J. Inst. Eng. India Ser. A
https://doi.org/10.1007/s40030-019-00423-6

ORIGINAL CONTRIBUTION

Assessment of Value Engineering Implementation in the Ghanaian Construction Sector

Humphrey Danso[1] · **Richard Osei Kwadwo**[1]

Received: 5 December 2018 / Accepted: 16 December 2019

Abstract One of the contemporary management techniques aimed at eliminating unnecessary cost and waste while optimizing full benefit of projects, especially in the building and construction sector, is value engineering. This study assesses the implementation of value engineering in the Ghanaian construction sector. The study adopted cross-sectional survey with stakeholders consisting of architects, contractors, project managers, civil and structural engineers, and consultants of construction and consulting firms. Snowball sampling technique was used through its nucleus to reach construction firms and respondents who practice value engineering but are difficult to trace. Questionnaire was used to collect data using a five-point Likert scale. Quality control and renewal of old ideas emerged as the meaning of value engineering regarding construction professionals' understanding of the concept. The factors that encourage values engineering implementation identified by the respondents include: reduced wastage of resources, quality improvements, reduced conflict and risks, efficient labour, creation of a climate of shared understanding, definition of programme objectives, early improvement, understanding of the needs and function, savings that can be redirected to add value, improved communication between the parties, and local material usage. Five main components identified as responsible for non-adoption of value engineering include: knowledge barrier, demand barrier, awareness barrier, readiness barrier, and human resource barrier. The study therefore concludes that value engineering stands feasible for implementation in the Ghanaian construction sector if the identified factors to the non-adoption are eliminated while adopting appropriate strategies to promote the factors that encourage its implementation.

Keywords Construction sector · Construction professionals · Ghanaian construction sector · Value engineering

Introduction

Value engineering is a technique that uses problem solving approach to creative function(s) that deliver the required quality of project and at the same time minimize cost [1–3]. It should not be associated with the traditional cost reduction techniques [4]. It goes beyond cost reduction, by considering a broader process that incorporates functional and quality ways of managing construction activities in order to achieve best value. It can, therefore, be practiced during all levels of construction activities such as pre-construction, construction and post-construction stages. Typically, value engineering has benefit of savings in project cost by eliminating unnecessary cost, proving project quality, saving time, better project objective understanding, and enhancing the value of the project [5].

Tagged as a key sector in growing the economy, the construction sector is tasked to generate income as well as provide employment [6]. The construction sector in Ghana is in its primary stage in terms of advanced management technologies and skills [7]. There is the need to relate and adapt a more advanced tool in creating a better product and improved construction process [8, 9]. Various studies have laid bare the essence and impact tapped from the use and

✉ Humphrey Danso
hdanso@uew.edu.gh; dansohumphrey@yahoo.co.uk

[1] Department of Construction and Wood Technology, University of Education Winneba, P. O. Box 1277, Kumasi, Ghana

Published online: 27 December 2019

practice of value engineering in construction. Atabay and Galipogullari [10] and Ahmed and Pandey [11] explained that the benefits earned from the application of value engineering include schedule savings, improve procedure, services and products in respect to cost, time and quality. Furthermore, Kemmochi and Koizumi [12] mentioned the significance accrued from the practice of value engineering on projects, such as identifying and removing unnecessary costs, enhancing understanding of total project, developing realistic budgets, improving decision making, encouraging cross-discipline communication and accelerating the design process. Currently, the practice of value engineering is being applied in many countries around the world. For example, market such as USA, UK, Japan, Canada, Australia, China and India has gained immensely in their respective economies by the application of this approach [11].

However, as a tool in promoting innovation in the construction sector, value engineering faces barriers that stifle its smooth implementation. Studies have revealed that to apply value engineering in better way, hindrances to its application must be eliminated [13]. This goes to help practitioners assess the challenges in applying value engineering and undertake appropriate strategies for acceptance of the value engineering methodology. Simister and Green [14] revealed that, to avoid value engineering implementation failure, factors such as expectation, power, participation, lack of time and uncertainty about the project should be considered. Some of the challenges with the application of value engineering include the lack of experts, lack of policy, obstructions, implementation challenges, the lack of strategies and wrong perception [13–16].

The Ghanaian construction sector is earmarked as developing, and the use of value engineering is unpopular though evidence suggests its application at some parts of the sector [7]. Few construction firms in Ghana apply value engineering techniques in reducing cost, and for enhancing quality, it is the foreign consulting firms such as the Korean and Japanese firms that apply the process to reduce costs and enhance the quality [17]. Carefully juxtaposing the benefits with the barriers that come with the use of value engineering, studies have proved little of its capability for implementation within the construction sector in Ghana,

