Journal of Facilities Management

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Received 7 January 2015
Revised 12 June 2015
9 July 2015
Accepted 14 September 2015

Analysis of causes and impact of variation order on educational building projects

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Abstract

Purpose – Construction process is complex and traditionally fragmented; thus, it is almost impossible to have a project completed without changes to the original plan or the construction process. The purpose of this study is to identify and examine the causes of variation orders, ascertain their effects and establish the cost and time performance implication as a result of variation orders.

Design/methodology/approach – This study obtained information from 90 construction stakeholders on 30 completed educational building projects to ascertain the causes and effects of variation orders on project delivery using questionnaire survey. In addition to this, a pro forma document was designed to obtain the project characteristics, cost and time data from these 30 completed educational building projects. Factor analysis was used to categorise the causes of variation orders, while severity index was used to examine their effects on project delivery. The hypothesised statement was tested using paired *t*-statistics to examine whether a statistically significant difference existed between variation orders, cost and time performance of the projects.

Findings – The study identified 13 main factors as causes of variation orders and the results revealed that the most frequent effects of variations were increase in construction costs, time, client dissatisfaction, increase construction project rework and demolition and project abandonment. The results also showed that variation orders had significant effects on both cost and scheduled performance of the educational building projects with average cost and time escalation of 33.95 and 29.45 per cent of the original project cost and time, respectively, for the entire projects studied, while average cost implication of variation orders is 23.79 per cent.

Practical implications – The findings in this study will be of assistance to government agencies and management of public works in higher institutions of learning in managing variations in construction projects. The study will also add to the current literature on the impact of variation orders on educational building projects in developing countries. Finally, it will create the much-needed awareness on the severity and implication of change or variation orders on project delivery.

Originality/value – The study identified and examined the causes of variation orders, ascertained their effects and established the cost and time effects of the causes of variation order on project

Journal of Facilities Management
Vol. 14 No. 2, 2016
pp. 139-164

1472-5967
DOI 10.1108/JFM-01-2015-0001

performance. This will assist project initiators, contractors, consultants and other stakeholders to fully appreciate and understand the significant effects of variation orders on project performance.

Keywords Nigeria, Construction industry, Projects, Change order, Educational building, Overrun

Paper type Research paper

Introduction

The construction industry is a key sector in the developmental process of any country, and the development of physical infrastructure such as building and civil engineering projects is one of the yardsticks for measuring its economic growth (Alzahrani and Emsley, 2013). In Nigeria, the construction industry occupies an important position in the country's economy in spite the fact that it contributes less than the manufacturing industry. The sector's linkage to other sectors of the economy and its contribution to national economic growth require improved efficiency in the industry by means of cost-effectiveness and timeliness which would certainly contribute to cost savings for the country. This is because the industry is a significant contributor to the process of development, and as such, its success is of primary concern to governments, end-users and communities in general.

Studies have also shown that the interdependency between the construction industry and other sectors such as the manufacturing industry is not static but varies as the country's economy improves (World Bank, 1984; Bon, 1988, 2000). The implication of this to the developmental policy is that unless the construction industry grows faster than the economy as a whole, it might constrain national development. This is buttressed by the World Bank (2009) Report, which estimated that every 1 per cent of (government) funds invested in infrastructure provision will yield an equivalent 1 per cent increase in gross domestic product (GDP). Nigeria's infrastructure challenge is enormous and, as such, requires between $12bn and $15bn on an annual basis for six consecutive years in attaining the infrastructure requirements (Yussuf, 2011).

However, the construction industry is a very complex and fragmented sector of the economy owing to its nature as project based. A construction project is a collection of multi-organisations which involves the coming together of numerous stakeholders such as clients, consultants, contractors, project financiers and a host of others on a temporary basis for a specific task depending on the nature and complexity of the project (Giritli and Oraz, 2004). These stakeholders have different objectives or distinct approaches of achieving project goals because of their different backgrounds and interests. As a result, many construction projects suffer from many performance-related issues, chief amongst these in public work projects is the number of variation orders during construction, causing project cost overrun, poor quality work, reworks and delay in schedule, as well as safety issues (Hsieh *et al.*, 2004). Changes or variations are not uncommon in modern construction projects, and this according to Motawa *et al.* (2007) are likely to happen from different sources, by various causes, at any stage of a construction project and may have considerable effects on project performance.

For example, a lack of integration of the design and construction processes of projects procured most especially through traditional procurement method often leads to variation orders. According to Hsieh *et al.* (2004), causes of variation orders are diverse, thus making the challenge of variation management difficult for many project owners. Research has also shown in Nigeria that variation in any given project if not controlled will lead to cost overrun and the result could be either project delay or abandonment

(Bhadmus *et al.*, 2015). Therefore, to eliminate or reduce the unwanted circumstances that could lead to these defects, it becomes essential to examine and analyse the causes of variation orders to understand their effects on project delivery. To achieve the objectives of this study, a review of existing relevant literature was carried out on potential causes of variations on building projects with a special emphasis on educational projects. This paper, thus, investigates the cause–effect of variation orders using data collected from public educational building projects that experienced variation order in Niger State, Nigeria. The study, therefore, identifies and examines the causes of variation orders, ascertains their effects on the entire project and establishes the cost implication of the causes of the variation order. The findings in this paper will assist government agencies and departments responsible for the management of public works in higher institutions of learning in managing variations in construction projects.

