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Value Engineering Adoption's Barriers and Solutions: The Case of Saudi Arabia's Construction Industry

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Abstract: Several developing countries around the globe have launched their future visions, which include concrete strategic plans that involve many kinds of mega-construction projects. One common goal across these visions is to increase the efficiency of construction projects' huge expenditures using recent sustainable, practical engineering tools, such as the value engineering (VE) approach. Although the VE approach has been around for a few years now, some barriers prevent the popularity of its application in different construction projects. This research investigates the barriers to adopting VE through a systematic literature review. This study has categorized the application barriers using thematic analysis under three main categories: barriers related to practitioners' knowledge and background, barriers associated with the behavior of practitioners towards VE, and barriers related to the implementation of VE. Moreover, this research has investigated solutions to overcome these barriers and improve the application of VE in construction projects. Saudi Arabia's construction industry is used as a case study. A survey was distributed to Saudi construction industry practitioners using the snowballing technique to evaluate the criticality of the found barriers to adopting VE and the best strategic solutions to overcome these barriers using the importance–performance analysis (IPA) approach. Based on the results of this study we have specifically recommended including a VE course in college engineering programs and an incentive clause in construction contracts to encourage VE application on construction projects at the top of the list of proposed solutions. Finally, defining the criticality of barriers and the effectiveness of solutions will help enhance the application of VE and sustainability practices in the Saudi Arabian construction industry and around the globe.

Keywords: value engineering; value management; Saudi Arabia's construction industry; value analysis; importance performance analysis (IPA); thematic analysis

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1. Introduction

Value engineering (VE) is a methodology that analyzes value to obtain the required functionality level at the lowest cost without compromising the quality, reliability, services, and performance [1]. It was developed in the U.S. in 1947 after the Second World War. Due to the effectiveness of the VE approach in terms of cost savings, it is applied in different industries, one of which is the construction industry.

Several studies have defined the VE approach as "a management tool to achieve essential functions of a product, service or project with the lowest cost" [2]. Additionally, VE is defined as a "powerful methodology for reducing costs while improving performance and quality requirements" [3]. Furthermore, VE is a structured and analytical process that aims to achieve value for money by providing all necessary functions at the lowest cost consistent with the required levels of quality and performance [4].

This study defines VE as a methodology that the project management team applies during a project's planning phase to remove unnecessary costs while maintaining the quality requirements. In other words, to construct the project with clear objectives, better value, improved design, and better performance at the lowest overall project cost.

Based on long-term experiences in developed countries, it has been found that the VE process is very effective in cost savings at the required level of functionality and quality [4]. However, it is a challenging method to adopt in the construction industry since construction projects are characterized as large and complex due to the variety of products, equipment, materials, designs, and location considerations involved [5]. This research has found, through a review of the related literature, that researchers in different countries have worked on finding the barriers to applying VE. Different common barriers have been found, but the response to them and their importance weight are different due to the uniqueness of construction projects, the differences in culture, regulations of countries, and traditional construction methods. Therefore, this research focuses on identifying the significant barriers to VE application from previous studies in the literature and investigates them in the context of Saudi Arabia's construction industry, one of the region's largest industries. In addition to finding significant barriers, this study provides potential strategies to overcome these barriers and widen the application of VE.

The main objective of this research is to widen the use of the value engineering approach in Saudi Arabia's construction industry by identifying the barriers to value engineering and providing prioritized strategic solutions to overcome these barriers. As a result, the VE's delivered projects can guarantee their target of higher quality, better functionality, and lower overall project costs. Finally, defining the criticality of barriers and the effectiveness of solutions will help enhance the application of VE and sustainability practices in the Saudi Arabian construction industry and around the globe.

1.1. Review of Related Literature

Several studies have been conducted worldwide to investigate different barriers related to VE [6–11]. Even though there are differences in the scope of the research, the discovered challenges and recommended strategies for adapting VE are incredibly beneficial for widening the application of VE in all types of projects. In this paper, previous studies were reviewed and summarized to capture all the critical challenges and proposed solutions.

A study was conducted to investigate and analyze the principal challenges that VE is facing in public projects in developing countries [10]. One of the barriers to applying VE was the increasing cost of the process and operations of the method. Consequently, the VE team was unwilling to proceed with more analyses. Additionally, the cost of implementation can prevent the application of VE when the client has insufficient knowledge about VE or is not assured about the benefits attained from the application of VE on the client's project.

In Malaysia, a study conducted in the private sector found a defensive attitude of the designers, who believe that VE is a process of finding defaults in the design [11]. They believe there is no need to apply VE in their projects since they have enough design experience, qualifications, background, and technical abilities. Another study in Malaysia investigated the implementation of VE in Malaysia's construction industry and found that a lack of knowledge and practice were the main barriers encountered during VE workshop sessions [7].

Additionally, conflicts of interest among project stakeholders are another barrier to implementing VE in Malaysia, while this research investigates similar barriers from a different perspective. This research investigates and asks the following question: is lack of knowledge about the benefits of VE between project parties becoming a barrier due to conflicts of interest, resulting in avoidance of the application of value engineering?

Jaapar (2009) noted that some advantages gained from the implementation of VE are that VE was able to produce better value for the project, lowered the project cost, eliminated unnecessary costs, the client's requirements were better met, and produced better functionality [7].

Moreover, another study was performed on the construction industry of Hong Kong, which linked one of the barriers to the aspect of project investment [12]. The scarcity of land led to increasing land costs and a fear that the VE studies would extend the time of the design. Owners preferred to proceed with construction without applying VE, believing that VE would save a low percentage of overall project cost and consume investment time. Hence, they preferred to use the study time to proceed with construction. Furthermore, another study that investigated the application of VE in China's construction industry found that the conflicts of interest between parties are one of the barriers due to little understanding of the VE principles and the potential benefits derived from VE studies [8].

