QATAR UNIVERSITY

COLLEGE OF ENGINEERING

ASSESSMENT OF IMPLEMENTATION OF VALUE ENGINEERING FACTORS ON DESIGN MANAGEMENT PERFORMANCE OF CONSTRUCTION PROJECTS

BY

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ABSTRACT

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Title: <u>Assessment of Implementation of Value Engineering Factors on Design Management Performance of Construction Projects</u>

Supervisor of Thesis: Murat Gunduz.

This research aims to assess the value engineering factors' implementation on construction projects' design management performance and identify the ranking of each factor's effective weights and its impact on the design management performance. Twenty-two factors were defined from the literature review and grouped into three categories. The online questionnaire was used to design the survey and collect the required data from the construction professionals, the data collected from both local and worldwide participants equal to 150 experts. A structural equation model was developed to define the relations among the value engineering factors and the design management performance. The SEM fitting results met the thresholds; the alternative model represents the relations and effective weights among the indicators and the design management performance. This research found that the first ranked group is the owner & stakeholders’ conditions, which has the highest effective weight on the design management performance, followed by the group of the value engineering conditions, design conditions respectively. This research recommended that construction professionals focus on the highest effective groups to enhance the design management performance while applying the construction projects' value engineering studies.

DEDICATION

I would love to dedicate this master thesis to my mother, son Baraa, and sister for their continuous encouragement to continue with my graduate studies. Also, my daughter Nada and my wife.

ACKNOWLEDGMENTS

Firstly, I would like to thank Prof. Dr. Tarek El Mekkawy, the first professor I met in the Engineering Management Program. Prof. Tarek gives through his courses; valued, unique, and reliable techniques can be applied in industrial management and the different management disciplines.

Secondly, I cannot forget the enormous support that I have received from Prof. Dr. Murat Gunduz at the beginning of preparing this research until achieving its objectives. That support, especially within the hard time that I faced to complete this research.

Finally, I would like to thank Qatar University and its members for the great opportunity and for their effort to make the Engineering Management Program is very successful and essential in our practical life.

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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

There is no doubt that the different types of disasters impact various aspects of life and impact countries, societies, and individuals. Among the types of these disasters that may befall life is like epidemics, for example, the Corona pandemic that hit the whole world recently, as well as among the types of disasters are reflected by their adverse effects on the environment, societies, and individuals. However, there are still good opportunities developed by those disasters.

The Second World War began on the first of September 1939; most countries from the Near East, the Soviet Union, Europe, and the United States of America was involved. This global disaster ended on the second of September 1945.

Those times were the beginnings of value engineering that arose in coming out into the world at the hands of the American engineer Lawrence D. Miles, who called the father of value analysis the first name for value engineering.

SAVE International Value Standard (2007) defined value engineering as the systematic process used by a multidisciplinary team to improve the project's value by analyzing functions and resources.

In addition, the value engineering best implementation is in the early design stage (Peter J. Arsenault 2019). This research discusses the effects of applying value engineering factors in construction, specifically in designing construction projects and their impact on design performance.

1.2 STATEMENT OF THE PROBLEM

During applying the value engineering studies in the design stage, the multidisciplinary team, designer, owner and stakeholders, and value team should understand and consider the most effective value engineering factors on the design management performance to get the optimal results.

This formation of the value engineering work team makes it necessary to understand value engineering factors to the different parties. First, the value engineering specialists party must understand the owner's requirements and the main function of establishing the project. Second, an understanding of the design authority and the stakeholders of value engineering's meaning leads to improving the design performance and the project outputs' accuracy at its optimal cost and performance required of the project.

Suppose these concepts are not clear to all work team members, and there is a leak of cooperation between parties. This case will lead to confusion and disruption of design performance and the consequent failure to obtain optimal project cost and performance expected from implementing value engineering study.

1.3 RESEARCH AIM AND OBJECTIVES

This research aims to study, analyze, and evaluate the value engineering factors' implementation on construction projects' design performance and find the corresponding weight for each factor and their relationships. The factors of value engineering include those related to the designer and stakeholders as well.

Value engineering can be applied in several stages of construction projects, whether in the design stage, the construction stage, or operation and maintenance. However, this study aims to focus on implementing value engineering in the early design stage because it is the stage that results in the best outputs from the value engineering application and evaluates its impacts on the design performance, as shown in Figure 1.1 (Heralova,2016).

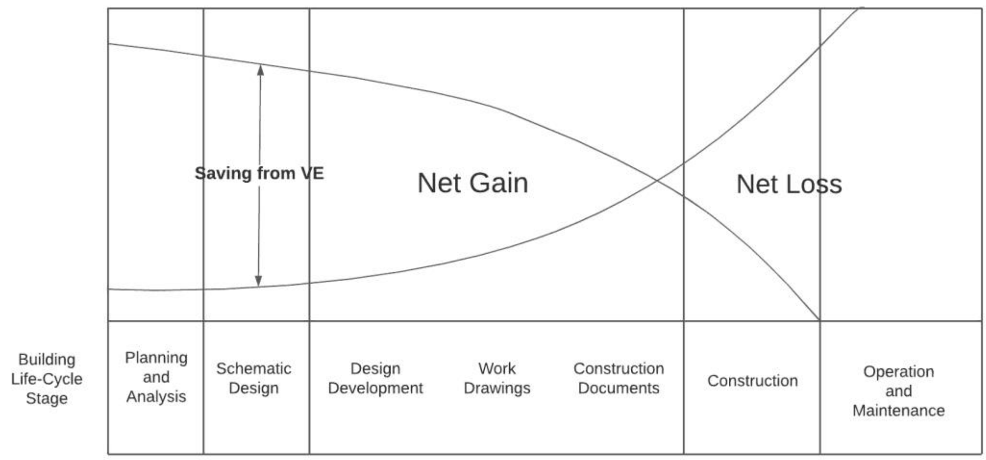

Figure 1.1. Potential Saving from Value Engineering

Value engineering factors determining, evaluating, and arranging their importance lead to those in charge of conducting value engineering studies in construction projects. This study would focus and pay attention to significant factors that affect the design performance in its early stages and ensure the best design outputs in terms of the appropriate cost measured over the project's life cycle. The implementation of value engineering in improving design performance would lead to more successful construction projects.

The existing studies about value engineering have studied and identified the success, hindering value engineering factors, or integrating with the different approaches such as sustainability without studying the effect of these factors on the design management performance. The effect of the value engineering factors on design management is crucial because the best implementation of value engineering is at the design stage. This study contributes to fills the gap of assessment of the implementation of value engineering factors on design management performance on construction projects and findings the effective weights of each factor and the group of factors on the design management performance.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The implementation of value engineering studies in construction projects has previously been used on their own choice of owners and stakeholders in several countries. Implementing value engineering has recently become essential and mandatory in some countries of the world due to preserving natural resources and sustainability. Besides, the construction projects' costs should meet these projects' expected performances of these projects without more project's costs on projects that exceed the owner's requirements from the project performance. On the other hand, the low cost, which can affect project performance, is not needed. The value engineering studies can be implemented through the different construction project stages, design, construction, operation, and maintenance. In all of these stages, the most saving from value engineering is in the early design stage. Therefore, this chapter reviews the literature related to the design stage and the implementation of value engineering and its effect on the performance of the design stage for construction projects.

These literature reviews have covered the three parties involved in the design phase of construction projects. The literature reviews of the design of construction projects party, the literature reviews of the owner's party and stakeholders, and thirdly literature reviews of value engineering studies were carried out.

This literature review's findings follow these reviews in relation to value engineering and its influence factors on the construction project's design performance.

2.2 VALUE ENGINEERING FACTORS OF THE DESIGN CONDITIONS.

Kelly et al. (2004) established that the project's constraints factors such as the site's shape and planning requirements must be sought to gather value engineering information to impose discipline upon the design. Danso and Kwadwo (2019) identified a better understanding of the project as one of the ranking factors in implementing value engineering studies.

According to Value Analysis Handbook (2009), the value analysis is defined as the balance between the project's objectives and costs.

Besides (SAVE International Value Standard, 2007 edition), the work team and project stakeholders must be aware, define, and understand the project's basic and secondary functions. The value analysis considers the project's objectives and obtains a commitment from the work team to the project's objectives achievement. Another study (Danso and Kwadwo, 2019) identified seven ranking factors in implementing value engineering in the Ghanaian construction sector.

Janani et al. (2018) studied life cycle cost. A rating analysis was conducted to evaluate the alternatives. Olanrewaju (2013) added that the life cycle cost in value methodology is an essential finding of his research based on the literature review.

Berawi et al. (2011) studied the implementation of value engineering in Indonesia at the construction projects' design stage. Based on the outcomes of the interviews and a questionnaire survey, the research found the absence of a complete understanding of the value engineering process. Therefore, a value engineering approach based on the awareness of international standards is recommended to resolve Indonesia's value engineering implementation issues. In addition, (SAVE International Value Standard, 2007) identified that practitioners and management might use the international value standard in order to guide the application of value engineering approach.

SAVE International Value Standard (2007) established that the alternatives within the conditions and terms of value engineering must illustrate each alternative's proposed performance improvements. Through simulating the original concept design, the management allows decision-makers to select the alternative that benefits the project enclosed with assumptions, cost comparison, and the other performance factors like reliability and schedule for each alternative. Also, (Anam et al. 2018) identified that the performance-based value is used to calculate each design alternatives.

Karami and Olatunji (2019) aimed to identify the key-value engineering approach for marine projects. Nevertheless, the marine projects' uniqueness but the value engineering approach is similar to those used in the other projects. A questionnaire survey had 126 valid participants from South Korea, Malaysia, Iran, and others to determine the significance of nineteen value engineering variables. One of the research suggestions is that marine projects could benefit when value engineering determines the design alternatives' construction methods. Among the research findings is that marine projects could gain when value engineering is aware of the design alternatives' construction methods. Also (Oke and Ogunsemi,2011) defined the construction methodology as a militating factor of value engineering in Nigeria.

Rad and Yaminib (2016), the study represents that value engineering could be used as a helpful tool from the beginning of the project's studies to designing, constructing, exploiting, and maintaining processes and overcoming civil designs' challenges and complexities. The research identified some of the barriers to unsuccessful use of value engineering in construction projects or causes of its failure in construction projects as follows:

Lack of belief, lack of accepting design agents involved, particularly construction projects employer. Lack of belief of design agents involved contractors, particularly in the value engineering process, due to other methods' unsuccessful experiences decreasing cost and improving design or construction. This study has attempted to briefly introduce concepts and the process of value engineering in construction projects. Also (Oke and Ogunsemi,2011) determine the inadequate knowledge of value management's benefits as a militating factor of value management.

Based on the literature review, seven factors (Observed Variables) have been defined and categorized in one group of the Design Conditions (Latent Variable), as shown in Table 2.1.

Table 2.1. Value Engineering Factors of the Design Conditions

No.	Factors	Referances
1	Designer awareness of project constraints.	Value Management of Construction Projects. Kelly et al. 2004 Danso and Kwadwo, 2019
2	Designer awareness of project objectives.	Value Analysis handbook 2009 SAVE International Value Standard, 2007 Danso and Kwadwo, 2019
3	Designer consideration of the life cycle cost of the alternatives.	Janani et al. 2018 Olanrewaju, 2013
4	Designer awareness of international value engineering standards.	Berawi et al. 2011 SAVE International Value Standard, 2007
5	Designer awareness of the performance of each design alternatives.	SAVE Standard, 2007 edition. Anam et al. 2018
6	Designer awareness of the construction methods of the alternatives.	Karami and Olatunji,2019 Oke and Ogunsemi,2011
7	Design team's belief in value engineering.	Rad and Yaminib,2016 Oke and Ogunsemi,2011

2.3 VALUE ENGINEERING FACTORS OF THE OWNER AND STAKEHOLDERS' CONDITIONS.

Mwakasungula and Mbewe (2018) studied and evaluated the attitudes of construction professionals in Malawi regarding using the value engineering approach. This study was conducted through an open and closed-ended questionnaire. Data have been collected from eighty-six participants specializing in the construction industry and fifty-six local consulting firms, representing 93% of the total consulting firms registered with Malawi's local construction professionals. This study and its results showed that specialists rarely use value engineering in Malawi, and in the case of its application, this is usually at the design stage. Most of the survey participants indicated that one of the reasons for the lack of value engineering applications is that the owners are not aware of it. They believe that its use constitutes an increase in the costs of services. Besides (Olawumi et al. 2016), the lack of a client’s awareness about value engineering is a possible cause for limited value engineering applications.

Berawi et al. (2011) studied and evaluated value engineering implementation in the design stage of Indonesia's construction projects.

The research questionnaire consisted of ten benefits of value engineering and obtaining the participants' answers from the Indonesian stakeholders in the construction found that most stakeholders are aware of only two of the benefits of the value engineering identified in the questionnaire, which enhance project value and improve effectiveness. Also (Alshehri 2020), defined that the awareness of value management between stakeholders is varied from country to other and needs to make more effort to maximize the awareness of value management between them.

Sesmiwati et al. (2016) showed the application of value engineering in Indonesia through previewing the literature review, identifying the opportunities and challenges encountered by value engineering, and proposing a new scheme to overcome the challenges of applying value engineering. The study found four critical challenges of using value engineering in Indonesia. Lack of regulation, lack of promotion, lack of knowledge, and lack of expertise. The study recommended solving the lack of regulations that the Government, as the primary client in construction projects, can regulate a strategic policy to promote value engineering. Also (Olawumi et al. 2016) identified that applying value engineering in specific government projects through regulations makes value engineering an essential activity in the Nigerian construction industry.