Context of the research

Nigeria is one of the fastest-growing countries both in the Sub-Saharan Africa and the world at large. The continuous growth in the country's population has made the educational system to undergo a series of developmental phases which can satisfactorily measure up with what is obtainable in the other countries of the world. This increase in population has led to the growth of tertiary institutions in Nigeria which was 4 at independence (1960) to about 365 tertiary institutions (104 Universities; 121 Mono and polytechnics; 85 Colleges of Education; and 65 innovative Enterprise institutions) (Bollag, 2002; Shu'ara, 2010). The increase in the number of students seeking admissions to tertiary institutions has resulted to the addition of buildings to cater for students across the institutions. Projects therefore executed in these tertiary institutions are referred to as educational buildings. These projects are either new construction or refurbishment projects. Arain and Pheng (2005) argued that the construction of an educational building also causes risks common to any other large projects. These risks could be because of the influence posed by very changing variables and unpredictable elements that could originate from different sources in the construction process, with variation that could result in the extension of project completion time as a consequence (Arain and Pheng, 2005).

However, variations have become phenomena in construction, as they have almost become unavoidable and have become so predominant that it is rarely possible to have a project completed without changes to either the original plans or the construction process itself (Ssegawa *et al.*, 2002; Oladapo, 2007). For example, Arain and Pheng (2005) studied the potential effects of variation orders on institutional building projects in Singapore, and their findings suggest that the most common effects of variations were increase in project costs, increase in payments to contractor, delay in project completion schedule, increase in overhead expenses and rework and demolition. This study argued that variations occur in all types of construction projects whether educational or otherwise (O'Brien, 1998; Ibbs *et al.*, 2001) and that the causes and effects are often the same and generic. Projects in Nigeria are known to be affected by variation orders (Oladapo, 2007) with consequential effects on time and cost (Oladapo, 2007; Oyewobi and Ogunsemi, 2010). Fisk (1997) stressed that the provisions in the contract documents appear to give credence to the variation orders in construction projects and which are often being misinterpreted by the stakeholders both on their limit and usage. This frequently leads to substantial adjustment to the contract schedule, total direct and indirect cost or both in construction projects (Ibbs *et al.*, 1998; Arain and Pheng, 2005). Therefore, this study is focused on the educational building projects of Federal Government-owned tertiary institutions, which included both new and refurbishment projects in Niger State, Nigeria. The survey was limited to the respondents that handled projects within these institutions over the period under consideration, in addition to the data sought on the project characteristics, cost and time of the 30 completed projects.

Literature review

According to Hanna *et al.* (2002), change may be defined as any event or occurrence that may result in a modification to the original scope, execution time or cost of work, while Bin-Ali (2008) viewed variation as the alteration or modification of the design, quality of works, as agreed upon in the contract drawings, bill of quantities and/or specifications. When a written instruction is, therefore, given by the architect requiring the contractor to alter the works in any of these circumstances, it becomes an order. This implies that both change or variation order is capable of bringing changes to the scope of work, schedule, cost and/or quality on most construction projects (Revay, 2002). Hence, based on these two definitions, change order or variation order may be used interchangeably in this paper to connote the same meaning. As the construction process is complex and traditionally fragmented, it is almost impossible to have a project completed without changes to the original plan or the construction process on most construction projects because of the uniqueness of each project and the limited resources available in terms of time and budget for planning (Hanna *et al.*, 2002; Ssegawa *et al.*, 2002).

Studies by Hanna *et al.* (2002), Arain and Pheng (2005) and Jawad *et al.* (2009) have advanced different reasons or causes of change orders on construction projects; these include design errors, design changes, additions to the scope or unknown conditions, technology application, bad contractual procedure, omission during construction, inaccurate briefing and consultant initiated changes. In a related development, Enshassi *et al.* (2010) submitted that amongst 64 causes of variation orders, the lack of materials and spare parts because of closure is considered as the most important cause of variation orders in construction projects in Gaza strip. Similarly, the most important cause of variation orders given by consultants according to Oladapo (2007) and Alnuaimi *et al.* (2010) is the changes in the specifications and scope, initiated mostly by project owners. While many of the identified causes may be generic, Arain and Pheng (2005) and Jawad *et al.* (2009) reported that the errors and omissions in design, change in the specifications by owner, design discrepancies, change in specifications by the consultant and lack of coordination, lack of understanding and correct interpretation of customers' requirement are the main factors causing variations in educational building projects. Keane *et al.* (2010) through a case study analysis also found that causes of variation include a lack of coordination between client and design team, not involving contractor at the design stage. Uttam and Bhirud (2015) in their own view considered changes in design plan and schedule by the owner as the main cause of change order, while change in the procedure and errors and design modification and changes in specification and scope of project mostly by clients and their consultants as the most sources of variation in construction.

From the foregoing, Bower (2000) and Ndihokubwayo and Haupt (2008) categorised these variation orders as those with direct and indirect cost implications. Direct costs constitute the additional costs incurred to perform the activities of the current variation orders which include: resources used such as labour, material and plant to carry out the actual variation orders. Additionally, increase in overheads-related charges and professional fees, cost of resources that were used to carry out the aborted or substituted works, cost of demolition of aborted or substituted works and cost for resources lying idle before the ordered task restarts also constitute direct costs, while the indirect costs are those incurred as a result of occurrence of variation orders and include change in cash flow, loss of productivity, cost for redesign and administration of variation order and litigation-related costs in case disputes arise because of variation orders.

Nature of variation orders

The nature of a variation order can be determined by referring to both the reasons for their occurrence and subsequent effects. Arain and Pheng (2005) classified variation into two main types: beneficial and detrimental variation orders.

Beneficial variation orders

Arain and Pheng (2005) stated that a variation order is beneficial when it is issued to improve the quality, standard of workmanship, reduce cost, schedule or degree of difficulty in a project. Ndihokubwayo and Haupt (2008) considered beneficial variation order as variation initiated for value analysis purposes to strike a balance within the cost, functionality and durability aspects of a project to the satisfaction of clients. A beneficial variation order removes unnecessary construction costs from a project, and as a result, it optimizes the client's value for money against the resource input by eliminating unwarranted costs. However, it should be noted that regardless of how beneficial a variation order might be, non-value-adding costs are likely to accrue (Palaneeswaran *et al.*, 2008). For example, a variation order to solve the discrepancies between contract documents involves the abortion of works that have already been executed. Cost for aborted works should not have been incurred if discrepancies were not found between contract documents.

