequent diminishing H&S standards."

Loss of employment

The respondents perceive that the introduction of Industry 4.0 technologies into construction H&S management can contribute to job losses to construction tradespeople and H&S officers. Technologies such as robotics, modularisation, and automation are perceived as likely to replace some of the traditional tasks performed by workers leading to job losses. This finding is consistent with previous studies which observed that the adoption of automation and robotics can contribute to permanent job losses[48, 51]. Loss of employment is an undesirable phenomenon for a country where the unemployment rate is over 80%.

Increased cost of H&S

The respondents perceive that Industry 4.0 will increase the cost of H&S. The cost drivers are purchase of the gadgets and associated infrastructure, maintenance of the technologies, and skills up-grade / further training for workers. The results corroborate findings from previous studies, which show that the high initial costs for Industry 4.0 technologies[51] lead to an unavoidable increase in cost or investment [47,48].

New H&S risks/ concerns

The respondents perceive that Industry 4.0 technologies are likely to introduce new unintended H&S risks / concerns. As highlighted by one of the respondents: "If implementers are not fully educated on how Industry 4.0 technologies work and their limitations, there is a likelihood of more harm." This finding corroborates with those of previous studies[31, 49], which highlighted that Industry 4.0 technologies such as robots could become a source of danger. The respondents highlighted some of the risks perceived to emerge from Industry 4.0 technologies as overwork, psychological pressure, and misuse of the technologies contributing to injuries. The uncertainty regarding employment status of workers following the adoption of technologies can aggravate the physiological stress among workers.

VIEWS REGARDING THE ADOPTION OF INDUSTRY 4.0 TECHNOLOGIES FOR H&S MANAGEMENT

Table 8 presents the views of construction professionals regarding whether construction firms should adopt Industry 4.0 technologies for H&S management. The results show that most of the professionals (85.7%) support the adoption of Industry 4.0 technologies and concepts as a strategy to improve construction H&S.

Table 8: Support for the integration of Industry 4.0 technologies in H&S management

Option	Frequency	Percent
Yes	18	85.7
No	1	4.8
Undecided	2	9.5
Total	**21**	**100.0**

It can be inferred from this finding that construction professionals perceive the H&S benefits to outweigh the negative effects hence the support for technology integration in H&S management. Nonetheless, interventions are required at various levels to promote the transition to technology-based solutions to H&S problems.

CONCLUSIONS AND RECOMMENDATIONS

The study investigated the impact of Industry 4.0 technologies on construction H&S. The research findings indicate that Industry 4.0 technologies can help to reduce work-related incidents, accidents, and contribute to creating a healthy and safe work environment through, inter alia: real-time gathering of H&S information, monitoring of workers, and the work environment; enhanced HIRAs; improved accident investigation, and enhanced communication and coordination between multiple parties. The results highlight the versatility of Industry 4.0 technologies to influence several key aspects of H&S management throughout the project lifecycle to enhance performance. Despite this, the research established that Industry 4.0 is at the early stage of adoption in construction, and the level of integration in construction H&S management is sub-optimal. The adoption of Industry 4.0 is perceived to contribute to job-losses, increased cost of H&S, and evolution of new H&S risks. Nevertheless, the respondents supported the adoption of Industry 4.0 technologies / concepts to improve construction H&S performance.

Despite the exploratory nature of the study, it has some important implications for policy and practice. First, the perceived H&S benefits of Industry 4.0 technology and support for its adoption for H&S management highlights the importance of interventions at various levels to promote the adoption of the technologies. The low level of knowledge of Industry 4.0 technologies among construction professionals highlights the need to raise awareness relative to Industry 4.0 technologies and places great responsibility on built environment tertiary education institutions to integrate the concepts in training to prepare their students and graduates for the work they will perform in practice. Second, the high investment cost associated with the technologies calls for government support in terms of creating a supportive policy and legislative framework to ensure affordability and practical implementation of the technologies. Third, the fear of job insecurity because of the adoption of Industry 4.0 technologies highlights the importance of (re)skilling of construction workers and professionals in line with the growth of digital technologies.

