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RESEARCH ARTICLE

Exploring Project Complexity Relations to Scope Changes in Construction Projects: A Case Study of NEC Projects in South Africa

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Abstract

Construction projects are of very complex nature, and subject to circumstances of high uncertainties and risks due to the interdependences of activities and processes in the project performance. As a result of the dynamic complexities inherited in construction projects, changes in the scope of work are inevitable. Of particular concern is that, when scope changes are introduced in a project, contractors follow a systematic procedure in managing the changes, but with poor planning and implementation thereof because the project complexities that underpin the scope changes are not fully understood. Therefore, despite that complexity is an inherent and defining feature of construction projects, studies in the literature have failed to grasp and present the dynamics of project complexity which underlie the scope changes in the delivery of construction project. The TEO (Technical Organizational Environmental) framework was adopted and applied on

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a multiple-case study research design in order to explore and denote project complexity relations to scope changes in construction projects. Through a content analysis procedure, six key elements of project complexities that relate to scope changes in the construction projects has emerged. Understanding these complexity elements could enable the project management team to apply a front-end planning approach in the initiation phase of the projects in order to better manage scope changes in the execution phase of the project, and eventually to improve the project performance.

Keywords

Project Complexities; Scope Changes; Construction Projects; NEC

Introduction

Scope Changes in construction projects are very common and likely to occur from different sources, by various causes, at any stage of the project, and as a result, may have considerable negative impacts on items such as costs and schedule delays (Hao, et al., 2008; Moayeri, Moselhi and Zhu, 2017), and quality (Pilehchian, Staub-French and Prasad, 2015) performance. Now, given the intrinsic interrelations of activities in construction projects (Taylan, et al., 2014; Bjorvatn and Wald, 2018), scope changes occurring in one aspect of the project may result in having a knock-on effect on other disciplines in the project. Worryingly, scope change may also result to the re-estimation of work statement, and extra demands of equipment, materials, labour, and overtime (Hao, et al., 2008). Scope changes, if not resolved through a formalized change management process, can become the major source of contract disputes (Hao, et al., 2008) which may lead to project failure.

Although previous studies have been published on scope changes and project performance, the findings thereof are unsatisfactory because they failed to grasp and present the dynamics of project complexity which underlie the scope changes in project performance. In essence, complexity as an inherent and defining feature of construction projects (Bosch-Rekveldt, et al., 2011) have been overlooked in the understanding of the scope changes in construction projects. Against this background, this study seeks to explore the relations between project complexities and scope changes in construction projects, with an aim to provide possible precautions and preventive measures to minimize the occurrence of scope changes in construction projects. This study uses a qualitative multiple-case study approach to explore the dynamics of project complexities within which scope changes are emanating. The three multiple-cases of construction projects were deemed relevant for the exploration of the relations of project complexities and scope changes because of its relatively new construction contract and unique system of change management procedures.

Though the New Engineering Contract (NEC) is commended for its change management procedures in term of the use of Early Warnings (EW) and Compensation of Event (CE) respectively (Construction Industry Development Board (CIDB), 2005; NEC, 2020), the assessment of the CE is always on the basis of its effect on the prices and the completion date (NEC, 2005), omitting the influence on changes in the scope of work. Moreover, given that the use of the NEC is relatively new in the South African construction industry, there are still some challenges in the application thereof in terms of discipline with rigorous timescales and response times, the operation of CE procedure, increased documentation and administration, the issuing and monitoring of notices and other documents; and the understanding of EW procedures (CIDB, 2005).

In the mist of these uncertainties in relation to the application of the construction contract, this study provides in-depth empirical insight to advance the understanding of the project complexities leading to scope changes. Understanding the complexities in a project as the underlying factor for scope changes, could enable the project management team to apply a pro-active and front-end planning approach in managing the scope changes in the delivery of construction projects. Therefore, this paper is structured into six sections, namely: Literature review; the theoretical background; research methodology; findings and discussion; as well as the conclusion. The first section covers the theoretical and conceptual background of the study.

Theoretical and Conceptual Framework

PROJECT COMPLEXITY DEFINITIONS

There is a lack of consensus, clear and unambiguous definition of complexity of projects in the literature (Bosch-Rekveldt, et al., 2010). As such, "there seems to be none single definition of project complexity that can capture the whole concept" (Cristobal, 2017, p.763). According to Qazi, Quigley, Dickson and Kirytopoulos, (2016, p.1184), "project complexity is the property of a project which makes it difficult to understand, foresee and keep under control its overall behaviour, even when given reasonably complete information about the project system". Baccarini, (1996) defines project complexity as a system consisting of many varied interrelated parts, which can be operationalized in terms of differentiation and interdependency. For Tatikonda and Rosenthal (2000), complexity consists of interdependencies among the process, technologies, novelty and difficulty of goals. Similarly, Bjorvatn and Wald (2018) note that project complexity can be understood as the "number and heterogeneity of different elements that interrelate". With reference to construction projects, Khodeir (2017) view complexity in terms of two main dimensions: that is, i) structural complexity in terms of the number of project elements and independence of elements, and ii) uncertainties in the project goals and execution methods thereof. Remarkable, what stands out in these definitions is the denotation that project complexity embeds interdependencies of heterogeneous elements of a particular system.