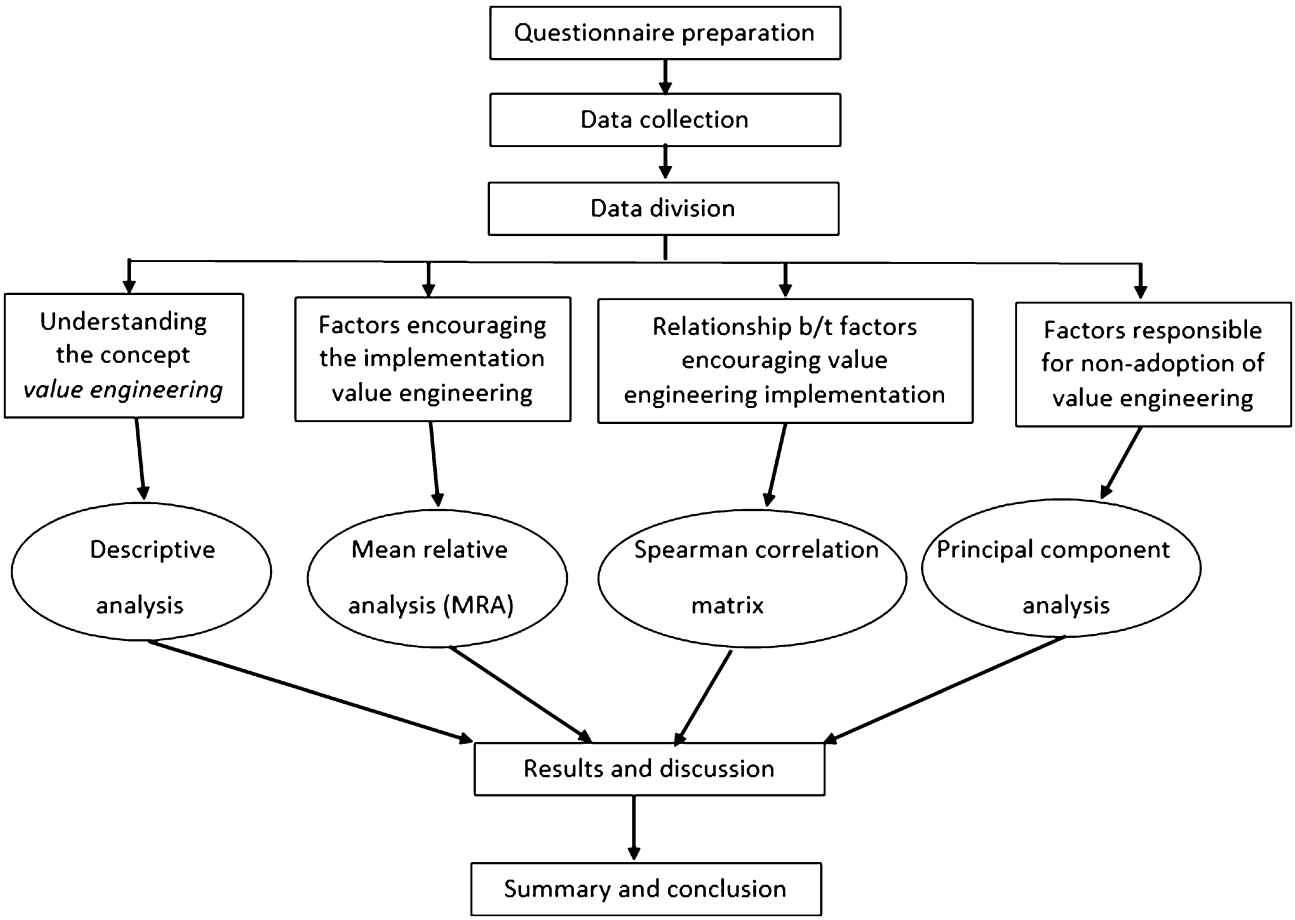

Fig. 1 Flowchart diagram of the research process

thus opening up a deficit in knowledge. This study, therefore, seeks to investigate the implementation of value engineering in the context of the Ghana within some selected cities. This could prepare the grounds and also serve as a window of opportunity for practitioners to effectively implement the techniques. The purpose of the study is to assess the implementation of value engineering in the construction sector in Ghana. The objectives are (1) find out the understanding of the concept of value engineering, (2) identify the key encouraging factors to value engineering implementation, (3) determine the relationship between the encouraging factors to the implementation of value engineering, and (4) identify the factors accountable for non-adoption of value engineering in Ghana. Figure 1 presents the flowchart of research process.

Methodology

The research adopted cross-sectional survey to study a sample of the population. The study was conducted across participants over a period and apparently didn't warrant to make follow-ups of the participants captured. The study was conducted within three geographical towns in Ghana, namely Sunyani, Kumasi and Accra. These towns were selected due to the huge presence of foreign direct investors (China, Portugal, Brazil, etc.) who virtually practice value engineering in their line of work. Also, capital intensive construction projects dominate these towns and they are characterized by massive construction and infrastructure development projects. The population of the study consisted of architects, contractors, project managers, civil/structural engineers, quantity surveyors and consultants of construction and consulting firms who are involved in the practice of value engineering. A distinctive feature of value engineering is its multidiscipline team approach which calls for such experts in the construction sector for its evaluation entirely [18]. Snowball sampling technique was used through its nucleus to reach construction firms and respondents who practice value engineering but were difficult to trace. Snowball technique is a sampling technique which the initial participants of the research help in recruiting other participants for the study [19]. A total number of the construction professionals who were traced for the study were 117.