However, given that the sample size for this exploratory study was small, the study provided findings, which although they may not be generalisable, they are indicative. Future research can expand the scope of the current study to include the perceptions of other key stakeholders in the industry such as clients in the private and public sectors. Furthermore, research should be conducted to establish the enablers and barriers to adoption of Industry 4.0 technologies / concepts in H&S management.

REFERENCES

[1] Badri, A., Boudreau-Trudel, B. and Souissi, A.S. (2018) "Occupational health and safety in the industry 4.0 era: A cause for major concern?" Safety Science, 109(2018), 403-411.

[2] Thye, T.S.L.L. (2019). "Occupational safety for Industry 4.0," Available from: https://www.thestar.com [accessed 26.02.2020).

[3] Polak-Sopinska, A., Wisniewski, Z., Walaszczyk, A. and Sopinski, P. (2019) "Impact of Industry 4.0 on occupational health and safety." Advances in Manufacturing, Production Management and Process Control, 40-52.

[4] Oesterreich, T.D. and Teuteberg, F. (2016) "Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of research agenda for the construction industry." Computers in Industry, 83(2016), 121-139.

[5] Farmer, M. (2016) The Farmer Review of the UK Construction Model: Modernise or Die, Construction Leadership Council, United Kingdom.

[6] Health and Safety Executive (HSE) (2018) Improving Health and Safety Outcomes in Construction: Making the Case for Building Information Modelling (BIM). HSE, London.

[7] International Labour Organisation (ILO) (2014) Safety and Health in the Construction Sector - Overcoming the Challenges. ILO, Geneva.

[8] Erol, M. (2019) "Occupational health and work systems in compliance with Industry 4.0: Research directions. International." Journal of eBusiness and eGovernment studies, 11(2), 119-133.

[9] Nnaji, C., Gambatese, J., Lee, H.W. and Zang, F. (2020) "Improving construction work zone safety using technology: A systematic review of applicable technologies." Journal of Traffic and Transportation Engineering, 7(1), 61-75.

[10] Aslan, I. (2019) "The role of Industry 4.0 in occupational health and safety." International European Congress on Social Sciences - IV, 334-345.