Cheah and Ting (2004) worked with a questionnaire among practitioners in construction in Southeast Asia that there is an absence of understanding of value engineering principles. Despite the application of value engineering in public contracts in the United States, it is seldom applied in Southeast Asia. The study determined that governments must encourage value engineering applications in the inclusion and different disciplines of a value engineering consultant to guide and coordinate between the multidisciplinary team's parties to minimize the conflicts between the numerous stakeholders. In another research (Sabiu and Agarwal, 2016), finding competent and qualified professional engagement is essential to minimize the constraint of value engineering application in Nigeria; this finding is based on a questionnaire among 80 construction professionals.

Male et al. (2007) concluded that value management, as a management style, concentrated on improving the value system within projects. Therefore, bringing the teams of stakeholders together at the right time achieves this development. The conclusion is based on the author and others' published materials and their multiple experiences in value management studies in private sectors and the public and all project phases in the United Kingdom from inception to operation. Besides, (Mandelbaum and Reed, 2006) mentioned that ensuring relevant stakeholders setting in the value study is an essential characteristic for team members.

According to Berawi et al. (2011) owner and management support are among the ten benefits of VE application cited in the research the questionnaire; for application of VE in the design phase, this study presents the evaluating value engineering implementation in the design stage of construction projects in Indonesia. Another research (Cheah and Ting,2004) showed that one of the causes of the limited application of value engineering is the lack of support from project parties. Kalani et al. (2017) added that the lack of support and active participation from owners and stakeholders has a relative weigh 18% as the second-ranked hindrance factor impeding value engineering application based on 100 questionnaires was distributed and analyzed by using the AHP approach.

Based on the literature review, six factors (Observed Variables) have been defined and categorized in one group of the Owner and Stakeholders' Conditions (Latent Variable), as shown in Table 2.2.

Table 2.2. Value Engineering Factors of the Owner and Stakeholders' Conditions.

No.	Factors	Referances
1	Owner awareness of value engineering	Mwakasungula and Mbewe ,2018 Olawumi et al. 2016
2	Stakeholders awareness of value engineering.	Berawi et al. 2011 Alshehri,2020
3	Government's notion to apply value engineering in strategic projects	Sesmiwati et al. 2016 Olawumi et al. 2016
4	Engagement of value engineering consultants	Cheah and Ting,2004 Sabiu and Agarwal, 2016

No.	Factors	Referances
5	Bringing all stakeholders together for value engineering practice.	Male et al. 2007 Mandelbaum and Reed, 2006
6	Owner and management support to value engineering during design process	Berawi et al. 2011 Cheah and Ting,2004 Kalani et al. 2017

2.4 VALUE ENGINEERING FACTORS OF THE VALUE ENGINEERING CONDITIONS.

Rachwan et al. (2016) stated that sustainability is an essential factor in project performance and therefore increases the project value. The research presented a case study that included the three principal axes of sustainability: the economic, environmental, and social aspects, as well as the methodology of value engineering.

The research demonstrated that the project's value improved upon integration between the three sustainability factors with value engineering. The proposed alternatives of integrated value engineering with sustainability led to a cost saving of about 40 %. Also, (Karunasena et al. 2016), through interviews with experts besides a questionnaire survey based on a literature review finding a framework to integrate the value and sustainability in construction projects.

Wao (2015) studied to achieve an improvement in the methodology of value engineering and obtain probably the best sustainable results. The study provided a summary of the traditional limitations in the value engineering methodology. The study found that traditional methodology doesn't enhance ideas among the work team. The study concluded that sustainable results require an enhanced new method for value engineering; one of those improvements is encouraging the development of ideas among team members. Another study (Danso and Kwadwo, 2019) mentioned that developing ideas for improved outcomes is ranked as the third-ranking factor. Besides

(Fong et al. 2001) define generating alternative ideas based on brainstorming is a CSFs of value management.

Arivazhagan et al. (2017) conducted in India focused on studying the effectiveness of value engineering applied in construction projects and the workers' familiarity with the concept of value engineering. The study concluded that most respondents do not follow a specific process for implementing value engineering or an organized value engineering job plan as it is assumed. Instead, they are dependent mainly on themselves and their previous experience. Also, (Chen et al. 2010) defined that the job plan is a vital and success factor in the value engineering workshop that the team leader must control.

Usman et al. (2018) evaluated BIM implementation in construction projects by conducting a case study for implementing value engineering using BIM to enhance costs. A 3d model was developed for the project as a BIM module to provide a robust visualization of the alternatives resulting from value engineering. It appeared that approach led to a reduction in costs by 27 %. Therefore, it is easier to encounter defects during the design stage and is easier to use and assist with BIM. It was agreed upon by the research that by applying value engineering with BIM, it is possible to enhance and save a high cost of the project. (Wei and Chen,2019) founded that the combination of BIM and value engineering can better optimize the design phase.

Oke and Ogunsemi (2009) reviewed the competencies of quantity surveyors in developing economies in Nigeria to ensure their readiness for the challenge of value management. Initial data were collected by way of a questionnaire and interviews, as well as the study concluded that areas of competency for surveyors are crucial for practicing value management. The study discovered a need for quantity surveyors training, especially the elderly, to simulate value management challenges in the construction industry. Stuart and Anita (2007) found that quantity surveyors are involved in the project's late-stage as cost-cutting professionals. The quantity surveyors must overcome this image and conduct value management during the early stage of the design.

Ahmed and Ali (2017) provided a value engineering decision-making model to decide on optimum alternatives depending on the assessment of alternatives in terms of several criteria through applying AHP. The case study's final selected criteria are eight criteria, which are flexibility for modifications is actually among the criteria. In another study in Nigeria (Sabiu and Agarwal, 2016) define the constraints of the value engineering application in 5 groups and determine that eliminate unnecessary design as an element of one of the groups can be a solution to minimize the hinders.

SAVE International Value Standard (2007) published, "Value methodologies can be applied during any stage of a project's development cycle, although the greatest benefit and resource savings are typically achieved early in development during the conceptual stages. At this point, the basic information of the project is established, but major design and development resources have not yet been committed. The reason this is the best time to apply a value methodology is that the manner in which the basic function of the project is performed has not been established, and alternative ways may be identified and considered.". Knoles (2018) concluded that value engineering's best performance is in the concept design stage.

Value Analysis handbook (2009) evaluated the value analysis success and its compliance with the value standards specified by Save International; three main elements should be focused on ensuring the value analysis's success. The qualifications of the Value Team Leader are among one of these elements. In addition, (SAVE International Value Standard, 2007 edition) identified the team leader's roles in 8 roles, ensuring the team leader's achievements. In another study (Fong et al. 2001), the literature review findings, the success factors of the value management, and the facilitator's skills are among these CSFs.

Kissi et al. (2016) applied a questionnaire among respondents to assess 22 variables gathered from the literature that challenges the successful implementation of value engineering in public projects in developing countries. A survey was conducted among construction companies and consulting firms in Ghana, and those variables had been divided into five groups that identify the challenges of value engineering. Lack of flexibility in contractual provisions is one of these variables. It has been recommended to include sections related to value engineering in public project contracts. The toughness in the agreements between the owner and the value engineering team and the Ghana procurement system's culture has enriched the lack of flexibility between contractual provisions. Another study (Cheah and Ting,2004) mentioned that the lack of flexibility in contractual provisions is one of the causes of limiting the application of the value engineering studies in Southeast Asia.

Based on the literature review, nine factors (Observed Variables) have been defined and categorized in one group of the Value Engineering Conditions (Latent Variable), as shown in Table 2.3.

Table 2.3. Value Engineering Factors of the Value Engineering Conditions.

No.	Factors	Referances
1	The integration of value engineering and sustainability goals over project value	Rachwan et al. 2016 Karunasena et al. 2016
2	Encouragement of promoting ideas by the value engineering team.	Wao,2015 Danso and Kwadwo, 2019 Fong et al. 2001

No.	Factors	Referances
3	Organized value engineering job plan.	Arivazhagan et al. 2017 Chen et al. 2010
4	Employment of BIM models when judging the alternatives of value engineering.	Usman et al. 2018 Wei and Chen,2019
5	Knowledge of value engineering by the quantity surveyors	Oke and Ogunsemi,2009 Stuart and Anita, 2007
6	The flexibility of design for changes.	Ahmed and Ali,2017 Sabiu and Agarwal, 2016
7	Employment of value engineering during the conceptual design stages	SAVE International Value Standard, 2007 Knoles, 2018
8	Value Engineering team leader's qualifications	Value Analysis handbook 2009 SAVE International Value Standard, 2007 Fong et al. 2001
9	Project's flexibility in contractual provisions	Kissi et al. 2016 Cheah and Ting,2004

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter describes the main five phases of the research used to identify the research problem statement. The steps also contain a quantitative questionnaire to collect the required data from construction professionals worldwide. Finally, achieving the research objectives by analyzing the questionnaire data using an advanced statistical approach.

3.2 RESEARCH QUESTIONS

The research problem statement was defined in Chapter 1, and its questions have been collected based on the qualitative literature review presented in Chapter 2.

3.3 QUESTIONNAIRE DESIGN

A questionnaire has been developed for gathering the required data about the research problem statement and its questions (Appendix A).

The design of the questionnaire consists of two main parts:

First, open-ended questions about each participant's unique data such as work experience in construction, registered professional, area of expertise, and others. Second, close-ended questions about the evaluation of "the implementation of value engineering factors on construction projects' design management performance."

The second part of the questionnaire has three factors groups Table 3.1: designer conditions, owner &stakeholders' conditions, and value engineering conditions.

The participants were requested to rate each factor's importance in the second part based on a Likert-Scale 1 to 5, not at all important, slightly important, moderately important, very important, or extremely important.

Table 3.1. Factors' Groups

No	Groups	Var.	Factors
1	Designer Conditions	DC.1	Designer awareness of project constraints.
		DC.2	Designer awareness of project objectives.
		DC.3	Designer consideration of the life cycle cost of the alternatives.
		DC.4	Designer awareness of international value engineering standards.
		DC.5	Designer awareness of the performance of each design alternative.
		DC.6	Designer awareness of the construction methods for each alternative.
		DC.7	Design team's belief in value engineering.
2	Owner &Stakeholders' Conditions	OSC.1	Owner awareness of value engineering.
		OSC.2	Stakeholders awareness of value engineering.
		OSC.3	Government's notion to apply value engineering in projects.
		OSC.4	Engagement of value engineering consultants.
		OSC.5	Bringing all stakeholders together for value engineering practice.
		OSC.6	Owner and management technical support to value engineering during design process.
3	Value Engineering Conditions	VEC.1	The integration of value engineering and sustainability goals over project value.
		VEC.2	Encouragement of promoting ideas by the value engineering team.
		VEC.3	Organized value engineering job plan.
		VEC.4	Employment of BIM models when judging the alternatives of value engineering.
		VEC.5	Knowledge of value engineering by the quantity surveyors.
		VEC.6	The flexibility of design for changes.
		VEC.7	Employment of value engineering during the conceptual design stage.
		VEC.8	Value engineering team leader's qualifications.
		VEC.9	Project's flexibility in contractual provisions.

3.4 DATA COLLECTION

A global leader online survey website (SurveyMonkey) has been used to construct the research questionnaire and collecting the respondents' answers.

The questionnaire link has been distributed to the professional committees in the construction field locally and globally.

181 responses were received where completed responses were 150 responses, corresponding to an 83% response rate.

3.5 RESEARCH METHODOLOGY

The research methodology consists of five consecutive phases, as shown and follow in Figure 3.1.

I. The preliminary phase is used to identify the research problem and the gap of understanding the effect of implementing the value engineering study on construction projects' design performance.

II. A qualitative literature review was conducted to identify the factors related to the research problem statement; the 22 factors were assigned and categorized into three groups based on their similarity.

III. A quantitative questionnaire was constructed on two main parties; first, the construction professionals' experiences and skills, the second, the research questions, and each factor's importance.

IV. The collected data from the online survey were analyzed after eliminating the incomplete responses from the data and adopting only 150 completed responses. First, a descriptive analysis of the participants was applied.

    Secondly, the collected data was analyzed by structural equation modeling, and the 1st and 2nd confirmatory factor analyses were developed. The analysis process ended up with the results of the Model Fit Indexes and reliability test.

V. The conclusion phase presents the research findings and the recommendations of the important factors of implementation value engineering on the construction project's design performance.

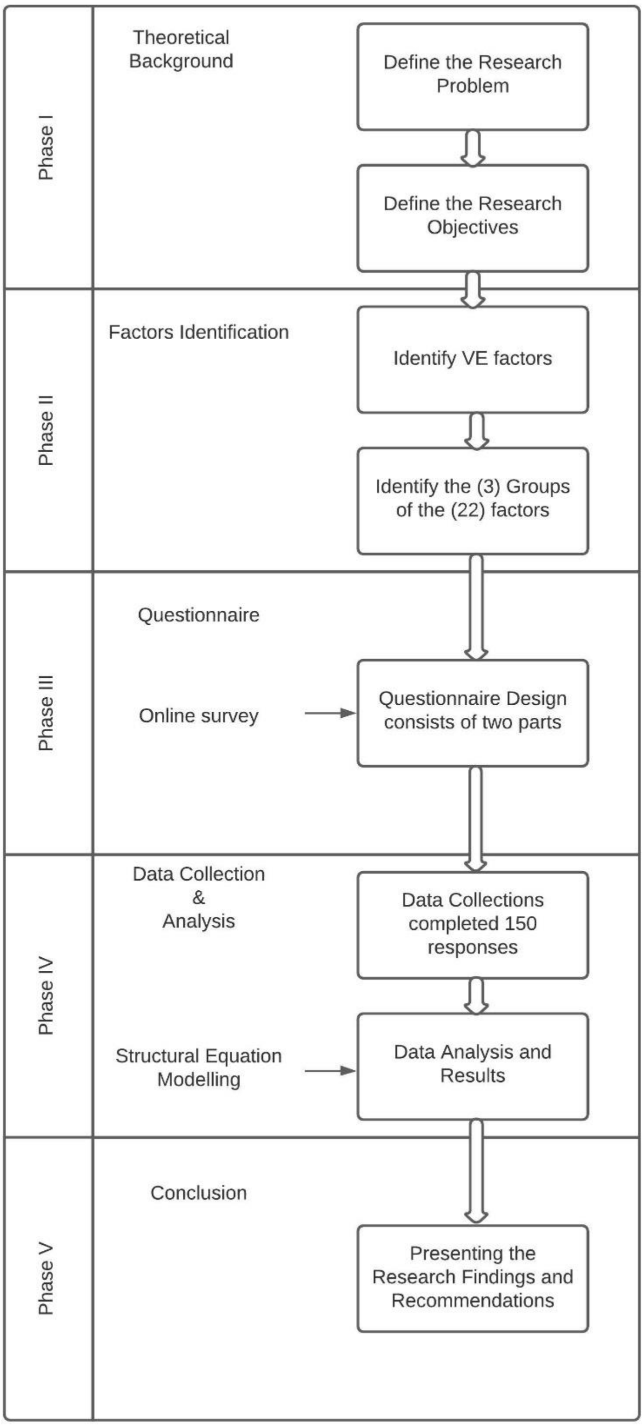

Figure 3.1. Research Methodology.

