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An Investigation of Variation Orders in Building Projects at the University for Development Studies, Tamale

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Abstract
This study provides an overview of the types, causes, effects and management of variations in building projects at the University for Development Studies (UDS). The effects of variations, including but not limited to cost and time overruns, were investigated at UDS in order to implement appropriate management and control practices on their occurrences. A structured questionnaire was administered to 46 building and construction consultants in *UDS. Of this number, which was determined using the Kish (1965) formula for sample size determination, valid data retrieved and analysed represented a response rate of 93 per cent (43). The results of the study revealed that variations constituted not less than 75% of instructions issued at the site and were mainly initiated by the consultant. The occurrence of variations on projects impacted regard to cost and time overruns but was however seen to contribute to the overall improvement of quality in the projects. Recommendations for managing variation orders include effective coordination among consultants, detailed specifications, detailed site analysis and setting up expenditure limits for variations in building contracts at UDS.*

***Key words**: Variation orders, causes, effects, cost, time overruns and building projects*

Introduction

The construction project life cycle has five main phases: initiation, planning, design, execution and handing over (close-out). Various engineering systems are integrated into architectural designs to form a harmonious unit. Changes (variations) in the original scope of works at the construction stage are inevitable (O'Brien, 1998; Ibbs *et al.*,2001). The variation that is issued from a variation order is defined as a means of altering, changing or modifying architectural and engineering designs (Ibbs *et al.*,2001). Changes in the type or standard of any materials or goods to be used, which are not in accordance with the provisions of the contract, will constitute a variation. Most variations are initiated by the clients upon whose failure to make broad analysis, inputs and appraisal at the design stage lead to changes in the original designs. Also, variations are incurred when architectural and engineering design is compounded with flaws and do not meet the national building codes and regulations (Ssegawa *et al*, 2002).

Mendelsohn (1997) observed that approximately 75% of the challenges faced on site originated in the design phase. Errors and omissions in the designs, conflicts between contract documents and inadequate scope of work for the contractor will invariably change the design and bring about variations in the project.

Design complexities and the consultant's lack of knowledge about the available materials and equipment can lead to variations in the final product. The order of variation may occur again at the construction stage when there is no availability or slow delivery of the required materials. Although the impacts of variations vary from project to project, their consequences on projects are often dire (Hester *et al.*, 1991; Barrie and Paulson, 1992; CII, 1994b; Ibbs *et al.*, 2001; Arain *et al.*, 2005). Variation orders in construction projects can cause changes in the contract schedule and in the cost of the project (Tiong, 1990). As much as variation orders can be damaging to projects, they can also be beneficial. A beneficial variation order improves quality standards; and reduces the cost and schedule of the project or the degree of difficulty in a project. It can also reduce unnecessary costs components of a project and for that matter optimises the client's benefits by eliminating unnecessary costs. However, the baselines for successful management should not be whether the project was free of variation orders, but rather, whether the variation orders were resolved timely to the benefit of all parties and the project (Ibbs *et al.*, 2001).

Problem Statement

Properly planned and scheduled construction projects are usually not immune from the appearance of variations before they are completed. Variations are very common and occur from different perspectives during the construction phase (Ming et al. 2004).

The University for Development Studies has so far witnessed the construction of various buildings to enhance academic and administrative work at its campuses. The development of the University infrastructure has been a success. However, there are still gaps between the original designs of the university buildings and the completed structures because of changes in the designs during construction. Projects are sometimes brought to a halt due to the insufficiency of funds.

Variation orders impact the overall performance of the project (Ruben, 2008). However, previous studies on these variations have mainly focussed on the sources and causes of these variations. In view of the foregoing, it is thus necessary to conduct this study to ascertain the specific types and nature of variations on UDS projects and their management for the benefit of the University as it pursues further development of physical infrastructure at the campuses to promote quality tertiary education. Specifically, this study intends to:

1. to determine the prevalence and types of project variations in UDS
2. to investigate the potential causes of variations in UDS
3. to investigate the effects of variations on UDS projects