Questionnaire was used to collect data through field surveys from primary sources on respondents' level of understanding of value engineering, reasons for its non-adoption and factors that encourage its implementation. As an effective instrument, its development was supported by literature using five-point Likert scale responses. The questionnaires were pre-tested and obtained a 0.845 Cronbach alpha which is above the 0.7 recommended threshold [20]. Out of the 117 questionnaires distributed, 100 were returned indicating a response rate of about 79%. After screening the returned questionnaires, 8 were found to be improperly completed, leaving 92 as useful questionnaires for analysis. Statistical Package for Social Sciences (SPSS) 20 and Microsoft excel software were used to analyse the data. *One sample t test* was used to establish significant differences in respondents' opinions in assessing their understanding of value engineering concept. The study also used factor analysis to summarize the data appropriately to principal dimensions in dealing with the reasons for non-adoption of value engineering in the construction sector in Ghana and the main factors that encouraged its implementation. In ranking the principal factors, mean relative analysis (MRA) was adopted. The calculation was done with the formula:Table 4

$$MRA = \frac{(5n5 + 4n4 + 3n3 + 2n2 + 1n1)}{(n5 + n4 + n3 + n2 + n1)}$$

where n5 to n1 are numbers of responses to the questionnaire from highly encourage to highly discourage. Spearman correlation matrix was used to determine the relationship between the factors.

Table 1 Respondents' demographic characteristics (n = 92)

Characteristics	Categories/options	Frequency	Percentage
Profession	Architect	24	26.1
	Structural engineer	13	14.1
	Project manager	20	21.7
	Quantity surveyor	21	22.8
	Contractor	14	15.2
Occupation relative to sector	General consultancy	43	46.7
	Architectural consultancy	16	17.4
	Quantity surveying firm	20	21.7
	Civil/structural engineering consultancy	13	14.1
Education	B.Sc. honors	53	57.6
	PG diploma	11	12.0
	M.Sc/M.Eng	12	13.0
	M.Phil.	12	13.0
	Ph.D.	4	4.3
Work experience	5 years or less	17	18.5
	6–10 years	21	22.8
	11–15 years	45	48.9
	Above 15 years	9	9.8

Results and Discussion

This section of the paper presents the results and further discusses the findings. The section is sub-divided into demographic characteristics of respondents, the

Table 2 Level of understanding of value engineering (n = 92)

Factor	Mean	SD	t	Sig. (p value)	Remark
Cost cutting	3.89	1.094	− .953	.343	Disagree
Design review	3.85	.825	− 1.77	.080	Disagree
Quality control	4.07	.899	.696	.019	Agree
Reduction of project profit	3.73	1.168	− 2.23	1.000	Disagree
Renewal of old ideas	4.00	1.059	.000	.028	Agree
Reduction of quantities	3.74	1.047	− 2.39	.488	Disagree
Use of cheap materials	3.58	1.424	− 2.86	.065	Disagree

understanding of value engineering concept, factors that encourage the value engineering implementation, relationship between the factors of value engineering the implementation, and the factors that are responsible for the non-adoption of value engineering.

Demographic Characteristics of Respondents

Information on demographic characteristics of respondents is presented in Table 1. This focuses on the respondent's academic background, professional background, relativeness of their job to the construction sector and work experience.

Understanding Value Engineering Concept

Table 2 represents the descriptive analysis of the level of respondent's understanding of value engineering concept. The findings depict variation in the mean values clearly indicating a fall of some of the values below the hypothesized mean of 4.0. This cut-off was chosen in order to determine the critical or major factors that were above the average value. This decision was influenced by the respondents' ratings on a five-point Likert response scale of between strongly agree and strongly disagree. 'Quality control' recorded the highest rating (mean = 4.07), followed closely by 'renewal of old ideas' (mean = 4.00). This indicates the respondents' understanding of value engineering as a concept means a quality control and at the same time a renewal of old ideas in the construction process.

The respondents' opinion on the other five factors: cost cutting, design review, reduction of project profit and use of cheap material, falls below the hypothesized mean on understanding value engineering concept. A significance level ($p < 0.05$) was used, rendering quality control and reward of old ideas to be statistically significant.

Mario [21] describes quality control as process of verifying work and materials to satisfy the applicable standards as specified within the project objectives. This falls in the ambit of value engineering as a tool that identifies unnecessary cost and determines to eliminate them from the project [10]. Sharma [22] explains that value engineering is not limited only to value improvement but also preserves the quality and function of the design. Maintaining quality in this regard places quality control as an element of value engineering attuned to its understanding by practitioners in the construction sector. Renewal of old ideas was the next element that emerged as the respondents' level of understanding of value engineering. Prashant and Teli [1] explain vale engineering as a process that uses creativity and teamwork to improve value of a design.

The result shows a strong disapproval to cost cutting, design review, reduction of project profit, reduction of quantities and use of cheap labour as the meaning of the concept of value engineering. This aligns with Prashant and Teli [1] that value engineering is not about cutting down cost or making project cheap. Similarly, Atabay and Galipogullari [10] explained that the concept of value engineering is not cost reduction of project but rather a systematic way of improving value of the product and the services through functional activities. Agreeably, Dutta [23] and [24] point out that the concept of value engineering does not centre on the cost or standard reduction of the project. The ability of the practitioners to sideline the factors mentioned from the proceedings of this argument justifies their consciousness of the existence of value engineering of the construction sector in Ghana. The possibility of implementing value engineering in the Ghana is promising but requires appropriate understanding of the concept of the entire process [25]. The advantages of implementing value engineering in the construction sector in Ghana are enormous [15].