Detrimental variation orders

Variation order is detrimental when it negatively affects the client's value or project performance (Arain and Pheng, 2005). A detrimental variation order compromises the client's value for money (Ndihokubwayo and Haupt, 2008). Hence, a client who is experiencing financial difficulties may require the replacement of quality, standard and expensive materials to sub-standard and cheap materials. Detrimental variation orders often lead to uncertainties and complicated project interfaces which are common in construction and often contribute to the occurrence of non-value-adding activities, such as rework (Palaneeswaran *et al.*, 2008).

Effects of variation orders on project performance and stakeholders

Doloi (2009) argued that in construction projects, some of the challenges for both clients and contractors to successfully deliver projects stem from growing complexity in design and the participation of a multitude of stakeholders. These challenges often give rise to variations because of conflicting opinions of stakeholders or change of decision-making authority during the course of construction as well as inconclusiveness or inconsistency between design and specifications (Hsieh *et al.*, 2004). Previous studies (such as Ibbs, 1997; Hsieh *et al.*, 2004; Ndihokubwayo and Haupt, 2008) have identified that some of the most detrimental effects of variation orders include reduced project quality, ineffective infrastructure investment and overruns. In fact, Oladapo (2007) and Sunday (2010) asserted that time and cost overruns are the major effects of variation orders and that it ranges between 25-78 per cent and 27-68 per cent for cost and time overruns, respectively. In addition, Keane *et al.* (2010) also found that the most common effect of variation is an increase in the project cost. Alaryan *et al.* (2014) findings conform to earlier results that the most common effect of change orders is on cost and time of the projects. While the Uttam and Bhirud (2015) reported that the effects of variations on construction projects are an increase in project cost, additional payment for the contractor, increase in the cost of the project, completion schedule delay and rework and demolition.

However, cost overruns and time extensions as a result of variation can be either avoidable or unavoidable. Overruns because of design plan or project management problems are avoidable because they could have reasonably been foreseen and prevented. However, some cost overruns are unavoidable because they cannot be reasonably prevented, such as those because of unanticipated events as a result of rework (Oyewobi and Ogunsemi, 2010). Ibbs *et al.* (2007) concluded that variation orders have tremendous effects on project performance, as they adversely affect the productivity and costs. In a related development, Thomas *et al.* (2002) contended that the occurrence of variation orders has an adverse impact on project performance and believed that variability generally impedes project performance. Hanna *et al.* (2002) indicated that projects affected by variation orders cause the contractors to achieve lower productivity levels than planned and consequently completing the projects behind schedules. Also, Arain and Pheng (2005) argued that variation orders are unwanted but inevitable reality of any construction project. Alnuaimi *et al.* (2010), thus, summarized in a study conducted in Oman to investigate causes, effects, benefits and remedies of change orders on public construction projects that the major effects of variation orders are dispute, delay and cost overruns.

Therefore, cost and time overruns as a result of variation orders pose danger to the performance of buildings, be it educational or otherwise; it has negative implications which may be perceived differently by both the direct and indirect stakeholders to the projects (Cleland and Ireland, 2004). The direct stakeholders include the client, consultant, contractor and the financiers, while the indirect includes the beneficiaries, that is, the community where the project is situated or the end users. The perception according to Mbachu and Nkado (2004), Aje (2008), Moodley *et al.* (2008), Cleland and Ireland (2004), Duncan (2004) and Thomsett (2002) varies across stakeholders. To the client, cost overrun means additional costs or over shooting the initial cost budget, resulting in the loss of returns on investment. To the end-user, the added costs are passed on as higher rental/lease costs or prices. To the professionals, cost overrun implies an inability to deliver value-for-money and could well tarnish their reputations and result in loss of confidence reposed in them by clients. To the contractor, it implies loss of profit through liquidated and ascertained damages payable for non-completion and acrimonious relationship that could threaten his chances of winning further jobs, if at fault. To the industry as a whole, cost overruns because of variation could bring about project abandonment and a drop in construction activities, bad reputation and inability to secure project finance or securing it at higher costs because of added risks. Therefore, the paper focused on the cause of the negative effects on project delivery brought about by variation orders and hypothesised that:

H1. Variation orders have significant effects on both time and cost performance of construction projects.

Research methodology

The main research objective of this paper is to examine the causes and effects of variation orders on educational building projects. The study further probes the effects of variation orders as one of the key elements influencing project performance. As shown in the literature review, the causes and effects of variation in construction could be said to be generic; however, some are project specific. To achieve the aim of this research, a combination of methods were adopted: a research pro forma, which is a document designed to obtain specific information about different projects identified for consideration in this study, and a quantitative questionnaire. The research pro forma was designed to elicit information relating to project specifics from 30 completed educational building projects in Federal Higher Institutions of learning in Niger State between 1999 and 2010. The information sought included the project characteristics, time and cost data, such as initial and final completion times, estimated contract sum, revised contract sum and change orders or variation cost that constitute delay or increase in the final contract sums which the researchers extracted. Information such as facility type, type of project and complexity of the projects were also sourced, but they were not used, as these have been reported not to have significant effects on the causes of variation (Oladapo, 2007). Initially, 45 educational building projects were identified, but only 30 projects were good enough for the study.