[11] Liu, Z., Xie, K., Li, L. and Chen, Y. (2020) “A paradigm of safety management in Industry 4.0.” Systems Research and Behavioural Science, 37, 632-645.
[12] Romero, D., Mattsson, S., Fast-Berglund, Å., Wuest, T., Gorecky, D. and Stahre, J. (2018) “Digitalising occupational health, safety and productivity for the Operator 4.0”. In: Moon, I., Lee, G., Park, J., Kiritis, D., von Cieminski, G. (eds) Advances in Production Management Systems. Smart Manufacturing for Industry, 437-481.
[13] Dapan, M., Vukićević, A., Mačužić, I., Todorović, P., Mijović, N. and Savković, M. (2019) Safety 4.0: Modern talking or necessity. In: Proceedings of the 13th IQC Quality Research: International Quality Conference, 349-354.
[14] Chigara, B. and Moyo, T. (2021). Factors affecting the delivery of optimum health and safety on construction projects during the COVID-19 pandemic in Zimbabwe. Journal of Engineering, Design and Technology, Forthcoming. https://doi.org/10.1108/JEDT-01-2021-0053.
[15] Moyo, D., Zungu, M., Kgalamono, S. and Mwila, C. (2015) “Review of occupational health safety organisation in expanding economies: The case of Southern Africa.” Annals of Global Health, 81(4), 495-502.
[16] Chipato, E., Chigara, B. and Smallwood, J. (2019) Health and safety practices in the Zimbabwean construction industry. In: Proceedings of the 14th International Conference Organisation, Technology and Management in Construction, Zagreb, Croatia, September 04-07, 2019, 621-632.
[17] National Social Security Authority (NSSA) (2017) Annual Statistics Report 2016. NSSA, Harare.
[18] National Social Security Authority (NSSA) (2015) Annual Statistics Report 2014. NSSA, Harare.
[19] Chigara, B. (2018) Integrating sustainability principles in construction health and safety management practices in Zimbabwe. PhD Thesis, Nelson Mandela University, Port Elizabeth, South Africa.
[20] World Health Organization (WHO) (2002) Good Practice in Occupational Health Services: A Contribution to Workplace Health. WHO, Copenhagen.
[21] Reyes, J., San-Jose, J., Cuadrado, J. and Sancibrian, R. (2013) “Health and safety criteria for determining the sustainable value of construction projects.” Safety Science, 62(4), 221-232.
[22] Leso,V., Fontana, L. and Iavicoli, I. (2018) “The occupational health and safety dimension of Industry 4.0.” Med Lav., 110 (5), 327-338.
[23] Digmayer, C. and Jakobs, E. (2019) Developing safety cultures for Industry4.0. New Challenges for professional communication. In: Proceedings of the IEEE International Professional Communication Conference (ProComm), 218-225.
[24] Häikiöa, J., Kalliob, J., Mäkeläc,S.M., and Keränend, J.S. (2020) “IoT-based safety monitoring from the perspective of construction site workers.” International Journal of Occupational and Environmental Safety, 4(1), 1-14.
[25] Erol, M. and Kecioren, E. (2019) “Occupational health and safety systems in compliance with industry 4.0: Research directions.” International Journal of eBusiness and eGovernment Studies, 11, 121-133.
[26] Howard, J. (2017) Industry 4.0: Evolving EHS practice. In: Proceedings of the California Industrial Hygiene Conference, 04 December 2017, San Francisco, California.
[27] Genders, W., Wang, J. and Razavi, S. (2016) Smartphone construction safety awareness system: A cyber-physical system approach. In: The 16th International Conference on Computing in Civil and Building Engineering, Osaka University, Japan, 1697-1704.
[28] Kan, C., Anumba, C.J., and Messner, J.I. (2017) “Potential for use of Cyber-Physical Systems for planning and operation of mobile crane on construction sites”. In: International Workshop on Computing in Civil Engineering, 25-27 June, Seattle, United States, 139-149. https://doi.org/10.1061/9780784480830.018
[29] Camacho, D.D., Clayton, P., O'Brien, W., Ferron, R., Juenger, M., Salamone, S. and Seepersad, C. (2017) “Applications of additive manufacturing in the construction industry – A prospective review”. In: Proceedings of the 3rd International Symposium on Automation and Robotics in Construction, 1-8.
[30] Chun, C.K., Li, H. and Skirtmore, R.M. (2012) “The use of virtual prototyping for hazard identification in the early design stage.” Construction Innovation: Information, Process, Management, 12(1), 29-42.
[31] European Agency for Safety and Health at Work (EU-OSHA) (2019) Digitisation and Occupational Safety and Health (OSH): An EU-OSHA Research Programme. EU-OSHA, Bilbao.