Factors that Encourage the Implementation of Value Engineering

Mean relative analysis (MRA) was used to analyse the factors that encourage value engineering implementation. The result in Table 3 shows the weight and rank obtained by each item dependent on the ratings obtained by each

Table 3 Ranking of the factors

Factors	1	2	3	4	5	TOTAL	∑W	MRA	Rank
Reduced wastage of resources	3	2	4	39	44	92	395	4.29	1
Quality improvements	1	2	8	41	40	92	393	4.27	2
Create ideas for improved outcomes	1	4	8	47	32	92	381	4.14	3
Reduce conflict and risks	0	2	16	41	33	92	381	4.14	3
Efficient labour	0	6	11	39	36	92	381	4.14	3
Create climate of shared understanding	3	1	13	38	36	92	376	4.13	6
Better definition of project objectives	2	1	14	44	31	92	377	4.10	7
Early improvement	2	2	11	53	24	92	371	4.03	8
Better understanding of needs/functions	3	3	12	43	31	92	372	4.04	9
Savings redirected to add value	0	5	16	43	28	92	370	4.02	10
Improved communication between parties	0	4	19	40	29	92	370	4.02	10
Better understanding of the project	0	5	17	39	31	92	370	4.02	10
Local material usage	2	3	16	41	30	92	370	4.02	10
Programmers staged/phased to allow progress	2	4	16	41	29	92	367	3.99	11
Time savings (schedule savings)	3	6	14	35	33	92	362	3.98	12
Cost reductions	4	2	13	47	26	92	365	3.97	13
Client insight into the project	1	5	19	39	28	92	364	3.96	14

using MRA to assess the factors on five-point scale from highly encourage to highly discourage.

From Table 3, it can be observed that the main factors ranked by the respondents as per the hypothesized mean of 4.0 include: reduced wastage of resources, quality improvements, create ideas for improved outcomes, reduce conflict and risks, efficient labour, create a climate of shared understanding, better definition of project objectives, early improvement, better understanding of the needs and functions, savings can be redirected to add value, improved communication between the parties, and local material usage.

Reduced wastage of resources was ranked first by the respondents. Resources can be in the form of materials, time, labour, among others. Value engineering seeks waste reduction and also aims at increasing the value of the project through good management of resources [26]. This view is supported also by Atabay and Galipogullari [10] who explained that value engineering uses rationalist evaluation techniques that exposes unnecessary costs of the project that has the potential of increasing the resources such as finance, workforce and materials.

Quality improvement, another important determinant that encourages the implementation of value engineering, was ranked second. Reduction of risk is just one of the benefits enjoyed besides improving the value of a product. SAVE International [18] elaborates further that value engineering is a multidisciplinary group that houses experienced professionals, experienced and experts in their respective fields. Such experts are keen on ensuring that products and services comply with requirements according to set standards so as to attain and improve quality.

The fundamental component from which value engineering is carved is derived from the ability to use alternate ideas and apply creativity to a project while focusing on reducing cost, improving product or both [27]. This goes to expand the third ranked factor of creating new ideas which in the rightful place corroborates possibility of implementing value engineering the construction sector. Prashant and Teli [1] explain that, as a problem solving approach, value engineering requires thinking and creative abilities to fulfil its requirements. Encouraging critical thinking and creative minds in the construction sector positions this proposition significant in its implementation in the construction sector [28].

Ranking fourth was reduction in conflict and risks. Value engineering follows a structured, disciplined procedure opposed to the interest and opinions of an individual [29]. This systematic process is carried out and supervised by experienced multidiscipline team that are pulled together from their respective disciplines [30]. With clearly defined project goals and objectives, the elimination of any obstructions and incompatibilities is prevalently on the high. This in totality goes to enhance its implementation in the construction sector [1].

Fifth among the factors was efficient labour. Boorman [31] suggests that value engineering is very influential in undertaking the responsibility of putting the parties involved in construction activities together to make them efficient and effective. Thompson and Rizova [32] explain that value engineering allows weakness in operation to be

Table 4 Relationship between encourage factors to the implementation of value engineering

Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Cost reduction	1																
Time saving	.420**	1															
Quality improvements	.253*	.472**	1														
Reduced waste of resources	.268**	.271**	.500**	1													
Better understanding of needs/functions	.471**	.280**	.323**	.470**	1												
Create new ideas for improved outcomes	.356**	.249*	.480**	.268**	.431**	1											
Create climate of shared understanding	.338**	.267*	.413**	.517**	.464**	.368**	1										
Reduce conflict/risks	.157	.111	.445**	.495**	.280**	.345**	.509**	1									
Better understanding of project	.274**	.146	.334**	.249*	.349**	.412**	.332**	.418**	1								
Better definition of project objectives	.162	.234*	.212*	.172	.267*	.254*	.119	.228*	.510**	1							
Programmers staged/phased to ensure progress	.244*	.318**	.229*	.267*	.288**	.387**	.375**	.289**	.194	.318**	1						
Client insight into the project	.295**	.209*	.197	.254*	.430**	.391**	.434**	.245*	.454**	.400**	.439**	1					
Savings redirected to add value	.114	.270**	.339**	.248*	.226*	.377**	.278**	.281**	.280**	.282**	.417**	.504**	1				
Improved communication between the parties	.242*	.182	.138	.219*	.434**	.162	.346**	.180	.392**	.225*	.168	.444**	.407**	1			
Early improvement	.267*	.254*	.299**	.132	.359**	.339**	.173	.207*	.491**	.345**	.284**	.284**	.204	.270**	1		
Local material usage	.279**	.223*	.250*	.216*	.086	.242*	.314**	.355**	.258*	.234*	.227*	.225*	.177	.225*	.295**	1	
Efficient labour	.284**	.177	.445**	.429**	.390**	.227*	.489**	.420**	.290**	.303**	.191	.404**	.264*	.311**	.245*	.323**	1

