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Understanding the barriers and drivers of sustainable construction adoption and implementation in South Africa: A quantitative study using the Theoretical Domains Framework and COM-B model

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The construction industry is one of the largest consumers of natural resources. Improving the sustainability of construction industry activities is therefore key to mitigating the negative impact of the industry on the environment. Given the extent of the environmental challenges faced by many countries, the transition towards the adoption of sustainable alternatives in the construction industry must include dimensions of changing human behaviour. These dimensions include influencing the capability, opportunity, and motivation to adopt the desired change in behaviour. In order to improve the adoption and implementation of sustainable practices within the construction industry, the behaviour change processes of stakeholders need to be considered. This study describes how the Capability, Opportunity, Motivation-Behaviour (COM-B) model and Theoretical Domains Framework (TDF) were used to identify the barriers to and drivers of sustainable construction practices by construction industry stakeholders. The study included a structured questionnaire survey completed by 108 construction industry stakeholders and indicated a need to improve the capability, opportunity, and motivation amongst construction industry stakeholders to facilitate the adoption of sustainable construction practices. The questionnaire identified that an increase in the awareness, knowledge, interest, and demand for sustainable construction will facilitate the adoption thereof. Additionally, providing training and access to education on best practices for sustainability can positively influence the behaviour of stakeholders and improve their confidence in implementing sustainable construction practices. Economic factors such as the cost of implementing sustainable solutions and the perception of the economic and social benefits of sustainable construction were identified as the critical barriers. These barriers and drivers are mapped to five TDF domains (knowledge, skills, social influences, beliefs about capabilities, and beliefs about consequences), which can be targeted for behaviour change amongst construction industry stakeholders in future interventions.

INTRODUCTION

Over the past few decades, international and local governments have recognised that the construction industry is a key role-player in the adoption and implementation of sustainable development. The construction industry, which includes the entire life cycle of a building project, from pre-feasibility to decommissioning and disposal, has a significant impact on the environment, economy and society (Kibert 2007). Since the initial development of the sustainability agenda in the late 1980s, the principle of sustainable development aims to simultaneously pursue environmental, economic, and social dimensions of development. However, various authors argue that sustainable development can be interpreted and pursued within a specific context, and therefore the objectives and development solutions vary (Amui *et al* 2017; Bebbington 2001; Du Plessis *et al* 2002; Elliot 2006; Hjorth & Bagheri 2006).

The construction industry has a unique position to create value by improving the quality of life of society and thereby positively contributing to sustainable development. Although the conventional

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approach to the built environment is driven by cost, quality and performance criteria, sustainable design and construction aims to additionally minimise resource depletion, minimise environmental degradation and create a healthy built environment (Kibert 2016). Sustainable construction (SC), although lacking a general definition and therefore lacking a universal approach (Ahn *et al* 2013; Du Plessis *et al* 2002; Ofori 2015), has been highlighted in documents such as the *Agenda 21 for Sustainable Construction* published by the International Council for Research and Innovation in Building and Construction (CIB). The purpose of this document was to provide guidance for all national agendas on a global scale to implement SC research and development strategies to overcome issues and challenges of sustainable development within the construction industry (Du Plessis *et al* 2002). Responses to the SC agenda have, however, varied amongst the different contexts of countries.

Although SC has been studied by authors in both developed and developing countries who recognise the need to develop and implement SC agendas (Ahn *et al* 2013; AlSanad 2015; Brennan & Cotgrave 2014; Chan *et al* 2017a; Darko *et al* 2017a; Häkkinen & Belloni 2011; Ismail *et al* 2012; Marchman & Clarke 2011; Saleh & Alalouch 2015), only a few researchers (Aigbavboa *et al* 2017; Du Plessis 2007) have conducted studies which extend the concept of SC to South Africa. In 2002, Du Plessis prepared a discussion document named the *Agenda 21 for Sustainable Construction in Developing Countries* (A21 SCDC), which sought to present a sector-and-developing-country response to the challenge of sustainable development. It also aimed to highlight the implications of sustainability in the built environment in a regional context and to suggest the principles and strategy for action for the developing world in partnership with the developed world. The objectives of this agenda aimed to provide a framework that could be used to guide research and development (R&D) in developing countries and to promote the exchange of learning of SC within the developing world. Du Plessis (2007) argues that developing countries will become the platform for infrastructure and industrial development, and therefore the construction sector in these countries has a critical role to play in responding to the sustainable agenda.

Although numerous strategies were further developed, as stated by Dalal-Clayton and Bass (2012), there has been very little impact of such strategies as a result of lack of integration between frameworks and key decision-makers, limited links between policies and practical applications, a narrow base of participation from multiple stakeholders, and many strategies lacking clear and concise priorities and achievable targets (Du Plessis 2007). Another study conducted by Sebake (2008), emphasised the challenges faced by professionals in the implementation of sustainability principles during the development of building projects. The study recognised that any strategies related to sustainable building projects must be dealt with at the initial stages of a project and must include both architects and the rest of the professional team (such as engineers and contractors). In doing so, the client's brief can be formulated and developed by taking advantage of all the participants' competencies and prerequisites, thereby ensuring a sustainable build and minimising silo design and development and clashes later in the project. The thematic analysis employed by Windapo (2014) found that green building is at an early stage of development in South Africa, and that rising energy costs and the Green Building Council of South Africa's (GBCSA) Green Star rating system were the primary drivers of green building. Windapo (2014) noted that these drivers have not changed since 2006, nearly a decade since the publication of the article, and highlighted that the drivers of green building were mainly financial and not necessarily to protect the environment. Evidence of this is substantiated by the case studies, which suggest that competitive advantage and corporate image were key drivers to achieving Green Star status. Therefore, the author concludes that without the economic benefit that green buildings provide to clients and developers, and with a lack of government regulations to support green building construction, a limited number of clients and developers would drive green building projects forward for the sole purpose of environmental sustainability. An empirical study done by Aigbavboa *et al* (2017) on the "lazy view" of construction professionals in the South African construction industry suggests that the following reasons were the key challenges facing the construction industry in a bid to achieve sustainable construction: additional cost of building sustainable buildings, a limited understanding of the benefits of sustainable construction, and lastly, the lack of mobilisation of sustainable construction resources to support technological changes in the industry.

Although there has been a shift towards adopting a green approach towards buildings since the establishment of the Green Building Council of South Africa in 2007, professional stakeholders in the built environment have been reluctant to pursue greening of buildings in their design and construction methodologies. In a study conducted by Coetzee and Brent (2015) it was found that the perception amongst key stakeholders in the built environment was that the additional costs associated with the design of sustainable buildings are too high. The results of the study, however, indicated that the perceived cost of sustainable design and construction was more than double what the actual cost was. This highlights one of the barriers towards effectively adopting and implementing SC. In addition to this, the lack of regulations and policies which govern SC in many developing countries has made it less likely for stakeholders in the industry to adopt SC practices (Aghimien *et al* 2018; Djokoto *et al* 2014; Foong *et al* 2017; Suliman & Omran 2009). Although there are regulations and frameworks available in South Africa, such as the Green Economy Accord, National Greening Framework and the Green Building Council, the latter which certifies green buildings, Simpeh and Smallwood (2015) suggest that the adoption of sustainable practices in the South African construction industry has been slow due to conflicting regulations and stakeholders who fear the liability and litigation when it comes to the performance of new sustainable products and systems. The current legislation is generally voluntary and prescriptive, which further reduces the transition towards a more sustainable approach to the multiple phases of the building life cycle (Ametepey *et al* 2015; Gan *et al* 2015; Mousa 2015). Assessing the current awareness amongst built environment stakeholders along with their perceptions is critical to identify and understand the barriers towards a more sustainable built environment in the South African context. By identifying these barriers, it allows key decision-makers to look at possible solutions to overcome these barriers and work towards driving the SC agenda forward.