4. to examine the control measures for managing project variations in UDS

Literature Review

It is said that architectural and engineering designs are successfully executed when the required quality standards are achieved. However, the continuous issuance of variation orders can erode the initial thoughts on the designs of the architect and the engineer and eventually affect the quality of the project. While some studies on variations (Cox, 1997; George D. Calkins et al, 2009; El Karriri, 2011) discussed the legal aspects, others (CII Publication, 1990; Thomas et al, 1994; Hester et al 1991) looked at the effects of changes on labour productivity. Considering the legal aspects of variations, the procurement practice guide publication (2008) considers certain principles should be applied to all variations in the instructions of construction projects that should be within the general scope of the contract unless the contractor agrees otherwise to perform such works. These may include:

- The Architect shall issue in writing to the contractor an instruction for a variation order.
- Variations are issued only after the full cost and time impacts have been evaluated by the contractor and approved by the client for the consultant's further action. This will be done and agreed upon in writing with the contractor.
- It is preferable that the contractor submits a revised quotation for the variation and the contractor will confirm the verbal agreements or written instructions to the consultants.
- The consultants will include in the written instruction a brief description of the variation work and may also attach specifications or drawings for the contractor to execute such change.
- Instructions for variations are allowed only if they are within the authority delegated by the client and can be funded.
- Variations can only occur before the completion of the project unless defects need to be dealt with after the project is completed.

Variations in a construction project can be classified based on the cause that forced them to occur (Burati et al., 1992). Changes in architectural and engineering design have represented a significant number of variations, as categorised below:

- Design changes are caused by improvement through the design process. Examples include changes resulting from design reviews, technological advances, or constructability reviews.
- Design changes originated from the owner. An example is the scope changes.
- Design changes are initiated by an Engineer or Consultant familiar with the process. Examples are the addition of pumps, valves, etc.

Secondly, the classification of variation orders can be influenced by both the reasons for their occurrence and subsequent effects. Arain and Pheng (2005) distinguished two types of variation orders, namely: beneficial and detrimental variation orders.

A beneficial variation is one which improves the quality of the building and reduces the original cost of the project. A detrimental variation could adversely affect the client's resources or reduce the performance of the work (Arain and Pheng, (2005). In this regard, it is imperative and practical that a construction contract provides for variation orders due to the duration and complexities of the design, particularly for prestigious projects. This is due to the daily advancement in technology that demands changes in design. Therefore, the need to adapt according to aesthetic excellence and the changing needs of the environment (Sikan, 1999).

Variations are more common in unit price contracts where the final cost of the project depends on the quantities necessary to carry out the work. Meanwhile, variations are not usually common in lump-sum contracts in which the contractor agrees to provide a specified amount of work for a specific sum.

Materials and Methods

The study population of 55 stakeholders consisted of the under listed who are involved in building construction at UDS and whose activities directly or indirectly have a bearing on construction projects within the University.

a) UDS development committee - 20
b) Consultancy firms - 10
c) Contracting firms - 25

Data for this study were obtained from construction project sites. This included the interpretation of participants' opinions and exploration of the works they executed. Data from memos, site instruction books and other official records were used to establish the preamble for the main quantitative inquiry. Project contract documents that included, drawings, the programme of works, bills of quantities and other relevant materials, were used as a source of information for empirical literature review. The quantitative phase however considered the measurements obtained and the number of characteristics put out by people and events studied

Sampling Strategy

Convenience and snowball sampling techniques were employed in this study. Information was derived from a sample of the population that is well informed about the subject matter. An initial telephonic inquiry was made to invite firms to participate. The study relied upon and built samples through informants. Neutens and Rubinson (2002) reported that persons possessing the characteristics are interviewed, who then identify others that may be added to the study.

Sample size calculation

The sample size is based on a list of registered professional firms in the construction industry located in Ghana and have worked in UDS. The sample size (Table 1) was determined using the Kish (1965) sample calculation formula and applied as follows:

$$n = \frac{n^1}{(1+n^1/N)}$$ Where:

n = Sample Sizeand

$$n^1 = \frac{S^2}{V^2}$$

N = Population Size
S = Maximum standard deviation in the population element
(Total error = 0.1 at a confidence level of 95%)
V = Standard error of sampling distribution = 0.05
P = The proportion of the population elements that belong to the defined class.
$S^2 = P(1-P) = 0.5(1-0.5) = 0.25$
$V^2 = 0.05^2 = 0.0025$

$$\Rightarrow n^1 = \frac{0.25}{0.0025} = 100$$

Table 1: *Sample size allocation for the selected institutions*

Establishments	**Population**	**Number of sample frames**
UDS Development Committee	20	17
Consulting firms	10	9
Contracting firm	25	20
Total	**55**	**46**