*Correlation is significant at the 0.05 (2-tailed)

**Correlation is significant at the 0.01 (2-tailed)

eliminated and, thus, halt the injection of capital into the operation which is of no value to the client but only creates cost. Value engineering is focused on ways of maximizing revenue. Maximizing revenue also is dependent on efficient labour [33]. Knowledge of such correlation can impact on the technically capabilities of the workforce to boost its implementation.

Relationship Between the Encouraging Factors to Value Engineering Implementation

A bivariate correlation was carried out to determine the relationship between the encouraging factors to the implementation of value engineering. Correlation matrix of the encouraging factors to the implementation of value engineering analysis is displayed in Table 4. There are both positive and negative relationships between the factors. Most of the factors correlated above 0.3 and multicollinearity is noticed as was also identified in the study by Danso and Obeng-Ahenkora [34]. The highest correlation coefficient was 0.510 existing between *better understanding of project* and *better definition of project objectives* at a significant level ($p < 0.01$). The factor *better understanding of project* further had a positive relationship with *early improvement* with correlation coefficient of 0.491. This implies that to implement a technique successfully, it is therefore appropriate to have a very clear understanding of the project so that it can be defined within the context of its objective. With clearly defined project goals and objectives, the elimination of any obstructions is prevalently on the high. This in totality goes to enhance the implementation of the value engineering technique within the construction sector [1]. As structured systematic procedure, any specified standard outlined in the project objective which does not lead to an increase in the projects value and resources are easily detected and dealt with [35].

There was correlation coefficient of 0.509 existing between *creation of climate of shared understanding* and *reduce conflict/risk* at $p < 0.01$. It was followed by correlation coefficient of 0.495 existing between *reduced waste of resources* and *reduce conflict/risks*. *Creation of a climate of shared understanding* further had a positive relationship with *efficient labour* with coefficient correlation of 0.489. Implying that if conflict and risk on construct sites

Table 5 Factors responsible for the non-adoption of value engineering ($n = 92$)

Factors	Component				
	1	2	3	4	5
Lack of legislation for use of VE in construction sector	.723				
Lack of professionals for construction works	.655				
Non-cooperative attitudes from other participants	.643				
Lack of contractual provision for implementations of VE among owners	.643				
Unqualified VE facilitators	.555				
Unstable economy	.528				
Lack of knowledge and practices	.524				
Technology level	.510				
Outdated standards and specification	.422				
Clients don't often pay for the services		.757			
Clients don't often request for the services		.739			
Not suitable for low cost projects		.620			
Procurement style		.554			
Inadequate finance/funding			.816		
Inadequate knowledge of benefits of value management			.678		
Lack of understanding by client organizations			.551		
Lack of active involvement of stakeholders			.549		
Lack of culture to accept changes			.524		
Lack of theoretical basis to underpin the field of value engineering in higher institutions of learning				.688	
Inadequate time to test appropriateness of the ideas generated				.587	
Lack of local guidance/information				.584	
Non-involvement of building services contractors				.557	
Lack of professionals in VE management					.805
Lack of VE experts					.738

are reduced, then the impact of factors such as creating a climate of shared understanding, reduced wastage of resources and labour efficiency will increase. The understanding of this knowledge by practitioners would foster smooth value engineering technique implementation in the construction sector [36].

Quality improvements had a positive correlation with *reduced wastage of resources* at correlation coefficient of 0.500. There was also a positive relationship between *quality improvements* and *creation of new ideas for improved outcome* with correlation coefficient of 0.480. Also, *time saving* had a positive relationship with *quality improvements* at 0.472 correlation coefficient. Furthermore, *cost reduction* correlated positively with *better understanding of needs/functions* at 0.472 correlation coefficient. This suggests that when quality improvement is created, it will reduce wastage on site, provide improved project outcome and save time, thereby reducing the associated overruns within the construction projects [37, 38]. Quality improvement helps to reduce risk, saves time and provides the benefits of improving the value of a product.

Factors Accountable for Non-adoption of Value Engineering

Result on the reasons for non-adoption of value engineering technique within construction sector is presented in Table 5, which provides a summary of result using factor analysis to ascertain the reliability and confidence of the dataset, as was also identified in a study by Obeng-Ahenkora and Danso [39]. The factors were adopted from literature which was used to prepare the questionnaire with a five-point response Likert scale. Results obtained were based on 92 responses. Factor analysis was used to analyse the interrelationship among factor with their common dimensions. Although the eigenvalue of 1 or greater picked six factors, five were selected which explained about 59% of total variance (Table 6) meeting the set standard of explaining 5%. Relatively, the breakdown of the accrued percentage explained individually was 27.46%, 9.032%, 8.785%, 7.229% and 6.323% with each corresponding with components 1 to 5, respectively. This relation was further consolidated by the scree plot displayed in Fig. 1, which identified five factors also. Each component had at least two clusters of variables.

