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Integrating theory and practice in value engineering within Egypt's construction industry

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Abstract

Egypt's economy is unstable, marked by high unemployment, low incomes, and safety concerns, which impede its rapid development. One crucial sector that faces difficulties is construction, dealing with issues like funding shortages, payment disputes, and ineffective project management. Conventional project success criteria strongly emphasize efficient resource use and waste minimization. These criteria are symbolized by the iron triangle of cost, time, and quality. A key instrument for obtaining value for money in building projects is value engineering (VE). Even though VE is acknowledged in theory, its application is still limited in most developing countries, including the Egyptian construction industry. Therefore, to bridge the gap between theory and practice, this paper attempts to investigate the current state and application of VE in Egypt. The study further outlines strategies for integrating VE into construction practices and identifies obstacles to their implementation. This study employed both qualitative and quantitative research approaches to attain the research aim, beginning with a thorough literature review to assess the application of value engineering (VE) in both local and international construction industries. Then, a web-based survey was conducted to gather diverse perspectives on VE's role and its current practice in Egyptian construction projects. The gathered data were analyzed mainly using descriptive and thematic analysis approaches. The paper's findings revealed that there is a large gap between VE in theory and practice in Egypt. Reasons include lack of awareness and understanding, time and financial constraints, and resistance to change. Bridging the gap to enhance VE in Egypt includes a focus on the role of educational institutions and training, public awareness and recognition, and early project lifecycle integration. This research has gained insights about VE environment, process, duration, types of projects applied, and effectiveness, aiming to get a comprehensive overview of VE in Egypt. Furthermore, this research has identified a significant gap between VE theory and practice in Egypt. To bridge this gap and enhance the implementation of VE in Egypt, strategies such as focusing on the role of educational institutions, increasing public awareness and recognition, and integrating VE approach early in the project lifecycle are suggested. These findings will guide construction industry practitioners to deeply understand the current state of VE in Egypt and practically integrate VE in the construction industry to minimize unnecessary costs, enhance functionality requirements, and achieve value for client's money.

Keywords: Value engineering, Egyptian construction industry, Theory–practice gap, Value for client's money

Introduction

Egypt is a fast-developing country with extremely risky economy as a result of high unemployment, low incomes, and safety concerns [10]. The risk associated with the Egyptian market is caused by sharp fluctuations in exchange rates, a dearth of private sector business decisions, and limitations on commercial models, particularly in the construction industry [30]. More broadly, Abd El-Razek et al. [1] have determined the main causes of building construction delays in this nation, which are the following: obstacles to funding construction projects, disputes with clients on secure payment, changes to the concept design, and a lack of building administration.

According to Lu et al. [23], the iron triangle—which stands for money, time, and quality—is the conventional method for determining whether a building project will be successful. Therefore, it is essential that resources be used as effectively as possible and that waste of any kind be reduced to the absolute minimum for a project because of its complexity [9]. Given that this is the primary goal of any project, generating value for the money is becoming essential [18]. Value for money is an essential component of project management [5]. According to Dell'Isola [12], function, quality, and cost are the three fundamental components that give the user a sense of value, where value is the most economical means of consistently achieving a goal that will satisfy the requirements, preferences, and expectations of the user. Managing value in construction projects results in projects being finished on schedule, within budget, and to the required standard of quality [7]. Abd-Karim [3] emphasized that this concept, which has functional analysis as one of its main components, emphasizes not only cost but also the relationship between function, value, quality, and cost.

Value management (VM) is a widely recognized concept in the construction industry and one of the key tools for managing the value of projects [14]. Value engineering (VE) is a relatively recent term that became well-known in the twentieth century. The foundation of value engineering, however, has long roots that go back to the earliest days of human civilization. According to Chen et al. [8], VE is a well-organized application that finds and removes unnecessary project costs to guarantee value for money by combining technical expertise with common sense. Even though a large body of literature has been published by numerous researchers discussing the theory of VE, there is a lack of its implementation in the construction sector [20]. While various studies have investigated VE from different perspectives, there remains a lack of evidence on bridging the gap between the theory and practice of VE within the Egyptian construction sector. Therefore, understanding the current state and application of VE in Egypt in terms of gaining insights about the VE environment, process, duration, type of projects applied, and effectiveness and identifying strategies to overcome barriers to VE implementation will facilitate the integration of theory and practice.