Likewise, a study on VE in Vietnam's construction industry was conducted. It concluded that the four major barriers are a lack of knowledge about VE, a lack of local VE guidelines, a lack of VE experts, and technical norms and standards [9]. The study did not mention recommendations or solutions to overcome these barriers and promote the adoption of VE, a gap this research will investigate.

A study was conducted on implementing VE for building projects in Egypt [13]. It concluded that the critical barriers were the difficulty of involving decision-makers and stakeholders in the VE workshop and inadequate facilitation of skills and training. The study was conducted in two cities in Egypt and on one type of construction project. This study covered different types of construction projects in the private and public sectors of the Saudi construction industry, and it provided potential solutions to overcome the identified barriers.

Another study was conducted on Nigeria's construction industry. It was found that VE awareness is not the issue in the application of value engineering, but that the readiness of the construction industry to apply VE is why it has not been adopted [14]. The study stated that there is a need to enlighten the stakeholders about VE in seminars, workshops, and conferences. The study showed a lack of application of VE, but it did not provide any potential solutions because the recommendations were generalized and not specific. Furthermore, a case study that investigated the barriers to adopting VE stated that lack of awareness of VE among clients, lack of VE experts, poor working relationships among stakeholders, and an absence of local VE guidelines are the major barriers to adopting value engineering [15]. Another study investigated the barriers to implementing VE in small construction projects in Malaysia. It stated that the barriers fall under the following major categories: guidance and knowledge, resources, environmental, methodological, and cultural barriers [16].

1.2. Review of Saudi Arabia's Construction Industry and Previous VE Studies

Regarding Saudi Arabia's construction industry, the gross domestic product (GDP) from construction averaged SAR 28.13 billion from 2010 to 2023, reaching an all-time high of SAR 32.87 billion in the third quarter of 2023 [17], which indicates that the construction industry is growing. The development of the construction industry will require more funds to support the development of projects related to Saudi Arabia Vision 2030, which states that one of the goals of the vision is increasing expenditure efficiency.

There were some efforts to increase the application of VE. Firstly, a study investigated barriers to applying VE in Saudi Arabia in only public organizations and architectural offices that work for designing public projects [18]. They found that a lack of knowledge about VE was one of the major barriers when they conducted the research, but they did not mention the reason for this barrier. This research expands on previous investigations to include the private sector, which was not covered in the study conducted by Assaf [18]. Furthermore, this research aims to find the best strategic solutions to overcome the barriers to VE.

Another research study was conducted on the construction industry of Saudi Arabia, which was an integrated approach to value management and sustainable construction in the public sector of Saudi Arabia. The research found that one of the major barriers to applying VE and sustainability in construction projects was the lack of information regarding the standard, specifications, building code, historical data, and cost estimation manual for whole life cycle calculations [19]. The research findings focused on integrating VE and sustainability in construction projects. The mentioned factor was generalized and not specified to VE. Additionally, the research focused on the public sector and did not mention the status of Saudi Arabia's private sector, while this research included the private sector.

A recent study on Saudi Arabia's construction industry found that 70% of practitioners did not participate in VE workshops. Additionally, it showed that only 55% of practitioners were familiar with the concept of VE [20]. This suggests that the VE participants' familiarity and awareness require adequate growth to implement VE widely. The research studied the success factors for VE. Still, it did not mention the criticality of the factors. In contrast, this research studied the criticality of all barriers related to VE and then proposed different solutions that were evaluated in terms of effectiveness and importance.

Lastly, a study titled The Success Factors for Implementing VE Proposals in Saudi Arabia focused mainly on success factors that will assist in obtaining the decision-maker's approval of the proposed VE study during the implementation meeting [21]. It was found that 50% of VE proposals were rejected for two main reasons: inappropriate timing for submitting the VE proposal and poor quality of the VE proposal. The study was mainly focused on the phase after completing the VE workshop and before implementing the VE proposal.

Lastly, the study of the related literature found that the knowledge gap that previous research mainly focused on was the barriers that prevented the adoption of VE in the public sector. However, this research includes the private and public construction sectors. It provides a detailed analysis of the criticality of the existing barriers and investigates their root causes. Furthermore, this research will provide potential prioritized solutions to overcome the identified barriers to adopting VE in Saudi Arabia's construction industry.

2. Methodology

2.1. Research Design

The research started with investigating previous studies to identify VE application barriers in different construction industries worldwide and identify potential solutions to overcome these barriers. Then, the efforts were narrowed down to review the related literature in Saudi Arabia's construction industry. This concentrated literature review study introduced a list of barriers and potential solutions for different situations. The identified barriers are randomly listed and not arranged. Afterward, these barriers were analyzed and categorized through various cycles of qualitative data analysis performed using thematic analysis procedures.

After the thematic analysis was completed, a questionnaire survey was prepared for publication, targeting practitioners in Saudi Arabia's construction industry as the unit of analysis.

The survey was used to evaluate the criticality of the found barriers to adopting VE and the best strategic solutions to overcome these barriers using the importance–performance analysis (IPA) approach. Then, an analysis of the data collected from the survey was performed, and the results were discussed. Figure 1 shows the flow chart of the research methodology.

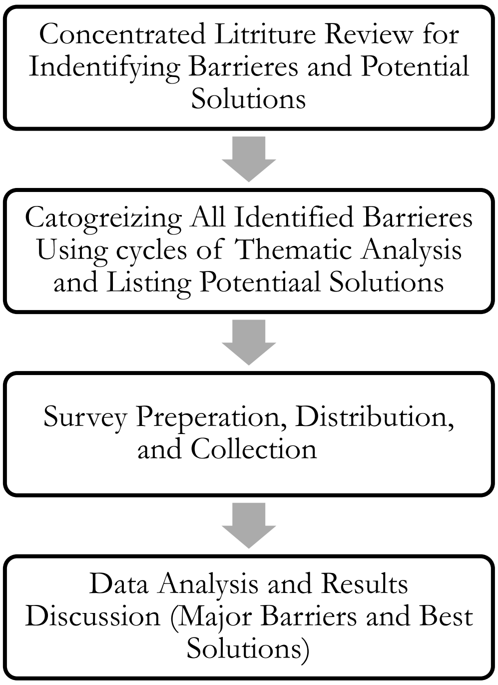

Figure 1. Research methodology.