Behaviour changes for sustainable construction adoption

On a regular basis, individuals, organisations, key stakeholders, and policymakers make decisions that have an impact on the earth's natural resources. Policies and intervention strategies that focus on transitioning these everyday behaviours towards more sustainable outcomes are imperative to achieving development and consumption that are more sustainable (UNEP 2017). However, changing human behaviour can be challenging (Cane *et al* 2012), as we do not always make rational decisions or behave in predictable ways. (Cane *et al* 2012) suggest that, although changing behaviour is not easy, it can be more effective if interventions are implemented that are based on evidence-based principles of behaviour change.

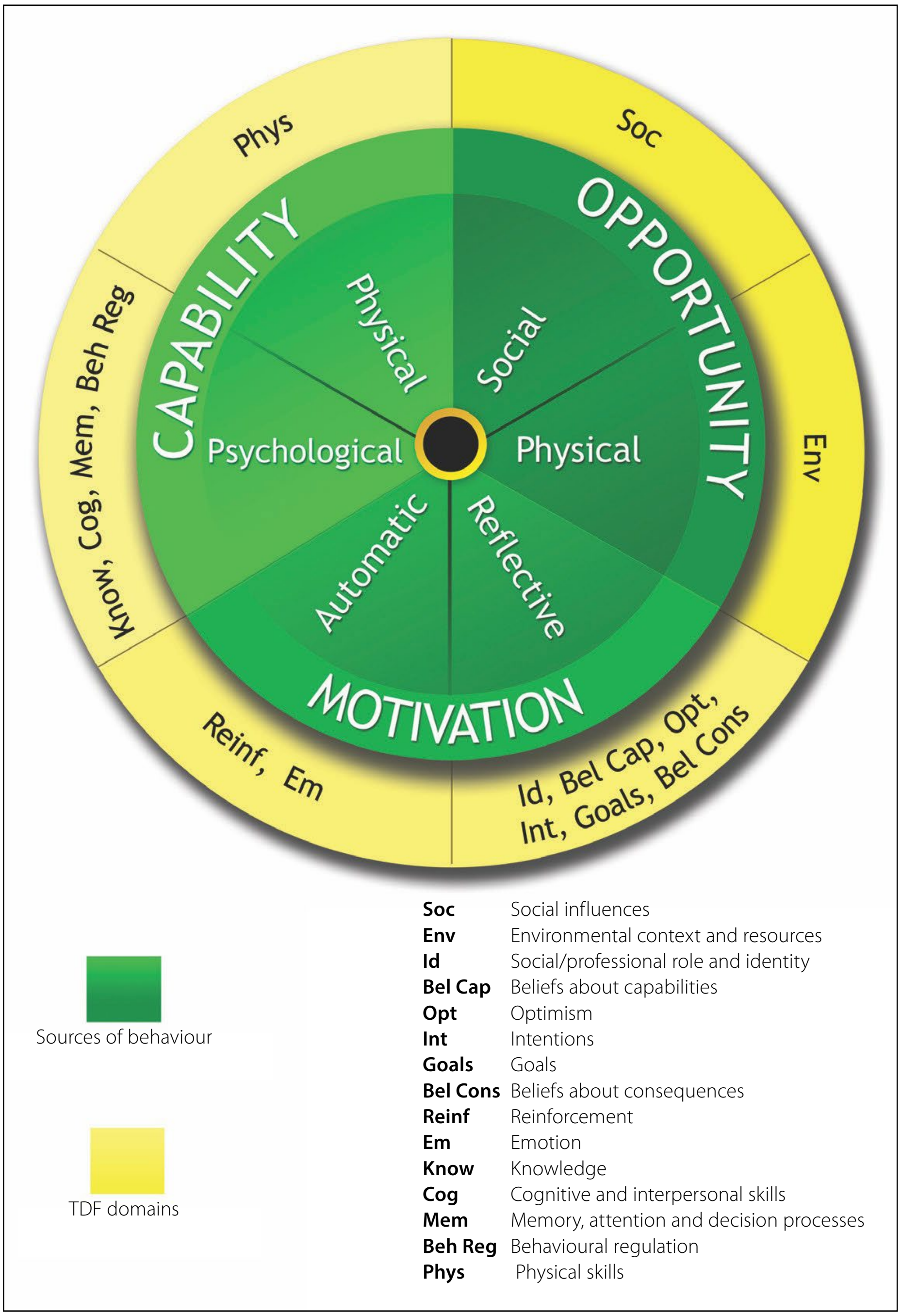

Figure 1 **TDF domains linked to COM-B components (Michie *et al* 2014)**

Theoretical Domains Framework

To change professional practice, it has been agreed that there is no "magic bullet" (Oxman *et al* 1995) and that the effectiveness of intervention strategies is sensitive to context (Wensing *et al* 1998). Michie *et al* (2005), however, suggest that the mixed results and limited practical value of implementation research were due to a limited theoretical underpinning for the development of interventions. The authors argue that a consensus of psychological theories is necessary to provide clarity and simplify the accessibility and usefulness of theories in behavioural change research. A team of behavioural scientists in collaboration with implementation researchers therefore developed the Theoretical Domains Framework (TDF) to provide access to a theoretical basis for implementation research. The TDF is an integrated framework grounded in psychological theory which synthesises 128 theoretical constructs from 33 theories relevant to implementation (Michie *et al* 2005). The original TDF contained 12 domains, and after validation through a consensus conducted by Cane *et al* (2012), 14 domains covering 84 theoretical constructs were identified, as illustrated in Table 1 (see page 14), which is adopted in this research study. The TDF domains can be condensed into three core components of behaviour, namely capability, opportunity and motivation (Michie *et al* 2014) (Figure 1). The COM-B model demonstrates that behaviour (B) is a result of the interaction between psychological and physical capabilities (C), to utilise social and physical opportunities (O) through reflective (self-conscious intentions) and automatic (personal needs and desires) motivators (M).

Globally, government authorities, intergovernmental organisations, educational institutions, businesses and organisations have begun to adopt behavioural science theory and methodologies to design and implement effective behaviour change policies and programmes (Klaniecki *et al* 2018). Most behaviour change interventions have primarily been applied in developed countries with high per-capita consumption rates. However, developing countries present many opportunities to adopt behavioural science to inform policy to align with sustainable development goals due to rapid growth of consumption (UNEP 2017). The application of utilising the TDF and COM-B model in research studies has mostly been adopted in literature to support research in the medical and implementation science field (Atkins *et al* 2017) and has yet to be applied to understanding and targeting change of behaviour amongst construction industry stakeholders. However, it has been adopted in studies about behaviour change relating to sustainable consumption and sustainable development. An example of this is a case study conducted by Gainforth *et al* (2016), which adopts the TDF and Behaviour Change Wheel (Michie *et al* 2014) to develop interventions to change recycling behaviours. Additionally, there have been examples of successful applications of behavioural design to priority consumption

Table 1 Theoretical Domains Framework (Cane *et al* 2012)