COMPLEXITIES IN CONSTRUCTION PROJECTS

Bosch-Rekveldt et al. (2010), propose the TOE framework which widely embraces the interdependencies of the various elements in construction project. For the purpose of this study, the framework for project complexity as proposed by Bosch-Rekveldt et al. (2010) is adopted given that it provides a broader spectrum and details of the dimensions of complexity in construction projects (Table 1).

Technical complexity

Technical complexity might stem from ambiguity that existed in several potential interpretations of goals and objectives, such as unshared goals and goal paths (Baccarini, 1996; He, et al., 2015). According to Bosch-Rekveldt et al. (2010), elements that contribute to technical complexity could be unveil with the following questions: Are the project goals clear amongst the project team? Are there uncertainties in the

Table 1. TOE framework for project complexity

Main categories	Elements of Project complexity		
	Technical	Organizational	Environmental
Subcategories	Goal	Size	External Stakeholders
	Scope	Resources	Location
	Task	Project Team	Market conditions
	Experience	Trust	Regulations

Source: (Bosch-Rekveldt, et al., 2010)

scope? What is the number and nature of dependencies between the tasks? Are there conflicting design standards and country specific norms involved in the project? Do the involved parties have experience with the technology involved? (Bosch-Rekveldt, et al., 2010). In addition, the trend of innovative and green technologies, energy conservation technologies, and new construction materials, also increases technical complexities (He et al., 2015).

Organizational complexity

Organizational complexity is defined from the fact that the execution of construction projects is conducted by a project organization, which involves project staff, organizational structure and various teams (He, et al., 2015). That is, the diversity of the cultural software in the human mind-set, which is manifested by a number of factors such as team trust, cognitive flexibility, emotional quotient and system thinking (He, et al., 2015) is the underlying element in the definition of organizational complexity. According to Bosch-Rekveldt et al. (2010), other elements that contribute to the understanding of organizational complexity could manifest from the following questions: What is the planned duration of the project? How many persons are within the project team? What is the size of the site area in square meters? Are there interfaces between different disciplines involved in the project that could lead to interface problems? Do you trust the project team members? Are there different main contract types involved? How many different languages were used in the project for work or work related communication?

Environmental complexity

Environmental complexity refers to the context where a project is initiated and subsequently operates. This includes influence from factors such as the natural, market, political and regulatory environment (He, et al., 2015), as well as the diversity stakeholders' interests and needs (Bosch-Rekveldt, et al., 2010; Kishan, Bhatt and Bhavsar, 2014). To determine the elements that contribute to environmental complexity in construction projects, Bosch-Rekveldt et al. (2010) probed the following questions: What is the number of stakeholders (internal and external) around the table? Do different stakeholders have different perspectives? Does the political situation influence the project? Do you expect interference with the current site or the current use of the (foreseen) project location? Do you expect unstable and/or extreme weather conditions? What is the required local content? Is the market environment stable in terms of exchange rates, raw material pricing? Do the involved parties have experience in that country? Collectively, there are some evidence to indicate that construction projects are initiated in complex and dynamic environment and are characterised by various interdependent activities which often, directly or indirectly, trigger scope change in the construction works.

PROJECT SCOPE CHANGE CONTROL

Project scope change control is one of the critical processes in the scope management cycle because it is at this stage that the project management team has to prevent scope creep, while ensuring that all the changes are beneficial to the project (Burke, 2010; PMI, 2013). However, previous studies have consistently maintained that it is not all the time that scope changes (Senouci, et al., 2017) are of mutual benefit to the stakeholders involved. The process of communicating scope changes between contractors and strategic clients can be lengthy and complex, and scope changes and the communication about the changes thereof can be a thorny topic between parties (Invernizzi, Locatelli and Brookes, 2018). On the same note, Motawa et al. (2007) maintain that scope changes constitute a major cause of disruption, and that the change effects are difficult to quantify and often lead to disputes. With regard to disputes as a result of scope changes, Kauffmann and Keating (2001) in their study point out that due to a failure in project management methods, contractors had minimal data to substantiate cost claims related to alleged scope changes. In some instances, scope change will lead to work repetition and reconstruction of project activities (Senouci, et al., 2017). However, the Project Management Institute (PMI) (2013) and Burke (2010) are of the view that it is only through a mature scope change control procedure that the success factors of the project could be achieved (Figure 1).