Furthermore, the variables used for the research questionnaire were derived from the critique of existing but relevant literature reviewed and these were amended to suit the purpose of the study to ensure reliability and validity of the variables used. The questionnaire was pretested through pilot survey amongst colleagues and construction professionals to improve its reliability and guarantee the clarity of the questionnaire developed for the study. The participants for the pilot study were randomly selected before the collection of the main data. The questionnaires (90) were self-administered to elicit information on the causes and impact of variation orders from the professionals (Architects, Builders and Quantity Surveyors) that participated in the 30 educational building projects. The respondents were asked to indicate their response on factors well recognized as causes of variation orders as identified through extensive literature review and reported in previous studies (Hsieh *et al.*, 2004; Wu *et al.*, 2005; Arain and Pheng, 2006; Bin-Ali, 2008; Sun and Meng, 2008). The aim of the questionnaire was to obtain data for ranking the causes and effects of variation orders. The questionnaire was divided in two parts (Appendix 1). Section A was designed to obtain information on the background of the respondents, while Section B was aimed at eliciting information on the potential causes and effects of variation orders for educational buildings. Five-point Likert scale was used for the ranking of the potential cause and effect of variation orders (Arain and Pheng, 2005). The data were analysed using factor analysis, severity index and *t*-test, which formed the basis for the conclusion reached and the recommendations made.

Respondents' profile

Table I shows the demographic information of respondents' that participated in this research. The table shows that approximately 97 per cent of the respondents are

Table I.
Demography of the respondents

Respondents' profile	Frequency	Valid %	Cumulative %
Years of experience			
Less than 5	13	14.44	14.44
5-10 years	15	16.67	31.11
11-15 years	21	23.33	54.44
16-20 years	28	31.11	85.55
Above 20 years	13	14.44	100
Professional designation			
Engineer/Builder	27	30.00	30
Architect	30	33.33	63.33
Quantity surveyor	30	33.33	96.66
Others	3	3.33	100
Highest academic qualification			
Ordinary National Diploma (OND)	17	18.89	18.89
Higher National Diploma (HND)	30	33.33	52.22
Bachelor	26	28.89	81.11
Master	17	18.89	100
Doctorate	0	0.00	100

professionals (builder/engineer, architect and quantity surveyor), with 81 per cent having minimum qualifications of Higher National Diploma (HND) and above; HND is the minimum requirement for professional registration in most construction-related disciplines in Nigeria. Also, 86 per cent of respondents have over five years of professional work experience in the industry, which is an indication that the responses could be relied upon, as the respondents have relevant knowledge of the subject area.

Factor analysis of factors responsible for variation orders

To identify the underlying structure for the causes and effects of variations in the construction of educational building projects, a factor analysis was performed. This was undertaken to reduce the large number of variables identified to be responsible for variation order for the projects considered to be very significant ones, which can then be used for further analysis. Principal components analysis was used to extract the underlying factors. To test the suitability of the data, the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy (MSA) and Bartlett test of sphericity were determined for the variables. These tests set the minimum standard that the data should meet to be considered adequate for further analysis. The value of the KMO varies between 0 and 1, with 0.50 suggested as a minimum (Hair *et al.*, 2010; Field, 2013). The KMO measure of the adequacy of the sample in this study is 0.923, which is higher than the threshold (0.5) considered to be the minimum value for factor analysis (Field, 2013). The Bartlett test indicates the strength of the relationship amongst variables and the significant level of the Bartlett's test is a requirement for suitability of the data for analysis (Field, 2013). Therefore, to determine how many factors would be required to represent the set of data, the total percentage of variance explained by each factor was examined. Principal factor extraction with a Varimax rotation was used on 42 items of factors causing variation from a sample of 90 responses. The extracted factors explained total cumulative variance of 90.821 per cent. The important factors are those whose eigenvalues are greater than or equal to 1. Factor loadings and the commonalities (h^2) of the determinants of the variables are then evaluated. Factor loadings are the correlation coefficient between an original variable and an extracted factor, while commonality is the variance in the variables that have been accounted for by the factors extracted.

Table II contains the details and initial statistics for each of the 42 factors. The total variance explained by each factor was listed in the column under factor loading. The percentage of the variance and the cumulative percentage of the variance are indicated in Table II. In all, 13 factors were extracted that accounted for 90.82 per cent of the variance in responses. The first two factors accounted for 25.94 and 37.67 per cent. Almost all factor loadings were greater than 0.5. In general, the loadings and the interpretation of the factors extracted were reasonably consistent. The average factor loading is 0.712, while the total loading factor is 29.89. The average eigenvalue is 3.354, average percentage variance is 6.986 and the cumulative percentage average is 67.480. The factors are as discussed below.

Factor 1: lack of understanding and correct interpretation of customer's requirement
In this factor, the problem of not getting the clients requirement or being able to interpret the customer's brief correctly has an effect on the quality of the project because of an inability to meet up the required quality specified. In many instances, contractor does not have a direct access to the project owner that endorses the construction contract; therefore, his perception may be misrepresented. This perhaps could be a major source of variation orders as indicated by Ayininuola and Olalusi (2004) that incessant variation of works by project owners is one of the key causes of the high incidence of building failures in Nigeria.

Factor 2: poor technology application
Usage of inadequate technology or poor approach has a definite impact on project delivery time; poor technology deployment could make the work slow as well as sub-standard. Although Enshassi *et al.* (2010) argued that technological changes in terms of materials and equipment for construction are not significant, they are capable of causing variations in the construction process.

Factor 3: bad contractual procedure
The procedure or line of work used in a project if altered could have an impact on the project. The procedure for construction defers with different works, so if there are loop holes in contractual arrangements leading to the award of contracts, then these may significantly affect the project performance. Alnuaimi *et al.* (2010) stated that contractors make use of loose ends or the different interpretation of the contract clauses with respect to the scope or design to their own gain by maximising their profit margins.

Factor 4: omission during construction
Construction is ordered; it has a step-by-step sequence; if a step is omitted, then it has to be done. For example, if hardcore is omitted and concrete flooring has commenced, then it has to be removed for hardcore to be placed; this definitely has an effect on the delivery of the work.