2.2. Data Collection

In this study, the instrument used for data collection was a questionnaire, and the purpose of using the questionnaire was to identify the major barriers and evaluate the potential solutions to improve and widen the application of VE in Saudi Arabia's construction industry. The survey was built to ensure that the questions must be direct and short to avoid misunderstanding and shorten the response time. The surveys that were not completed were omitted, and the completed ones were collected.

The questionnaire survey was designed to target practitioners in the construction industry of Saudi Arabia (owners, consultants, and contractors) who are involved in the construction industry. The survey consisted of five sections. Section 1 captured the biography of the respondents. Section 2 consisted of barriers to value engineering in terms of knowledge and background. Section 3 consisted of different barriers related to practitioners' behavior toward value engineering. Section 4 consisted of barriers related to the implementation of value engineering. Using the seven-point Likert scale, participants evaluated the barriers. Section 5 captured experts' responses to different proposed strategies to improve and widen the application of value engineering in the construction industry of Saudi Arabia. Participants were asked to evaluate each strategy's importance and performance. Using the IPA model, the potential strategic solutions to overcome the barriers to adopting value engineering in the construction industry of Saudi Arabia will be identified.

The second technique used in the data collection is the Likert scale, which evaluates the barriers and potential solutions listed on the questionnaire by the respondents. The Likert scale is one of the most used instruments in research; Rensis Likert created it in 1932 [22]. In this research, the Likert scale was used to capture the respondents' evaluation of the barriers and potential solutions to improve the application of VE in Saudi Arabia's construction industry.

The Likert scale has five-point, seven-point, and eleven-point scales. The scale used in this research was a seven-point scale because it reflects a respondent's true evaluation [23]. The barriers are evaluated based on seven points: strongly disagree, disagree, somewhat agree, neutral, somewhat agree, and agree. Each evaluation point has a scale and weight range, as shown in Table 1. This scale is used to find a weighted range by calculating the range interval. Based on the weighted score, the barrier score will fall in the weighted range of one of the seven evaluation points. Then, the barrier will be classified according to its weighted score (Table 1). For example, if the weighted score of the barrier is 5.35, the barrier classification will be "agree", and will be considered a barrier to adopting VE.

Table 1. The scale and weighted range of the seven-point evaluation scale for the barriers.

Evaluation Category	Scale	Weight Range *
Strongly Disagree.	1	1.00–1.86
Disagree.	2	1.87–2.73
Somewhat Disagree.	3	2.74–3.59
Neutral	4	3.60–4.46
Somewhat Agree.	5	4.47–5.31
Agree.	6	5.32–6.17
Strongly Agree.	7	6.18–7.00

* Weight range interval calculation = $\frac{7-1}{7}$ = 0.86.

After completing the survey design, an online survey was prepared and distributed through an online service using the SurveyMonkey platform. The reason for selecting this technique was that it would provide better access to a larger audience in different locations.

2.3. Population and Sampling Techniques

The population of this research comprises practitioners working in the Saudi construction industry. Since this research investigated the topic of value engineering, participants must be engineers with bachelor's degrees or above who worked in Saudi Arabia's construction industry. The practitioners were randomly selected, and then the snowballing technique [24] was used in this research to increase the sample size. It was useful because they were asked to invite other interested practitioners on the topic through a shareable survey link. The snowballing procedure increased the number of specialized and interested participants in the VE approach, which helped us to obtain more responses by reaching a larger audience in different locations. The practitioners were randomly selected to diversify the initial 'seed' contacts, and non-leading inclusion criteria were used to minimize bias in the snowball sampling. Due to the use of the snowballing technique, there is a possibility that a participant's experience and education do not meet the requirements of the research. So, the collected surveys were filtered based on the population criteria, and the study did not include the responses of participants who met this criterion.

Data saturation has been used as a methodological principle to indicate that further data collection or analysis is unnecessary [25]. The saturation can be defined as a criterion at which the researchers/authors decide to stop sampling as they see similar instances repeated many times and become confident that the data they reached are saturated [25]. Additionally, data saturation can be described as the point at which the new data are redundant with respect to the already collected data [26]. Based on that, in this study, conditions were used to test if the collected data had reached saturation, leading to the decision to either collect more or stop the data collection. First, the sample size must be with a confidence level of 95%, and the confidence interval must be less than 10%. Due to limitations of available and published statistical resources regarding the number of practitioners in the construction industry of Saudi Arabia (population of the research), the formula of the unknown population was selected to decide the required sample size [27]. Based on the formula of the unknown population using a confidence level of 95% and a margin of error of less than 10%, the required sample size for this research was 96 participants. So, the condition to test data saturation was that the sample size must be equal to or above 96.

The second condition was that the distribution of responses per each barrier was repeated while the sample size increased, indicating that the data had reached saturation.

Based on the satisfaction of these conditions, the researcher decided to conclude the data collection and move to data analysis.

2.4. Data Analysis Tools

Several data analysis tools were used, starting with a thematic analysis to categorize the barriers found in the literature. A thematic analysis identifies, analyzes, and reports patterns (themes) within data [28]. The thematic analysis was performed to categorize the identified barriers in the list. The process went through different cycles to reach the final categorization. It started with cycle one, and the objective of this cycle was to become familiar with the listed barriers. Then, the process moved to cycle two, and the main aim of this cycle was to identify the common pattern of the barriers. Finally, the third cycle started to arrange the listed barriers under the specified patterns.