3.6 CONTRIBUTION OF THE RESEARCH

The research outcomes contributed to existing knowledge by identifying the leading indicators enhancing value engineering implementation on the construction projects' design performance.

It also identified the less important indicators which have less weights and was indicated in the proposed model based on the research hypotheses as follow:

1. Designer Conditions Group has leading indicators on design management performance except for the Designer awareness of project constraints.
2. The whole indicators of the Owner &Stakeholders' Conditions Group have a leading effect on design management performance
3. Only three indicators of the Value Engineering Conditions Group have a maximum effect on design management performance.

CHAPTER 4: DATA COLLECTION AND RESULTS

4.1 INTRODUCTION

This chapter presents the analysis of the collected data through an online questionnaire distributed locally and worldwide in the construction field, especially in value engineering and design management, as identified in data collection 3.4.

The questionnaire was designed by using the Monkey Survey software in two main parts; the chapter presents the analysis of each part as follow:

1. Descriptive analysis of the collected data in part 1.
2. Descriptive analysis of the collected data in part 2.
3. Advanced statistical analysis (SEM) of the collected data of part 2.

4.2 DESCRIPTIVE ANALYSIS I

The descriptisve analysis of part 1 shows the 150 completed responses were adopted for the analysis out of 181 total responses. The descriptive analysis presents the individuals' different skills, such as years of work experience, registered professional, major experience, and others.

4.2.1 YEARS OF WORK EXPERIENCE IN CONSTRUCTION

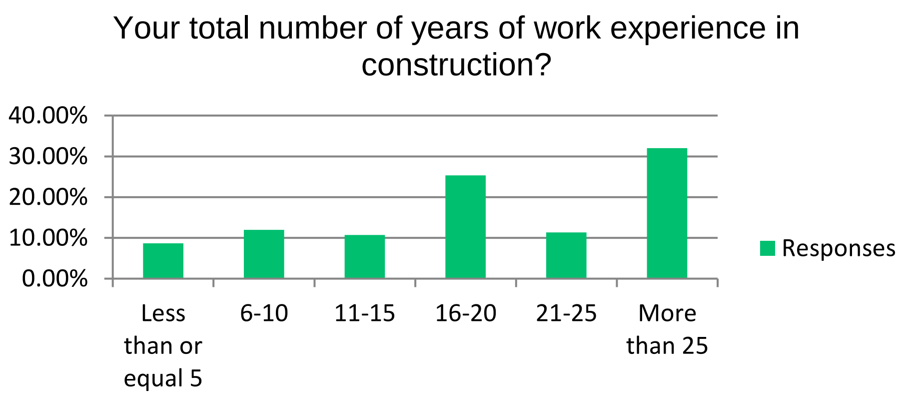

Figure 4.1. Years of Work Experience in Construction

Table 4.1. Years of Work Experience in Construction

Answer Choices	Responses	No.
Less than or equal 5	8.67%	13
6-10	12.00%	18
11-15	10.67%	16
16-20	25.33%	38
21-25	11.33%	17
More than 25	32.00%	48
	Answered	150

The vertical bar graph Figure 4.1 displayed presents data showing the number of years of working experience for 150 participants in Table 4.1.

Looking from an overall perspective, it is readily apparent that most participants have had work experience for more than 25 years, with the least proportion of participants having less than or equal to 5 years of experience. One hundred fifty people participated in this survey.

A small percentage of 8.67%,13 of the participants has had less than or equal to 5 years of work experience. Eighteen participants have had 6-10 years of working experience accounting for 12.00% of the total number of responses. 10.67% of the responders have had 11-15 years of work experience; 16 people responded favorably.

The 16-20 years of experience came second in the most voted at about 38 people making 25.33% of the responses. Seventeen people have had 21-25 years of experience; they made up 11.33% of the total responses. An impressive number of people have had more than 25 years of experience as 48 people fell under this category making up 32.00% of the responses.

4.2.2 REGISTERED PROFESSIONAL, SYNDICATE, CHARTERED, PE...

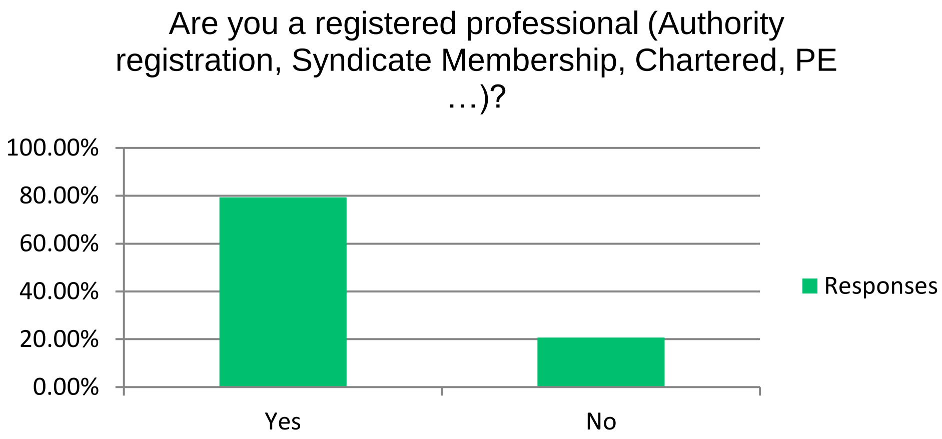

Figure 4.2. Registered Professional, Syndicate, Chartered, PE

Table 4.2. Registered Professional, Syndicate, Chartered, PE

Answer Choices	Responses	No.
Yes	79.33%	119
No	20.67%	31
	Answered	150

The vertical bar graph Figure 4.2 displayed gives information about whether the 150 participants in Table 4.2 are registered professionals or not.

The registered professionals work in Authority registration, Syndicate Membership, Chartered, PE, just to name a few.

More than half of the survey participants are registered professionals, and about a quarter has not registered as professionals.

One hundred nineteen participants are registered professionals accounting for 79.33%. The remaining participants “31” who aren’t registered professionals make up 20.67%.

4.2.3 SECTOR REPRESENT THE MAJOR EXPERIENCE

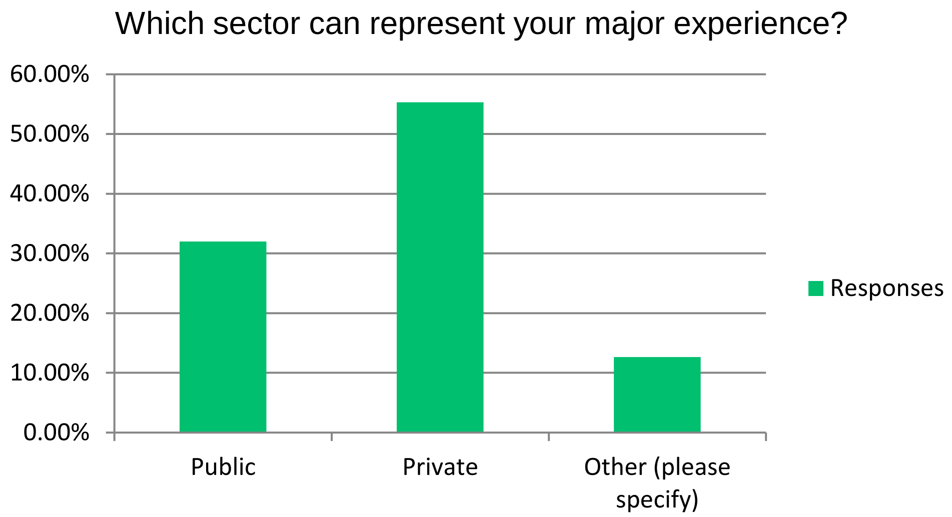

Figure 4.3. Sector Represent the Major Experience

Table 4.3. Sector Represent the Major Experience

Answer Choices	Responses	No.
Public	32.00%	48
Private	55.33%	83
Other (please specify)	12.67%	19
	Answered	150

The vertical bar graph Figure 4.3 displayed presents data about the sector that the 150 participants Table 4.3 has gained major experience.

Looking from an overall perspective, more than half of the participants received a large proportion of their private sector experience. While public sectors were the second most popular sector, other sectors, such as public & private and Projects Description, were the least popular among the participants.

Forty-eight of the participants making up 32.00%, gained major experience from working in the public sector. A stunning 83 people accounting for 55.33%, gained experience from working in private sectors.

Table 4.3.1. Other

Other (please specify)	Responses	No.
Both Public & Private	73.68%	14
Different Project Descriptions by participants	26.32%	5

Table 4.3.1 shows the 19 participants' details, 12.67%, gained most of their experience working in other sectors. The other sectors are divided into two main zones: The Private & Public sectors and Different Project Descriptions.

14 out of the 19 participants gained major experience working in both the private & public sectors; they made up 73.6%. Furthermore, only 5 participants, 26.32%, gained experience from different Project Descriptions by participants.

4.2.4 ORGANIZATION REPRESENT THE MAJOR EXPERIENCE

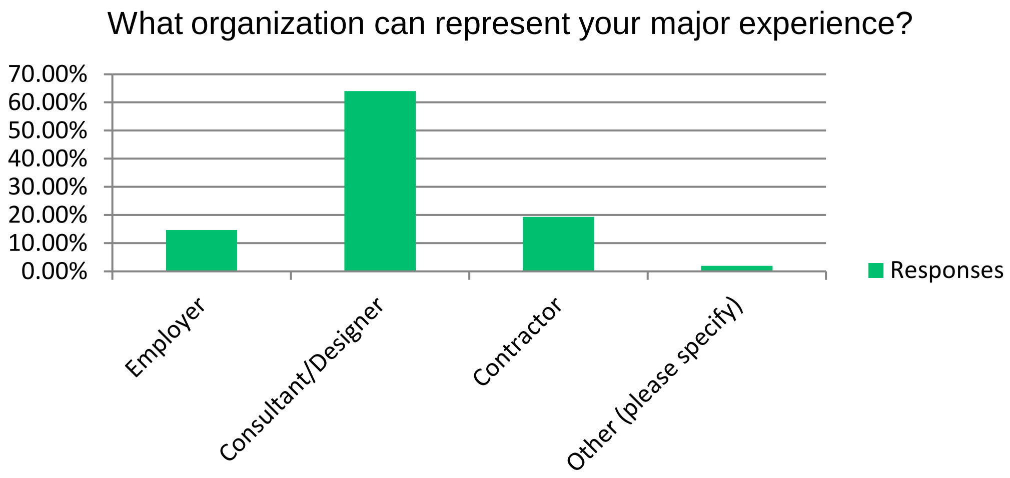

Figure 4.4. Sector Represent the Major Experience

Table 4.4. Sector Represent the Major Experience

Answer Choices	Responses	No.
Employer	14.67%	22
Consultant/Designer	64.00%	96
Contractor	19.33%	29
Other (please specify)	2.00%	3
	Answered	150

The vertical bar graph Figure 4.4 displayed presents data about organizations representing the participants' major experience.

Looking from an overall perspective, it is noticeable that a large proportion of participants gained major experience from working in Consultant/Designer organizations.

Table 4.4 shows 96 participants accounting for 64.00%, worked in organizations related to Consultant/Designer. Working in Contractor organizations was the second most popular out of the responses as 29 of the participants making up 19.33%, gained major experience from this organization. While Employer was the third most popular making up 14.67. Employer organizations slightly outnumbered “other organizations” as 3 participants 2.00%.

Table 4.4.1. Other

Other (please specify)	Responses	No.
Multiple Affiliations	100%	3

Regarding other organizations in Table 4.4.1, only 3 participants gained similar experience in these organizations.