Domain (definition[1])	Theoretical construct
Knowledge An awareness of the existence of something	■ Knowledge (including knowledge of condition / scientific rationale) ■ Procedural knowledge ■ Knowledge of task environment
Skills An ability or proficiency acquired through practice	■ Skills ■ Skills development ■ Competence ■ Ability ■ Interpersonal skills ■ Practice ■ Skill assessment
Social/professional role and identity A coherent set of behaviours and displayed personal qualities of an individual in a social or work setting	■ Professional identity ■ Professional role ■ Social identity ■ Identity ■ Professional boundaries ■ Professional confidence ■ Group identity ■ Leadership ■ Organisational commitment
Beliefs about capabilities Acceptance of the truth, reality, or validity about an ability, talent or facility that a person can put to constructive use	■ Self-confidence ■ Perceived competence ■ Self-efficacy ■ Perceived behavioural control ■ Beliefs ■ Self-esteem ■ Empowerment ■ Professional confidence
Optimism The confidence that things will happen for the best or that desired goals will be attained	■ Optimism ■ Pessimism ■ Unrealistic optimism ■ Identity
Beliefs about consequences Acceptance of the truth, reality or validity about outcomes of a behaviour in a given situation	■ Outcome expectancies ■ Characteristics of outcome expectancies ■ Beliefs ■ Anticipated regret ■ Consequents
Reinforcement Increasing the probability of a response by arranging a dependent relationship, or contingency, between the response and a given stimulus	■ Rewards (proximal/distal, valued / not valued, probable/improbable) ■ Incentives ■ Punishment ■ Consequents ■ Reinforcement ■ Contingencies and sanctions
Intentions A conscious decision to perform a behaviour or a resolve to act in a certain way	■ Stability of intentions ■ Stages of change model ■ Transition model/stages of change
Goals Mental representations of outcomes or end states that an individual wants to achieve	■ Goals (distal/proximal) ■ Goal priority ■ Goal/target setting ■ Goals (autonomous/controlled) ■ Action planning ■ Implementation intention
Memory, attention and decision processes The ability to retain information, focus selectively on aspects of the environment and choose between two or more alternatives	■ Memory ■ Attention ■ Attention control ■ Decision-making ■ Cognitive overload/tiredness
Environmental context and resources Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence and adaptive behaviour	■ Environmental stressors ■ Resources / material resources ■ Organisational culture/climate ■ Salient events / critical incidents ■ Person X environment interaction ■ Barriers and facilitators
Social influences Those interpersonal processes that can cause individuals to change their thoughts, feelings or behaviours	■ Social pressure ■ Social norms ■ Group conformity ■ Social comparisons ■ Group norms ■ Social support ■ Power ■ Intergroup conflict ■ Alienation ■ Group identity ■ Modelling
Emotion A complex reaction pattern, involving experiential, behavioural and physiological elements, by which the individual attempts to deal with a personally significant matter or event	■ Fear ■ Anxiety ■ Affect ■ Stress ■ Depression ■ Positive / negative effect ■ Burn-out
Behavioural regulation Anything aimed at managing or changing objectively observed or measured actions	■ Self-monitoring ■ Breaking habit ■ Action planning

1 All definitions are based on definitions from the American Psychological Associations' *Dictionary of Psychology* (VandenBos 2007).

areas: energy, water, transportation and mobility, food and diet, and waste and disposal (UNEP 2017).

Objective of this paper

There is a need to change the current behaviour of stakeholders in the construction industry to ensure the sustainability of the industry by adopting sustainable alternatives throughout the life cycle of construction projects. Moreover, the impact of the construction industry on the environment needs to be mitigated. The aim of this study was to use the COM-B model and TDF to identify barriers and drivers of SC to inform the design of future interventions to promote SC adoption and implementation through SC methods, processes and materials.

RESEARCH METHODS

Given the exploratory nature of this study, a survey research approach was adopted. A structured questionnaire survey was conducted through recruiting various stakeholders who are currently working in the construction industry in South Africa. The purpose of the survey was to understand the perception and attitude towards sustainable construction by stakeholders in the construction industry.

Study population and sampling

The population of this study comprised construction industry professionals working in the built environment in South Africa on building projects. Due to the large number of professionals in the construction industry, no available list of all construction industry professionals, and potential challenges with access and communication, the sampling frame adopted was a nonprobability sample. Nonprobability sampling is a sampling technique in which the researcher chooses participants based on their willingness to participate in the research study (Etikan *et al* 2015). A purposive snowball sampling technique was therefore used in this research to obtain a valid and effective overall sample size. This method has been used in previous construction, engineering and management studies and allows for data to be gathered from participants who share the research study or make referrals of prospective participants (Gan *et al* 2015; Jiang & Wong 2016; Darko *et al* 2017b; Chan *et al* 2018). The online questionnaire survey was distributed via LinkedIn (a professional social media platform) to professionals who met the inclusion criteria (i.e. working in the built environment in South Africa on building projects). Using search criteria to filter each of the discipline services provided within the design and development phase of building projects (e.g. quantity surveyors, architects, landscape architects, structural engineers, civil engineers, building services engineers which include mechanical, electrical and fire), as well as location (South Africa), individuals were sent messages inviting them to participate in the research study. Initial participants were asked to share the survey with other professionals in the built environment who they knew also worked on building projects.

Research instrument

The purpose of the questionnaire survey in this study was to understand which barriers and drivers of sustainable construction need to be prioritised for an intervention strategy. A self-administered online questionnaire is the preferred type of data collection procedure for this phase of the research for the following reasons:

i. Cost-effective to administer.
ii. Ease of gathering data, as surveys can be distributed and completed rapidly.
iii. Data inputs are readily available from an online survey database.
iv. Due to automated data capturing, there is a reduced possibility of errors whilst handling the data.
v. Online surveys are convenient for potential participants as they can complete the survey at a time and a place that are convenient for them.

Design of the questionnaire survey

The questionnaire survey was adapted from Huijg *et al* (2014) and informed by the TDF and COM-B model to guide the behavioural analysis and understand the perceived barriers and drivers of sustainable construction identified by participants. The results of the questionnaire survey allowed the researcher to identify key perceptions from the various domains of the TDF that can be targeted in an intervention strategy to facilitate the adoption and implementation of SC. The questionnaire survey consisted of seven sections covering:

i. Background to the research study and informed consent
ii. Key definitions pertaining to the study
iii. Demographics of participants
iv. Knowledge, skills and social and professional role and identity
v. Beliefs about capabilities, optimism, and beliefs about consequences
vi. Reinforcement, intentions, goals, social influences, and behavioural regulation
vii. Environmental context and resources.

The scales used to measure the items include categorical nominal (e.g. type of profession, type of service disciplines at organisations, yes/no questions) and ordinal scales (e.g. years of experience, number of employees at an organisation, Likert scale). The Likert scale which makes up the majority of the questionnaire items was a five-point scale measuring: 1 – strongly disagree, 2 – disagree, 3 – neither disagree or agree, 4 – agree, and 5 – strongly agree. The Likert scale provides an overview of the intensity of an attitude towards a statement and was therefore deemed the appropriate scale used to measure the TDF domain items (Bryman 2010).

Data analysis

The data collected was manipulated and analysed using the statistical software package SPSS. The data analysis was conducted by performing various statistical analysis approaches. Firstly, the Cronbach's Alpha test was used to measure the reliability of the data, frequency tables were used to report the results from the Likert scale items, followed by determining if there was a significant difference between two or more groups of participants using the Mann-Whitney U test and Kruskal Wallis test. The Mann-Whitney test is a nonparametric test to compare two categorical unpaired groups of data (Gaddis & Gaddis 1990). In this study, the two groups that were studied were structural and civil engineers, as these groups represented a significant sample of at least 30 data sets each. The Kruskal Wallis test is another nonparametric used when more than two categorical groups are compared (Gaddis & Gaddis 1990), which in the case of this research study was identified as the *years of experience,* which had four groups (0 to 4 years, 5 to 9 years, 10 to 19 years, more than or equal to 20 years).

ANALYSIS OF RESULTS

Demographics and background information

Out of the 290 questionnaire surveys that were sent out, 108 responses were received, which represents a 37% response rate. It has been argued that studies within the construction industry generally have a lower response rate between 20% and 30% (Abidin & Powmya 2014); Gan *et al* 2015). However, the sample size can be considered representative of the population, as the central limit theorem holds true with a sample size greater than 30, which means statistical analysis can be conducted. The descriptive statistics of the sample population are presented in Tables 2 and 3.