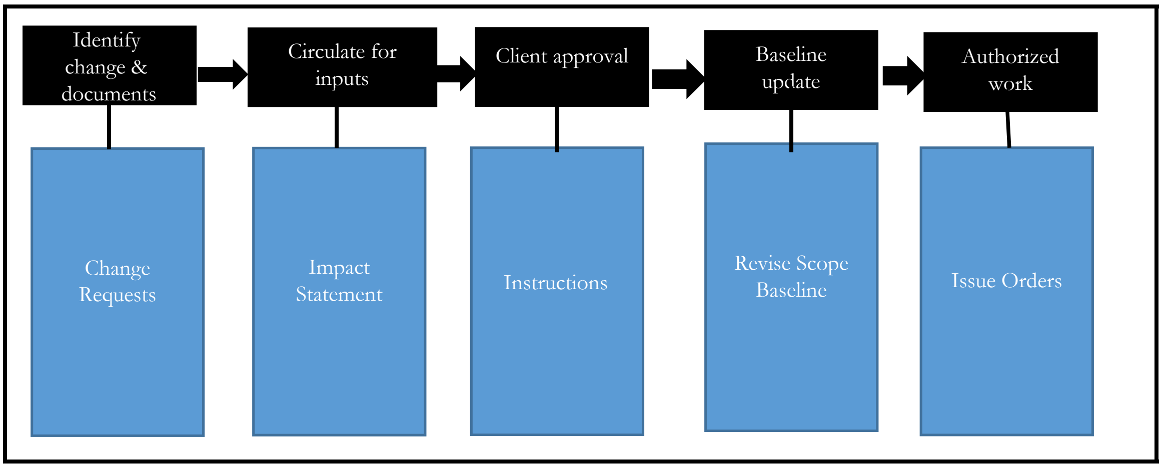

Figure 1. Scope change control system in project management

The scope change control is also concerned with influencing the factors which initially create scope changes to ensure that the changes are beneficial to the project (Burke, 2010). Given that the scope change control system allows for scope changes to be initiated by any of the project stakeholders (Burke, 2010; PMI, 2013), the process of scope change is inherent of dynamic complexities, particular in construction projects.

MANAGING CHANGES IN CONSTRUCTION WORKS: CONTEXT OF NEC PROJECTS

In recent years, the New Engineering Contract (NEC) provides an alternate contracting method for procuring construction projects (Siu, Leung and Chan, 2018). The NEC3 Engineering and Construction Contract (ECC) is the main construction contract within the NEC3 family, from which the options A-F are extracted (NEC, 2020). The first NEC contract was published in 1993, and the second edition, called the NEC Engineering and Construction Contract (ECC), was published in 1995 respectively (NEC, 2020). The ECC is designed to encourage collaboration and teamwork and to improve opportunities for partnering (CIDB, 2005). After a decade of extensive international use, the third edition of the NEC contract, also known as NEC3, was launched in 2005. To date, the NEC3 suite has been endorsed by governments and industry worldwide and has an unrivalled track record for delivering projects on time and on budget. Subsequently, the NEC4 contract suite was launched in 2017. Though the NEC contracts are commended for its effectiveness in control of change, early warning of risks, CE and potential change, and quick dispute resolution mechanisms (CIDB, 2005; NEC, 2020), the assessment of the CE event is always of its effect on the prices and the completion date (NEC, 2005), omitting the effect on changes in the scope of work (Figure 2).

Some of the major causes of scope change in construction projects were outlined by Senouci et al. (2017) in their study: 1) design errors, 2) changes in design request, 3) significant changes in quantity of work, 4) change of plan or scope by owner, 5) differing site conditions, 6) utility companies, and 7) mechanical and electrical provisions. In the view of all the factors mentioned above, it is evident that scope change is inevitable in construction projects, hence the NEC contracts make provision for scope change control (Table 2).