4.2.5 POSITION AT THE COMPANY

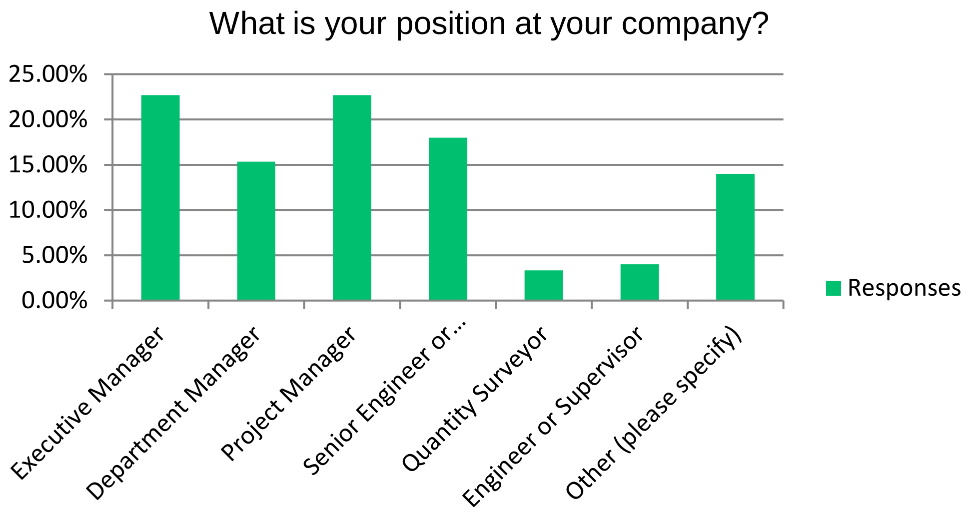

Figure 4.5. Position at the Company

Table 4.5. Position at the Company

Answer Choices	Responses	No.
Executive Manager	22.67%	34
Department Manager	15.33%	23
Project Manager	22.67%	34
Senior Engineer or Architect	18.00%	27
Quantity Surveyor	3.33%	5
Engineer or Supervisor	4.00%	6
Other (please specify)	14.00%	21
	Answered	150

The vertical bar graph Figure 4.5 displayed presents data about the participants' position in their company.

Looking from an overall perspective, a similar number of participants worked as an Executive manager and a project manager. They were the two most popular positions among the 150 participants in Table 4.5.

Thirty-four participants worked as Executive managers making up 22.67%; the statistics were precisely the same for participants with the Project manager position. Being a Senior Engineer or Architect was common between participants as it was the position of 27 participants accounting for 18.00%. Twenty-three participants were Department Managers accounting for 15.33% of the total.

Quantity Surveyor and Engineer or Supervisor had 5 and 6 participants making up 3.33% and 4.00%, respectively.

Table 4.5.1. Other

Other (please specify)	Responses	No.
Contract Manager	9.52%	2
Design Manager	28.57%	6
Freelancer	14.29%	3
Partner	9.52%	2
Planner	23.81%	5
Value Engineering Specialist	14.29%	3

Regarding other positions, Table 4.5.1, 21 of the participants worked in other positions; there were 6 main positions different from those stated above. Being a Design Manager was the most popular position as 6 out of the 21 participants worked in this position; they accounted for 28.57%. Being a planner came second in most popular positions in the others category as 5 participants held this position; they made up 23.81%.

3 participants held a Freelancer position making up 14.29%; the statistics were the same for the Value Engineering Specialist.Only 2 participants were Contracts Manager, and they accounted for 9.52%; the statistics were the same for the Partner position.

4.2.6 AREA(S) OF EXPERTISE

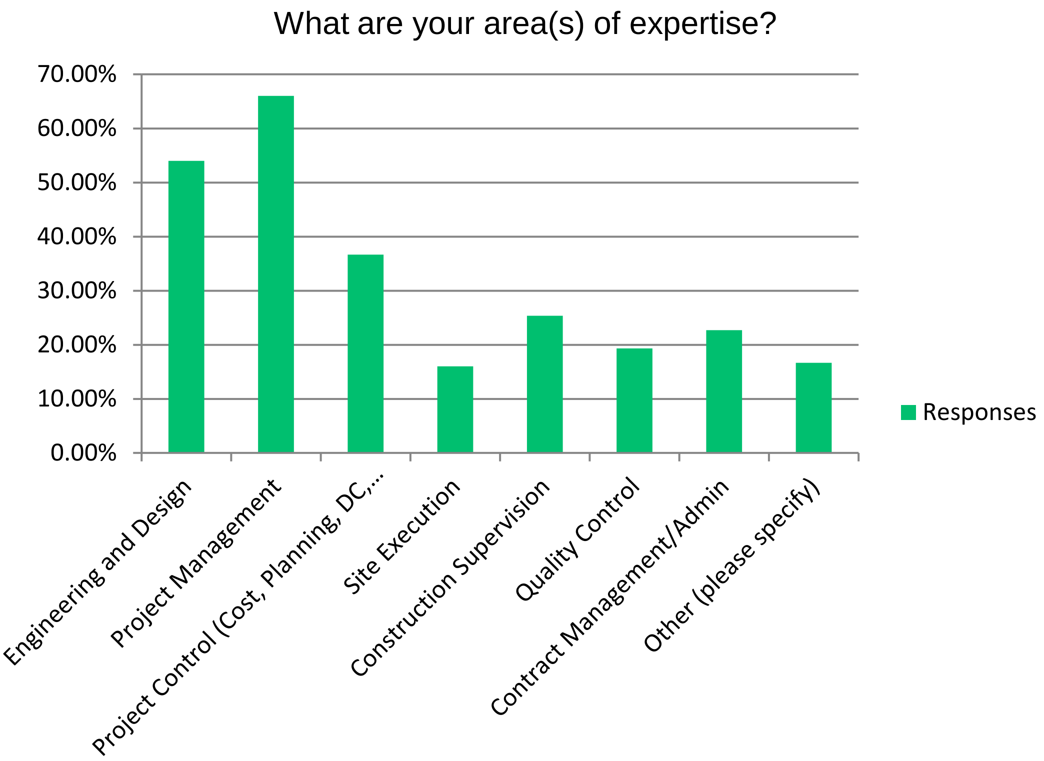

Figure 4.6. Area(S) of Expertise

Table 4.6. Area(S) of Expertise

Answer Choices	Responses	No.
Engineering and Design	54.00%	81
Project Management	68.67%	103
Project Control (Cost, Planning, DC, Risk…)	36.67%	55
Site Execution	16.00%	24
Construction Supervision	25.33%	38
Quality Control	19.33%	29
Contract Management/Admin	22.67%	34
Other (please specify)	14.00%	21
	Answered	150

The vertical bar graph Figure 4.6 displayed presents data about the area of expertise for participants.

Overall, it's clear that the two most common areas of expertise within the participants were "Engineering and Design" and "Project Management." The least common area of expertise was Site Execution.

Table 4.6 A significant number of 103 participants' expertise was in Project Management; they accounted for 68.67%. Out of the 150 participants, 81 of the area of expertise was Engineering and Design, accounting for 54.00%. Project Control (Cost, Planning, DC, Risk, etc.) was the area of expertise for 55 participants who accounted for 36.67%.

Construction Supervision and Contract Management/Admin were the area of expertise for 38 and 34, respectively. These participants accounted for 25.33% and 22.67% individually.

Twenty-nine participants (19.33%) area of expertise was Quality Control. As well as this, 24 participants area of expertise was Site Execution; they accounted for 16.00%.

Table 4.6.1. Other

Other (please specify)	Responses	No.
Lean & HSE	10%	2
Sustainable & Design	28%	6
Value Engineering	62%	13

Twenty-one participants making up 14.00% had other areas of expertise. These areas can be divided into three areas. 13 out of the 21 participants area of expertise is Value engineering, accounting for 62% of the other category. Sustainable & Design was the area of expertise for 6 participants that accounted for 28%. Lean & HSE was the area of expertise for 2 participants making up 10%. Management statistics is precisely double that of Lean & HSE.

4.2.7 TYPE OF PROJECT REFLECTS THE EXPERIENCE

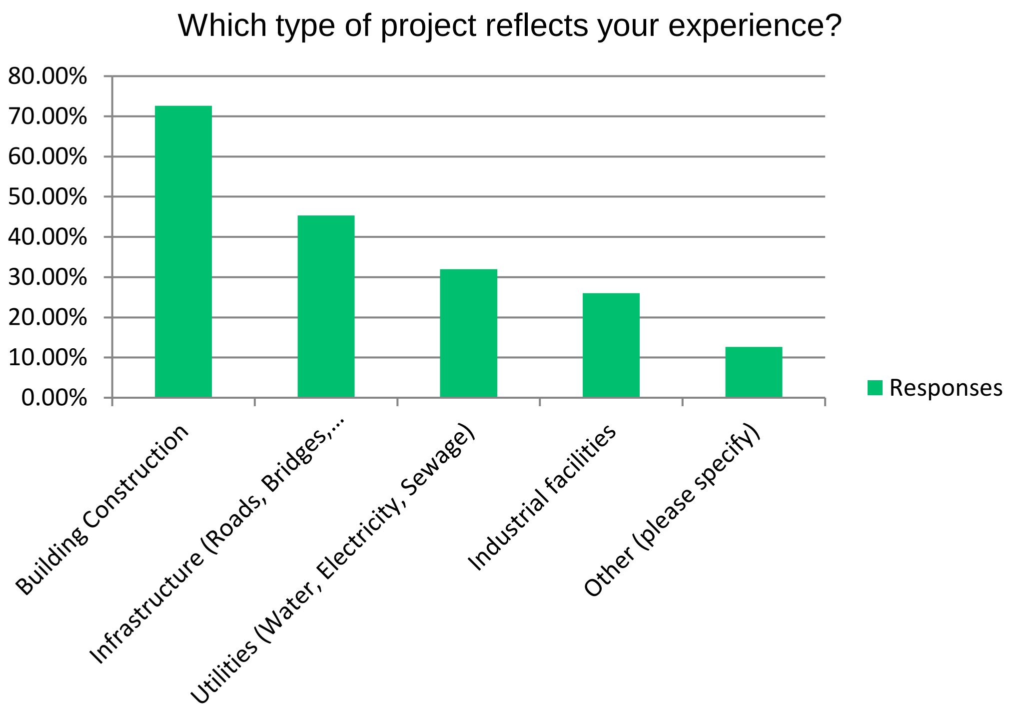

Figure 4.7. Type of Project Reflects the Experience

Table 4.7. Type of Project Reflects the Experience

Answer Choices	Responses	No.
Building Construction	72.67%	109
Infrastructure (Roads, Bridges, Railways)	45.33%	68
Utilities (Water, Electricity, Sewage)	32.00%	48
Industrial facilities	26.00%	39
Other (please specify)	12.67%	19
	Answered	150

The vertical bar graph Figure 4.7 displayed presents data about the project that reflected the 150 participants' experience.

Overall, Building Construction reflected more than half of the participants' experience. Building Construction reflected the experience of 109 participants; they accounted for 72.67%. Infrastructure such as Roads, Bridges, and Railways reflected the experience of 68 participants accounting for 45.33%. Forty-eight of the participants' experiences were reflected by Utilities such as Water, Electricity, and Sewage, the participants, accounted for 32.00%. Industrial facilities didn’t reflect participants' experience as much as other projects, as it reflected the experience of only 39 participants, which accounted for 26.00%.

Table 4.7.1. Other

Other (please specify)	Responses	No.
All of the above	10.53%	2
Infra., Health, or Edu.	31.58%	6
Interior Fit-Out	10.53%	2
Mixed Development	15.79%	3
Petro. & Industrial	26.32%	5
Value Engineering	5.26%	1

Table 4.71 reflected participants' experience regarding other projects, 19 participants (26.00%) fell under this category. The “others” category can be divided into 6 areas. Infra, Health, or Edu., reflected the experience of 6 participants making up 31.58%. Five participants' experience was reflected by the Petrol & Industrial project making up 26.32%. Mixed Development and Interior Fit-out projects reflected 3 and 2 participants; respectively, they accounted for 15.79% and 10.53% individually.

Value Engineering reflected the experience of only 1 participant who made up 5.26%. Only 2 participants' experience was affected by all the listed projects; they accounted for 10.53%.

4.2.8 FORM OF CONTRACT ARE FAMILIAR WITH

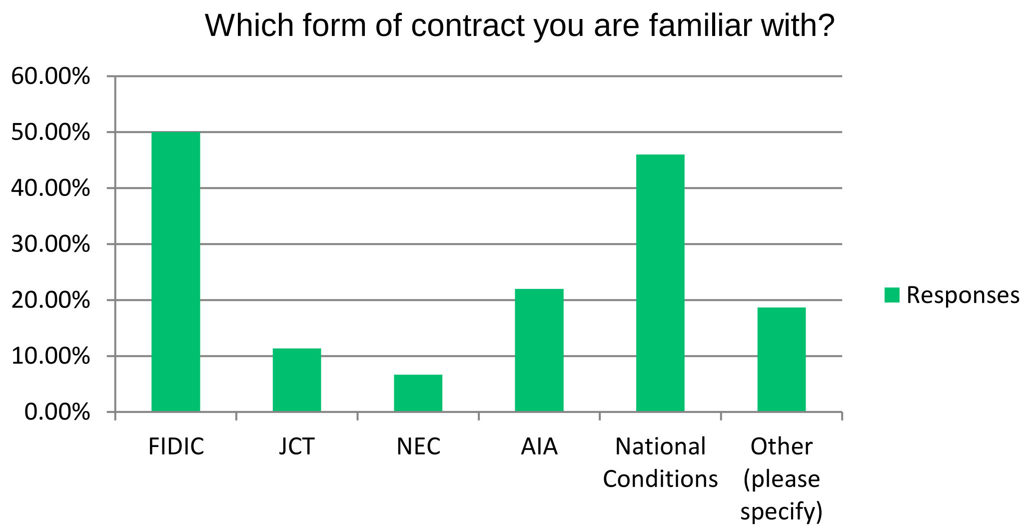

Figure 4.8. Form of Contract Are Familiar With

Table 4.8. Form of Contract Are Familiar With

Answer Choices	Responses	No.
FIDIC	50.00%	75
JCT	11.33%	17
NEC	6.67%	10
AIA	22.00%	33
National Conditions	46.00%	69
Other (please specify)	18.67%	28
	Answered	150

The vertical bar graph Figure 4.8 displayed presents information about the form of contracts the participants are familiar with.