To ascertain the reasons for non-adoption of value engineering in the construction sector, Table 5 outlines a clearer picture of the factors loaded onto the various components using the varimax method of rotation. The existing factors for component one were the lack of professionals for construction works, non-cooperative attitudes from other participants, the lack of contract provision on implementations of value engineering among owners, unqualified value engineering facilitators, unstable economy, the lack of knowledge and practices, technology level, outdated standards and specification, and the lack of legislation concerning the use of value engineering. This was labelled as *knowledge barrier* and explained 17.3432% of the variance. Four factors were loaded onto the second component, and they were clients don't often pay for the services, clients don't often request for the services, not suitable for low cost projects, and procurement style. These factors explained 11.7842% of the variance and thus named *demand barrier*. The third component that explained 11.1992% consisted of inadequate finance/funding, inadequate knowledge of value engineering benefits, the lack of understanding by client organizations, the lack of active involvement of stakeholders, and the lack of culture to accept changes which were also labelled as *awareness barrier*. Factors such as: the lack of theoretical basis to underpin the field of value engineering in higher institutions of learning, inadequate time to test appropriateness of the ideas generated, the lack of local guidance and information, and non-involvement of building services contractors, constituted the fourth component, explaining 10.0582% of variance. This subsequently was captioned as *readiness barrier*. Eventually, the fifth component had the following as their factors: the lack of trained professionals in value management and the lack of VE experts. This

Table 6 Total variance explained

Components	Total variance explained								
	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %	Total	Variance %	Cumulative %
1	7.139	27.46	27.46	7.139	27.46	27.46	4.509	17.3432	17.3432
2	2.348	9.032	36.492	2.348	9.032	36.492	3.064	11.7842	29.1274
3	2.284	8.785	45.277	2.284	8.785	45.277	2.912	11.1992	40.3266
4	1.879	7.229	52.506	1.879	7.229	52.506	2.615	10.0582	50.3848
5	1.644	6.323	58.829	1.644	6.323	58.829	2.195	8.4432	58.828

Extraction method: principal component analysis

Table 7 Kaiser–Meyer–Olkin and Bartlett's test

Kaiser–Meyer–Olkin (KMO) and Bartlett's test	
KMO measure of sampling adequacy	.714
Bartlett's test of sphericity	
Chi-square	921.127
df	325
Sig. (*p*)	.000

component explained 8.4432% of variance and was named *human resource barrier*.

In addition to the variables analysed, Table 7 presents an overview of results from the Kaiser–Meyer–Olkin measure of Sample Adequacy and Bartlett's Test of Sphericity. The Kaiser–Meyer–Olkin (KMO) value of 0.714 and the Bartlett's test (Chi-square = 921.127, $df = 325$ and $p < 0.000$) significantly warrant factor analysis to proceed as it proves sampling adequacy and also provides enough evidence to reject the null hypothesis of identity matrix.

Component 1: Knowledge Barrier

The principal component described 27.46% of the total variance with nine (9) factors contributing to non-adoption of value engineering in the construction sector. This component reveals one of the many reasons for non-adoption of the value engineering in the construction sector of Ghana. Knowledge in value engineering envelops its principles, applicability, methodology and its benefits. The barrier in knowledge creates a chain of unqualified value engineering experts, incompetent value management team, inadequate professionals, influx of wrong ideas and attitudes among others. Kim et al. [13] in their study conducted in Vietnam found similar result and therefore introduced foreign certification system granted by SAVE International [18] and also trained more value engineering experts. Adapting this intervention will enlighten and broaden the knowledge base of practitioners and encourage its adoption in the Ghanaian construction sector.

Component 2: Demand Barrier

The component 2 (demand barrier) explained 9.032% of the overall variance which consists of four (4) factors loading onto it. Client's commitment as suggested by Al-Yami and Price [40] was among the five major hindering factors of value engineering implementation in Pakistan. Clients are often limited in knowledge as well as advice or guidance in value engineering application. A concern attributed extensively to the lack of value engineering experts; clients in a great deal take this value improvement technique as an embodiment of the whole project cost. The clients become reluctant in paying for this extra cost in implementing the process as they are completely naive of its returning benefits. Sometimes blurred with the understanding of incurring extra cost, clients request for this approach is often stifled. Interestingly, many practitioners devoid of this practice rate the traditional procurement system of cost cutting even to the value engineering process. This sends a strong notification of their unawareness of the impact of this tool in the Ghanaian construction sector.

Component 3: Awareness Barrier

The third principal component explained 8.785% of the overall variance consisting of five (5) factors. Inevitably, accepting change in our part of the world both in deed and in practice is very challenging. Still glued to the traditional methods, we turn to embrace value engineering into our system. Typical in practice is the use of Bill of Quantities which gradually is diminishing [41]. A study by Kelly and Male [42] emphasized surveyors in this area; specifically those in large firms are changing from the usual roles to a development of management service. Many in the Ghanaian construction sector fear this technique may scrap off their profession and even add little or no improvement to the traditional method. This belief has generated in them a hostile perception restraining them from becoming aware of the new methods, and participation or involvement in the construction sector. This is further explained by Cheah and Ting [43] that none awareness of the knowledge about value engineering causes limitation in its use. An intensive training by way of seminars and workshops for practitioners will bring them up to speed with the current trends and processes of value engineering in the construction sector.