[32] Alaloul, W.S., Liew, M.S., Zawawi, N.A.A. and Kennedy, I.B. (2020) “Industrial revolution 4.0 in the construction industry: Challenges and opportunities for stakeholders.” Ain Shams Engineering Journal, 11(2020), 225-230.
[33] Dainty, A. (2008) Methodological Pluralism in Construction Management Research. In: Knight, A. and Ruddock, L. (Eds.) Advanced Research Methods in the Built Environment, Wiley-Blackwell, United Kingdom.
[34] Creswell, J.W. and Creswell, J.D. (2018) Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. 5th ed., Sage, Los Angeles.
[35] Chigara, B. and Smallwood, J. (2021). Barriers to Industry 4.0 technology integration in construction health and safety management in Zimbabwe. CIB W099 & W123 Annual International Conference (Virtual): 'Changes and Innovations for Improved Wellbeing in Construction', Glasgow, 9 – 10 September 2021, 54-64.
[36] Chiocha, C., Smallwood, J. and Emuze, F. (2011). “Health and safety in the Malawian construction industry”. Acta Structilia, 18(1), 68-80.
[37] Losby, J. and Wetmore, A. (2012) CDC Coffee Break: Using Likert Scales in Evaluation Survey Work. National Centre for Chronic Disease Prevention and Health Production.
[38] Ikediashi, D.I., Ogunlana, S.O., and Boateng, P. (2012) “Analysis of risks associated with facilities management outsourcing: A multivariate approach.” Journal of Facilities Management, 10(4), 301-316. https://doi.org/10.1108/14725961211265756
[39] Doloi, H., Sawhney, A., Iyer, K.C. and Rentala, S. (2012) “Analysing factors affecting delays in Indian construction projects.” International Journal of Project Management, 30, 479-489.
[40] Gliem, J.A. and Gliem, R.R. (2003). “Calculating, intepreting, and reporting Cronbach's apha co-eeficient for Likert-type sclaes”. Paper presented at the Midwest Research-to Practice Conference in Adult, Continuing and Community Education. The OHIO State University, Columbus, OH, October 8-10, 2003.
[41] Hruschka, D.J., Schwartz, D., John, D.C., Picone-Decaro, E., Jenkins, R.A. and Carey, J.W. (2004). Reliability in coding open-ended data: Lessons learned from HIV behavioral research. Field Methods, 16(3), August 2004, 307-331. DOI: 10.1177/1525822X04266540.
[42] Bogdan, R.C. and Biklen, S.K. (2007). Qualitative research for education: An introduction to theory and methods. 5th ed. Pearson: Boston.
[43] Smallwood, J. (2019) “Core values that support construction health, safety and wellbeing (HSW)”. In: Gorse, C. and Nelson, C.J. (Eds) Proceedings of the 35th Annual ARCOM Conference, 2-4 September 2019, Leeds, UK, Association of Researchers in Construction Management, 527-536.
[44] Covielloa, N.E. and Jones, M.V. (2004) “Methodological issues in international entrepreneurship research.” Journal of Business Venturing, 19 (2004), 485-508.
[45] Yong, Y.C. and Mustaffa, Y.E. (2012) “Analysis of factors critical to construction project success in Malaysia.” Engineering, Construction and Architectural Management, 19(5), 543-556. DOI 10.1108/09699981211259612.
[46] Hair, J.F., Black, W.C., Babin, B.J. and Anderson R.E. (2010). Multivariate data analysis. 7th ed. New York: Pearson Prentice Hall.
[47] Holt, E.A., Benham, J.M., and Bigelow, B.F. (2015) “Emerging technology in the construction industry: Perceptions from construction industry professionals.” 122nd Annual Conference and Exposition, 14-17 June 2015, WA, 1-10.
[48] Zhou, Z., Irizarry, J. and Li, Q. (2013) “Applying advanced technology to improve safety management in the construction industry: a literature review”. Construction Management and Economics, 31(6), 606-622. http://dx.doi.org/10.1080/01446193.2013.798423.
[49] Štefanič, M. and Stankovski, V. (2018) “A review of technologies and applications for smart construction”, Proceedings of the Institution of Civil Engineers – Civil Engineering, 1-5. https://doi.org/10.1680/jcien.17.00050
[50] Llale, J., Setati, M., Mavund, S., Ndlovu, T., Root, D and Wembe, P. (2019) “Construction stakeholders' perceptions on the wider adoption of construction automation and robotics: An exploratory pre-study”. In: Gorse, C. and Neilson, C.J. (Eds) Proceedings of the 35th Annual ARCOM Conference, 2-4 September 2019, Leeds, UK, 567-576.
[51] Sima, V., Gheorghe, I.G., Subi´c, J, and Nancu, D. (2020). “Influences of the Industry 4.0 Revolution on the human capital development and consumer behaviour: A systematic review”. Sustainability, 12(4035), 1-28.