Exactly half of the participants were familiar with FIDIC. The National Conditions came in second as the contract’s participants were familiar with 69 participants making up 46.00% were familiar with it. Table 4.8 shows 33 participants were familiar with the AIA; these participants accounted for 22.00%. 17 and 10 participants were familiar with JCT and NEC; respectively, they accounted for 11.33% and 6.67% individually.

Table 4.8.1. Other

Other (please specify)	Responses	No.
Design & Build	14.29%	4
EJCDC, CSI, AGC, US Gov.	28.57%	8
ppp	10.71%	3
Public & Local	46.43%	13

Table 4.8.1 shows twenty-eight participants were familiar with other contracts; they accounted for 18.67%. 13 participants were familiar with Public & Local, making up 46.43%. Design & Build was familiar to 4 participants accounting for 14.29%. The EJCDC, CSI, AGC, US Gov. accounting for 28.57% was familiar to 8 participants. Finally, PPP was familiar with only 3 participants making up 10.71%.

4.3 DESCRIPTIVE ANALYSIS II

The descriptive analysis of part 2 shows the 150 completed responses were adopted for the analysis out of 181 total responses. The descriptive analysis presents the participants' responses to the importance of each factor in part 2.

4.3.1 GROUP 1: DESIGNER CONDITIONS

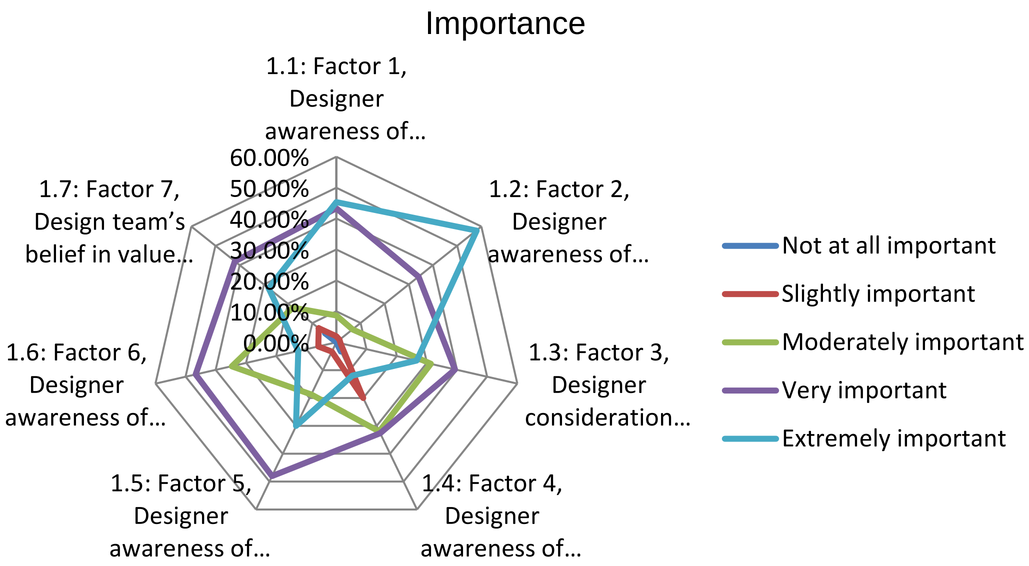

Figure 4.9. Designer Conditions

Table 4.9. Designer Conditions

Factors	NI	No.	SI	No.	MI	No.	VI	No.	EI	No.	Total
DC.1	0.67%	1	2.00%	3	8.67%	13	43.33%	65	45.33%	68	150
DC.2	0.00%	0	1.33%	2	6.67%	10	34.00%	51	58.00%	87	150
DC.3	1.33%	2	1.33%	2	31.33%	47	39.33%	59	26.67%	40	150
DC.4	3.33%	5	20.00%	30	32.00%	48	32.67%	49	12.00%	18	150
DC.5	0.00%	0	3.33%	5	18.67%	28	48.00%	72	30.00%	45	150
DC.6	0.00%	0	6.00%	9	34.67%	52	46.67%	70	12.67%	19	150
DC.7	4.67%	7	7.33%	11	18.00%	27	42.00%	63	28.00%	42	150

Where NI is Not at all important VI is Very important

SI is Slightly important EI is Extremely important

MI is Moderately important

And DC.1 Designer awareness of project constraints

DC.2 Designer awareness of project objectives

DC.3 Designer consideration of the life cycle cost of the alternatives

DC.4 Designer awareness of international value engineering standards

DC.5 Designer awareness of the performance of each design alternative

DC.6 Designer awareness of the construction methods for each alternative

DC.7 Design team's belief in value engineering

Figure 4.9 illustrates the overview of the difference in the importance among the factors of the group of designer conditions.

Table 4.9 shows the Designer Conditions' Factors.

4.3.2 GROUP 2: OWNER &STAKEHOLDERS' CONDITIONS

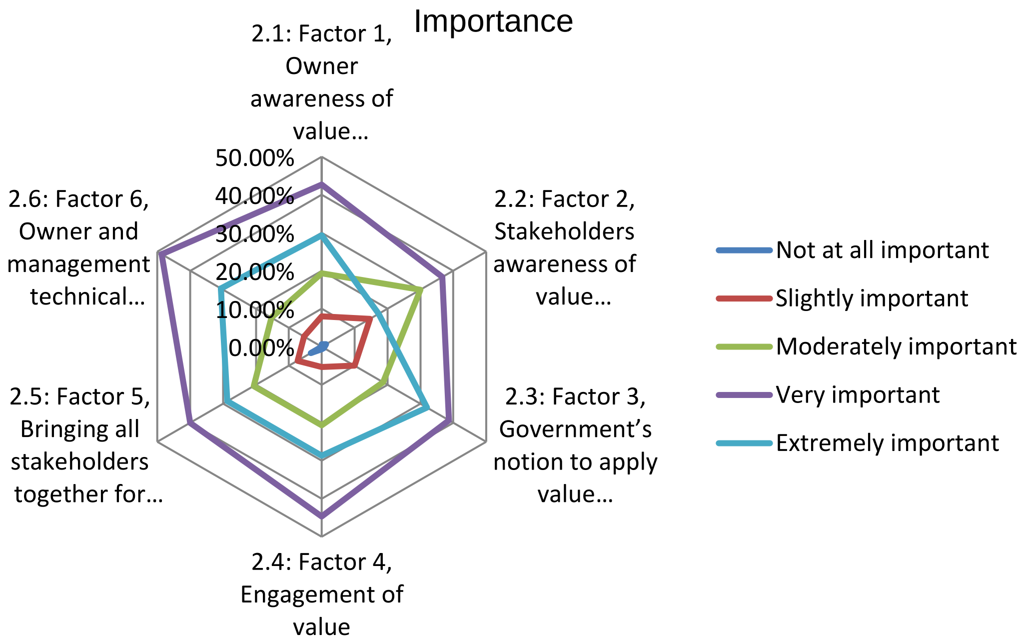

Figure 4.10. Owner & Stakeholders' Conditions

Table 4.10. Owner & Stakeholders' Conditions

Factor	NI	No.	SI	No.	MI	No.	VI	No.	EI	No.	Total
OSC.1	0.67%	1	8.00%	12	19.33%	29	42.67%	64	29.33%	44	150
OSC.2	1.33%	2	14.67%	22	30.00%	45	36.67%	55	17.33%	26	150
OSC.3	0.67%	1	10.00%	15	18.67%	28	38.67%	58	32.00%	48	150
OSC.4	0.67%	1	5.33%	8	20.67%	31	44.67%	67	28.67%	43	150
OSC.5	3.33%	5	7.33%	11	20.67%	31	40.00%	60	28.67%	43	150
OSC.6	0.00%	0	5.33%	8	15.33%	23	48.67%	73	30.67%	46	150

Where OSC.1 Owner awareness of value engineering

OSC.2 Stakeholders awareness of value engineering

OSC.3 Government's notion to apply value engineering in projects

OSC.4 Engagement of value engineering consultants

OSC.5 Bringing all stakeholders together for value engineering practice

OSC.6 Owner and management technical support to value engineering during design process

The radar chart, Figure 4.10, displays each factor's importance in the group of the Owner & Stakeholders' Conditions.

4.3.3 GROUP 3: VALUE ENGINEERING CONDITIONS

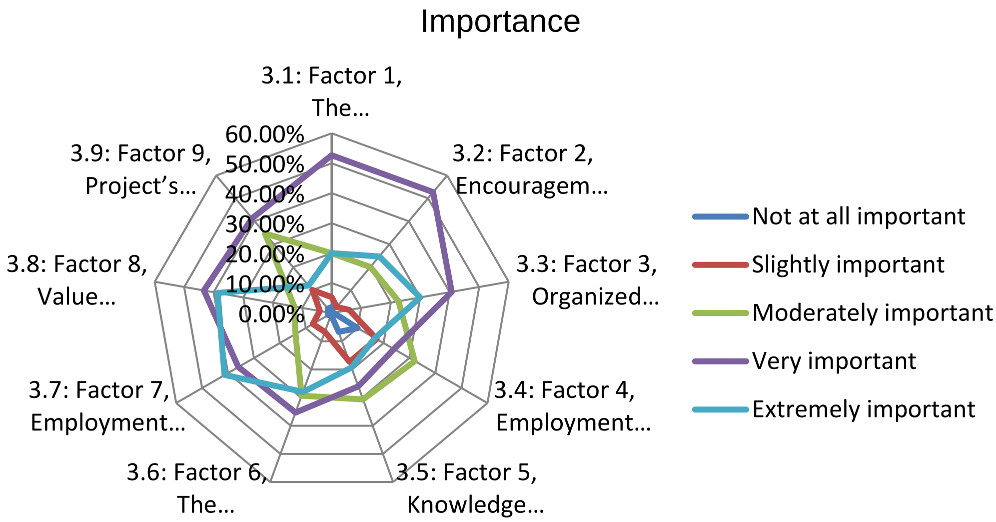

Figure 4.11. Value Engineering Conditions

Table 4.11. Value Engineering Conditions

Factors	NI	No.	SI	No.	MI	No.	VI	No.	EI	No.	Total
VEC.1	2.00%	3	5.33%	8	20.00%	30	52.67%	79	20.00%	30	150
VEC.2	0.00%	0	2.67%	4	20.00%	30	52.67%	79	24.67%	37	150
VEC.3	0.67%	1	6.00%	9	22.67%	34	40.67%	61	30.00%	45	150
VEC.4	10.00%	15	17.33%	26	32.00%	48	24.00%	36	16.67%	25	150
VEC.5	6.67%	10	17.33%	26	30.67%	46	26.00%	39	19.33%	29	150
VEC.6	0.67%	1	6.67%	10	29.33%	44	35.33%	53	28.00%	42	150
VEC.7	1.33%	2	7.33%	11	14.00%	21	36.00%	54	41.33%	62	150
VEC.8	1.33%	2	4.00%	6	12.67%	19	43.33%	65	38.67%	58	150
VEC.9	2.00%	3	10.00%	15	34.67%	52	41.33%	62	12.00%	18	150

Where VEC.1 The integration of value engineering and sustainability goals over project value

VEC.2 Encouragement of promoting ideas by the value engineering team

VEC.3 Organized value engineering job plan

VEC.4 Employment of BIM models when judging the alternatives of value engineering

VEC.5 Knowledge of value engineering by the quantity surveyors

VEC.6 The flexibility of design for changes

VEC.7 Employment of value engineering during the conceptual design stage

VEC.8 Value engineering team leader's qualifications

VEC.9 Project's flexibility in contractual provisions

Figure 4.11 illustrates the overview of the difference in the importance among the factors of the group of value engineering conditions.

Table 4.11 shows the Value Engineering Conditions' Factors.

4.4 RELATIVE IMPORTANCE INDEX (RII)

Table 4.12. Relative Importance Index

Factors	Likert Scale Points					N	Responses		RII	Ranking
	1	2	3	4	5		Min.	Max.		
DC.2	0	2	10	51	87	150	2	5	0.897333	1
DC.1	1	3	13	65	68	150	1	5	0.861333	2
VEC.8	2	6	19	65	58	150	1	5	0.828000	3
VEC.7	2	11	21	54	62	150	1	5	0.817333	4
DC.5	0	5	28	72	45	150	2	5	0.809333	5
OSC.6	0	8	23	73	46	150	2	5	0.809333	6
VEC.2	0	4	30	79	37	150	2	5	0.798667	7
OSC.4	1	8	31	67	43	150	1	5	0.790667	8
VEC.3	1	9	34	61	45	150	1	5	0.786667	9
OSC.1	1	12	29	64	44	150	1	5	0.784000	10
OSC.3	1	15	28	58	48	150	1	5	0.782667	11
DC.3	2	2	47	59	40	150	1	5	0.777333	12
OSC.5	5	11	31	60	43	150	1	5	0.766667	13
VEC.1	3	8	30	79	30	150	1	5	0.766667	14

Factors	Likert Scale Points 1	2	3	4	5	N	Responses Min.	Max.	RII	Ranking
VEC.6	1	10	44	53	42	150	1	5	0.766667	15
DC.7	7	11	27	63	42	150	1	5	0.762667	16
DC.6	0	9	52	70	19	150	2	5	0.732000	17
OSC.2	2	22	45	55	26	150	1	5	0.708000	18
VEC.9	3	15	52	62	18	150	1	5	0.702667	19
VEC.5	10	26	46	39	29	150	1	5	0.668000	20
DC.4	5	30	48	49	18	150	1	5	0.660000	21
VEC.4	15	26	48	36	25	150	1	5	0.640000	22

Table 4.12 shows the Relative Importance Index and the ranking of the 22 factors of implementing the following value engineering factors on construction projects' design management performance.