Table 2 Profile of respondents

Professions	Frequency	Percentage (%)
Contractor	1	0.9
Quantity surveyor	7	6.5
Architect	7	6.5
Structural engineer	37	34.3
Civil engineer	36	33.3
Mechanical engineer	14	13.0
Electrical engineer	2	1.9
Environmental engineer	3	2.8
Façade engineer	1	0.9
Total	**108**	**100.0**

Table 3 Experience of respondents

Professions	Years of experience (construction industry)				Sustainable / Green Building experience	
	0–4	5–9	10–19	≥20	Yes	No
Contractor	0	1	0	0	1	0
Quantity surveyor	4	3	0	0	0	7
Architect	0	4	3	0	3	4
Structural engineer	17	12	6	2	12	25
Civil engineer	22	10	3	1	8	28
Mechanical engineer	4	4	4	2	12	2
Electrical engineer	0	2	0	0	1	1
Environmental engineer	0	2	1	0	1	2
Façade engineer	0	0	1	0	1	0
Subtotal	**47**	**38**	**18**	**5**	**39**	**69**
Percentage (%)	**43.5**	**35.2**	**16.7**	**4.6**	**36.1**	**63.9**

TDF and COM-B variable analysis

The questionnaire provided five response categories ranging from "strongly disagree" to "strongly agree". During the frequency analysis, the responses "agree" and "strongly agree" were combined into one category, *agree*, which represents a participant who agrees with a statement, and the responses "disagree" and "strongly disagree" were combined into one category, *disagree*, which represents a participant who disagrees with a statement. This is referred to as *categorisation* in the tables provided. Questionnaire statements have been simplified for ease of reference. The following section describes the data within the TDF and COM-B model domains and categories.

Capability

Capability represents an individual's ability to engage in a target behaviour and having the necessary knowledge and skills to do so (Michie *et al* 2011). Construction industry stakeholders' psychological capabilities influence their adoption and implementation of SC. Table 4 displays the means and standard deviations for the *knowledge*, *skills* and *behavioural regulation* domains linked to psychological capability and provides the frequency of responses for each questionnaire statement.

Construction industry stakeholders' assessment of their capabilities regarding their knowledge of SC was generally positive, as the most frequent responses to all five questions was "agree". Responses in the *skills* domain indicated that the majority of stakeholders understand SC (88.9%) and participants agree that education on SC is available (61.1%) through external service providers (56.5%). However, most participants do not have access to training within their organisations (38.9%). Participants perceived that there is a requirement for behaviour change in the construction industry (92.6%), as current construction practices are not sustainable and 71.3% agreed that there is resistance to adopt sustainable alternatives to construction industry processes and methods.

Opportunity

Opportunity represents the social and physical environment that shapes the opportunity to engage in a target behaviour (Michie *et al* 2011). Social opportunity refers to the social factors that influence the way we think about things (i.e. cultural norms and social cues). Physical

Table 4 Capability questionnaire statement responses

Capability		Questionnaire response (%)					
Questionnaire statement	**Mean (SD)**	**1**	**2**	**3**	**4**	**5**	**Categorisation**
Knowledge domain							
CF1 – Awareness of SC	3.83 (0.78)	1.9	4.6	14.8	65.7	13.0	Agree
CF2 – Knowledge of SC	3.46 (0.88)	1.9	11.1	35.2	42.6	9.3	Agree
CF3 – Familiarity with SC	3.72 (0.81)	2.8	3.7	22.2	61.1	10.2	Agree
CF4 – Interest in SC	3.56 (0.98)	3.7	12.0	21.3	50.9	12.0	Agree
CF5 – Demand for SC	3.47 (0.94)	0.9	14.8	34.3	36.1	13.9	Agree
Skills domain							
CF6 – Understanding of SC	4.13 (0.76)	1.9	1.9	7.4	59.3	29.6	Agree
CF7 – SC skills are within the scope of construction industry professionals	3.87 (0.86)	2.8	2.8	18.5	56.5	19.4	Agree
CF8 – SC education is available	3.66 (0.90)	1.9	7.4	29.6	45.4	15.7	Agree
CF9 – External training on SC is available	3.52 (0.95)	1.9	13.9	27.8	43.5	13.0	Agree
CF10 – Internal training on SC is available	2.86 (0.99)	8.3	30.6	28.7	31.5	0.9	Disagree
Behavioural regulation domain							
CF51 – Resistance to change behaviour	3.81 (0.80)	0.9	4.6	23.1	54.6	16.7	Agree
CF52 – Commitment to change behaviour	4.26 (0.62)	0	0.9	6.5	58.3	34.3	Agree

Table 5 Opportunity questionnaire statement responses

Opportunity		Questionnaire response (%)					
Questionnaire statement	**Mean (SD)**	**1**	**2**	**3**	**4**	**5**	**Categorisation**
Social influences domain							
CF48 – Industry peers support and encourage SC	3.83 (0.79)	0.9	5.6	18.5	59.3	15.7	Agree
CF49 – Industry superiors encourage and support SC skills development	3.37 (0.86)	0.9	13.9	40.7	36.1	8.3	Agree
CF50 – Industry peers demonstrate an interest in SC	3.40 (0.93)	2.8	14.8	29.6	45.4	7.4	Agree
Environmental context and resources domain							
CF53 – Lack of interest in SC	3.30 (0.85)	0.9	19.4	31.5	45.4	2.8	Agree
CF54 – Lack of communication and integrated work environment	3.58 (0.83)	0.0	12.0	27.8	50.0	10.2	Agree
CF55 – Lack of sustainable technology specifications	3.56 (0.82)	0.9	11.1	26.9	53.7	7.4	Agree
CF56 – Limited availability of sustainable product suppliers	3.41 (0.90)	1.9	13.9	34.3	41.7	8.3	Agree
CF57 – Lack of databases and information for SC technologies	3.55 (0.77)	0.0	10.2	31.5	51.9	6.5	Agree
CF58 – SC promotes environmental protection	4.31 (0.69)	0.0	0.9	10.2	45.4	43.5	Agree
CF59 – SC promotes energy conservation	4.34 (0.67)	0.0	0.9	8.3	46.3	44.4	Agree
CF60 – SC promotes water conservation	4.37 (0.66)	0.0	0.9	7.4	45.4	46.3	Agree
CF61 – SC promotes resource conservation	4.38 (0.64)	0.0	0.9	5.6	48.1	45.4	Agree
CF62 – SC promotes waste reduction	4.19 (0.80)	0.0	3.7	13.0	44.4	38.9	Agree
CF63 – SC requires support from executive management	4.18 (0.64)	0.0	0.0	13.0	56.5	30.6	Agree
CF64 – Organisations should promote a culture and awareness about SC	4.25 (0.60)	0.0	0.0	8.3	58.3	33.3	Agree
CF65 – Organisations should facilitate best practice sharing of SC	4.28 (0.61)	0.0	0.9	5.6	58.3	35.2	Agree
CF66 – Mutual understanding and commitment amongst SC professionals is required	4.20 (0.65)	0.0	0.9	10.2	56.5	32.4	Agree
CF67 – Performance-based measurements will promote SC	4.19 (0.73)	0.0	1.9	13.0	49.1	36.1	Agree
CF68 – Mandatory SC building policies and regulations will promote SC	4.17 (0.74))	0.0	2.8	12.0	50.9	34.3	Agree
CF69 – Better enforcement of SC building policies after development will promote SC	4.11 (0.74)	0.0	2.8	13.9	52.8	30.6	Agree
CF70 – Developing and strengthening regulatory mechanisms will promote SC	4.14 (0.76)	0.0	3.7	11.1	52.8	32.4	Agree
CF71 – Institutional frameworks to guide SC is required	4.24 (0.65)	0.0	0.9	9.3	54.6	35.2	Agree
CF72 – Product and material innovation and/or certification is required	4.22 (0.62)	0.0	0.9	7.4	60.2	31.5	Agree
CF73 – Materials manufacturers should be proactive in development of SC technologies	4.31 (0.65)	0.0	1.9	4.6	53.7	39.8	Agree
CF74 – Collaborative and strengthened R&D within the construction industry	4.24 (0.65)	0.0	1.9	6.5	57.4	34.3	Agree
CF75 – Availability of better information on cost and benefits of SC technologies from a reliable database	4.32 (0.68)	0.0	1.9	6.5	49.1	42.6	Agree

opportunity is represented by the environment which includes time, resources and location. The results from the *social influences* and *environmental context and resources* domains linked to social and physical opportunity are presented in Table 5.