Component 4: Readiness Barrier

Principal Component 4 had four factors loading onto it and explained 7.229% of the total variance. Some experts in the Ghanaian construction sector as well as owners may have little or no idea of value engineering. Kim et al. [13] suggest that, little awareness of value engineering and engineering application can result in lack of interest and confidence from construction parties. Many owners still remain clouded as they equate cost cutting to value engineering. They argue that this technique consumes time and add extra cost to the project. Overriding this barrier and making it beneficial while aiming at improving awareness are that seminars and training workshops should be organized to update and upgrade owners and practitioners in the construction sector. This can help them to appreciate better

the need for value engineering so as to support and encourage its implementation [44].

Component 5: Human Resource Barrier

This principal component explained 6.323% of the total variance with two factors loading onto it. Value engineering is a process which employs creativity and functional analysis to achieve value [11]. The proceedings clearly indicate the features bonded to value engineering in terms of training, requisition, and sense of competency one has acquire to be qualified before applying value engineering [44]. There is shortage of experts, knowledge and trained professionals in value engineering in the construction sector [13]. A remedial to this barrier places responsibility on the Ghanaian construction sector to invite experts from countries advanced in this methodology to train practitioners in this direction [12]. Additionally, engaging in exchange programmes with such countries to learn and gain this body of knowledge will result in obtaining qualified engineers for the domestic construction sector [36].

Summary and Conclusion

The study assessed the implementation of value engineering in the construction sector of Ghana. The objectives were to find out the understanding of the concept of value engineering, identify the key encouraging factors to value engineering implementation, determine the relationship between encouraging factors to the value engineering implementation, and identify the factors accountable for non-adoption of value engineering in Ghana. Quality control and renewal of old ideas emerged significantly as the meaning of value engineering regarding the professionals understanding of the concept. The key encouraging factors identified by the respondents include reduced wastage of resources, quality improvements, creation of new ideas, reduced conflict and risks, efficient labour, creation of a climate of shared understanding, early improvement, better understanding of needs/functions, savings that can be redirected to add value, improved communication between the parties, and local material usage. Most of the variables correlated above 0.3 and multicollinearity were noticed, with the highest correlation coefficient of 0.510 found between *better project understanding* and *better definition of programme/project objectives* at a significant level of 0.01. Five factors were identified as the main components accountable for non-adoption of value engineering. These include knowledge barrier, demand barrier, awareness barrier, readiness barrier and human resource barrier. The study therefore concludes that value engineering stands feasible for widely implementation in the Ghanaian construction sector if the factors to its non-adoption are attended to, while taking steps to promote the factors that encourage its implementation. The study recommends to the government and the construction professionals to take the necessary steps to curb the factors accountable for the non-adoption of value engineering in Ghana. The methodology and design of this study were not without limitations. The respondents for the study were selected from only construction and consultancies firms that practice value engineering, and therefore limited the number of respondents used in the study. Furthermore, there was limitation in the number of regions selected for the study which makes it difficult to generalize the findings.

References

1. J. Prashant, S.N. Teli, Weight reduction of flying wheel applying value engineering: a case studying. Int. J. Eng. Sci. Manag. Res. **2**(10), 28–44 (2015)
2. J.C. Goodpasture, *Maximizing project value*, 1st edn. (Tyson Corner, Virginia, 2013)
3. S. Nie, J. Liu, Discussion on objective-cost planning for construction project objective-total cost management. Appl. Mech. Mater. **638–640**, 2323–2326 (2014)
4. V. Kalluri, R. Kodali, Component cost reduction by value engineering: a case study. J. Inst. Eng. (India): Ser. C **98**(2), 219–226 (2017)
5. J. Flaig, Improving project selection using expected net present value analysis. Qual. Eng. **17**(4), 535–538 (2005)
6. G. Ofori, Y. Debrah, Flexible management of workers: review of employment practices in the construction sector in Singapore. Constr. Manag. Econ. **16**(4), 397–408 (1998)
7. E. Kissi, D. Ahadzie, J. Cobbinah, A qualitative enquiry into professional project management practices in the Ghanaian construction sector. Eng. Manag. Res. **4**(1), 5–12 (2015)
8. M. Annacchino, *The pursuit of new product development*, 1st edn. (Butterworth-Heinemann, Amsterdam, 2007)
9. R. Issa, I. Flood, *Computing in civil and building engineering*, 1st edn. (American Society of Civil Engineers, Reston, 2014)
10. S. Atabay, N. Galipogullari, Application of value engineering in construction projects. J. Traffic Transp. Eng. **1**(1), 39–40 (2013)
11. K.A.A. Ahmed, R.K. Pandey, Concept of value engineering in construction sector. Int. J. Sci. Res. **5**(4), 1231–1237 (2016)
12. S. Kemmochi, A. KoizumI, A study on the application of value engineering to the construction sector. J. Jpn. Soc. Civ. (Constr. Manag.) **68**(1), 28–39 (2012)
13. S. Kim, Y. Lee, V.T. Nguyen, V.T. Luu, Barriers to applying value management in the Vietnamese construction sector. J. Constr. Dev. Ctries. **21**(2), 55–80 (2016)
14. S.J. Simister, S.D. Green, Recurring themes in value management practices. Eng. Constr. Archit. Manag. **4**(2), 113–125 (1997)
15. E. Kissi, T. Adjei-Kumi, E. Badu, Critical barriers to the practice of effective cost planning in the Ghanaian construction sector. J. Constr. Eng. Proj. Manag. **6**(2), 8–15 (2016)
16. E. Kissi, E.B. Boateng, T. Adjei-Kumi, Strategies for implementing value management in the construction sector of Ghana,