Factor 5: consultant initiated changes
Changes initiated by the consultant have to be verified by the client and this might take a while, and if not verified, accepted and endorsed by the client, then it could change and

Variables	Factor loading	h^2	Eigen-value	% variance	Cumulative %
Factor 1					
Quality failure	0.575	0.93			
Quality deviation	0.931	0.945			
Poor quality contract documentation	0.844	0.561			
Poor and unbridged communication gap	0.621	0.917			
Lack of proper monitoring and evaluation	0.55	0.925			
Inaccurate briefing	0.534	0.926			
Lack of information technology use	0.553	0.893			
Non-conformance to project requirement	0.629	0.908			
Lack of understanding and correct interpretation of customer requirement	0.713	0.839			
Defect identification	0.631	0.935	12.451	25.94	25.94
Factor 2					
Lack of proper monitoring and evaluation	0.512	0.925			
Sub-standard products and services	0.666	0.921			
Incomplete documentation at the time of award	0.625	0.858			
Poor information use	0.912	0.908			
Poor technology application	0.744	0.914			
Checking procedures	0.805	0.958	5.629	11.726	37.667
Factor 3					
Fraudulent practices and kickbacks	0.679	0.932			
Inconsistent government policy	0.881	0.891			
Bad contractual management	0.785	0.901			
Lack of attention to site condition	0.828	0.954			
Ineffective co-ordination and integration of components	0.738	0.958	4.382	9.126	46.792
Factor 4					
Error during design	0.922	0.932			
Omission during design	0.886	0.891			
Error during construction	0.552	0.925			
Omission during construction	0.796	0.945			
Ineffective construction and integration of components	0.522	0.947	3.811	7.939	54.731
Factor 5					
Consultant initiated changes	0.76	0.96	3.476	7.243	61.974
Factor 6					
Inaccurate briefing	0.614	0.947			
Incomplete design information	0.542	0.885	2.759	5.748	67.722
Factor 7					
High cost of materials	0.911	0.939			
Duration of contract period	0.565	0.953			
Improper planning	0.566	0.925			
Inadequate resources	0.682	0.836	2.309	4.811	72.533

(continued)

Table II.
Factor extraction for factor responsible for variations

Variables	Factor loading	h^2	Eigen-value	% variance	Cumulative %
Factor 8					
Change in plan and scope by client	0.832	0.932			
Change in the specification by client	0.785	0.817	1.921	4.002	76.535
Factor 9					
Poor contract procedure	0.726	0.942			
Error during design	0.561	0.925	1.678	3.495	80.03
Factor 10					
Inadequate work separation	0.899	0.94	1.639	3.415	83.445
Factor 11					
Numerous construction projects going on simultaneously	0.914	0.866	1.331	2.772	86.217
Factor 12					
Defective materials	0.585	0.871			
Complex drawing details	0.837	0.906	1.146	2.387	88.604
Factor 13					
Contractor-initiated changes	0.744	0.888	1.064	2.217	90.821

Table II.

affect the construction time. Enshassi *et al.* (2010) posited that one of the reasons for initiated changes in design may be because of the inconclusiveness of the design process before starting the construction phase. Thus, consultants may have to resolve or correct errors noticed through issuance of variation orders to make changes to the design during the construction phase.

Factor 6: inaccurate briefing information

If the briefing for the project is delivered inaccurately, then the work would also be inaccurate, thereby slowing the work pace down and finally affecting the delivery time of the project.

Factor 7: inadequate resources

If the resources for the execution of the project are insufficient or not readily available, then it is either the materials present on site are used, as they are available, thereby leading to low quality of work, or the work could move at a slow pace. Sometimes, the parties to a project or contract (such as client and consultant) initiate variation orders because of financial constraint to omitting some activities or change some material specifications that may lead to cost savings without compromising the quality of the project.

Factor 8: client's inconsistency

The client's requirement and satisfaction are paramount in construction; if the client is inconsistent in his requirement, then the pace of the work is slow to meet up the client's needs. So the client is a key contributor to the work. In a study conducted in Kuwaiti, the authors argued that the major causes of variation orders in building construction project were orchestrated by owners, and this was found to be responsible for 47 per cent of variation orders, A/E for 26 per cent (Bassioni and Hamza, 2005).

Factor 9: improper coordination of contract

Good coordination resulting into the achievement of stability in an uncertain environment can be attained by an increase in the contract point between parties to the contract, and proper coordination is a reflection of the expectation of each party from the other parties in fulfilling stated tasks.

Factor 10: inadequate work separation

Ambiguity of instructions may give rise to conflict of opinions, and this is one of the major factors responsible for having building that will not be free of variation. Also, inadequate work separation may result because of a lack of adequate information, buildability of many designs and the separation of the contracts interfaces (i.e. the design and construction interface) coupled with the fact that our construction processes are still sequential in nature.

Factor 11: many construction projects going on simultaneously

When many construction projects are going on at the same time, they have an effect on project delivery in the sense that controlling all these work in progress at the same time might not be possible. Multitasking is quite demanding, and the ability to control them is quite slim.

Factor 12: complex drawing details

Simplicity of drawings has an impact on the delivery of the project. If the drawing is complex, then it could be difficult for it to be free from errors or variations and brought to reality, thereby delaying delivery and affecting negatively the project. For example, Arain and Pheng (2005) found that an error in design is a key factor responsible for variation orders in buildings projects. Therefore, the consultant can play a vital role in reducing these errors or variations in the design to eliminate likely problems before the commencement of the construction phase (Enshassi *et al.*, 2010).

Factor 13: contractor-initiated changes

In some cases, construction contractors may, out of experience, see impossibility of some site activities. So changes which the contractor suggests are referred to as contractor-initiated changes. These changes by the contractor may occur because of the lack of information from the architect or his representative, including necessary instructions that are required in achieving the goals of the project. The reasons for these changes in design or construction process which often lead to variations, according to Enshassi *et al.* (2010), may include insufficient time for design process and the lack of integration of the construction phase.