Social structures within organisations, as well as in the construction industry, influence stakeholders' behaviour towards adopting and implementing SC. 75% of participants agreed that their peers in the construction industry support and encourage SC, and more than half of the participants (52.8%) agreed that their peers in the construction industry demonstrate an interest in SC. Most participants agreed that there is a lack of communication and an integrated work environment amongst construction industry stakeholders (60.2%) and a lack of sustainable technology specifications (61.1%). Participants indicated that organisations are responsible for facilitating a culture of best practice sharing in relation to SC (93.5%) and should promote a culture and awareness about SC (91.6%).

The results further indicated that, for the successful implementation of SC, materials manufacturers should be proactive in the development of SC technologies (93.5%), and availability of better information on cost and benefits of SC technologies from a reliable database is necessary (91.7%).

Motivation

Motivation to engage in a target behaviour can either be reflective or automatic. Reflective motivation processes involve plans (self-conscious intentions) and

Table 6 Motivation questionnaire statement responses

Motivation		Questionnaire response (%)					
Questionnaire statement	**Mean (SD)**	**1**	**2**	**3**	**4**	**5**	**Categorisation**
Social/professional role and identity domain							
CF11 – Construction industry professionals have a responsibility towards SC	4.10 (0.81)	0.0	5.6	11.1	50.9	32.4	Agree
CF12 – SC forms part of construction industry professionals' work	4.28 (0.78)	0.9	1.9	9.3	44.4	43.5	Agree
CF13 – Construction industry professionals play a role in the implementation of SC	4.30 (0.78)	0.9	2.8	5.6	47.2	43.5	Agree
CF14 – SC provides a good corporate image	4.29 (0.81)	0.9	0.9	13.9	37.0	47.2	Agree
CF15 – SC provides a competitive advantage	4.12 (0.92)	0.9	7.4	9.3	43.5	38.9	Agree
CF16 – SC shows an organisation's commitment to social responsibility	4.28 (0.81)	0.9	3.7	5.6	46.3	43.5	Agree
CF17 – SC provides collaboration amongst construction industry professionals	4.15 (0.76)	0.0	2.8	13.9	49.1	34.3	Agree
CF18 – SC provides an integrated and whole-building design approach	4.10 (0.72)	0.0	0.9	18.5	50.0	30.6	Agree
CF19 – SC sets a standard for future development in the built environment	4.20 (0.77)	0.9	1.9	10.2	50.0	37.0	Agree
Beliefs about capabilities domain							
CF20 – CI professionals would adopt SC if they had the skills	4.19 (0.71)	0.0	2.8	9.3	54.6	33.3	Agree
CF21 – CI professionals would adopt SC even if there are time constraints on building projects	3.77 (0.82)	0.0	9.3	19.4	56.5	14.8	Agree
CF22 – CI professionals would adopt SC even if there is no incentive to do so on building projects	3.94 (0.71)	0.0	3.7	16.7	61.1	18.5	Agree
Optimism domain							
CF23 – Adopting and implementing SC will mean positive outcomes for the economy, society and the environment	4.27 (0.68)	0.0	0.9	10.2	50.0	38.9	Agree
CF24 – SC represents a positive change for the construction industry in South Africa	4.37 (0.69)	0.0	1.9	6.5	44.4	47.2	Agree
Beliefs about consequences domain							
CF25 – Sustainable buildings improve end-users' productivity	3.72 (0.85)	0.9	4.6	34.3	41.7	18.5	Agree
CF26 – Sustainable buildings improve indoor environmental quality, enhanced occupants' health, comfort and wellbeing	4.07 (0.72)	0.0	0.9	19.4	50.9	28.7	Agree
CF27 – SC ensures green market growth and provides job opportunities	3.95 (0.78)	0.0	1.9	26.9	45.4	25.9	Agree
CF28 – Necessity to adopt and implement SC	4.08 (0.81)	0.0	4.6	14.8	48.1	32.4	Agree
CF29 – SC is time-consuming which could cause project delays	3.24 (0.98)	4.6	15.7	38.9	32.4	8.3	Agree
CF30 – SC implementation will increase the capital cost of construction of building projects	3.61 (0.86)	0.9	9.3	30.6	46.3	13.0	Agree
CF31 – Sustainable products and materials will increase the capital cost of building projects	3.54 (0.89)	0.9	13.0	28.7	46.3	11.1	Agree
CF32 – Risk of investment with implementing new sustainable materials and construction methods	3.13 (0.87)	1.9	24.1	35.2	37.0	1.9	Agree
CF33 – Scepticism about the necessity to implement SC principles on building projects	2.21 (0.88)	18.5	51.9	20.4	8.3	0.9	Disagree
CF34 – SC reduces the whole life-cycle cost of a building	3.29 (1.07)	6.5	14.8	34.3	32.4	12.0	Agree
CF35 – SC has long pay-back periods	3.25 (0.87)	2.8	12.0	50.0	27.8	7.4	Neutral
CF36 – SC provides high return on investment of buildings	3.46 (0.75)	0.0	7.4	47.2	37.0	8.3	Neutral
CF37 – SC enhances property value	3.52 (0.78)	0.0	8.3	40.7	41.7	9.3	Agree
CF38 – SC improves performance of the economy	3.74 (0.81)	0.0	4.6	35.2	41.7	18.5	Agree
Intentions and goals domain							
CF43 – Intention to develop SC knowledge and skills	4.09 (0.62)	0.0	0.0	14.8	61.1	24.1	Agree
CF44 – Intention to consider adopting SC	4.20 (0.54)	0.0	0.0	6.5	66.7	26.9	Agree
CF45 – Intention to promote the education of SC internally	3.85 (0.72)	0.0	1.9	28.7	51.9	17.6	Agree
CF46 – Intention to promote internal training of SC	3.74 (0.79)	0.0	6.5	27.8	50.9	14.8	Agree
CF47 – Increasing SC awareness and knowledge is an important career goal	4.06 (0.72)	0.0	0.9	20.4	50.9	27.8	Agree
Reinforcement domain							
CF39 – Access to funding	4.13 (0.70)	0.0	2.8	10.2	58.3	28.7	Agree
CF40 – Financial and market-based incentives	4.33 (0.56)	0.0	0.0	4.6	57.4	38.0	Agree
CF41 – Tax relief	4.33 (0.76)	0.9	1.9	6.5	44.4	46.3	Agree
CF42 – Subsidies for R&D	4.33 (0.77)	0.9	1.9	7.4	42.6	47.2	Agree

evaluations (beliefs about what is good and bad) (Michie *et al* 2014). On the other hand, automatic motivation processes involve the wants and needs, desires, impulses and reflex responses of individuals. The results from the *social/professional role and identity*, *beliefs about capabilities, optimism, beliefs about consequences, intentions and goals,* and *reinforcement* domains linked to reflective and automatic motivation are presented in Table 6.

All the questions related to participants' social and professional role and identity had highly positive responses with small variance. Participants agree that construction industry professionals play a role in the implementation of SC (90.7%) and that SC adoption shows an organisation's commitment towards its social and environmental responsibility (89.8%). Construction industry professionals are confident that they would adopt SC if they had the skills (87.9%) even if they had no incentive to do so (79.6%). Participants are highly optimistic about SC as it represents a positive change for the construction industry (91.6%) and the adoption and implementation thereof will have a positive impact on the economy, society and environment (88.9%).