in *Proceeding of the Conference on Infrastructure Development and Investment Strategies for Africa*, Livingstone, Zambia (2015)
17. A. Dansoh, Strategic planning practice of construction firms in Ghana. Constr. Manag. Econ. **23**(2), 163–168 (2005)
18. SAVE International, Value Standard and Body of Knowledge, www.value-eng.org (2007)
19. I. Etikan, Comparison of snowball sampling and sequential sampling technique. Biom. Biostat. Int. J. **3**(1), 1–2 (2016)
20. J.F. Hair, W.C. Black, B.J. Babin, R.E. Anderson, *Multivariate Data Analysis*, 7th edn. (Pearson Education Limited, England, 2014)
21. B. Mario, Quality assurance and quality control methodologies used within the Austrian UV monitoring network. Radiat. Prot. Dosim. **111**(4), 359–362 (2004)
22. J. Sharma, A cross-disciplinary approach to product development and design through quality function deployment, target costing and value engineering. Int. J. Prod. Qual. Manag. **9**(3), 309 (2012)
23. B.N. Dutta, *Estimating and Costing in Civil Engineering: Theory and Practice* (UBS Publishers, New Delhi, 2002)
24. Total cost management framework: a process for applying the skills and knowledge in cost engineering, 1st edn. AACE International, Morgantown, VA (2006)
25. R. Dobgegah, D. Owusu-Manu, K. Omoteso, A principal component analysis of project management construction sector competencies for the Ghanaian. Aust. J. Constr. Econ. Build. **11**(1), 26 (2011)
26. H.C. Dekker, P.E. Smidt, A survey of the adoption and use of target costing in Dutch firms. Int. J. Prod. Econ. **84**, 293–305 (2003)
27. R. Farrell, T. Simpson, Improving cost effectiveness in an existing product line using component product platforms. Int. J. Prod. Res. **48**(11), 3299–3317 (2009)
28. H. Xue, S.J. Zhang, Relationships between engineering construction standards and economic growth in the construction industry: The case of China's construction industry. KSCE J. Civil Eng. **22**(5), 1606–1613 (2018)
29. T. Hurka, Value and what follows. Philos. Rev. **110**(2), 281–283 (2001)
30. S. Assaf, A. Musallami, M. Sughaiyer, Value engineering in public construction projects in Saudi Arabia. Build. Res. Inf. **24**(3), 152–159 (1996)
31. M. Boorman, Experiences in the delivery value management over a decade. Inst. Value Manag. UK **18**(1), 7–15 (2009)
32. F. Thompson, P. Rizova, How Government creates value? Econ. Themes **53**(4), 449–466 (2015)
33. B. Moro, The theory of the revenue maximizing firm. SSRN Electron. J. (2004)
34. H. Danso, N.K. Obeng-Ahenkora, Major determinants of prices increase of building materials on Ghanaian construction market. Open J. Civ. Eng. **8**(4), 142–154 (2018)
35. S. Green, Beyond value engineering: smart value management for building projects. Int. J. Project Manag. **12**(1), 49–56 (1994)
36. X. Zhang, X. Mao, S. AbouRizk, Developing a knowledge management system for improved value engineering practices in the construction sector. Autom. Constr. **18**(6), 777–789 (2009)
37. P.A. Pinamang, T. Adu Gyamfi, H. Danso, K.J. Ampofo, Schedule delay analysis of construction projects in Ghana: objectives, importance and effects. Civ. Environ. Res. **10**(4), 25–30 (2018)
38. H. Danso, J.K. Antwi, Evaluation of the factors influencing time and cost overruns in telecom tower construction in Ghana. Civ. Environ. Res. **2**(6), 15–24 (2012)
39. N.K. Obeng-Ahenkora, H. Danso, Principal component analysis of factors influencing pricing decisions of building materials in Ghana. Int. J. Constr. Manag. **20**(2), 122–129 (2020)
40. A.M.H. Al-Yami, A.D.F. Price, A framework for implementing sustainable construction in building briefing project, in ed. by D. Boyd, *Proceedings of 22nd Annual ARCOM Conference*, 4–6 September 2006 Birmingham
41. K. Potts, Quantity surveying tools and techniques: a review of client and contractor requirements, in *The International Construction Research Conference of the Royal Institution of Chartered Surveyors*, September 7–8th 2004, Leads Metropolitan University (2004)
42. J. Kelly, S. Male, *Value Management in Design and Construction; the Economic Management of Projects* (E & FN Spon, London, 1993)
43. C.Y.J. Cheah, S.K. Ting, Appraisal of value Engineering in construction in Southeast Asia. Int. J. Project Manag. **23**(2), 151–158 (2005)
44. A. Naderpour, M. Mofid, Improving construction management of an educational center by applying earned value technique. Procedia Eng. **14**, 1945–1952 (2011)