The second instrument is the importance–performance model used to analyze the collected data from the survey to identify the most effective solutions to improve the application of VE in Saudi Arabia's construction industry. The importance–performance analysis (IPA) was developed by [29] to identify which product or service attributes an organization should focus on to enhance customer satisfaction. Different tools are used to evaluate the solutions, such as SERVPERF and SERVQUAL; however, these tools mainly focus on performance, while the IPA focuses on the importance and performance, prioritizes attributes, provides attributes, and provides guidance for strategic development [30]. This research involved using the IPA model to evaluate the potential solutions of VE adoption and different evaluation scales were used to assess performance and importance. Table 2 shows the seven evaluation points of the solutions for the IPA model.

Table 2. The scale of the seven-point evaluation scale for the IPA model.

Importance Evaluation	Performance Evaluation	Scale
Extremely Not Important	Extremely Not Effective	1
Somewhat Not Important	Somewhat Not Effective	2
Not Important	Not Effective	3
Neutral	Neutral	4
Somewhat Important	Somewhat Effective	5
Important	Effective	6
Extremely Important	Extremely Effective	7

Lastly, the weighted scores used for barriers analysis will define each barrier's classification and the significant barriers. Additionally, the weighted score is used to build the IPA model and evaluate each potential solution in terms of performance and importance to recommend the best strategies for widening VE adoption.

3. Results

Preliminary Results of Literature Review

During the literature review, different barriers and solutions were identified. Then, a thematic analysis was performed to categorize the identified barriers, resulting in three significant categorizations (themes): barriers related to background and knowledge, barriers associated with the behavior of practitioners toward VE, and barriers related to the implementation of VE. The lists of categorized barriers are presented in Tables 3–5, respectively. Additionally, different potential strategic solutions to overcome VE barriers were identified during the literature review, as shown in Table 6.

Table 3. Barriers related to background and knowledge.

No	Barrier	Reference
1	The lack of awareness and knowledge of practitioners about value engineering	[9,10]
2	The lack of local value engineering guidelines and standards	[8]
3	The difficulty of conducting a value engineering analysis	[9]
4	The difficulty of evaluating value engineering alternatives	[9]
5	The limited skills of construction practitioners to accurately estimate the cost of value engineering alternatives	[9]
6	The low knowledge level of project stakeholders about value engineering benefits	[10]

Table 4. Barriers related to the behavior of practitioners toward value engineering.

No	Barrier	Reference
1	Lack of teamwork spirit	[10]
2	The defensive behavior of the designer	[8]
3	The owner believes that "projects are designed by best designers, so there is no need for value engineering."	[10]
4	The project team believes that value engineering is complicated and theoretical.	[10]
5	The project team is unwilling to use value engineering because of a time limitation.	[31]

Table 5. Barriers related to the implementation of value engineering.

No.	Barrier	Reference
1	Value engineering is not used because of project complexity	[9]
2	Value engineering is not used because of the absence of competent/experienced value engineering contractors	[9]
3	The lack of cooperation and communication with the internal value engineering team	[9]
4	The limited number of value engineering experts in the construction industry	[12]
5	Value engineering is too difficult to apply	[8]
6	The conflicts of interest among project parties	[11]
7	The lack of communication among stakeholders	[9]
8	Value engineering is not demanded by clients	[8]
9	The absence of contract incentive clauses to apply value engineering	[8]

Table 6. Potential solutions to overcome value engineering barriers.

No	Strategic Solutions	Reference
S1	Conducting conferences and seminars for knowledge sharing between construction professionals.	[32]
S2	Developing local guidelines for value engineering study.	[33]
S3	Clarifying the client's understanding of value engineering.	[9,33]
S4	Involving key stakeholders in value engineering workshops.	[8,33]
S5	Selecting well-trained value engineering team members to obtain the optimum outcome.	[33,34]
S6	Adequate communication among stakeholders, especially during value engineering workshops.	[32,33]
S7	Strengthening the teamwork spirit for every participant.	[32,33]
S8	Clarifying the objective of value engineering at the initiation of the value engineering workshop.	[9,33]
S9	Organizing value engineering training courses with value engineering experts.	[9,11]
S10	Establishing a group support system that helps the participants to solve problems.	[35]
S11	Assigning value engineering experts to leading value engineering workshops.	[35]
S12	Including a value engineering course in engineering college programs.	[9,32,33]
S13	Adding value engineering incentive clause in the construction contract.	[9,11]
S14	Enhancement of publicity on value engineering achievements and benefits.	[33,36]
S15	Adding a clause for value engineering in the Public Works Contract.	Expert Opinion

4. Questionnaire Results

4.1. Data and Demographic Information of Respondents

The data were collected using an online survey. The survey was distributed to practitioners in Saudi Arabia's construction industry using snowballing techniques to capture their expertise in VE practices. The invitations were sent online through email services provided by the SurveyMonkey Website to 377 participants. Only 305 invitations were successfully delivered to participants, and the remaining 72 invitations were not shown due to technical issues. Of the 305 invited participants, only 128 participated in the survey, and 102 completed it. After performing data cleansing on the completed surveys to remove any corrupt or inaccurate responses, the final number of completed surveys was 97. Finally, the rate of return of invitations was 42%, which is higher than the acceptable average response rate (20–30%) for surveys in the construction industry [37].

Participants were asked to select their level of education, and the results show that 65.69% of the respondents had bachelor's degrees, 33.33% had master's degrees, and around 0.98% had Ph.D. degrees. Additionally, participants were asked to select which type of project they had experienced; the results show that residential projects form 28.49% of the background of the participants. Commercial projects form 31.18% of the background of the participants. Industrial projects form 20.97% of the participants' experience. Finally, governmental and infrastructure projects form 19.35% of the participants' backgrounds.