Participants agree that SC benefits the end-user through sustainable buildings, which improve indoor air quality and comfort (79.6%) and end-user's productivity (60.2%). Participants were probed about the economic benefits of SC, and the results suggest that SC will ensure green market growth and provide job opportunities (71.3%) and improve the performance of the economy (60.2%). On the other hand, participants believe that the key barriers to adopting SC are that the implementation of SC will increase the capital cost of construction (59.3%) through the adoption of sustainable products and materials (57.4%). Despite this, most participants indicated that there is a need to adopt SC (80.5%). The highly positive responses to questions about participants' intentions and goals indicated that they do intend to consider adopting SC (93.6%) and further develop their SC knowledge and skills (85.2%). Participants indicated that government support and encouragement through financial and market-based incentives (95.4%), tax relief on projects which adopt SC (90.7%), subsidies for research and development linked to SC (89.8%), and access to funding through financial institutions (87%), would increase SC adoption and implementation.

TDF domains analysis

The Cronbach's alpha values for the subscales of the questionnaire (i.e. the TDF domains) were shown to have very good reliability (above 0.80 for five scales and above 0.70 for four scales) (Table 7). The items in the questionnaire were therefore combined into the TDF domains for further analysis. To identify which domains need to be targeted in the behaviour change intervention, the TDF domains were analysed as scales. Table 7 displays the minimum and maximum value for the responses, means and standard deviations averaged across all participants. The means for all scales indicate that, on average, participants were positively inclined towards the adoption and implementation of sustainable construction. The *optimism* scale had the highest mean (4.32{0.60}) followed by the *reinforcement* scale (4.28{0.57}) and *social/professional role and identity* scale (4.20{0.60}). All these scales fall under the category of Motivation within the COM-B model which indicates that there is a strong motivation to adopt and implement SC amongst construction industry professionals. The *beliefs about consequences* scale had the lowest mean (3.49{0.43}) followed by the *social influences* scale (3.53{0.74}), the *knowledge* scale (3.61{0.59}) and the *skills* scale (3.61{0.65}). These scales also indicate the largest variability in responses, which indicates that there could be improvement in all the COM-B categories to improve the adoption and implementation of SC. However, capability (*knowledge* and *skills*) and opportunity (*social influences*) will often influence the motivation (*beliefs about consequences*) to enact a behaviour (Michie *et al* 2014). Therefore, the more capable stakeholders are by developing their SC knowledge and skills, and by being in an environment which encourages their SC development, the more they are likely to adopt and implement SC practices.

Table 7 Descriptive statistics for TDF domains and COM-B components

Scale	Number of items	Scale reliability (α)	Minimum	Maximum	Mean (*)	SD {*}
Capability						
Knowledge	5	0.683	1	5	3.61	0.59
Skills	5	0.770	1	5	3.61	0.65
Behavioural regulation	2	0.521	2	5	4.04	0.59
Opportunity						
Social influences	3	0.824	1	5	3.53	0.74
Environmental context and resources	23	0.912	3	5	4.08	0.42
Motivation						
Social / professional role identity	9	0.905	2	5	4.20	0.60
Beliefs about capabilities	3	0.761	2	5	3.97	0.62
Optimism	2	0.704	3	5	4.32	0.60
Beliefs about consequences	14	0.768	3	5	3.49	0.43
Intentions and goals	5	0.885	3	5	3.99	0.57
Reinforcement	4	0.83	3	5	4.28	0.57

Table 8 Barriers and drivers mapped to COM-B and TDF domains

COM-B		Capability		Opportunity		Motivation	
		Psychological		Social		Reflective	
TDF		**Knowledge**	**Cognitive and interpersonal skills**	**Behavioural regulation**	**Social influences**	**Beliefs about capabilities**	**Beliefs about consequences**
Barriers and drivers	Awareness, knowledge and information of SC	■					
	Interest in SC and demand for SC	■					
	Training availability of SC		■				
	Access to education on SC		■				
	Behavioural change towards SC			■			
	Industry peer influences				■		
	Confidence in SC implementation					■	
	Economic factors						■
	Perception of SC						■
	Social benefits						■

The analysis of the TDF domains indicate that there are five key behavioural domains which should be targeted, including construction industry stakeholders' *beliefs about consequences, knowledge, social influences, skills,* and *beliefs about capabilities.* Ten key barriers and drivers identified in each of these domains are summarised in Table 8.

DISCUSSION

Although there is a high level of awareness and familiarity with SC, there is a variation in the results when it comes to knowledge about SC and the demand for SC in the construction industry. The high level of awareness and familiarity amongst construction industry stakeholders is contrary to previous studies conducted in developing countries by authors such as Ismail *et al* (2012), Shari and Soebarto (2012), and Djokoto *et al* (2014). Their studies suggest that there is a lack of awareness amongst construction industry stakeholders and the public. Firstly, the difference in results could be due to the nature of the research designs adopted – Shari and Soebarto (2012) conducted a qualitative study using semi-structured interviews to identify the barriers to the adoption of SC, whilst the current research study used a survey questionnaire. Secondly, previous research studies focused on specific stakeholder groups, such as developers only, architects only, or contractors only. An example of this is the research study conducted by Ismail *et al* (2012), which only included developers. This is a different target population to the current research study which included architects, engineers, contractors and quantity surveyors. Lastly, the research instrument is structured differently, as shown in the study conducted by Djokoto *et al* (2014), where the authors prompted participants to rate the extent to which each of the identified barriers affects SC using a five-point Likert scale, whereas in the current study participants were prompted to rate the extent to which they agreed or disagreed with various belief statements about SC.

In a study conducted by Lim *et al* (2019), the authors stated that, although quantity surveyors in Australia had a reasonable level of awareness of SC, there was still a lack of implementation, which could be attributed to individuals' attitudes towards SC, cultural and institutional challenges. This provides insight into the variation of results regarding the knowledge and demand for SC, which could be explained by a lack of "actionable" knowledge that presents itself in the form of limited information about best practices, access to existing relevant knowledge and the perception of information overload (Wilson & Rezgui 2013). In other words, although participants have the knowledge of what the contents and objectives of SC are, there is no knowledge sharing amongst professionals, or information guides to inform SC implementation. Furthermore, the variation in the results for the demand for SC suggests that there might be a lack of demand from clients for sustainable projects (Serpell *et al* 2013), a lack of evidence of the benefits and opportunities of SC, and the perception that SC will increase project costs (Shari & Soebarto 2012). Participants indicated that SC is within the scope of construction industry professionals and that they have access to education and training related to SC. This, however, highlights the gap between access to knowledge and training related to SC and the relatively low percentage of participants who have worked on a sustainable building project and successfully implemented SC practices. Additionally, the resistance to the change in current construction industry practices could further hinder the adoption and implementation of SC. Participants felt that it is critical for construction industry stakeholders to change their current behaviour and adopt sustainable alternatives to design and construction methods and processes.

Participants described the social opportunity to adopt and implement SC as positive in relation to the support and encouragement from peers in the construction industry. However, there could be limitations to career development within the scope of sustainability, as superiors in the construction industry might not support the development of skills related to SC. As Opoku and Ahmed (2014) state, there is a shortage of skills and capacity in terms of numbers of construction industry professionals who can support the implementation of SC. Construction industry stakeholders should therefore be encouraged by their industry peers and superiors and given the opportunity to develop their skills to improve the sustainability of the construction industry. Furthermore, without an integrated work environment where stakeholders are working in collaboration to achieve the objectives of SC, the successful adoption and implementation of SC will be deterred (Häkkinen & Belloni 2011). The physical opportunity to adopt and implement SC highlights various barriers, such as the lack of availability of sustainable technologies, lack of sustainable product and material suppliers, and lack of databases with information about sustainable products. This is well-documented in the literature as common technological barriers to the adoption and implementation of SC (Aigbavboa *et al* 2017; Chan *et al* 2017b; Häkkinen & Belloni 2011; Khalfan *et al* 2015; Pham *et al* 2019; Pitt *et al* 2009; Shi *et al* 2013). Participants appreciate that the principles of SC encourage environmental protection through the conservation of resources, energy and water, and waste reduction. Providing opportunities within organisations to develop a culture of sustainability, best practice sharing and commitment to increasing the awareness of SC will improve the adoption of SC. Furthermore, regulations and frameworks to guide the adoption and implementation of SC, as well as reliable databases with sustainable product information, will further aid the adoption and implementation of SC. The findings suggest that there are opportunities to transition towards a more sustainable construction industry.