Data collection

A pre-test was first conducted on the final questionnaire after reviews were made on it by experts. This was to ensure the validity and reliability of the instrument. The questionnaire was divided into six sections, with instructions for respondents to define the key terms in the study contained in the first section. The second section contains general information about the respondents. The third section addresses the general industry characteristics, whilst the fourth section addresses the causes leading to project variation orders. A list of major causes of variation as read from the literature is presented and the respondent is asked to state the frequency of occurrence of these causes in his projects. The respondents were then given a chance to add other causes and rate them. The fifth section addresses the possible effects of variation orders. The last section in the questionnaire addresses the normally adopted controls of variations in the construction industry and the administrative procedures set to minimise their impact. Questionnaires were personally sent to contractors, consultants and the UDS staff by the researcher.
After sending out the questionnaire (46) and making contact with the respondents over a period of 3 weeks, 43 responses were retrieved, representing93%This consisted of 20 contractors, 10 consultants and 13 staff of UDS. Table 2 shows the percentage distribution of the respondents.

***Table 2:** Percentage distribution of respondents*

Establishments	No. of Respondents	No. of Respondents (%)
UDS Development Committee	13	30.0
Consulting firms	10	24.0
Contracting firms	20	46.0
Total	**43**	**100.0**

Validity and Reliability

Questions were used based on information collected from the literature review and research objectives to provide a representation of the types of variations, their occurrence, impacts and management in building projects. Validity was also ensured as the questionnaires were administered personally by the researcher. Simple language and clarity of the questionnaires were used to provide an easy understanding of the questions.

Again, the reliability of an instrument is built on the fact that the level of standardisation or consistency in pursuing the intended measure of work is achieved (O'Leary, 2004). It is thus proven reliable if the results provided are the same even when it is repeated and with consistency and stability, therefore predictable and accurate. Reliability can also be guaranteed by reducing the sources of measurement error like data collector bias. This was done by the researcher's personal delivery of questionnaires and his friendliness and support. Questionnaires were also delivered during off-peak hours to the UDS staff, contractors and consultants to provide them time to be able to provide the required answers.

Ethical considerations were observed for self-determination, anonymity, confidentiality and seeking consent from stakeholders (respondents, UDS authorities, etc.). The contracting firms and consortiums were pre-informed, and permission was granted to conduct the research with their staff. The firms were also given a background of the study and that the research work was for academic purposes. The willingness of the respondents was taken into consideration before administering the questionnaires.

Results and Discussions

Data gathered from an exploratory study and the questionnaire were analysed and discussed for the research work. A total number of forty-six (46) questionnaires were administered to the clients, who were mainly staff of the UDS, building contractors and consultants. The consultants included architects, engineers, quantity surveyors and clerks of works. Forty-three (43) valid questionnaires were obtained for the data analysis with a response rate of 93% that represented a reflection of the views of the entire population.