Moreover, participants were asked about the extent of the application of VE in their projects. The gathered data about the extent of the application of VE in construction projects show that 10.78% of participants mentioned that they always apply VE in their projects, 27.45% of the participants mentioned that they usually apply VE in their projects, 40.20% of participants mentioned they sometimes apply VE in their projects, 13.73% stated that rarely apply VE, and 7.84% never apply it in their projects. The varying percentages of VE applications indicate that there are barriers to VE application that this study aims to identify, analyze, and find the best strategic solutions to overcome.

Participants were also asked about the cost savings percentage after applying VE to their projects. Based on a detailed analysis of the data extracted from the survey. It was found that cost savings due to the application of VE varied between the construction projects in which participants were involved. It was found that 19% of participants saved 5.92%, 68% saved 17.42%, 5% saved 36.13%, and 7% stated that they saved more than 36.13% of the total project cost.

4.2. Evaluation of Barriers Related to Background and Knowledge of Practitioners

The respondents were asked at what level they agree that the background and knowledge-related parameters are considered barriers to using VE in Saudi's construction industry. Based on the weighted scores, the barriers' scores, ranks, and classification were listed from highest to lowest, as shown in Table 7. It was discovered that the participants agreed that all the identified parameters were considered barriers to using VE in Saudi's construction industry. However, the level of agreement was "Agree" for all barriers except one, which acquired the "Somewhat Agree" level, which was the difficulty of conducting VE analysis.

Table 7. The scores of barriers related to background and knowledge.

No.	Barriers	Score	Category
1	The lack of awareness and knowledge of practitioners about value engineering.	5.77	Agree
2	The lack of local value engineering guidelines and standards.	5.73	Agree
3	The low knowledge level of project stakeholders about value engineering benefits.	5.68	Agree
4	The limited skills of construction practitioners to accurately estimate the cost of value engineering alternatives.	5.52	Agree
5	The difficulty of evaluating value engineering alternatives.	5.42	Agree
6	The difficulty of conducting value engineering analysis.	5.23	Somewhat Agree

Based on the scores of the barriers related to background and knowledge, it can be noted that these factors significantly affect the adoption of VE in Saudi Arabia's construction industry. The results for one of the parameters showed that the project stakeholders have little knowledge about the benefits of applying VE. Therefore, in the planning phase, the project's stakeholders need assurance about the benefits their project can obtain after applying VE. Additionally, practitioners must overcome the difficulty of accurately estimating the cost of different alternatives of one item function through continuous education and up-to-date information on the market's new products.

4.3. Evaluation of Barriers Related to the Behavior of Practitioners towards Value Engineering

The results presented in Table 8 show the scores, ranks, and classification of barriers related to the adoption of VE associated with the behavior of the practitioners toward the application of VE. The significant barrier associated with the behavior of practitioners toward VE is that practitioners are unwilling to use VE due to time limitations. Instead, they prefer to use the time of the VE study to prepare the bidding documents and quotes for the project and then proceed directly to the execution phase. Another probable reason is that project owners require the project to meet their requirements and then proceed to implementation if its cost is feasible.

Table 8. Scores of barriers related to the behavior of practitioners towards value engineering.

No.	Barrier	Score	Category
1	The project team is unwilling to use value engineering because of time limitations.	5.57	Agree
2	The defensive attitude of the designer.	4.96	Somewhat Agree
3	The owner believes "projects are designed by best designers, so there is no need for value engineering".	4.91	Somewhat Agree
4	The project team believes that value engineering is complicated and theoretical.	4.76	Somewhat Agree
5	The lack of team spirit.	4.60	Somewhat Agree

Furthermore, the trust of the project owner that the best designers designed the project, so there is no need for VE, forces the project team to proceed to the next phase and not consider time for VE study. There is some agreement among practitioners that the defensive attitude of the original design team toward adopting VE is due to the belief that VE is a process of finding design defaults. Additionally, the project team believes that VE is complicated and theoretical. The score related to the lack of team spirit indicates that the project team must be supported and encouraged to apply VE in their project and motivated during the VE study in order to achieve the optimum results.

4.4. Evaluation of Barriers Related to the Implementation of Value Engineering

The first barrier related to implementing VE is the absence of a contract incentive clause for applying VE. Construction contracts should have an incentive clause for VE to enhance its application. Additionally, the incentive will motivate project parties to provide the best results. The limited number of VE experts in the construction industry seems to be a considerable barrier. VE experts are a critical success factor in widening the implementation of VE in construction projects due to the influence of their experience. They can assist in achieving the best results, facilitate the process, and lead the VE workshops. This study showed that there was a limited number of experts, which became a barrier to VE application on construction projects. The lack of cooperation and communication with the internal VE team comes next on the barriers list. The fourth barrier is that clients do not demand VE, which is caused by the insufficient knowledge of the clients about the benefits of VE.

The fifth barrier is that VE is not used due to the absence of contractors' competence/experience in VE. However, the practitioners somewhat agree that the lack of communication between stakeholders, the project team's unwillingness to adopt VE to avoid the project's cost increase, and the conflicts of interest between project parties are barriers to the implementation of VE, and are the sixth, seventh, and eighth barriers, respectively.

Lastly, regarding the last two barriers, VE is not used because of project complexity or because it is too difficult to apply; the practitioners' opinions were neutral. Table 9 shows the scores, ranks, and classification of barriers related to VE's implementation.

Based on the scores of the barriers in each classification, it can be noticed that the barriers related to background and knowledge about VE are more critical in adopting VE. Then, the barriers associated with implementing VE come into play second. At the same time, the behavior of practitioners toward VE has the lowest effect on the adoption of VE.

Table 9. The scores of barriers related to the implementation of value engineering.