The survey results indicate that motivation plays a role in determining the likelihood of participants engaging with SC. In terms of reflective motivation, all participants indicated that SC was beneficial to the development of their careers as construction industry professionals. Participants agreed that if they had the skills, they would adopt SC and were highly optimistic about the benefits of SC for the construction industry in the long term. Participants had strong intentions to develop their SC knowledge and skills and encourage the education and training thereof. In terms of automatic motivation, participants indicated government should support and encourage SC through incentives, tax relief, subsidies and access to funding for projects that incorporate sustainable principles and practices. These findings are supported by previous literature, which suggests that motivation and support from key role players in the construction industry, such as government, developers and clients, are essential for the successful and widespread adoption of SC, specifically in the early stages of adoption. The results from the survey suggest that addressing the barriers to the implementation of SC linked to the capabilities, opportunities and motivation of construction industry stakeholders may facilitate the transition towards a more sustainable construction industry.

Limitations

The findings from this study should be interpreted and understood with the following limitations in mind: Although the study aimed to seek the perceptions of all construction industry stakeholders, structural and civil engineers represented 67.6% of the sample. The findings of the research related to the targeted TDF domains should therefore be interpreted as such; however, it is deemed to be transferrable to other stakeholder groups. There were limitations and challenges with recruitment of participants. Nonetheless, the participants who responded provided sufficient contextual data, which helped to achieve the objectives of this research study.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The overall positive response to the study suggests that there is a need to adopt and implement SC, and construction industry stakeholders are optimistic about the positive impact SC could have on the economy, environment and society. The findings of the research study highlight a range of factors related to construction industry stakeholders' capability, opportunity and motivation that require improvement to increase the adoption and implementation of SC practices. Using a theory-based approach, ten barriers and drivers of SC adoption and implementation, related to construction industry stakeholders' capability, opportunity and motivation, were identified. The ten barriers and drivers included: awareness, knowledge and information of SC, interest in SC and demand for SC adoption, training availability of SC, access to education on SC, behavioural change towards SC, industry peer influences, confidence in SC implementation, economic factors, perception of SC, and social benefits of adopting SC. Five key target domains were identified: *beliefs about consequences, knowledge, social influences, skills* and *beliefs about capabilities*, which can be used to develop behaviour change interventions, such as interventions aimed at adopting circular economy principles or agile and lean principles to improve the adoption and implementation of SC amongst construction industry stakeholders.

Recommendations

Recommendation 1

By adopting a qualitative theory-based approach, a future research study may provide greater in-depth detail about which domains should be targeted using the TDF domains as a guide. Specific domains may also be identified that were not highlighted by the quantitative approach, which restricts the participants' responses to a structured set of questions.

Recommendation 2

Future research should include additional disciplines from other stages of the project life cycle, such as clients and project managers, to understand the context of the research from varying perspectives.

Recommendation 3

Universities are key contributors to education, research and innovation which are essential to achieve the goals of sustainable development within the construction industry. Integrating sustainability as part of the undergraduate curriculum and postgraduate studies in higher education is necessary to promote sustainable development in the built environment. This ensures that graduates are aware of their ethical and social responsibility towards the environment and the welfare of society.

Recommendation 4

Organisations should provide stakeholders with access to education, training and upskilling through continuing professional development courses to improve the knowledge and skills available to facilitate the adoption and implementation of SC. Sustainable development strategies and internal policies should be developed to further enhance the organisation's offering within the industry.

Recommendation 5

Policies and legislation which govern the adoption and implementation of SC should be developed and regulated by government to emphasise the need to change the current trajectory of the construction industry. Financial and market-based incentives would further encourage organisations to adopt best practices within the industry in relation to sustainable construction.

REFERENCES

Abidin, N Z & Powmya, A 2014. Perceptions on motivating factors and future prospects of green construction in Oman. *Journal of Sustainable Development*, 7(5): 231–239.

Aghimien, D, Aigbavboa, C, Oke, A & Musenga, C 2018. Barriers to sustainable construction practices in the Zambian construction industry. *Proceedings*, 8th International Conference on Industrial Engineering and Operations Management, 6–8 March 2018, Bandung, Indonesia, pp 2383–2392.

Ahn, Y H, Pearce, A R, Wang, Y & Wang, G 2013. Drivers and barriers of sustainable design and construction: The perception of green building experience. *International Journal of Sustainable Building Technology and Urban Development*, 4(1): 35–45.

Aigbavboa, C, Ohiomah, I & Zwane, T 2017. Sustainable construction practices: A "lazy view" of construction professionals in the South African construction industry. *Energy Procedia*, 105: 3003–3010.

AlSanad, S 2015. Awareness, drivers, actions, and barriers of sustainable construction in Kuwait. *Procedia Engineering*, 118: 969–983.

Ametepey, O, Aigbavboa, C & Ansah, K 2015. Barriers to successful implementation of sustainable construction in the Ghanaian construction industry. *Procedia Manufacturing*, 3: 1682–1689.

Amui, L B L, Jabbour, C J C, Jabbour, A B L & Kannan, D 2017. Sustainability as a dynamic organizational capability: A systematic review and a future agenda toward a sustainable transition. *Journal of Cleaner Production*, 142: 308–322.

Atkins, L, Francis, J, Islam, R, O'Connor, D, Patey, A, Ivers, N, et al 2017. A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. *Implementation Science*, 12(1): 1–18.

Bebbington, J 2001. Sustainable development: A review of the international development, business and accounting literature. *Accounting Forum*, 25(2): 128–157.

Brennan, M C & Cotgrave, A J 2014. Sustainable development: A qualitative inquiry into the current state of the UK construction industry. *Structural Survey*, 32(4): 315–330.

Bryman, A 2010. *Social Research Methods*, 4th ed. New York: Oxford University Press.

Cane, J, Connor, D O & Michie, S 2012. Validation of the Theoretical Domains Framework for use in behaviour change and implementation research. *Implementation Science*, 7(37): 1–17.

Chan, A P C, Darko, A & Ameyaw, E E 2017a. Strategies for promoting green building technologies adoption in the construction industry: An international study. *Sustainability*, 9(6): 969.

Chan, A P C, Darko, A, Ameyaw, E E & Owusu-Manu, D-G. 2017b. Barriers affecting the adoption of green building technologies. *Journal of Management in Engineering*, 33(3): 04016057.

Chan, A P C, Darko, A, Olanipekun, A O & Ameyaw, E E 2018. Critical barriers to green building technologies adoption in developing countries: The case of Ghana. *Journal of Cleaner Production*, 172: 1067–1079.

Coetzee, D A & Brent, A C 2015. Perceptions of professional practitioners and property developers relating to the costs of green buildings in South Africa. *Journal of the South African Institution of Civil Engineering*, 57(4): 12–19.

Dalal-Clayton, B & Bass, S 2012. *Sustainable Development Strategies*, 1st ed.: London: Earthscan.

Darko, A, Zhang, C & Chan, A P C 2017a. Drivers for green building: A review of empirical studies. *Habitat International*, 60: 34–49.