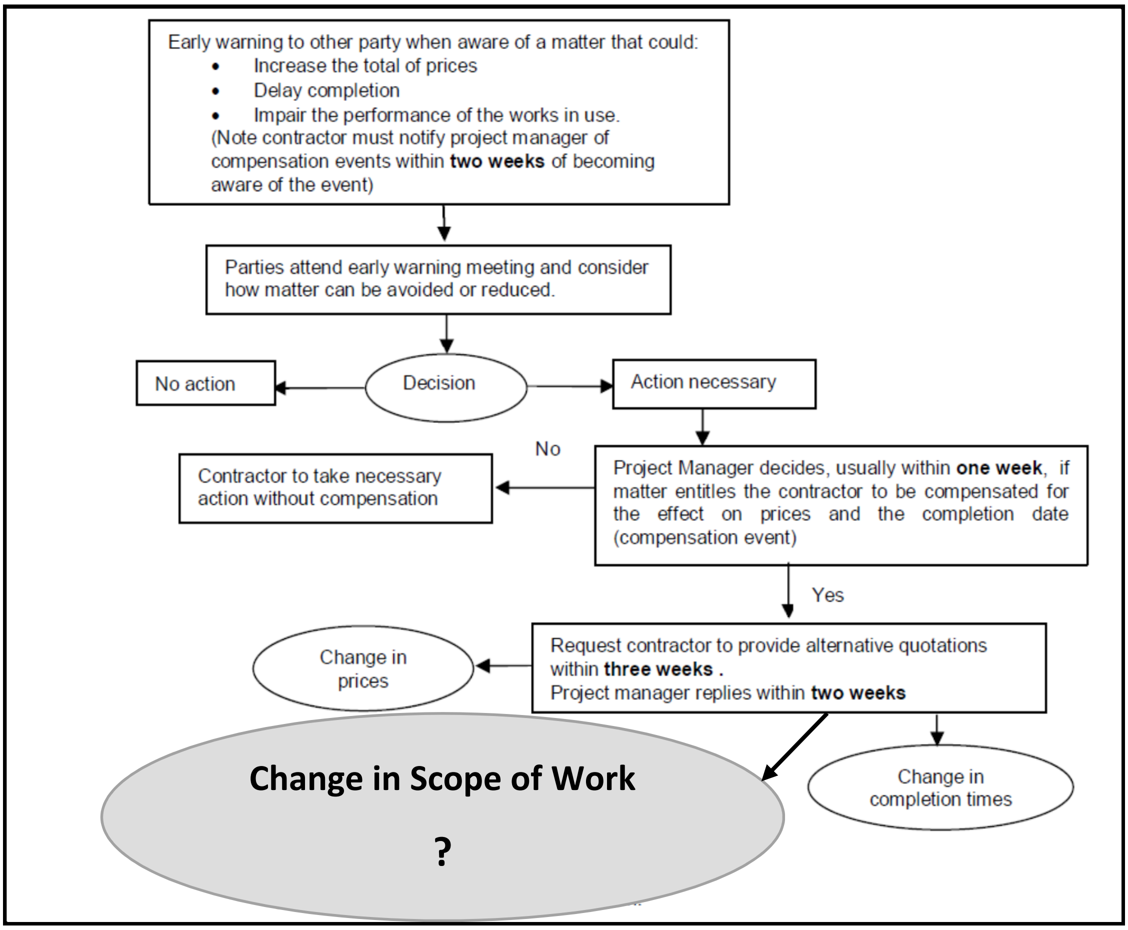

Figure 2. Change control system in the NEC

Table 2. NEC change control system for construction works

Steps	Code	Document Name	Contractual Clause	Responsible parties	Description
1	WI	Works Information	60.1(1)	Consultant	Change request
2	CE	Compensation of Event	61.3	Contractor	Impact statement
3	ICE	Notification and Instruction to submit Quotation	61.1	Client: PM	Instruction
4	QCE	Quotation for a Compensation of Event	62.1, 62.2	Contractor	Revised Scope baseline
5	PMRCQ	Response to Contractor's Quotation	62.3	Client: PM	Issue Orders

Source: (Adopted from the NEC, 2020 and Burke, 2010)

The change control system for NEC based projects is not only administration intensive, but also is a lengthy and complex process (Imvernizzi, Locatelli and Brookes, 2018) given that "scope changes could be initiated by any of the project stakeholders" (Burke, 2010, p.121) in the principle of promoting a collaborative working environment based on the spirit of mutual trust and co-operation (CIDB, 2005; NEC, 2020).

Design and Methodology

CASE STUDY DESIGN

This study adopts a qualitative multiple-case study research design. A case study approach is essentially suitable for learning more about little known or poorly understood situation (Leedy and Ormrod, 2014), as it is the case with the project complexities and scope changes in construction projects. The choice of the case study design is founded on its utility for the conduct of in-depth investigations into phenomena in its particular context (Yin, 2011; Frey, 2018), and its usefulness for exploratory studies (Baxter and Jack, 2008; Gaudet and Robert, 2019). Accordingly, boundaries are therefore to be established in a qualitative case study design in order to ensure that the study remains within a reasonable scope (Baxter & Jack, 2008). Therefore, three construction projects which were delivered through the NEC3 contract at the New Institution of Higher Learning (NIHL) in South Africa has been identified as the case to explore the project complexities that underpin the scope changes in the delivery of the projects. The dominant indicators of project complexity (Bosch-Rekveldt, et al., 2011; Kishan, et al., 2014) were identified in the case study (see Table 3).