It is noteworthy that all these factors are shared across many empirical studies that examined the causes of variation or change orders in construction projects (Hsieh *et al.*, 2004; Arain and Pheng, 2005; Sunday, 2010; Enshassi *et al.*, 2010; Alaryan *et al.*, 2014).

Effects of variation orders on project delivery

Table III assesses the impact that variation order has on project performance and uses the severity index (SI) method to analysis the variables that affect severely on projects

Variable	SI	Rank	FI %
Increase in construction cost	82	1	8.86
Increase in construction time	79	2	8.54
Client dissatisfaction	76	3	8.22
Project failure	73	4	7.89
Contractor dissatisfaction	73	4	7.89
Total project abandonment	73	4	7.89
Dispute among the parties	72	7	7.78
Contractor's financial difficulties	72	7	7.78
Arbitrator/litigation	69	9	7.46
Poor contract management	69	9	7.46
Lack of commitment	67	11	7.24
Poor post-contract relationship	62	12	6.70
Determination of contract	58	13	6.27
Total			100

Table III. Severity index

performance. The construction cost exhibits the most significant impact with the severity and frequency indices of 82 and 8.86 per cent, respectively. Time overrun is ranked second with SI of 79 per cent and frequency index (FI) of 8.54 per cent and followed by client dissatisfaction (SI = 76 per cent, FI = 8.22 per cent), project failure (SI = 73 per cent, FI = 7.89 per cent) and total project abandonment (SI = 73 per cent, FI = 7.89 per cent), and contractors' dissatisfaction (SI = 73 per cent, FI = 7.89 per cent) ranked fourth. Dispute amongst the parties to the contract and contractors' financial difficulties exhibited SI of 72 per cent, while arbitration/litigation and poor contract management were also inclusive with an FI of 7.46 per cent. Lack of commitment had an FI of 7.24 per cent, poor post-contract relationship had 6.70 per cent and, finally, determination of the contract had a less significant impact on variation on project performance amongst the set of variables that were sampled with SI of 58 per cent and FI of 6.27 per cent. The ranking of the effects is consistent with the project success factors identified by the Project Management Institute (2010), which is determined by timeliness, budget compliance and the degree of customer satisfaction.

These results also compare well with the findings from previous studies such as Alnuaimi *et al.* (2010) that examined the effects of change orders on public construction projects in Oman and found that a delay in completion time, dispute and cost overruns are the most ranked effects of change orders. Meanwhile, Alaryan *et al.* (2014) argued that an increase in cost of the project is the first effect of change order on both private and public projects in Kuwait. In fact, Motawa *et al.* (2007) argued that change orders constitute a major cause of delay and disruption in management of construction works and that the effects of change orders are difficult to quantify, which often lead to disputes as generally accepted by both owners and contractors. However, on institutional buildings, Arain and Pheng (2005) argued that the major effects of variation orders include increase in project costs, additional payments for contractor, completion schedule delay and increase in overhead expenses, as well as rework and demolition. This assertion was supported by Keane *et al.* (2010), who posited that the most common effect of variation is increase in project cost. Keane *et al.* (2010), however, asserted that the increase in project cost could be minimized through successful project management, sustenance of good relationship with the parties and appointment of qualified and experienced contractor. However, Alaryan *et al.* (2014) viewed that instituting a control measure, checking and reviewing contract document, reviewing design before approval and making clear the scope of change order will to a large extent reduce the effects.

Time and cost performance due to variation orders

Time and cost performance of construction projects were determined using two indices: variation order ratio (VOR) and time extension ratio (TOR). VOR is an index that measures the ratio of total addition on the project cost because of variation orders (Hsieh *et al.*, 2004); this is expressed as VOR = (Sum of additional value for a project due to variation orders/Original tender price) × 100 per cent. TOR is an index used in measuring the ratio of total addition to the project schedule because of variation orders (Hsieh *et al.*, 2004); this is given as TOR = (Project extension due to a given cause of change order/Contract schedule of a given project) × 100 per cent.

According to Alnuaimi *et al.* (2010) and Alaryan *et al.* (2014), it is almost impossible to have construction projects executed without changes, and mostly, variation orders are given to make corrections or modifications to the initial design or scope of work. These modifications or corrections have been identified to be the chief causes of construction project cost and time overruns (Alnuaimi *et al.*, 2010; Oladapo, 2007). All the projects considered experienced considerable cost overrun and the magnitude of the overrun ranged between 1.88 and 92.60 per cent of the initial contract sum, while time overruns ranged between 0.00 and 115.38 per cent of the initial contract duration. The average cost and time overruns suffered by all the educational building projects considered are 33.95 and 29.45 per cent, respectively, while average cost implications of variation orders is 23.79 per cent as shown in Table IV. This result is similar to that of Sunday (2010), where an approximate cost and time overruns of construction projects in Seychelles were estimated to be around 25.29 and 27.25 per cent, respectively.

However, the cost overrun is inclusive of all loss and claims expenses, as well as additional cost incurred through variation orders as allowed by the project conditions of contract. Also, time overrun was because of some of the factors identified in the literature (Oladapo, 2007), which includes delays by the contractors, extension of time by the owners as a result of variation orders and other causes. The study analysed the effects of variation orders on individual project studied and estimated the overall, as well as the average, effect of variation order on the project cost and time.