No.	Barrier	Score	Category
1	The absence of contract incentive clauses to apply value engineering.	5.86	Agree
2	The limited number of value engineering experts in the construction industry.	5.56	Agree
3	The lack of cooperation and communication with the internal value engineering team.	5.47	Agree
4	Value engineering is not demanded by clients.	5.38	Agree
5	Value engineering is not used because of the absence of contractors' competence/experience in value engineering.	5.33	Agree
6	The lack of communication among stakeholders.	5.30	Somewhat Agree
7	The project team is unwilling to apply value engineering because they do not want to increase the cost due to the cost of the value engineering study.	5.12	Somewhat Agree
8	The conflicts of interest among project parties.	5.04	Somewhat Agree
9	Value engineering is not used because of project complexity.	4.14	Neutral
10	Value engineering is too difficult to apply.	3.71	Neutral

4.5. Evaluation of Potential Solutions to Overcome Value Engineering Barriers

One of the research objectives was to find strategic solutions to improving the application of VE in Saudi Arabia's construction industry. A list of solutions was presented to practitioners to seek their evaluation of the proposed solutions. Then, the data collected from the practitioners were analyzed using the IPA model to find the best-recommended solutions to improve the application of VE. The strategic solutions are listed with the weighted importance and performance scores in Table 10. Then, it is plotted on the model to conclude the analysis results, as shown in Figure 2.

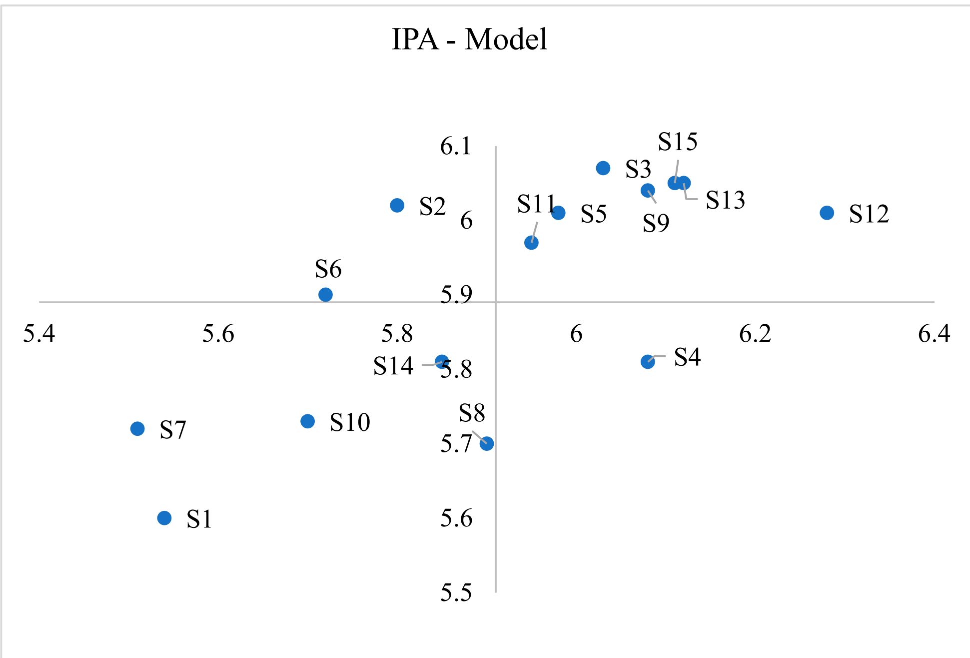

Figure 2. IPA model for potential strategies to overcome VE barriers.

Table 10. The scores of strategic solutions to overcome VE barriers.

Strategic Solutions	I	P
S1: Conducting conferences and seminars for knowledge sharing between construction professionals.	5.60	5.54
S2: Developing local guidelines for the value engineering study.	6.02	5.80
S3: Clarifying the client's understanding of value engineering.	6.07	6.03
S4: Involving key stakeholders in value engineering workshops.	5.81	6.08
S5: Selecting well-trained value engineering team members to obtain the optimum outcome.	6.01	5.98
S6: Adequate communications among stakeholders, especially during value engineering workshops.	5.90	5.72
S7: Strengthening teamwork spirit for every participant.	5.72	5.51
S8: Clarifying the objective of value engineering at the initiation of the value engineering workshop.	5.70	5.90
S9: Organizing value engineering training courses with value engineering experts.	6.04	6.08
S10: Establishing a group support system that helps the participants to solve problems.	5.73	5.70
S11: Assigning value engineering expert for leading value engineering workshops.	5.97	5.95
S12: Including a value engineering course in engineering colleges' programs.	6.01	6.28
S13: Adding value engineering incentive clause in the construction contract.	6.05	6.12
S14: Enhancement of publicity on value engineering achievements and benefits.	5.81	5.85
S15: Adding a clause for value engineering in Public Works Contract.	6.05	6.11

I(y): importance. P(x): performance.

4.6. First Quadrant

The solutions in the first quadrant are low-performance and high-importance. They are "S2", developing local guidelines for VE study, and "S6", adequate communications among stakeholders, especially during VE workshops. These solutions are important but need improvements to be effective. So, as per the IPA approach, they must be developed before adoption.

4.7. Second Quadrant

This quadrant contains the best strategic solutions to improving the application of VE in Saudi Arabia's construction industry. The first recommended solution is "S12", to include a VE course in engineering colleges' programs. Including a VE course in engineering majors' curriculums will enhance engineering students' background and knowledge, supporting their careers. This research finds that "The lack of awareness and knowledge of practitioners about VE" is a significant barrier that could be overcome by implementing this solution.