INSTRUCTION FOR AUTHORS

JOURNAL OF CONSTRUCTION

SUBMISSION OF MANUSCRIPTS

Authors should submit their papers in a Microsoft Word document electronically to the Editor @ joc@asocsa.org. Authors will be sent a Clearing Permissions Form for completion.
Manuscripts must be submitted in English and must be original, unpublished work not under consideration for publication elsewhere.

Manuscripts are blind peer reviewed by acknowledged experts. Revisions may be required before a decision is made to accept or reject the paper. If an author is uncertain about whether a paper is suitable for publication in JoC, it is acceptable to submit a synopsis first.

EFFECTIVE COMMUNICATION

The paper should be written and arranged in a style that is succinct and easily followed. An informative but short title, a concise abstract and keywords of no more than 150 words and a well written introduction will help achieve this. Simple language, short sentences and a good use of headings all help to communicate information more effectively. Discursive treatments of the subject matter are discouraged. Figures should be used to aid the clarity of the paper. The reader should be carefully guided through the paper.

PUBLICATION FEES

The Journal of Construction is an Open Access Journal, and all accepted articles carry a publication fee.

PREPARATION OF THE MANUSCRIPT

Length:
The manuscript should be between 8 and 12 pages, roughly 3000-6000 words.

Layout:
The manuscript must be in English, typed and 1.5 line-spaced 10-pt Arial font type on one side of A4 paper only, with a 3cm margin on the left-hand side. All other margins to be 2cm. All text should be linked to the left and right margins i.e., paragraphs should not be indented, and the text should be justified. One-line spacing should be between paragraphs and double line spacing before a new heading. Leave one line space between a heading and the following paragraphs. All headings should be 12-pt Arial Bold Capitals. Paragraphs and sub-paragraphs should not be numbered.

The pages should be numbered consecutively. There should be no loose addendum or notes or other explanatory material. The manuscript should be arranged under the headings and sub-headings.

Title page (page 1):
The first page of the manuscript must contain a concise and informative title, the name(s), the affiliation(s) and the address(es) of the author(s) and the name, address, telephone and email of the author who will be responsible for the correspondence and corrections. The title should be in 12-pt bold capitals, the name(s) of the author(s) in 10-pt bold upper and lower case with a single line spacing between each.

Abstract and keywords:
To produce a structured abstract, complete the following fields about the paper. There are four fields which are obligatory (Purpose, Design, Findings and Value); the other two (Research limitations/implications and practical implications) may be omitted if they are not applicable to the paper. Abstracts should contain no more than 150 words. Write concisely and clearly. The abstract should reflect only what appears in the original paper. Provide no more than 5 keywords.

Purpose of the Paper
What are the reasons for writing the paper or the aims of the research?

Design/Methodology/approach
How are the objectives achieved? Include the main method(s) used for the research. What is the approach to the topic and what is the theoretical or subject scope of the paper?

Findings
What was found in the course of the work? This will refer to analysis, discussion, or results.

Research Limitations/Implications (if applicable)
If research is reported on in the paper this section must be completed and should include suggestions for future research and any identified limitations in the research process.

Practical implications (if applicable)
What outcomes and implications for practice, applications and consequences are identified? Not all papers will have practical implications, but most will. What changes to practice should be made because of this research/paper?

What is original/value of the paper?
What is new in the paper? State the value of the paper and to whom. All headings and sub-headings should be in 10-pt bold capitals and the keywords themselves should be in 10-pt bold upper and lower case.

Introduction (page 3):
The introduction should clearly state the purpose (aims and objectives) of the paper. It should include key references to appropriate work but is NOT the place for a comprehensive historical or literature review.

Discussion:
The discussion should emphasize the implications and practical significance of research findings, their limitations and relevance to previous studies.

Acknowledgements:
A short acknowledgement section of one paragraph is permissible at the end of the text.