Hypothesis testing

The *t*-test is used in this study to test the hypothesis on the difference between the means of variation orders and cost overrun and between the means of variation orders and time overruns. Table V shows the results of paired sample *t*-test carried out to examine whether a statistically significant difference existed amongst the mean variation orders ratio and cost overrun, as well as time overrun. Assumption testing indicated that there is no gross violation of assumptions. The results of the paired sample *t*-test were significant, $t\ (29) = 4.911$, $p < 0.000$, $\eta = 0.5$, indicating that the projects experienced more significant effects as a result of variation orders in terms of the cost overrun compared to time overrun, $t\ (29) = 4.439$, $p < 0.000$, $\eta = 0.5$. The effect (using R^2) was large based on Cohen (1992), who categorised the effects size of 0.01 might be a "small"

Table IV. Time and cost performance of the selected educational building projects

Projects	Initial sum	Claims	Variation order	Final sum	Cost overrun	Percentage cost overrun	Variation order ratio	Initial duration	Final duration	Time overrun	Schedule extension ratio
1	26.92	0.88	5.89	33.69	6.77	25.15	21.88	16.00	29.00	13.00	81.25
2	20.55	0.72	3.26	24.53	3.98	19.37	15.86	17.00	20.00	3.00	17.65
3	21.53	2.64	8.00	32.17	10.64	49.42	37.16	18.00	20.00	2.00	11.11
4	21.77	6.89	10.22	38.88	17.11	78.59	46.95	17.00	18.00	1.00	5.88
5	21.13	0.22	0.59	21.94	0.81	3.83	2.79	16.00	28.00	12.00	75.00
6	21.02	0.24	1.63	22.89	1.87	8.90	7.75	18.00	19.00	1.00	5.56
7	22.01	1.23	3.08	26.32	4.31	19.58	13.99	18.00	18.00	0.00	0.00
8	21.32	0.15	0.25	21.72	0.40	1.88	1.17	18.00	20.00	2.00	11.11
9	25.26	0.81	2.30	28.37	3.11	12.31	9.11	19.00	19.00	0.00	0.00
10	24.20	7.56	14.85	46.61	22.41	92.60	61.36	16.00	26.00	10.00	62.50
11	29.11	0.29	1.28	30.68	1.57	5.39	4.40	18.00	19.00	1.00	5.56
12	22.19	0.57	2.88	25.64	3.45	15.55	12.98	20.00	23.00	3.00	15.00
13	25.31	0.35	0.78	26.44	1.13	4.46	3.08	18.00	21.00	3.00	16.67
14	24.20	0.50	1.30	26.00	1.80	7.44	5.37	21.00	22.00	1.00	4.76
15	23.98	0.73	2.06	26.77	2.79	11.63	8.59	16.00	20.00	4.00	25.00
16	22.39	0.90	2.64	25.93	3.54	15.81	11.79	18.00	20.00	2.00	11.11
17	21.82	0.40	2.00	24.22	2.40	11.00	9.17	19.00	22.00	3.00	15.79
18	20.59	1.00	2.23	23.82	3.23	15.69	10.83	14.00	16.00	2.00	14.29
19	21.19	0.89	2.40	24.48	3.29	15.53	11.33	19.00	24.00	5.00	26.32
20	23.12	0.64	1.78	25.54	2.42	10.47	7.70	13.00	28.00	15.00	115.38
21	25.34	7.80	19.51	52.65	27.31	107.77	76.99	18.00	28.00	10.00	55.56
22	22.35	1.96	3.27	27.58	5.23	23.40	14.63	18.00	20.00	2.00	11.11
23	22.37	2.37	8.16	32.90	10.53	47.07	36.48	18.00	19.00	1.00	5.56
24	21.96	4.52	13.29	39.77	17.81	81.10	60.52	15.00	30.00	15.00	100.00
25	24.48	10.15	23.61	58.24	33.76	137.91	96.45	17.00	24.00	7.00	41.18
26	26.14	5.72	15.45	47.31	21.17	80.99	59.10	24.00	32.00	8.00	33.33
27	53.06	1.73	3.27	58.06	5.00	9.42	6.16	14.00	19.00	5.00	35.71
28	116.31	5.30	8.16	129.77	13.46	11.57	7.02	15.00	22.00	7.00	46.67
29	67.36	5.98	13.29	86.63	19.27	28.61	19.73	16.00	20.00	4.00	25.00
30	70.71	9.21	23.61	103.53	32.82	46.41	33.39	21.00	23.00	2.00	9.52
Total	909.69	82.37	201.04	1,193.10	283.41	998.86	713.73	525.00	669.00	144.00	883.56
Average	30.32	2.75	6.70	39.77	9.45	33.30	23.79	17.50	22.30	4.80	29.45

effect, around 0.30 a "medium" effect and 0.50 to infinity, a "large" effect. The mean increase was 2.745 for cost overrun and 2.587 for time overrun, with the 95 per cent confidence interval for the difference between the means of 1.60 to 3.89 and 1.565 to 3.658, respectively. Thus, the hypothesis that predicted that variation orders have significant effects on both time and cost performance of construction projects is, therefore, supported. These results corroborated the findings of Oladapo (2007) and Bhadmus *et al.* (2015), who posited that variation orders have significant effects on both cost and time performance of building projects.

Conclusions

In this paper, the perceptions of construction professionals on the causes and effects of variations orders on educational building projects were sought using structured questionnaires amongst those involved directly in the building projects. The study identified 48 potential causes of variation orders, and these were reduced to 13 main factors that were capable of causing variation orders in educational building projects. Furthermore, 13 possible effects of variation orders for these projects were identified from literature and their influence on project performance examined. It is believed that the study will be of great benefit to construction professionals in evaluating the unfavourable effects of variation orders and device mechanism for reducing the influence of variations orders on project delivery, especially in educational buildings.

The potential causes of variation orders as categorised in this study included lack of understanding and correct interpretation of customer's requirement; poor technology application; bad contractual procedure; omission during construction; consultant initiated changes; inaccurate briefing information; inadequate resources; client's inconsistency; improper coordination of contract; inadequate work separation; numerous construction projects going on simultaneously; complex drawing detail; and contractor initiated changes. However, the most frequent and severe effects of variation orders for educational buildings as rated were related to increase in building construction cost, increase in construction time, client dissatisfaction and project failure. These have significant effects on project performance as demonstrated above. The study, thus, concluded that effective project delivery and performance can only be achieved when factors which have potentially negative effects on project performance as a result of variation orders are identified, reduced or possibly eliminated.