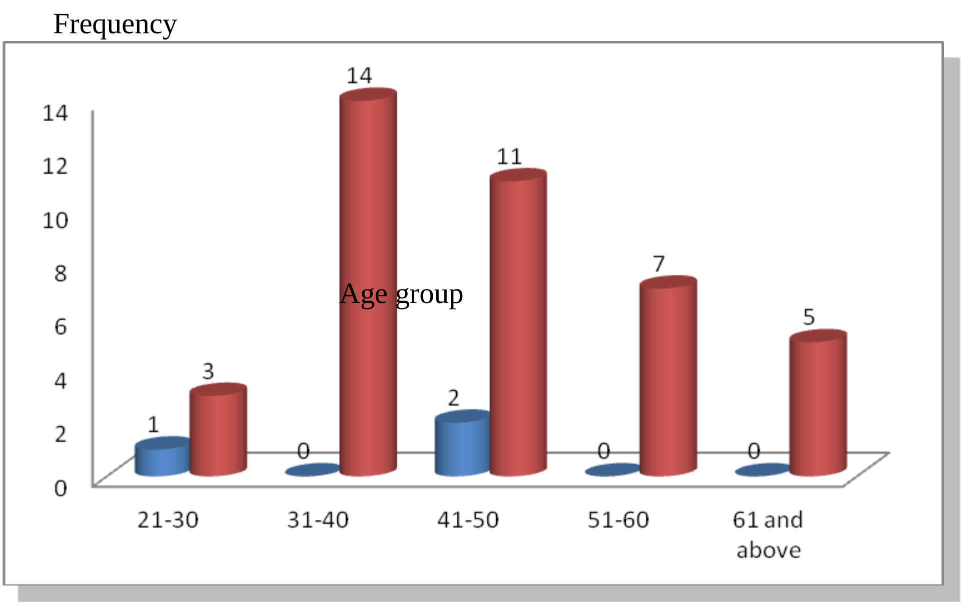
Respondents Background Information

Table 3 indicates the sex of the respondents. Of the responses collected from the study, 40 respondents, representing 93% were male, and 3 respondents, representing 7% were female. Note that the male population showed their dominance in building construction projects at the UDS. Also, a youthful (31– 40) team of stakeholders predominates other age groups in the construction projects and the least age group of project stakeholders at UDS falls within the 21 – 30 age bracket, as shown in Figure 1.

Table 3: *Demography and Age Group of Respondents*

Age Range		**Gender**		**Total**
		Female	**Male**	
21-30	Count	1	3	4
	% within Age	25.0%	75.0%	100.0%
31-40	Count	0	14	14
	% within Age	0.0%	100.0%	100.0%
41-50	Count	2	11	13
	% within Age	15.4%	84.6%	100.0%
51-60	Count	0	7	7
	% within Age	0.0%	100.0%	100.0%
61 and above	Count	0	5	5
	% within Age	0.0%	100.0%	100.0%
Total	**Count**	**3**	**40**	**43**
	% within Age	**7.0%**	**93.0%**	**100.0%**

Figure 1: *Age Group involvement in Projects*



Prevalence and Types of Variations

An exploratory study was conducted at the early stage of the research and investigated two completed projects (the library block and the student hostel block at the Tamale Campus) to ascertain the prevalence of variation orders at UDS. Table 4 shows the analysis of the records of the two completed projects, including site instructions confirming the occurrence of variations, which supports the findings of Ssegawa *et al.* (2002) and Mohamed (2001), that it is hardly difficult to complete a building project without recording changes to the architectural or engineering designs.

Table 4: *Prevalence of Variation Orders in Two Projects*

Description		Library Block		Hostel Block	
No. of site instructions issued		40		51	
No. of instructions (N) constituting variations		N	33	N	40
		%	82.50	%	78.43
Causes of variations	Additional work	N	15	N	9
		%	45.50	%	22.50
	Construction	N	5	N	17
		%	15.15	%	42.50
	Change of specifications	N	11	N	6
		%	33.30	%	15.00
	Site conditions	N	2	N	6
		%	3.06	%	15.00
Origin agents of variations	Client	N	6	N	2
		%	18.18	%	5.00
	Consultant	N	21	N	12
		%	63.64	%	30.00
	Contractor	N	4	N	19
		%	12.12	%	47.50
	Other	N	2	N	3
		%	6.06	%	7.50
Type of contract		Unit Price		Unit Price	

In establishing the type of variation in a building project at UDS, the means shown in Table 5 below were compared. Variations originating from the consultant (1.3256) dominated as the most occurring type of variations followed, by Directed Variation (1.3953). Variation originated by the client is ranked third (1.4186) which is at variance with the views held by Mohammed et. al., (2010) and Al-jishi and Marzoug (2008), that variations are mostly initiated by the client. Another type of variation identified in this study and discussed by Fisk (1997) is directed variation. The high response of the directed variation indicated that variation orders on the projects are mostly executed under formal instructions.