Table 3. Characteristics of project complexities in the case study

Characteristics	Case A	Case B	Case C
Functionality of the Building (Goal)	Conferencing & Wellness Centre	Science & Research Facility	Residential & Dinning
Built area (Size)	1182M^2 on 2 Floors	8972m^2 on 3 Floors	8500m^2 on 3 Floors
Project Duration (Size)	10 Jan 2018 to 31 Jan 2019	02 Oct 2017 to 31 Jan 2019	02 Oct 2017 to 26 March 2019
Project Value (Resources)	R46 283 367	R279 445 690	R225 278 804
Number of Disciplines (Resources)	22	56	22
Number of Subcontractors (Tasks)	15	73	18
Number of Contractor's Employees (Size)	95	50	160
Number of Milestone Activities (Tasks)	12	14	10
Number of CEs issued during construction (Scope)	122	160	599
Number of organizations forming the management team (Project Team)	14	17	18

Source: (Field work data)

Therefore, the chosen unit of analysis of the study was the three construction projects, on only for its complex nature, but also for the reason the use of the construction contract in the delivery of the project was relatively new to most of the construction professionals involved in the project management. For that reason, all the construction professionals involved in the project management team were purposively sampled to participate in the study.

SAMPLING AND DATA PROCEDURE

The study has adopted a purposive sampling method for selecting both the construction projects as a case and the construction professionals as participants of the study. With regard to the cases, the three construction projects that were sampled were delivered through the NEC contract. That is, all the three selected construction projects were using the CE document as part of the change management system. From each of the selected projects, the CEs which specifically underline changes in project scope, were sampled for the purpose of this study. Moreover, the selected cases were all at the beginning phases of construction when the sampling was conducted. On one hand, the sampled cases consist of diverse and unique set of construction projects in terms of scope, use and size of the building. On the other hand, the

Table 4. Participants' profiles

Categories	Participants	Experience (*y*)	Responses (*n*)	Responses (%)
Client	Project Manager	7	1	3
Consultant	Architecture	46;43;26	3	10
	Landscape Architecture	30; 5; 4	3	10
	Mechanical Engineer	6	1	3
	Structural Engineer	5;6	2	7
	Fire & Safety Engineer	30	1	3
	Civil Engineer	35;7;5	3	10
	Electrical Engineer	20;6	2	7
	Health and Safety Officer	10	1	3
	Environmental Officer	8	1	3
	Cost Engineer	10;9;8	3	10
	ICT Engineer	15;3	2	7
Contractor	Construction Project Manager	17;4	2	7
	Site Manager	7	1	3
	Project Manager	2	1	3
	Managing Director	14	1	3
	Electrical Engineer	17	1	3
	Quantity Surveyor	6; 6	2	7
Total			**31**	**100**

Source: (Field work data)

sampled participants were selected based on their diverse roles (Awuzie and Emuze, 2017) and respective responsibilities. Moreover, the selected participants consist of a range of professionals which includes the client, consultant and the contractor segments (Table 4). According to Yin (2011) and Frey (2018), diversity in the sampled elements enables comparisons between and within the cases.

As stated by Jin et al. (2017), the execution of a project is likely to be determined by participants' characteristics such as power, interest, and influence based on the level of education and experience as well as their assigned role in the construction project. Therefore, in the context of this study, the characteristics of the participants (*P*) have been profiled in based on their number of years (*y*) of work experiences of the participants, and as such, the participants in this study are referred to as *P(y)*. For ethical considerations prior to the interview schedules, the permission to conduct the study was secured from the designated authorities, and the Research Ethics Clearance Certificate was granted (Ref: H18-ENG-CMa-001) respectively. Initially, Fourth-two potential participants were identified by the researcher.

To arrange the interview sessions with the participants, emails were sent to all the participants to request and schedule appointments on times and places that were convenient for them during the working hours. In this emails, semi-structured interview schedule, the consent form as well as the ethical certificate were also attached for preparations and transparency. In replicating the procedure by Vatandost, Cheraghi and Oshvandi (2020), the possibility to perform the interviews during the participants' working hours was of course a great mutual benefit because the participants did not have to use their leisure time to participate in the interviews. Ultimately, the majority of the participants had responded positive to the request for interviews. At the last count, thirty-one (31) interviewees participated in the study, and the data was collected from all the participants. To this extent, the participants have expressed their views and experiences in relation to design and scope changes in the duration of the construction projects. On the other hand, thwenty-eight (28) CEs were also sampled for the purpose of the study. Together, the blended data collection approach has enhanced the data analysis process in this study.

DIRECT CONTENT ANALYSIS

The study has adopted a qualitative analysis approach in a form of a direct content analysis. The direct content analysis is typically used as a means of deductive data analysis, where the coding process is guided by and predetermined from a theoretical framework (Miles and Huberman, 1994). In this regard, the project complexities theoretical framework has been applied to provide a multi-lens framework through which the deductive analysis of the data has been performed. Based on the hypothesis of the study that complexity is an inherent and defining feature of construction projects, and as such, has a bearing on project scope changes, a logical conclusion has been derived through the theoretical patterns of the TOE framework and the specific observations (Babbie, 2010) of the characteristics of real-life events (Yin, 2011). Although this the direct content analysis approach is generally criticized that researchers may result in premature conclusions and result to important findings being excluded (Miles and Huberman, 1994; Flyvbjerg, 2006), this method is most useful when it is used for in-depth explorations of complex phenomena (Leedy and Ormrod, 2014) such as scope changes in construction projects. Moreover, the direct content analysis approach has a utility value to prove or disapprove a theory (Yin, 2011). In order to derive the logical conclusion (Babbie, 2010), the data analysis was conducted through a descriptive coding processes with multiple coding cycles as illustrated in Figure 3. This rigorous coding process was adopted from Gaudet and Robert (2019) because it provides a basis to deduce a rational and logical conclusion while strengthening the validity and reliability of the study (Mitchell and Roux, 2009).