As evident in the literature review, educating the client on the importance of clarity of their requirements, early involvement of professionals during the design phase, efficient coordination and direct communication amongst professionals, clarity of instruction capable of causing variation orders, detailed design to enhance good interpretation and coordinated team effort by all professionals to control variation orders will be of tremendous advantage in reducing effects of variation orders.

Table V.
Pair samples test and paired differences

Paired variables/samples		Mean	SD	Standard error mean	95 % confidence interval of the difference: Lower	Upper	*t*	df	Significance (two-tailed)
Pair 1	VAR–COR	−2.74500	3.06120	0.55890	−3.88807	−1.60193	−4.911	29	0.000
Pair 2	VAR–TOR	−2.587	2.808	0.454	−3.658	−1.565	−4.439	29	0.000

Recommendations

The research acknowledged the fact that variations are almost inevitable in construction, frequent in most types of construction projects and capable of causing risk in educational building projects like any other large projects; however, the following are thus recommended:

- There should be proper and common understanding amongst professionals when interpreting customers' requirements and briefs. If this is done early enough, then it may help in removing the causes of variations that may likely emanate as a result of ambiguous scope of work, errors or discrepancies in interpreting design during the construction stage, where the effects of the variations can be severe.
- Improvement on contractual procedures, elimination of omissions during construction and application of new technology (e.g. building information modelling) will not only eliminate errors and discrepancies or omissions in design but will also afford construction professionals the chance of reviewing effectively the contract documents which could assist in removing the variations arising because of discrepancies in contract documents.
- Reduction in the frequency of changes because of complexity of design or incomplete drawing details should be eliminated through detailed design, though this may be difficult in projects that their scope could not be adequately defined at the outset. This will assist professionals in identifying and reducing the potential causes of variation both during the design and construction phase, where the impact of variations could be significant.

The paper examined the causes and effects of variation orders on educational building projects in the Nigerian construction industry. This will assist project initiators, contractors, consultants and other stakeholders to fully appreciate and understand the significant effects of variation orders on project performance. Further research should examine the impact of variation that may lead to demolition and rework during the construction stage on project delivery using mixed methods.

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Appendix 1

Questionnaire on the analysis of causes and impact of variation order on educational building projects

Questionnaire A: causes of variation orders

Section A: Profile of organisations/respondents.

(1) Professional designation of the officer responding

a. [ ] Architect, b. [ ] Engineer, c. [ ] Quantity surveyor,

d. [ ] Other (Please specify). . .. .

(2) Highest academic qualification of the officer responding

a. [ ] Ordinary National Diploma (OND), b. [ ] Higher National Diploma (HND),

c. [ ] BSc [ ] MSc, d. [ ] PhD, e. [ ] others (Please specify). . .

(3) Years of professional experience (in the Nigerian construction industry) of the officer responding

a. [ ] 1-5 years, b. [ ] 6-10 years, c. [ ] 11-15 years, d. [ ] 16-20 years,

e. [ ] Over 20 years

Section B: Causes of variation orders in building projects.

(4) The following factors have been identified as some of the factors responsible for the causes of variation orders (VOs) in building projects. The "frequency" of occurrence due to the following factors was given on a scale of 1 to 5, where 1 was "not at all" and 5 was "always".

No		**Frequency of occurrence**				
1	Quality failure	**5**	**4**	**3**	**2**	**1**
2	Quality deviation					
3	Poor quality contract documentation					
4	Poor and unbridged communication gap					
5	Lack of proper monitoring and evaluation					
6	Inaccurate briefing					

(*continued*)

7	Non-conformance to project requirement					
8	Lack of understanding and correct interpretation of customer requirement					
9	Defect identification					
10	Lack of proper monitoring and evaluation					
11	Substandard products and services					
12	Incomplete documentation at the time of award					
13	Poor information use					
14	Poor technology application					
15	Checking procedures					
16	Fraudulent practices and kickbacks					
17	Inconsistent government policy					
18	Bad contractual management					
19	Lack of attention to site condition					
20	Ineffective co-ordination and integration of components					
21	Error during design					
22	Omission during design					
23	Error during construction					
24	Omission during construction					
25	Ineffective construction and interrogation of components					

(*continued*)

26	Consultant initiated changes					
27	Inaccurate briefing					
28	Incomplete design information					
29	High cost of materials					
30	Duration of contract period					
31	Improper planning					
32	Inadequate resources					
33	Change in plan and scope by client					
34	Change in specification by client					
35	Poor contract procedure					
36	Error during design					
37	Inadequate work separation					
38	Numerous construction going on simultaneously					
39	Defective materials					
40	Complex drawing details					
41	Contractor initiated charges					
42	Lack of information technology use					

(*continued*)

(5) The following are some of the effects of variation orders on building projects. Rate their effect on project performance on a sliding scale of 1-5 on "severe", where 1 was "not severe" and 5 was "very severe"

	Variables	**Severity**				
		5	**4**	**3**	**2**	**1**
1	Increase in construction cost					
2	Increase in construction time					
3	Client dissatisfaction					
4	Project failure					
5	Contractor dissatisfaction					
6	Total project abandonment					
7	Dispute among the parties					
8	Contractor's financial difficulties					
9	Arbitrator/Litigation					
10	Poor contract management					
11	Lack of commitment					
12	poor post contract relationship					
13	Determination of contract					

(*continued*)

B. Research Proforma: Project characteristics, cost and time data on the effect of variation orders on building projects

(1) Title of the project. . .. .

(2) Location of the project. . .. .

(3) Using Table below, please provide information on completed projects which suffered both time and cost overruns for which you have records.

Project type (public or private)	
Year of execution	
Project size	
Initial sum	
Claims	
Variation order	
Final Sum	
Initial Duration	
Final Duration	

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