The RII values were calculated as follows:

$$\mathbf{RII = (5\,n_5 + 4\,n_4 + 3\,n_3 + 2\,n_2 + 1\,n_1) / (A*N)}$$

Where: $\mathbf{n_5}$ number of respondents for extremely important

$\mathbf{n_4}$ number of respondents for very important

$\mathbf{n_3}$ number of respondents for moderately important

$\mathbf{n_2}$ number of respondents for slightly important

$\mathbf{n_1}$ number of respondents for not at all important

A = 5 in the 5-point Likert Scale

N = total number of the respondents

RII is range from 0 to 1, and the Importance Level, according to Rooshdi et al. (2018) as follows:

$0.8 \leq RII \leq 1$ is considered High

$0.6 \leq RII \leq 0.8$ is considered High-Medium

$0.4 \leq RII \leq 0.6$ is considered Medium

$0.2 \leq RII \leq 0.4$ is considered Medium-Low

$0 \leq RII \leq 0.2$ is considered Low

Table 4.12, the factors DC.2, DC.1, VEC.8, VEC.7, DC.5, and OSC.6 were considered a High Importance level factor on the construction projects' design management performance.

4.5 ADVANCED STATISTICAL ANALYSIS (SEM)

In this part of the research, the data collected in part 2 through the questionnaire must be inspected before starting using the advanced statistical analysis method of part 2. The completed 150 completed responses were inspected to determine both the outliers and non-normality of the data as an essential step before applying the advanced analysis by using structural equation modeling (SEM). 134 responses were adopted in the study of SEM as the remaining 16 responses were outliers responses.

4.5.1 DATA SCREENING

4.5.1.1 OUTLIERS

The data were examined for outliers using SPSS software v26 Table 13. The Mahalanobis distance and probability were determined and eliminated the values of Mahalanobis less than 0.05.

Table 4.13. Mahalanobis Distance

MAH_1	Probability_MD	Outliers	ID
43.54407	0.00	1.00	5
43.55442	0.00	1.00	11
40.07280	0.01	1.00	14
40.51910	0.01	1.00	20

MAH_1	Probability_MD	Outliers	ID
35.22089	0.04	1.00	27
43.36905	0.00	1.00	41
38.47552	0.02	1.00	52
34.15849	0.05	1.00	53
34.23736	0.05	1.00	61
35.59643	0.03	1.00	68
42.28324	0.01	1.00	111
42.00022	0.01	1.00	116
34.43872	0.04	1.00	124
44.71231	0.00	1.00	144
42.50098	0.01	1.00	149
36.21896	0.03	1.00	150

4.5.1.2 NORMALITY

The data were examined for normality using before applying structural equation modeling. Both skewness and kurtosis values are indicated for the univariate non-normal data; Skewness and Kurtosis's absolute values more than extreme ones are an indication for non-normality (Xiong et al. 2015). In addition, multivariate kurtosis should not more than 5.0 (Bentler 2006).

The bootstrapping at 1000 number of bootstrap samples were adopted and finding the bollen-stine bootstrap value.

4.5.2 STRUCTURAL EQUATION MODELLING

The structural equation modeling (SEM) is an advanced statistical method which has different name such as Analysis of Moment Structure (AMOS), Covariance Structure Analysis, Analysis of Linear Structural Relationship (LISREL), and Causal Modeling. The structural equation modeling has many definitions. Arbuckle (2017) defines SEM as a general approach for data analysis, known as the analysis of covariance structures.

4.5.3 SEM DEVELOPMENT

The main reason for developing the SEM is to examine a proposed model based on theory or literature review. The proposed model may be supported by the data, which means the theory is verified; if not, a modified model must be developed. In order to construct the proposed model, many software is used for SEM. In this research, the SPSS Amos ver.26 was adopted to construct and analyze both the proposed and modified models.

The model development has five essential steps Model Specification, Identification, Estimation, Testing, and Model Modification Figure 4.12.

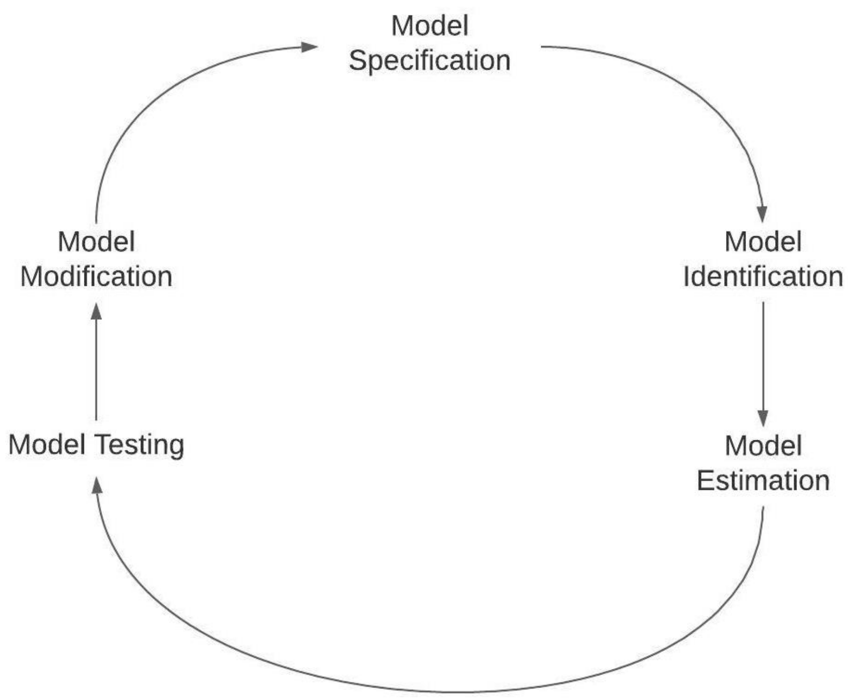

Figure 4.12. SEM Model Development

4.5.3.1 MODEL SPECIFICATION

The model specification is the step to draw the proposed model, which consists of:

1. Latent Variables (Oval Shape) which cannot be measured.
2. Observed Variables (Rectangle Shape) can be measured.
3. Latent errors for the Observed Variables.
4. The unidirectional relationships.
5. The covariance between independent variables.

4.5.3.2 MODEL IDENTIFICATION

The model identification means that the model has a sufficient amount of information about the observed variables to find the model's unique results.

The model in this step must be the Over Identified Model or Just Identified Model. In case the model is an Unidentified Model, new observed variables must be added to the proposed model.

4.5.3.3 MODEL ESTIMATION

The model estimation is the step to obtain numerical values for the model's parameters by solving a set of equations using the Maximum Likelihood Method.

4.5.3.4 MODEL TESTING

In this step, the model fit must be evaluated based on the Model Statistic and Goodness Fit Index as follows:

1. Model Testing Statistics

   Relative Chi-Square ($\chi 2/df$), also called the parsimonious fit, shall have a value between 1.0 to 3.0 for preferred fit (Hair et al. 2014; Xiong et al. 2015).

2. Goodness Fit Indices

   The Goodness Fit Indices describes how well the model fits the sample of the data as follows:

   2.1 Goodness of Fit Index (GFI)

   Goodness Fit Index is ranged between 0 and 1 (Engel and Moosbrugger, 2003); GFI's value bigger than 0.90 is an acceptable fit.

   2.2 Comparative Fit Index (CFI)

   Zero to one are the Comparative Fit Index values where the value 0.92 is considered a good model fit (Hair et al., 2014).

   2.3 Standardized Root Mean Square Residual (SRMR)

   It is considered as the Badness Fit Index, which increasing the means of not fit model. Therefore, 0.08 is the acceptable value of SRMR (Hu and Bentler 1999).

   2.4 Root Mean Square Error of Approximate (RMSEA)

   RMSEA is Badness Fit Index as SRMR, RMESA is ranging between 0.05 to 0.1 as acceptable values (Byrne 2010).

   2.5 PCLOSE

   In order to conclude that the model fit is close, PCLOSE shall have values more than 0.05.

4.5.3.5 MODEL MODIFICATION

The model modification would be an essential step if the model were not fit in the previous step of the model development. In this case, the modification indices must be reviewed to identify the model fitting enhancing and reapply the five steps of model development.

4.5.4 ANALYSIS RESULTS

The analysis results in this section have three main results, as follow:

1. The Proposal (measurement) Model results.
2. The Modified Model (1st order degree).
3. The Structural Model (2nd order degree).

4.5.4.1 The Proposal Model

The Analysis summary of the Proposed Model as follows in Table 14:

Table 14. The Proposed Model Fit

Measure	Estimate	Threshold	Interpretation
CMIN	428.244	--	--
DF	206	--	--
CMIN/DF	2.079	1 to 3	Excellent
GFI	0.777	>0.90	Not Ok
CFI	0.714	>0.95	Not Ok
SRMR	0.081	<0.08	Acceptable
RMSEA	0.085	<0.06	Not Ok
PCLOSE	0.000	>0.05	Not Ok

The proposed model based on the results in Table 14 is not fit. The Modification Indices were inspected to enhance the proposed model and developed the modified model based on the Covariances Table 15.

Table 15. Covariances

Covariances			M.I.	Par Change
e19	<-->	e22	20.602	.280
e18	<-->	e22	13.282	.283
e18	<-->	e20	4.503	-.175
e17	<-->	e22	7.320	.216
e17	<-->	e18	19.741	.461
e16	<-->	e22	13.036	-.195
e16	<-->	e18	13.675	-.260
e15	<-->	OSC	4.360	.054
e15	<-->	DC	6.732	-.080
e15	<-->	e22	8.230	-.125
e15	<-->	e16	10.965	.131
e14	<-->	DC	8.938	.119
e14	<-->	e16	5.964	-.124
e13	<-->	e18	4.046	.137
e11	<-->	e21	4.918	.109
e11	<-->	e19	5.749	-.133
e11	<-->	e18	5.085	-.157
e11	<-->	e16	9.274	.148
e11	<-->	e12	5.413	.129
e10	<-->	e12	4.282	-.123
e10	<-->	e11	5.017	.115
e9	<-->	e16	5.714	-.126
e9	<-->	e11	5.430	-.122
e8	<-->	e17	6.286	-.186
e8	<-->	e12	5.631	-.136
e8	<-->	e11	5.429	-.116
e8	<-->	e9	26.247	.276
e7	<-->	e9	10.453	.195
e5	<-->	e14	4.307	-.092
e4	<-->	e20	6.070	-.165
e4	<-->	e18	11.265	.276
e4	<-->	e17	11.894	.292
e4	<-->	e11	4.049	-.114
e4	<-->	e7	5.648	.154
e3	<-->	e13	4.021	.088
e2	<-->	e18	4.912	-.128
e2	<-->	e17	8.716	-.176
e2	<-->	e7	4.559	-.098
e2	<-->	e4	8.094	-.134
e1	<-->	e14	10.152	.144
e1	<-->	e7	5.125	-.113
e1	<-->	e2	19.551	.159

Figure 4.13 Shows the Proposal Model consists of three latent variables and 22 observed variables.

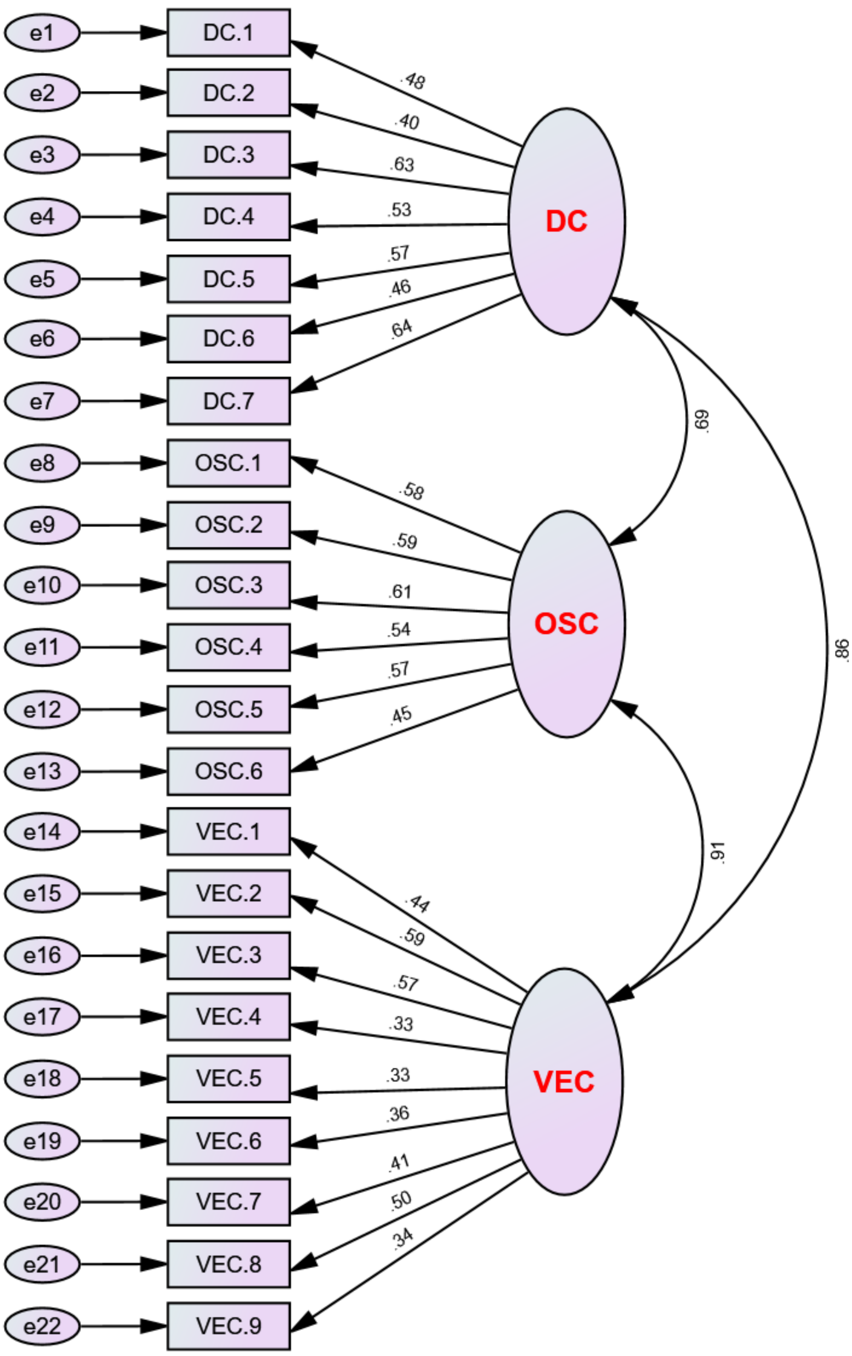

Figure 4.13. the Proposed Model

4.5.4.2 The Modified Model

The Analysis summary of the Modified Model as follows in Table 16:

Table 16. The Modified Model Fit

Measure	Estimate	Threshold	Interpretation
CMIN	116.937	--	--
DF	85	--	--
CMIN/DF	1.376	1 to 3	Excellent
GFI	0.901	>0.90	Excellent
CFI	0.928	>0.95	Acceptable
SRMR	0.052	<0.08	Excellent
RMSEA	0.053	<0.06	Excellent
PCLOSE	0.396	>0.05	Excellent
p-value (Bollen-Stine)	0.124	>0.05	Excellent

The modified model achieved the Goodness Fit Indices shows in Table 16.