Table 5: *Types of variations in project*

Types of variation		Variation originated by the consultant	Directed variation	Variation originated by the client	Variation originated by the contractor	Constructive variation	Cardinal Variation	Other
N	Valid	43	43	43	43	43	43	43
	Missing	0	0	0	0	0	0	0
Mean		1.33	1.40	1.42	1.60	1.77	1.86	1.98
Std. Deviation		0.474	0.495	0.499	0.495	0.427	0.350	0.152
Ranking		**1**	**2**	**3**	**4**	**5**	**6**	**7**

Causes of Variations

Changes in specifications were reported to be the most frequent cause of variations with a mean score of 1.35. Differing site conditions and funding problems were ranked second (mean = 1.54) and third (mean = 1.56) respectively. Some studies (Apolot et al., 2010; Mohammed et al., 2010) in the built environment also confirmed the occurrence of variation due to changes in specifications.

Table 6: *Causes of variation orders (Overall responses)*

Causes of variations		Change of specifications	Differing site conditions	Funding problems by the client	Lack of stakeholder consultation	Weather	Inadequate working drawings	Errors or omissions in	Lack of experience by the contractor	Lack of experience by the consultant	Change of schedule	Other
N	Valid	43	43	43	43	43	43	43	43	43	43	43
Mean		1.35	1.54	1.56	1.65	1.65	1.7	1.74	1.86	1.88	1.88	2.26
Std. Deviation		.482	.505	.503	.482	.482	.465	.442	.351	.324	.324	2.80
Ranking		**1**	**2**	**3**	**4**	**4**	**6**	**7**	**8**	**9**	**9**	**11**

From Table 6, it is evident that the experience of contractors (1.86), experience of consultants (1.88) and change of schedule (1.88) were the least causes of variation orders.

Effects of Variations

Cost overruns score of 30.1% were the most prevalent effects of variation orders at UDS, followed by time overruns with a 30% prevalence score. The above findings are also found in the Nigerian construction industry from studies carried out by Aibinu and Jagboro (2002) and supported by other studies (Chan and Yeong, 1995; Mohamed, 2001; Arain and Pheng, 2005) reviewed in the literature. Response to improving quality of projects was reported at 28%, indicating that variations are sometimes beneficial to projects. On the general response on whether variation was beneficial or detrimental, an overwhelming 74.4% of respondents agreed that variation orders are beneficial to UDS as 20.9% of the respondents reported otherwise. However, 4.7% of respondents could not determine whether or not variations were beneficial (Figure 2).

This however defies the position held by Koushki (2005) that variations are generally detrimental. Table 7 also established the fact that disputes between parties were quite insignificant as it recorded a low 2.7%. The reason could be that contracts have always addressed the issue of variations and payments for variations are always made.

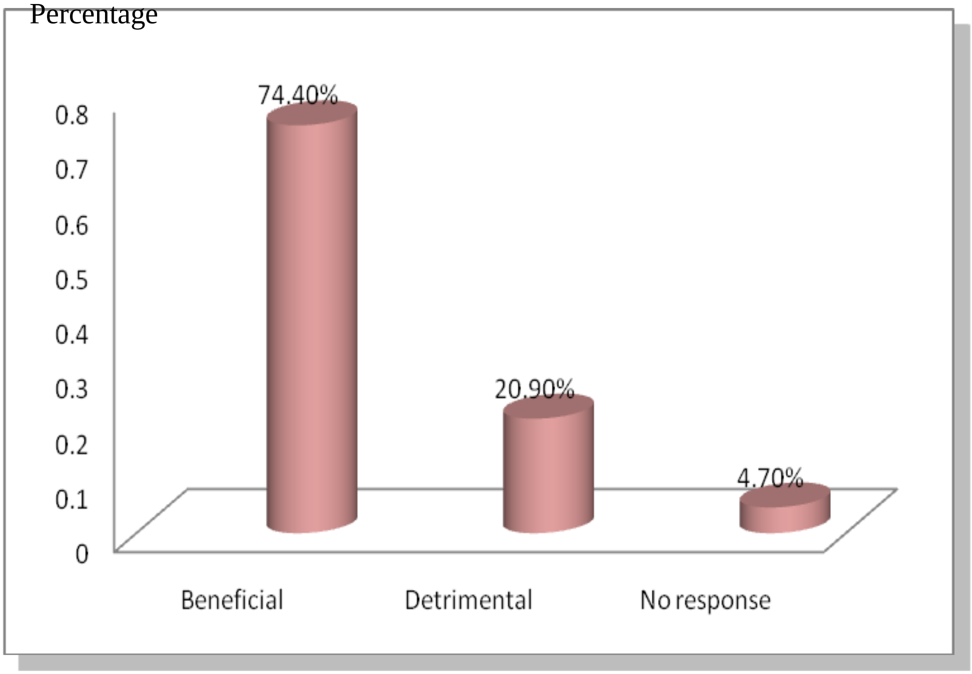
Table 7: *Effect of variation order according to means*