Darko, A, Chan, A P C, Gyamfi, S, Olanipekun, A O, He, B J & Yu, Y 2017b. Driving forces for green building technologies adoption in the construction industry: Ghanaian perspective. *Building and Environment*, 125: 206–215.

Djokoto, S D, Dadzie, J & Ohemeng-Ababio, E 2014. Barriers to sustainable construction in the Ghanaian construction industry : Consultants' perspectives. *Journal of Sustainable Development*, 7(1): 134–143.

Du Plessis, C 2007. A strategic framework for sustainable construction in developing countries. *Construction Management and Economics*, 25(1): 67–76.

Du Plessis, C, Adebayo, A, Ebohan, J, Irurah, D, Rwelamila, P D, Hassan *et al*. 2002. *Sustainable construction in developing countries*. Pretoria: CSIR Building and Construction Technology.

Elliott, J A. 2006. *An Introduction to Sustainable Development*. 3rd ed. London: Routledge.

Etikan, I, Alkassim, R & Abubakar, S 2015. Comparision of snowball sampling and sequential sampling technique. *Biometrics & Biostatistics International Journal*, 3(1): 00055.

Foong, D, Mitchell, P, Wagstaff, N, Duncan, E & McManus, P 2017. Transitioning to a more sustainable residential built environment in Sydney. *Geo: Geography and Environment*, 4(1): e00033.

Gaddis, G M & Gaddis, M L 1990. Introduction to biostatistics. Part 5. Statistical inference techniques for hypothesis testing with nonparametric data. *Annals of Emergency Medicine*, 19(9): 1054–1059.

Gainforth, H L, Sheals, K, Atkins, L, Jackson, R & Michie, S 2016. Developing interventions to change recycling behaviors: A case study of applying behavioral science. *Applied Environmental Education and Communication*, 15(4): 325–339.

Gan, X, Zuo, J, Ye, K, Skitmore, M & Xiong, B 2015. Why sustainable construction? Why not? An owner's perspective. *Habitat International*, 47: 61–68.

Häkkinen, T & Belloni, K 2011. Barriers and drivers for sustainable building. *Building Research & Information*, 39(3): 239–255.

Hjorth, P & Bagheri, A 2006. Navigating towards sustainable development: A system dynamics approach. *Futures*, 38: 74–92.

Huijg, J M, Gebhardt, W A, Crone, M R, Dusseldorp, E & Presseau, J 2014. Discriminant content validity of a theoretical domains framework questionnaire for use in implementation research. *Implementation Science*, 9(11): 1–16.

Ismail, Z, Idris, N H, Nasir, N M & Alam, S 2012. Sustainable initiative and impediments towards promoting sustainable construction in Malaysia. *Proceedings*, IEEE Colloquium on Humanities, Science & Engineering Research (CHUSER 2012), 3–4 December 2012, Kota Kinabalu, Malaysia, pp 32–37.

Jiang, W & Wong, J K W 2016. Key activity areas of corporate social responsibility (CSR) in the construction industry: A study of China. *Journal of Cleaner Production*, 113: 850–860.

Khalfan, M, Noor, M A, Maqsood, T, Alshanbri, N & Sagoo, A 2015. Perceptions towards sustainable construction amongst construction contractors in the State of Victoria, Australia. *Journal of Economics, Business and Management*, 3(10): 940–947.

Kibert, C J 2007. The next generation of sustainable construction. *Building Research & Information*, 35(6): 595–601.

Kibert, C J 2016. *Sustainable Construction: Green Building Design and Delivery*, 4th ed. New York: Wiley.

Klaniecki, K, Wuropulos, K & Hager, C P 2018. Behaviour change for sustainable development. In

Leal Filho, W (Ed). *Encyclopedia of Sustainability in Higher Education.* Cham, Switzerland: Springer International, pp 1–10.

Lim, B TH, Liu, A Z J & Oo, B L 2019. Awareness and practices of sustainable construction in Australia: Consultant quantity surveyors' perception. *AIP Conference Proceedings*, 2124: 020060.

Marchman, M & Clarke, S N 2011. Overcoming the barriers to sustainable construction and design through a cross-reference of West Coast Practices. *Proceedings*, 47th ASC Annual International Conference, 6–9 April 2011, Omaha, Nebraska.

Michie, S, Johnston, M, Abraham, C, Lawton, R & Parker, D 2005. Making psychological theory useful for implementing evidence based practice: a consensus approach. *Quality and Safety in Health Care*, 14: 26–33.

Michie, S, Van Stralen, M M & West, R 2011. The Behaviour Change Wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science*, 6(1): 42.

Michie, S, Atkins, L & West, R 2014. *The Behaviour Change Wheel: A Guide to Designing Interventions*, 1st ed. London: Silverback. Available at: **www.behaviourchangewheel.com**.

Mousa, A 2015. A business approach for transformation to sustainable construction: An implementation on a developing country. *Resources, Conservation and Recycling*, 101: 9–19.

Ofori, G 2015. Nature of the construction industry, its needs and its development: A review of four decades of research. *Journal of Construction in Developing Countries*, 20(2): 115–135.

Opoku, A & Ahmed, V 2014. Embracing sustainability practices in UK construction organizations: Challenges facing intra-organizational leadership. *Built Environment Project and Asset Management*, 4(1): 90–107.

Oxman, A D, Thomson, M A, Davis, D A & Haynes, R B 1995. No magic bullets: A systematic review of 102 trials of interventions to improve professional practice. *Canadian Medical Association Journal*, 153(10): 1423–1431.

Pham, H, Kim, S Y & Luu, T Van 2019. Managerial perceptions on barriers to sustainable construction in developing countries: Vietnam case. *Environment, Development and Sustainability*, 22: 2979–3003.

Pitt, M, Tucker, M, Riley, M & Longden, J 2009. Towards sustainable construction: Promotion and best practices. *Construction Innovation*, 9(2): 201–224.

Saleh, M S & Alalouch, C 2015. Towards sustainable construction in Oman: Challenges and opportunities. *Procedia Engineering*, 118: 177–184.

Sebake, T N 2008. Limitations of implementing sustainable construction principles in the conventional South African design approach. *Proceedings*, 3rd Built Environment Conference, 6–8 July 2008, Cape Town, pp 479–491.

Serpell, A, Kort, J & Vera, S 2013. Awareness, actions, drivers and barriers of sustainable construction in Chile. *Technological and Economic Development of Economy*, 19(2): 272–288.

Shari, Z & Soebarto, V I 2012. Delivering sustainable building strategies in Malaysia : Stakeholders' barriers and aspirations. *Alam Cipta*, 5(2): 3–12.

Shi, Q, Zuo, J, Huang, R, Huang, J & Pullen, S 2013. Identifying the critical factors for green construction: An empirical study in China. *Habitat International*, 40: 1–8.

Simpeh, E K & Smallwood, J J 2015. Factors influencing the growth of green building in the South African construction industry. *Proceedings,* Smart and Sustainable Built Environment Conference, 9–11 December 2015, Pretoria.

Suliman, L K M & Omran, A 2009. Sustainable development and construction industry in Malaysia. *Manager Journal*, 10(10): 76–85.

UNEP (UN Environment Programme) 2017. *Consuming differently, consuming sustainably: Behavioural insights for policymaking.* Nairobi, Kenya: UNEP.

VandenBos, G R 2007. *APA Dictionary of Psychology.* Washington, DC: American Psychological Association.

Wensing, M, Van Der Weijden, T & Grol, R 1998. Implementing guidelines and innovations in general practice: Which interventions are effective? *British Journal of General Practice*, 48: 991–997.

Wilson, I E & Rezgui, Y 2013. Barriers to construction industry stakeholders' engagement with sustainability: Toward a shared knowledge experience. *Technological and Economic Development of Economy*, 19(2): 289–309.

Windapo, A O 2014. Examination of green building drivers in the South African construction industry: Economics versus ecology. *Sustainability*, 6: 6088–6106.