Figure 4.14 Shows the Modified Model consists of three latent variables and 15 observed variables after eliminating the observed variables, which have a weight less than 0.4 (Matsunaga 2010).

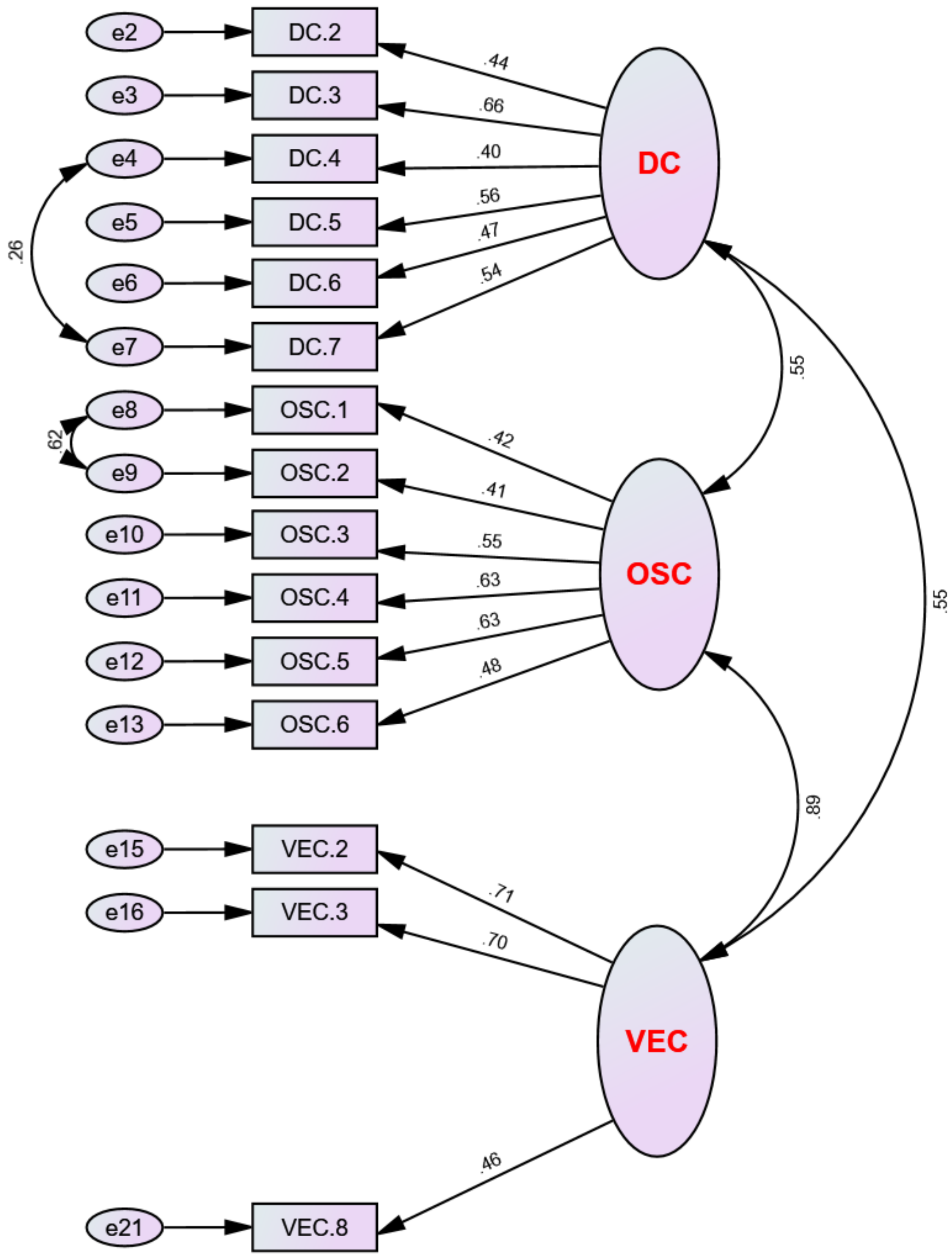

Figure 4.14. The Modified Model

4.5.4.2.1 The Assessment of Normality

Table 17 shows the values of the univariant and multivariate normality after Bootstrap.

Table 17. Assessment of Normality

Variable	min	max	skew	c.r.	kurtosis	c.r.
VEC.8	2.000	5.000	-.632	-2.988	-.069	-.163
VEC.3	2.000	5.000	-.366	-1.729	-.620	-1.466
VEC.2	2.000	5.000	-.271	-1.282	-.121	-.286
OSC.6	2.000	5.000	-.699	-3.305	.339	.800
OSC.5	1.000	5.000	-.790	-3.732	.371	.877
OSC.4	1.000	5.000	-.660	-3.120	.285	.674
OSC.3	2.000	5.000	-.558	-2.639	-.505	-1.193
OSC.2	1.000	5.000	-.302	-1.426	-.370	-.874
OSC.1	2.000	5.000	-.517	-2.442	-.366	-.865
DC.7	1.000	5.000	-.891	-4.211	.533	1.259
DC.6	2.000	5.000	-.108	-.509	-.280	-.661
DC.5	2.000	5.000	-.470	-2.219	-.055	-.130
DC.4	1.000	5.000	-.274	-1.294	-.411	-.972
DC.3	1.000	5.000	-.509	-2.405	.374	.884
DC.2	2.000	5.000	-1.177	-5.564	.967	2.285
Multivariate					13.753	3.525

The Bootstrap was applied for 1000 number of Bootstrap Samples, and the results as below:

1. The model fits better in 877 bootstrap samples.

2. It fit worse or failed to fit in 123 bootstrap samples.

3.Testing the null hypothesis that the model is correct.

4. Bollen-Stine bootstrap p = .124

The Bollen- Stine Value, as in Table 16, is 0.124, which is greater than 0.05, which is considered an excellent achievement. Figure 4.15 Shows the Bootstrap Distribution.

```
                          |--------------------
                 46.954   |*
                 56.422   |***
                 65.890   |********
                 75.359   |***************
                 84.827   |*******************
                 94.295   |*******************
                103.763   |****************
N = 1000        113.232   |**********
Mean = 93.745   122.700   |*******
S. e. = .618    132.168   |***
                141.636   |**
                151.105   |*
                160.573   |*
                170.041   |*
                179.509   |*
                          |--------------------
```

Figure 4.15. The Bootstrap Distributions

4.5.4.2.2 The Composite Reliability Test (CR)

Table 18 shows Composite Reliability (CR) values as 0.756, 0.741, and 0.778, which is greater than 0.7 and considered excellent results.

Table 18. The Reliability Test

Observed		Latent	Estimate	Error	(Sum(Estimate))^2	CR	Threshold
DC.2	<---	DC	0.441	0.333	9.412624	0.756239	Greater Than 0.7
DC.3	<---	DC	0.663	0.407			
DC.4	<---	DC	0.396	0.848			
DC.5	<---	DC	0.563	0.368			
DC.6	<---	DC	0.468	0.413			
DC.7	<---	DC	0.537	0.665			
OSC.1	<---	OSC	0.417	0.603	9.728161	0.741354	Greater Than 0.7
OSC.2	<---	OSC	0.412	0.744			
OSC.3	<---	OSC	0.552	0.58			
OSC.4	<---	OSC	0.63	0.44			
OSC.5	<---	OSC	0.632	0.558			
OSC.6	<---	OSC	0.476	0.469			
VEC.2	<---	VEC	0.714	0.234	3.508129	0.778178	Greater Than 0.7
VEC.3	<---	VEC	0.697	0.353			
VEC.8	<---	VEC	0.462	0.413			

4.5.4.3 The Structural Equation Model

Figure 4.16 Shows the Structural Equation Model as a 2nd Degree Order.

The Analysis summary of the Structural Model as follows:

Table 19. The SEM Model Fit

Measure	Estimate	Threshold	Interpretation
CMIN	116.937	--	--
DF	85	--	--
CMIN/DF	1.376	1 to 3	Excellent
GFI	0.901	>0.90	Excellent
CFI	0.928	>0.95	Acceptable
SRMR	0.052	<0.08	Excellent
RMSEA	0.053	<0.06	Excellent
PCLOSE	0.396	>0.05	Excellent

The Structure Model achieved the Goodness Fit Indices shows in Table 19, and Table 20 shows the Standardized Regression Weights of the SEM.

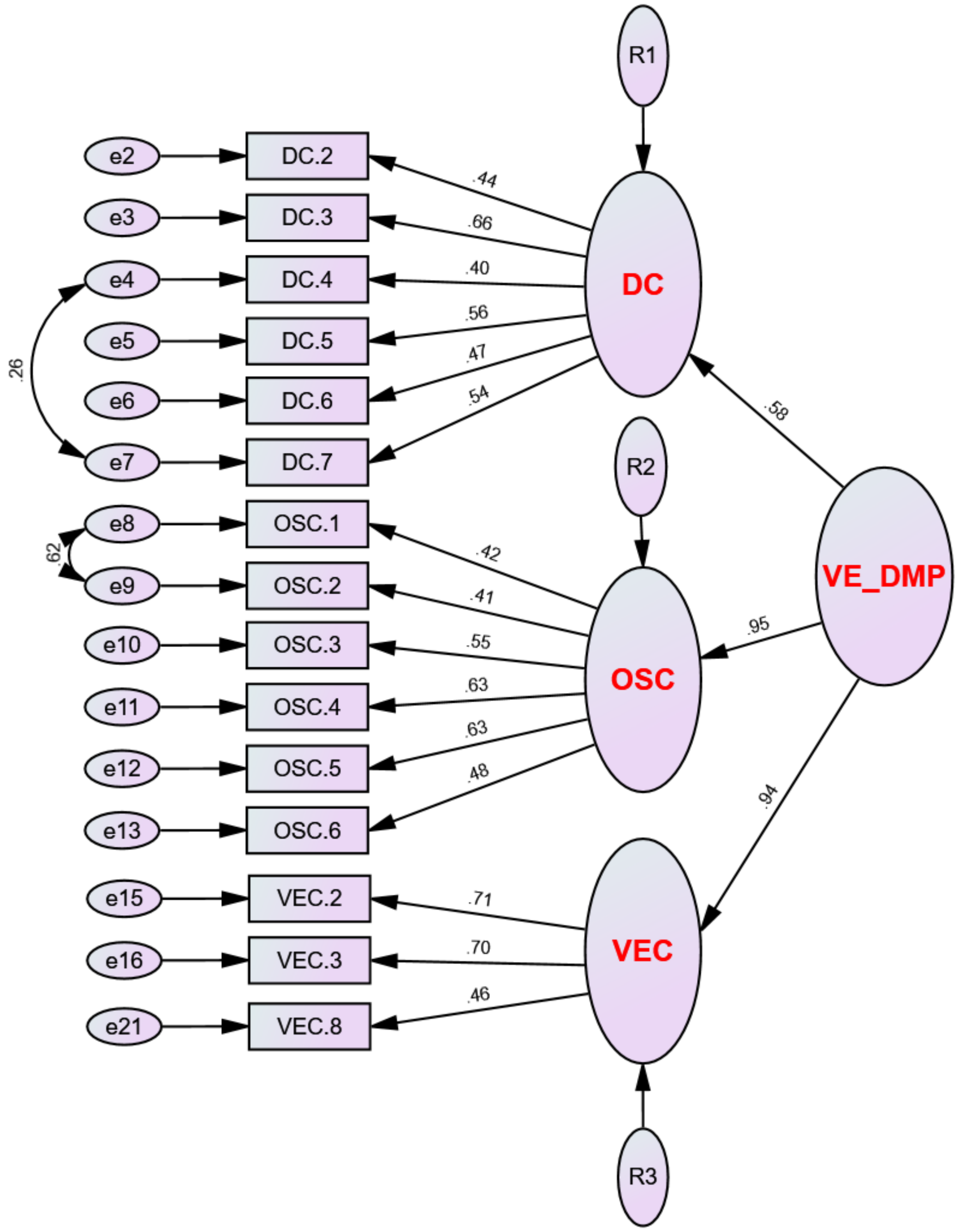

Figure 4.16. The Structural Equation Model

Table 20. The Standardized Regression Weights (SEM)

			Estimate
DC	<---	VE_DMP	0.58
OSC	<---	VE_DMP	0.95
VEC	<---	VE_DMP	0.94
DC.2	<---	DC	0.44
DC.3	<---	DC	0.66
DC.4	<---	DC	0.40
DC.5	<---	DC	0.56
DC.6	<---	DC	0.47
DC.7	<---	DC	0.54
OSC.1	<---	OSC	0.42
OSC.2	<---	OSC	0.41
OSC.3	<---	OSC	0.55
OSC.4	<---	OSC	0.63
OSC.5	<---	OSC	0.63
OSC.6	<---	OSC	0.48
VEC.2	<---	VEC	0.71
VEC.3	<---	VEC	0.70
VEC.8	<---	VEC	0.46

The Structural Equation Modelling has achieved the thresholds shown in Table 19 as GFI value is 0.901 greater than 0.90, the acceptable fit, CFI reached 0.928 above the acceptable fit 0.95, RMSEA reported 0.053 below the acceptable fit 0.06. The PCLOSE is 0.396 > 0.05 as an excellent achievement.