Conclusions:
Conclusions should state concisely the most important propositions of the paper, as well as the recommendations of the authors based on the propositions.

Illustrations:
Illustrations must accompany the manuscript and should be included in the text. Photographs, standard forms, and charts must be referred to as Figure 1, Figure 2, etc. They should be numbered in the order in which they are referred to in the text. The figure identification and accompanying description and any reference should be one line space immediately below the figure and linked to the left margin.

Illustrations should be submitted in a form ready for reproduction, preferably as high-resolution jpg files. Diagrams and drawings should be drawn in black ink on white background. Alternatively, it should be high quality laser computer printouts from a reputable computer software drawing package.

Drawings and diagrams must not exceed 140mm in width and all dimensions must be in mm. Annotation must be in upper- and lower-case lettering, the capital of which must be 3mm high.

Figures will normally be reduced in size on reproduction and authors should draw this with this in mind. With a reduction of 2:1 in mind the authors should use the lines not less than 0.25mm thick and upper- and lower-case lettering, the capitals of which should be 4mm high. Typewritten annotations are not acceptable.

Tables:
Tables must be located close to the first reference to them in the text and must be referred to as Table 1, Table 2, etc. and be numbered in the order in which they are referred to in the text. The table identification and accompanying informative description on and any reference should be one line space immediately above the table and linked to the left margin. The table identification should be in bold. Identify all statistical methods and sources of data.

Tables should only have horizontal lines, the heading and the bottom lines being in bold, all words should be in upper and lower case lettering. The headings should be aligned to the left of their column, start with an initial capital and be in bold. Units should be included in the heading. Any explanations should be given at the foot of the table, not within the table itself.

Table 1 Components of expenditure

Component	Expenditure
Cleaning works	40,9
Mechanical Services	37,7
Building Works	13,6
Civil Works	7,8
Total	100,0

Source[1]

Symbols, abbreviations, and conventions:
Symbols, abbreviations, and conventions in
Papers must follow the recommended SI units. Where non-standard abbreviations are used, the word(s) to be abbreviated should be written out in full on the first mention in the text, followed by the abbreviation in parentheses.

References:
The numbered superscript reference system must be used. References in the text should be numbered consecutively (1) , etc. References should be collected at the end of the paper as they appeared in the manuscript. The style should follow the examples below:

[1] Bon, R. (1997) "The future of international construction." Building Research and Information 25, 137-41.
[2] Stone, P.A. (1980) Building Design Evaluation: Costs-in-use. E & FN Spon, London.
[3] Barre, S. (1981) "Implementation of public policy." In Policy and Action, Barre, S. and Fudge, C. (eds), Chapman & Hall, London, 1-33.

If no person is named as the author the body should be used (for example: Royal Institution of Chartered Surveyors (1980) Report on Urban Planning Methods, London.

End Notes:
A limited number of explanatory notes is permissible. These should be numbered 1, 2, 3, consecutively in the text and denoted by superscripts. They should be typed on a separate sheet of paper at the end of the. Endnotes should not be used for academic or project citations.

Copyright:
Submission of a paper to JOC is taken to imply that it represents original, unpublished work, not under consideration for publication elsewhere. The Journal of Construction is committed to open access for academic work and is, therefore, an open access journal, which means that all articles are available on the internet to all users immediately from the date of publication. This allows for the reproduction of all articles, free of charge, for non-commercial use only and with the appropriate citation information. All authors publishing in the Journal of Construction accept these as terms of publication and will have to complete a copyright agreement before the paper is published.

Permission to publish illustrations must be obtained by the author before submission and any acknowledgements should be included in the figure captions. Should the author wish to have the paper published elsewhere, such as in an anthology, the author must write and seek consent from the publisher which will normally be given provided acknowledgement of the original source is provided.

Copyright of the content of all articles and reviews remains with the designated author of the article or review. Copyright of the layout and design of the Journal of Construction on articles and reviews remains with the Journal of Construction and cannot be used in other publications.

EDITORIAL COMMITTEE