Effects of variations	Overall degradation of quality	Professional reputation	Time overrun	Cost overrun	Disputes between parties and the consultant	Overall improvement of quality	Time reduction	Cost reduction
N	7	9	30	34	3	28	1	1
%	6.1	8.0	26.5	30.1	2.7	24.8	0.9	0.9
Mean	1.837	1.791	1.302	1.209	1.930	1.349	1.977	1.977
SD	.3735	.4116	.4647	.4116	.2578	.4822	.1525	.1525

Thus, the four most prevalent effects from the above table are listed below:

1. Cost overruns
2. Time overruns
3. Overall improvement of quality
4. Professional reputation

Figure 2: *Beneficial and Detrimental variation orders*



Control measures and management of variations

The following comments were obtained from consultants and contractors, which are intended as guiding principles to effectively control and manage the occurrence of variations on the projects.

1. Adherence to bills of quantities when instructing contractors on variations to be guided by the contingencies made available for any possible variations and protect the contract sum from excessive changes. This is supported by Soujeri (2010).
2. Encouraging stakeholder participation in project initiation and regular monitoring of construction projects by the stakeholders. This management method is similar to the project risk and management model developed by Stare (2011).
3. Detailed site investigations should be conducted and properly shown in drawings with clarity. All specifications should also be properly detailed in the drawings and research for new but affordable building materials done before finalising the working drawings and preparing tender documents. This will maximise construction performance as postulated also by Al-Sedairy (2001)

Conclusion

Prevalence and Types of variations

The study found that variation orders were prevalent in the construction projects at the UDS. It was also revealed that not less than 75% of site instructions constituted variation orders. It was established that the consultant as an origin agent, was the most occurring type of variation orders with a mean of 1.33 followed by directed variation (1.40). Variation originating from the client (1.42) was ranked third.

The change in specifications was reported to be the most frequent cause of variations with a mean score of 1.35. This was followed by differing site conditions (1.54) and funding problems by the client (1.56) was third. The results reported cost overruns (30.1 %) as the most prevalent effects of variations orders at UDS. This was followed by Time overrun with a 30 % prevalence score.

Despite the recorded overruns in time and cost, the University benefited from the occurrences of variation orders since the improvement in overall quality of work was reported third with 24.8 %. Omissions from a design that could reduce time and cost had little influence on the causes of variations and this was reflected in the effects of variations as a reduction in time and cost recorded at 0.9 % each.

Lastly, factors such as disputes arising out of variation orders that could potentially delay the completion date or cause substantial damage to the project were not significant as an effect on the projects at the UDS. At a reported value of 2.7 %, the research showed that parties to the projects and other documentation for the successful execution of the project were managed effectively.

The study identified the adherence to Bills of Quantities as a guide to effective control of variations. It also recognized the need to involve all stakeholders at the initiation of projects and to conduct detailed site investigations before the production of working drawings and specifications.

Recommendations

Variations originating from the consultants, directed variation and variation emanating from the client were revealed as the various types of variations in the study. It is recommended that consultants in the design team coordinate closely and ensure that the client provides a clear brief of the scope of work to identify all factors associated with the usability of the project, to eliminate the possibility of variations during construction.

The most frequent cause of variations was a change of specifications and can be brought under control when consultants produce working drawings with detail specifications for materials for the projects. It is also recommended to do detailed site analysis with the geological and geodetic engineers prior to the preparation of the working drawings to reduce the effect of differing site conditions as the second most frequent cause of variations. Funding problems by the client were the third most contributing cause of variations. It is recommended for the UDS to make adequate financial planning and secure alternative funding for projects at the campuses to complete projects on schedule.

Cost and time overrun mainly affect the execution of projects in UDS due to variations. The effect could be lessened if an appropriate management control system such as including estimated variation amounts is construction contracts. Appropriate scheduling of project completion dates is also recommended to take care of variations.

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