The first coding cycle was done through the use of the in-vivo coding methods. The in-vivo coding was used to capture the codes in the overtly stated words of the participants in relation to scope changes in

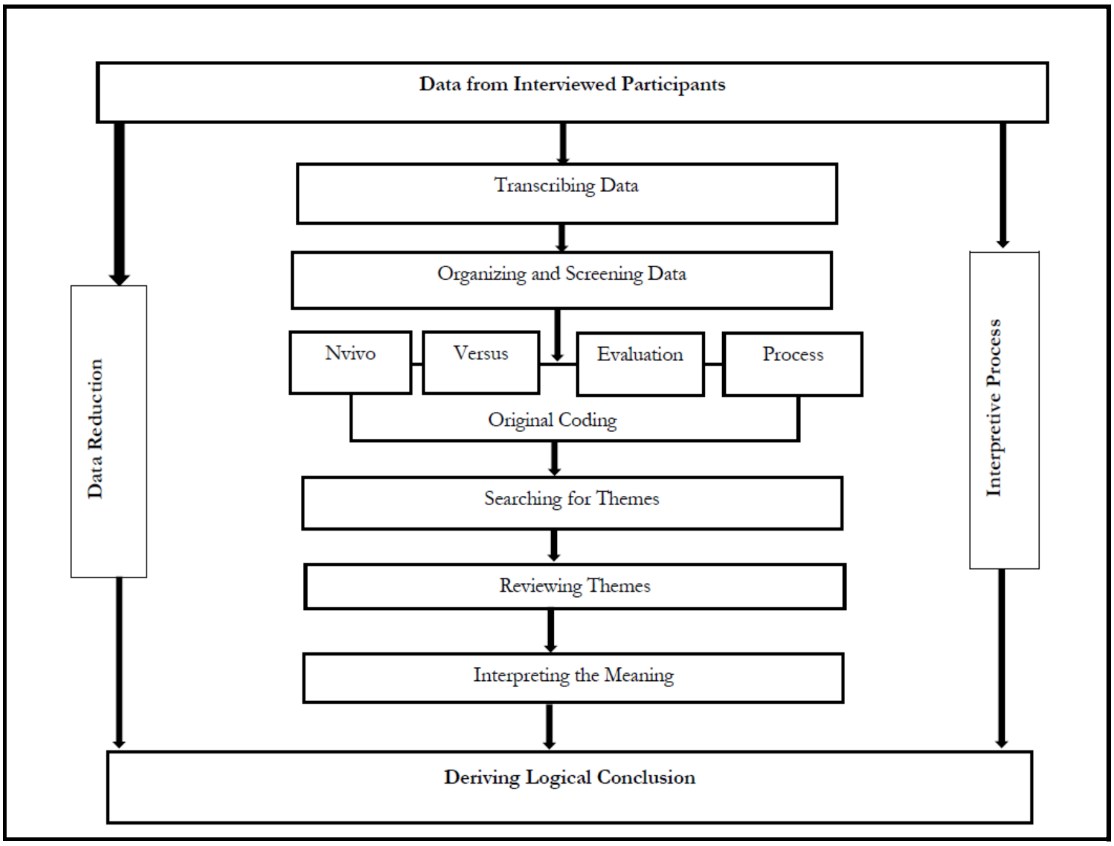

Figure 3. Qualitative data analysis procedure

construction works. The second coding cycle is the evaluation coding process was conducted in order to make a judgement meaning on the implicit of the scope changes. The third coding cycle is the versus coding which was used to identify contrasts and differences in the experiences of one construction project and the other, as well as experiences of the contractors, the consultants as well as the client representatives. The forth coding cycle is the process coding which was used to identify the particular activities and processes in the scope change control of the construction works. Based on the similar patterns in the data after this interpretive process, the codes were then rationally reduced into categories in accordance with the elements of project complexity in order to form a meaning, and eventually a logical conclusion. That is, "the formulated meanings are then clustered into broader themes that pinpoint" (Gaudet and Robert, 2019) and confirm the common key elements as predetermined by the theoretical framework (Miles and Huberman, 1994). Considering that every project is delivered in unique settings, the findings of this study could not be generalized beyond the scope of the study (Babbie, 2010; Yin, 2011), however, the methodology thereof could be replicated in other similar studies (Saldaña, 2013) in relation to scope change in construction projects.