4.5.5 DISCUSSION OF RESULTS

This part discusses the research findings of the indicators affecting the Design Management Performance and the related groups (Constructs).

4.5.5.1 RANKING OF THE CONSTRUCTS

The research's main finding is to find the relation between the three constructs and VE_DMP, which is the Design Management Performance. Table 21 represents the Owner& Stakeholders' Conditions (OSC) ranked first, affecting the Design Management Performance with the highest effective weight of 0.3846.

Secondly, the Value Engineering Conditions (VEC) has the second-highest effective weight, 0.3806. The third effective weight is the Designer Conditions (DC), which has 0.2348 effective weight.

Table 21. Ranking of Constructs

Code	Constructs	SFLs	EW	Rank
OSC	Owner & Stakeholders' Conditions	0.95	0.3846	1
VEC	Value Engineering Conditions	0.94	0.3806	2
DC	Designer Conditions	0.58	0.2348	3

Where

SFLs: Standardized Factor Loading

EWci: Effective Weight

4.5.5.2 RANKING OF INDICATORS OF EACH CONSTRUCT

Table 22. Ranking of Owner& Stakeholders' Conditions Indicators

Code	Indicators	SFLs	EWi	Rank
OSC.4	Engagement of value engineering consultants	0.63	0.2019	1
OSC.5	Bringing all stakeholders together for value engineering practice	0.63	0.2019	2
OSC.3	Government's notion to apply value engineering in projects	0.55	0.1763	3
OSC.6	Owner and management technical support to value engineering during design process	0.48	0.1538	4
OSC.1	Owner awareness of value engineering	0.42	0.1346	5
OSC.2	Stakeholders awareness of value engineering	0.41	0.1314	6

Table 22 shows that six indicators of the construct (OSC). Both, The Engagement of Value Engineering Consultants (OSC.4) and Bringing all Stakeholders together for Value Engineering Practice (OSC.5) ranked first and second indicators, which have the heights effective weight 0.2019. The third-ranked effective weight 0.1763 is the Government's Notion to apply Value Engineering in Projects. Owner and Management Technical Support to Value Engineering during Design Process has the fourth-ranked by EWi 0.1538. OSC.1 and OSC.2 ranked the fifth and sixth effective weights 0.1346 and 0.1314, respectively.

Table 23. Ranking of Value Engineering Conditions Indicators

Code	Indicators	SFLs	EWi	Rank
VEC.2	Encouragement of promoting ideas by the value engineering team	0.71	0.3797	1
VEC.3	Organized value engineering job plan	0.7	0.3743	2
VEC.8	Value engineering team leader’s qualifications	0.46	0.2460	3

Table 23 represents the highest effective weight 0.3797 of the Encouragement of Promoting Ideas by the Value Engineering Team. The second-ranked indicator is the Organized Value Engineering Job Plan with an effective weight of 0.3743. the Value Engineering Team Leader’s Qualification is the third-ranked indicator with an effective weight of 0.2460.

Table 24. Ranking of Design Conditions Indicators

Code	Indicators	SFLs	EWi	Rank
DC.3	Designer consideration of the life cycle cost of the alternatives	0.66	0.2150	1
DC.5	Designer awareness of the performance of each design alternative	0.56	0.1824	2
DC.7	Design team’s belief in value engineering	0.54	0.1759	3
DC.6	Designer awareness of the construction methods for each alternative	0.47	0.1531	4
DC.2	Designer awareness of project objectives	0.44	0.1433	5
DC.4	Designer awareness of international value engineering standards	0.4	0.1303	6

Refer to Table 24, the first the Designer Consideration of the Life Cycle Cost of the Alternatives as the highest effective weight 0.2150. Secondly, the Designer Awareness of Each Design Alternative's Performance is the second-ranked with EWi 0.1824. The third effective weight 0.1759 of the Design Team's Belief in Value Engineering. DC.6, DC.2, and DC.4 are ranked 4,5, and 6 with effective weights 0.1531,0.1433, and 0.1303, respectively.

4.5.6 THE INDICATORS OVERALL EFFECTIVE WEIGHTS

Table 25 presents VEC.2 Encouragement of Promoting Ideas by the Value Engineering Team with the highest effective weight of 0.1445 and DC.4 Designer awareness of international value engineering standards as the minimum effective weight 0.0306.

Table 25. The Indicators Overall Effective Weights

SN	Code	SFLs	within construct EW	SFLs (Groups)	Construct EW	Overall EW	within construct Rank	Overall Rank
1	OSC.1	0.4200	0.1346	0.9500	0.3846	0.0518	5	8
2	OSC.2	0.4100	0.1314			0.0505	6	9
3	OSC.3	0.5500	0.1763			0.0678	3	6
4	OSC.4	0.6300	0.2019			0.0777	1	4
5	OSC.5	0.6300	0.2019			0.0777	2	5
6	OSC.6	0.4800	0.1538			0.0592	4	7
7	VEC.2	0.7100	0.3797	0.9400	0.3806	0.1445	1	1
8	VEC.3	0.7000	0.3743			0.1425	2	2
9	VEC.8	0.4600	0.2460			0.0936	3	3
10	DC.2	0.4400	0.1433	0.5800	0.2348	0.0337	5	14
11	DC.3	0.6600	0.2150			0.0505	1	10
12	DC.4	0.4000	0.1303			0.0306	6	15
13	DC.5	0.5600	0.1824			0.0428	2	11
14	DC.6	0.4700	0.1531			0.0359	4	13
15	DC.7	0.5400	0.1759			0.0413	3	12

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This research focused on assessing the value engineering factors' implementation on the design management performance in construction projects. In order to evaluate this, SEM was developed to define the relationships among the factors and determine the effective weight of each variable and group of variables.

5.2 CONCLUSION

The research's first objective is to identify the value engineering factor that affects design management performance; this has been determined through the literature reviews to determine 22 factors and grouped in three.

The second objective is to develop SEM for the different factors as observed variables and find each group and variable's weights and its effect on the design management performance.

5.3 RECOMMENDATIONS

Table 21 showed the three groups OSC, VEC, and DC, were ranked based on each construct's effective weights. The owner& stakeholders conditions (OSC) should consider the first ranked construct that may affect design management performance. Value engineering conditions (VEC) and designer conditions should be regarded as the second and third-ranked constructs, influencing the design management performance.

5.3.1 The Owner and Stakeholder’s Conditions (OSC)

This group of indicators has the highest effective weight of 0.3846 toward the Design Management Performance. The professionals should consider this group of indicators as the highest effective group when applying value engineering studies during the design management, and the indicators of this group should be considered as follows;

Engagement of value engineering consultants in the design stage while applying the value engineering studies can ensure the proper study without conflicting with the design management.

Bringing all stakeholders or their representatives together for value engineering practice in order to ensure excellent communication between parties and find the commitment of each party to ensure the success of applying value engineering in the design stage.

The government’s notion to apply value engineering in projects is essential to encourage the other parties involved in construction, such as the private sector, to adopt value engineering during the design phase.

Owner and management technical support to value engineering during the design process is essential to the design management performance's success to get the most cost optimization in the design's early stage.

Owner awareness of value engineering can enhance the opportunities to find the final design to meet the required project performance at a fair cost.

Stakeholders' awareness of value engineering is significant for understanding the benefits of value engineering and preventing any actions from stakeholders that can affect the design process.

Checking the owner and stakeholders perceptions of value engineering during the design stage.

5.3.2 The Value Engineering Conditions (VEC)

This group of indicators is the second-ranked group, which has an effective weight of 0.3806 on design management performance. Their indicators must be considered during the process of the value engineering as follow;

Encouraging ideas by the value engineering team through different techniques such as brainstorming should be deemed to create sufficient design alternatives.

Organized value engineering job plan must be considered as the proper plan can lead the value engineering to the appropriate process, enhancing the design management.

The value engineering team leader's qualification is crucial to lead the parties, giving support during the process and preventing the conflicts.

5.3.3 The Design Conditions (DC)

The third group is the design conditions have an effective weight of 0.2348. The design conditions have six indicators as follow;

Designer Consideration of the alternative's life cycle cost is considered the most crucial tool to judge the alternatives based on their life cycle, not on the initial cost.

Designer awareness of each design alternatives' performance is essential when judging the alternative based on value engineering aims to achieve the required project performance with the optimal cost.

The design team’s belief in value engineering must be considered necessary, without believing in value engineering, making the design team resist the process and affecting the design management performance.

Designer awareness of each alternative's construction methods is crucial to understand the alternative design's constructability and correctly find the alternative's life cost.

Designer awareness of project objectives must be focused on when applying value engineering to ensure that the alternatives achieve the exact required objectives, leading to proper design management performance.

Designer awareness of international value engineering standards leads the designer to manage the design phase based on a well understanding of the international standard requirements from the design's early steps to complete.

Checking the design team perceptions of value engineering during the design stage.

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APPENDIX A: QUESTIONNAIRE

Assessment of implementation of value engineering factors on design management performance of construction projects

Thank you for participating in my survey. Your feedback is important. This questionnaire has been prepared for my master's thesis in "Assessment of implementation of value engineering factors on design management performance of construction projects" in the College of Engineering in Engineering Management Program at Qatar University. All information collected will be absolutely kept confidential. Thanks for the kind support.

Best Regards,

Student: Aly Abdel Fattah Aly

aa1700036@qu.edu.qa

Advisor**: Prof. Murat Gunduz**

Part-1: General Information

Dear Participant

This part consists of questions regarding you and your organization. Please select the suitable choices and fill in the blank in the table below cells.

Part-1: General questions

1. Your total number of years of work experience in construction?

☐ Less than or equal 5

☐ (6-10)

☐ (11-15)

☐ (16-20)

☐ (21-25)

☐ More than 25

2. Are you a registered professional (Authority registration, Syndicate Membership, Chartered, PE …)?

☐ Yes

☒ No

3. Which sector can represent your major experience?

☐ Public

☐ Private

☐ Others (please specify)

4. What organization can represent your major experience?

☐ Employer

☐ Consultant/Designer

☐ Contractor

☐ Others (please specify)

5. What is your position at your company?

☐ Executive Manager

☐ Department Manager

☐ Project Manager

☐ Senior Engineer or Architect

☐ Quantity Surveyor

☐ Engineer or Supervisor

☐ Others (please specify)

6. What are your area(s) of expertise?

☐ Engineering and Design

☐ Project Management

☐ Project Control (Cost, Planning, DC, Risk…)

☐ Site Execution

☐ Construction Supervision

☐ Quality Control

☐ Contract Management/Admin

☐ Others (please specify)

7. Which type of project reflects your experience?

☐ Building Construction

☐ Infrastructure (Roads, Bridges, Railways …)

☐ Utilities (Water, Electricity, Sewage)

☐ Industrial facilities

☐ Others (please specify)

8. Which form of contract you are familiar with?

☐ FIDIC

☐ JCT

☐ NEC

☐ AIA

☐ National Conditions

☐ Others (please specify)

Part-2: Assessment of implementation of value engineering factors on design management performance of construction projects

This part groups the implementation of value engineering factors on design management performance of construction projects based on designer conditions, owner &stakeholders' conditions, and value engineering conditions. Under each group, the importance of value engineering factor on design management performance is asked.

Evaluate the following factors based on:

1. Importance (**What is the importance of the implementation of the following value engineering factors on design management performance of construction projects?)**

Group 1: Designer Conditions.

Factor 1: Designer awareness of project constraints

9. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 2: Designer awareness of project objectives

10. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 3: Designer consideration of the life cycle cost of the alternatives

11. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 4: Designer awareness of international value engineering standards

12. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 5: Designer awareness of the performance of each design alternative

13. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 6: Designer awareness of the construction methods for each alternative.

14. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 7: Design team's belief in value engineering

15. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Group 2: Owner &Stakeholders' Conditions.

Factor 1: Owner awareness of value engineering

16. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 2: Stakeholders awareness of value engineering

17. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 3: Government's notion to apply value engineering in projects

18. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 4: Engagement of value engineering consultants

19. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 5: Bringing all stakeholders together for value engineering practice

20. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 6: Owner and management technical support to value engineering during design process

21. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Group 3: Value Engineering Conditions

Factor 1: The integration of value engineering and sustainability goals over project value

22. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 2: Encouragement of promoting ideas by the value engineering team

23. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 3: Organized value engineering job plan

24. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 4: Employment of BIM models when judging the alternatives of value engineering

25. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 5: Knowledge of value engineering by the quantity surveyors

26. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 6: The flexibility of design for changes

27. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 7: Employment of value engineering during the conceptual design stage

28. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 8: Value engineering team leader's qualifications

29. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important

Factor 9: Project's flexibility in contractual provisions

30. What is the importance of the implementation of the value engineering factor on design management performance of construction projects?

☐ Not at all important

☐ Slightly important

☐ Moderately important

☐ Very important

☐ Extremely important