This research ranks the absence of contract incentive clauses to apply VE as the first barrier to implementing VE in Saudi Arabia's construction industry. This study investigated this barrier and found that adding a VE incentive clause in the construction contract "S13" will overcome it and enhance the application of VE. The purpose of this type of clause is to motivate project parties to find cost-effective solutions [38]. This solution will effectively contribute to cost savings, better product functionality, and more innovative ideas.

Clarifying the client's or project owner's understanding of VE "S3" before the VE workshop is another solution to barriers to applying VE in construction projects. This solution will help the workshop leader understand the client's background. Furthermore, it will contribute to correcting some misunderstandings about VE, such as the owner's belief that the best designer designs the projects and that there is no need for VE. This strategy will also help with the barrier of knowledge about VE benefits among stakeholders.

Additionally, this research found that one of the barriers related to VE implementation in Saudi Arabia's construction industry is the limited number of VE experts. After the analysis using the IPA model, the research found that organizing training courses with VE experts will enhance the background and knowledge of practitioners and increase the number of VE experts in Saudi Arabia's construction industry.

Selecting well-trained VE team members to obtain the optimum outcome, and assigning VE experts to lead VE workshops, will contribute to solving and overcoming three barriers found by this study. These barriers are the difficulty of conducting VE analysis, evaluating VE alternatives, and the limited skills of construction practitioners to accurately estimate the cost of VE alternatives. Involving and selecting very well-trained VE members and assigning VE experts to lead them will help to overcome these barriers and result in better analysis and evaluation during the VE workshop, which will result in obtaining the optimum outcomes of the VE study.

4.8. Third Quadrant

Solutions located in the third quadrant are of low performance and low importance. Solutions that fall in this quadrant are "S1," conducting conferences and seminars for knowledge sharing between construction professionals; "S7" strengthening teamwork spirit for every participant; "S10" establishing a group support system that helps the participants to solve problems; "S8" clarifying the objective of VE at the initiation of VE workshop; and "S14" enhancement of publicity on VE achievements and benefits. The analysis of the IPA model showed that these solutions are not effective and not important. So, they should not be adopted.

4.9. Fourth Quadrant

Solutions in this quadrant are categorized with high performance and low importance. Following the IPA methodology, solutions in this quadrant are above average in terms of effectiveness and below average in terms of importance, so these solutions should not be adopted [11]. The solution in this quadrant is "involving key stakeholders in VE workshops".

5. Discussions

This research aims to investigate the barriers to VE adoption and propose strategic solutions to overcome these barriers. This research has found that practitioners in the construction industry have low knowledge and lack awareness about the value of engineering. Surprisingly, this barrier was found to be a significant barrier related to the background and knowledge of practitioners in the construction industry. A possible explanation might be that the project stakeholders need to gain more knowledge about the benefits of VE, which explains why they do not demand to apply VE in their projects. If the stakeholders do not require VE, the practitioners will not be motivated to enhance their knowledge background in VE. Another possible explanation is the need for local VE guidelines and standards for VE. Guidelines will facilitate the application of the VE procedures, and the standards will illustrate the requirements for practitioners that will positively impact the practitioners' background and knowledge about VE. This research work recommends (based on the IPA model analysis) overcoming this barrier in two ways. Firstly, for practitioners in the construction industry, a VE training course with VE experts will be organized, which will increase practitioners' background and awareness of VE. The training with VE experts will help practitioners to apply VE methodology easily. The second approach will be to implement an undergraduate engineering course in a college of engineering programs, which will enhance their knowledge about VE applications. Moreover, during the process of the VE application, clarifying the VE benefits to clients and stakeholders before proposing the application and involving key stakeholders in VE workshops will significantly benefit the adoption of VE in their projects. Regarding the barriers of the limited skills of construction practitioners to accurately estimate the cost of VE alternatives, the difficulty of evaluating VE alternatives, and the difficulty of conducting VE analysis, the recommendation to overcome these challenges is to assign VE experts to lead VE workshops and involve well-trained VE team members during discussions to obtain the optimum outcome. This study confirms the result of a previous study conducted on the construction industry of Saudi Arabia [18], which showed a lack of knowledge. However, they did not show the barriers caused by the lack of knowledge nor propose any solution to overcome this barrier.

Regarding the second categorization, where the barriers are related to the behavior of practitioners toward VE, this research confirms the result of a previous study [31], that practitioners are unwilling to apply VE due to time limitations. A possible explanation is that they prefer to use the time for the VE study to prepare the bidding documents and quote for the project if it is designed based on the client's requirements. However, this study previously discovered that the stakeholders need to gain more knowledge about the benefits of VE. Thus, practitioners should explain why VE should be applied and assign a time duration for the process that results in the client's favor. Another reason is that some owners focus on the project's total cost. If the cost is feasible per their feasibility study, they move forward with the construction without considering applying VE. Another barrier related to the practitioners' behavior is the designer's defensive behavior due to the belief that VE is a process of finding errors in the design. Additionally, the researcher found that the owner believes that "projects are designed by the best designers, so there is no need for VE.". It is recommended before starting the VE workshop to clarify the understanding of VE and indicate that VE is applied to increase the functionality of the project and decrease the total life cycle cost.

Regarding the third categorization, the barriers are related to implementing VE. Research has found that one of the barriers to implementing VE is the absence of a contract incentive clause to apply VE. Incentives in construction contracts will motivate parties to earn the incentive resulting from applying VE in construction projects. This study found that the best strategic solution to overcome this barrier was to add a VE incentive clause in the construction contracts. This solution will motivate parties to study the project to increase its functionality and decrease its cost, which will ultimately widen the application of VE.