Findings and Discussion

This section presents and discuss the data and findings obtained through the interview sessions with the participants, as well as those that have been obtained from the Compensation of Events documents, which is the basis of the scope change control systems in the delivery of the NEC based construction projects.

TECHNICAL COMPLEXITIES

Uncertainties in scope

With regard to technical complexities, in all the cases the participants have expressed concerns regarding the constant changes in the project scope as a result of incomplete designs and drawing during the delivery of the projects. The lack of complete designs in the project may result to uncertainties in project scope among the involved construction professionals (Moayeri, Moselhi and Zhu, 2017), as [P26] said that:

> **…receiving preliminary designing designs from the architect and then starting our design on that. And then that design is not finalized with the client and confirmed with the client. So the risk lies in us having to redesign our layout... they make drastic changes to a building, and then we have to redesign again.**

Hao et al. (2008) warn that having incomplete drawings during project execution is a risk which often lead to the re-estimation of work statement, extra demands of equipment, materials and labour. In this regard, [P5] outlined that: "*if not enough information is provided on the drawing, then they built something wrong there*" … Drawing from these findings, it is evident that scope changes in one discipline as a result of scope uncertainties often have effects on other disciplines given the interrelations and dependencies of tasks in construction projects.

Dependencies between tasks

As mentioned by Bjorvatn and Wald (2018, p.877) that project complexity can be understood as the "number and heterogeneity of different elements that interrelate" in the process of the project delivery. Issues in relation to the interrelations and dependencies between project activities were prominent in explaining the scope changes in the cases, and the knock-on-effects thereof. The comments below, as expressed by [P26] and [P14] respectively, illustrate the knock-on-effects as a result of scope changes in one discipline in the project:

> **The first fix, for example, is if the mechanical engineer says that there must be an air corn. The electrical contractor must supply a control point, for instance, from that point, we must chase, we must take a conduit, and make a route…but what happens is the mechanical engineer half way through the project, he move that to that position. now on our drawing, now we have to coordinate that with the contractor. So that's additional time…for us to change the drawing…**

> **… if something changes from the top, it filters all the way down. So if the structural engineers design change and we have to change. Um well, especially in the ground, for instance, the design change and therefore the pile layout had to change considerably to accommodate the new design. So when a structural engineer designs, he designs from the top down.**

Consequently, the coordination of the scope changes made in the various disciplines in the project could be a tedious and challenging task, as [P6] explained: "*…changes coming from each and every disciplines: it could be the architect, it could be the mechanical, it could be the electrical. So, those are the challenges which we come across cause you will find that I've sat down in the office and then we design everything*." Apparently, the more the number of disciplines and the number of organizations forming the management team in the project, the more likely to have frequent scope changes in the project. Therefore, it is in this context that, the organizational dimension of project complexity describing the "who" and the "how" of a project, could be seen as the key elements determining the project's complexity (Bosch-Rekveldt, et al., 2010). Apparently, the more the number of disciplines and the number of organizations forming the management team in the project, the more likely to have frequent scope changes in the project. Therefore, it is in this context that, the organizational dimension of project complexity describing the "who" and the "how" of a project, could be seen as the key elements determining the project's complexity (Bosch-Rekveldt, et al., 2010).

ORGANIZATIONAL COMPLEXITIES

Trust in project team

One of the issues that emerged in relation to organizational complexities in the construction projects was pertaining to trust in the reimbursement of the costs associated with the scope changes in the construction project. According to Invernizzi, Locatelli and Brookes (2018), the process of communicating scope changes between contractors and strategic clients can be lengthy and complex, and scope changes and the communication about the changes thereof can be a thorny topic between parties. This view was echoed by [P7] and [P17] respectively, who illustrated that:

> We find them a bit difficult, they cut on most of our costings... Some of the submitted Quotes not paid… I think most of the reasons is because, it's not proven cost, but some of the things you can't prove, maybe you get the works information to put up a column. You can prize the foam or you can price the column, but the labour that's going around that you can't, there is nothing to proof it. So that's the difficult part…

> …a bit of an infighting between the consultants…because they've got budgets. So if the one consultancies, but add this and then the other consultancies, but it's not in my budget, I don't have money. So there's a bit of rubbing shoulders between the consultants in that extent…

These findings resonate with the findings of Motawa et al. (2007) who maintain that scope changes constitute a major cause of disruption, and that the change effects are difficult to quantify and often lead to disputes. On the same note, Kauffmann and Keating (2001) point out that due to a failure in project management methods, contractors had minimal data to substantiate cost claims related to alleged scope changes.

Resource and skills availability

The skills shortage in the construction industry in the country was highlighted as one of the factors leading to scope changes in the construction projects. Skills availability is one of the critical components in the successful delivery of construction project (Bosch-Rekveldt, et al., 2010). In this regard, [P26] felt that:

> …the biggest problem we have us in our industry is the lack of trained individuals. But I also blame the contractors for using that as an excuse...be it from a highly developed skill to a very simple skill of holding a hammer. I think the enthusiasm is there, but we just don't have enough skill and a transfer of skills. And, I think that has had a huge impact on the quality of our buildings.

In another case, when [P5] was commenting on the design discrepancies, and eventually scope changes in the projects as a result of the unavailability of skilled labour, alluded that:

> …the reality is, in South Africa we have to use, unskilled labour and labour from the (local) area. And what I've picked up is that due to the requirement of using unskilled labour and enabling and creating jobs in such a manner that there are sometimes, regarding technical risks, the way they interpret the drawings differently than what it is actually is.

The importance of skills development in the construction industry was emphasised by Okoye, Ngwu and Ugochukwu (2015) when stating that in the face of "the dynamic nature of clients, the complexity of construction projects and continuous demand for improved and efficient project delivery, the right skills should be possessed and appropriate management strategies be applied in order to deal with the challenges facing construction practice.

ENVIRONMENTAL COMPLEXITIES

Interference with existing services

Regarding environmental complexities, with specific reference to the location of the project, scope variations due to unexpected and unfavourable site conditions may be unavoidable (Amadi and Higham, 2019) in construction projects. As such, in all the cases, most participants including [P7] and [P14] respectively, have attested that clashes and interferences with existing underground services was one of the challenges led to scope changes in the projects' execution:

> **There is also the issue of clashes of services as well during the construction. For example, we have got the storm water, it's crossing sewer pipes, it's crossing water pipes. so sometimes those things clash.... It's either you rout around it or you drop the levels...this comes with additional costs.... Cause sometimes they made changes on the fly on sites that are not as per the drawing, then you end up with clashes....**

> **…storm water management is, was a trouble, was a problem on a building site… The asbestos was under the ground services, old services, old existing service... there was some sewer lines, some old water pipes that we have discovered them in various places as we were getting along...**

The clashes and interferences with the existing services on site may suggest that the geotechnical exercise prior to project execution was inadequate. According to Amadi and Higham (2019), failure to adequately evaluate the geotechnical properties of construction project may not only cause scope variations, also result in increased costs.

Geo-technical conditions on site

Most of the participants have expressed concerns about the lack of proper geo-technical exercise on site prior to the construction phase of the project. Consequently, the inadequate geotechnical evaluation has led to extensive scope changes, particular in the design of the foundation of the buildings as pointed out by [P10], [P7] and [P6] respectively:

> **…the geo-technical report wasn't merely accurate as it should have been, which means that the structural engineer designed the buildings for certain type of foundations but when we got the site, the site was like 90% rock. So I had to go back and redesign the foundations which impacted the time and cost because now we had to put pilling, its' a whole lot of money went into blast that rock which is things we didn't account at the beginning of the project because that geo-technical report did not say there was rock on site...**

> **…If the contractor has already started excavation, and only to find that there is rock, and more time has to be spent to cater for that, but there are some instances where you found that maybe there was rock…some portion they expected it to be rocky but there wasn't. they had to put piles...because the rock just deepens down…**

> **…a lot of the piles were refused, which means that for the foundation conditions we assume that they would change to a certain foundation pile. And once the contractor actually started digging, they find out that all the pile refusers were actually just for smaller rocks, not for adequate rock. And**

that meant a significant delay. And cost increases to alter our foundation design based and that was only identified in the construction phase.

In accordance with the work of Bosch-Rekveldt et al. (2010), together these results have broadly comprehended and demonstrated the influence of project complexities on scope changes in construction projects. That is, construction projects are in its own nature initiated in dynamic complex environment which result in circumstances of high uncertainties and risks due to the accumulation of many interrelated parameters (Taylan, et al., 2014) in terms of technical, organizational and environmental dimensions.

Conclusion

Through the content analysis procedure, six elements of project complexity relating to the scope changes in construction projects has emerged. Drawing from the findings, this study was able to provide a comprehensive understanding and illustration of the project complexities as an inherent and defining feature of construction projects. This study argues that construction projects by its very own nature are dynamic and complexity, and as such, scope changes is inevitable during the project delivery. The TOE framework, as proposed by Bosch-Rekveldt et al. (2010) have been applied as a theoretical lens through which the underlying elements of project complexity could be understood. Through this framework, this study provides new insight that could help to understand the nexus in project complexity and scope changes in construction. Notwithstanding that the NEC provides mechanism for effective for change control in terms of the Compensation of Event procedure, the change assessment of the CE procedure is only based on the project cost and the completion date (NEC, 2005), omitting the consequences thereof on scope changes in the construction works. The empirical findings in this study provide a new insight of project complexities as the inherent and defining feature of construction projects. As such, once the complexities of construction project are better understood, it could enable the project management team to apply a proactive and front-end planning approach in the initiation phase in order to better manage scope changes in the delivery of the project, and eventually improve the project performance. Further research on the current topic should be undertaken in determining the statistical significance and the cause-effect of the variables thereof.

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