Another barrier the research has found is that the number of VE experts needs to be increased, which is correlated with other barriers related to the implementation of VE. This explains why clients do not demand VE. So, to overcome this barrier, this research proposes organizing VE training courses and workshops with VE experts. Additionally, this strategic solution will positively impact other barriers, such as the need for more cooperation and communication with the internal VE team and the fact that VE is not used because of the absence of competent/experienced contractors. Training courses will help to increase the number of VE experts in construction, which directly widens the application of VE in Saudi Arabia's construction industry. This study showed that there needs to be more communication among stakeholders, which is considered one of the barriers to implementing VE. The research has found the solution to this barrier: involving key stakeholders in the VE workshops will result in better communication between them. In addition, this strategic solution will positively impact the conflicts of interest among project parties, which are one of the barriers to implementing VE. This research has found that the conflicts of interest among project parties, which are caused by low knowledge about the benefits of VE, are a barrier to adopting VE. Thus, to overcome this barrier, the VE workshop should be led by VE experts who can help the members find the optimum results and clarify the objective of the VE workshop so they can be more focused on the goals rather than their interests. What is surprising is that one of the barriers investigated in this study is the complexity of construction projects. Unlike previous studies [8,9], this study found that the complexity of a construction project is not a barrier to applying VE. Additionally, practitioners agreed that VE is relatively easy to apply.

Study Implications

The implications of this research hold substantial significance for all stakeholders interested in adopting the value engineering approach. In terms of practical implications, adopting the Value Engineering (VE) approach can significantly enhance the value and efficiency of construction projects. Studies have shown that VE can increase the project value and reduce the overall project cost by 5% to 15%, and even more in some instances [39]. Moreover, the VE methodology has been found to not only decrease project costs but also improve construction project performance by reducing construction time. Thus, this makes it an effective strategy for increasing construction firm profits and enhancing their capabilities [40]. In the context of the growing Saudi construction industry, using sustainable, practical engineering tools like VE can optimize the vast expenditures of construction projects, leading to delivering projects with higher functionality and lower overall costs.

In terms of theoretical implications, this study provides researchers with several areas to focus on to overcome the research limitations related to the topic in future research. These areas include conducting an in-depth survey of the factors that caused the significant identified barriers in this research. Additionally, more solutions and different analysis methods could be used to compare and recommend the best solutions.

Regarding managerial implications, this study provides practitioners and other construction industry stakeholders with actions that decision-makers need to take based on the proposed strategic solutions. The study findings suggest that including VE courses in engineering college programs will enhance engineering students' background in value engineering theory, resulting in a better understanding of VE. Meanwhile, for the practitioners, this study suggests that an organized VE training course with VE experts will expand the knowledge of the practitioners of VE, which will result in better implementation and widen the application of VE. Another finding of this study related to behavior is that this study suggests that clarification of the client's understanding of VE will reduce their behavioral resistance to adopting VE, which will positively affect the implementation of VE. Furthermore, to enhance the implementation of VE in construction projects, this study suggests that adding a VE incentive clause in the construction contract will prompt the adoption of VE.

6. Conclusions

Several developing countries around the globe have strategic plans that involve many kinds of mega-construction projects. One common goal across these visions is to increase the efficiency of construction projects' huge expenditures using recently developed sustainable, practical engineering tools, such as the value engineering (VE) approach. Although the VE approach has been around for a few years now, some barriers prevent the popularity of its application in different construction projects. Saudi Arabia's construction industry is used as a case study. The study of the related literature found that the knowledge gap that previous research mainly focused on was the reason for the barriers that prevented the adoption of VE in the public sector. However, this research includes the private and public construction sectors. It provides a detailed analysis of the criticality of the existing barriers and investigates their root causes. Additionally, this study contributed to widening the application of VE by providing different potential prioritized solutions to overcome the barriers to adopting value engineering in the construction industry of Saudi Arabia.

This research investigated the barriers to adopting VE through a systematic literature review. This study has categorized the application barriers using thematic analysis under three main categories: barriers related to practitioners' knowledge and background, barriers associated with the behavior of practitioners towards VE, and barriers related to the implementation of VE. This study has found that practitioners in the construction industry have insufficient knowledge about VE. Additionally, they have limited skills in accurately estimating the cost of VE alternatives. This study also found that the major barriers that are related to the background and knowledge of practitioners are the following: the lack of awareness and knowledge of practitioners about VE, the lack of local VE guidelines and standards, the low knowledge level of project stakeholders about VE benefits, the limited skills of construction practitioners to accurately estimate the cost of VE alternatives, and the difficulty of evaluating VE alternatives. Furthermore, this study found that the major barrier related to practitioners' behavior toward VE is that the project team is unwilling to use VE because of time limitations. Finally, this study found that the major barriers that are related to the implementation of VE are the following: the absence of contract incentive clauses to apply VE, the limited number of VE experts in the construction industry, the lack of cooperation and communication with the internal VE team, and that VE is not demanded by clients or not used because of the absence of competent/experienced contractors.

Moreover, this research has investigated solutions to overcome these barriers and improve the application of VE in construction projects. This study suggests the following prioritized solutions to enhance the application of VE in Saudi Arabia's construction industry: (1) adding VE courses to engineering college programs, (2) adding VE incentive clauses to construction contracts, (3) adding VE clauses to Public Works Contracts, (4) educating clients on the benefits of VE, (5) providing VE training courses with experts, (6) holding VE workshops with key stakeholders, (7) selecting well-trained VE team members for better results, and (8) assigning a VE expert to lead the workshops.

To overcome the research limitations related to the topic, researchers could focus on several areas in future studies. These areas include conducting an in-depth survey of the factors that caused the significant identified barriers in this research. Additionally, more solutions and different analysis methods could be used to recommend the best solutions. Another potential area of investigation is integrating the VE approach with Building Information Modelling (BIM) to promote the application of VE in construction projects. Finally, studying the barriers to VE application based on project type in Saudi Arabia's construction industry could provide more specific recommendations for different project types.

Additionally, defining the criticality of barriers and the effectiveness of solutions will help to enhance the application of VE and sustainability practices in the Saudi Arabian construction industry and the global industry.

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