The paper structure begins with an introduction to the study and is followed by a literature review on VE concepts and their applications in local and international industries in the "Value engineering in the construction industry" section. The "Methods/experimental" section presents the research methodology and data collection approach, and the "Results and discussion" section presents the findings regarding the current state and application of VE in the Egyptian construction industry and also presents bridging the gap between the theory and practice of VE. The final section summarizes conclusions derived from the research findings and presents recommendations.

Definition and principles of value engineering

The majority of professionals, academics, and practitioners in the building industry have expressed interest in using value management. In the last 10 years, value management, which utilizes generally understood tools and techniques, has gained approval [26]. To identify and cultivate value and innovation, both private industries and government agencies utilize a process called value methodology. Also referred to as value engineering, value analysis, or value management, thevValue methodology process significantly optimizes projects, processes, and product development. This method enables companies and government agencies to regularly reduce costs, increase profits, enhance quality and performance, and improve customer satisfaction [33]. Dell'Isola [12] defined value engineering as a methodology that seeks to eliminate unnecessary costs while ensuring that quality, reliability, performance, and other essential factors meet or surpass customer expectations.

El-Senoussi [15] identified VE principles as a systems-oriented, multi-disciplined team approach, life cycle-oriented, a proven management technique, and function-oriented. He also identified that VE is neither a design review, a cheapening process, a requirement done on all designs, nor a quality control.

Zhang et al. [34] determined that VE is a management tool that helps accomplish a project's, service's, or product's primary goals at the lowest possible cost, whereas VE was identified by [25] as a methodological value-enhancing management style. According to Chen et al. [8], VE is a well-organized application that finds and removes unnecessary project costs to guarantee value for money by combining technical expertise with common sense.

VE job plan

VE employs techniques like function analysis, creative thinking, cost models, FAST diagrams, and evaluation matrix in a job plan to effectively implement the program, identifying high-cost areas without affecting the quality [35]. A job plan is a systematic process that supports decision-making by organizing available information. Various job plans have been introduced during the past 30 years since 2000 [15]. Barrie and Paulson [6] highlighted that the differences between these job plans primarily lie in giving more emphasis to certain aspects of the process, yet they all have the same approach.

The SAVE International standard defines a six-phase job plan as one of the three stages that make up a value study. These stages are the following: Pre-Study (preparation), Study (execution of the six-phase job plan, which consists of the following phases: information, function analysis, creative, evaluation, development, and presentation), and Post-Study (documentation and implementation). This job plan, as shown in Table 1, will be used in the study as it organizes, formalizes, and structures value engineering techniques, focusing on phases, value study teams, and manager qualifications, based on Miles' original ideas [16].

Table 1 Value engineering job plan [13]

Value engineering job plan		
Phase	**Sub-phase**	**Related steps**
Pre-study		Collect user/customer attitude, complete data file, determine evaluation factors, scope the study, build data models, determine team composition
Value study	Information phase	Complete data package, modify scope
	Function analysis phase	Identify functions, classify functions, develop function models, establish function worth
	Creativity phase	Create a large quantity of ideas to achieve the functions specified
	Evaluation phase	Rank and rate alternative ideas, select ideas for development
	Development phase	Conduct cost benefit analysis, complete technical data package, create implementation plan, prepare final proposals
	Presentation phase	Present oral report
Post-study		Complete changes, implement changes, monitor status

Value engineering in the construction industry

Dell'Isola [12] states that to get the best results in projects, VE should be carried out as soon as possible—before funds are committed and systems, services, or designs are approved. Senay Atabay and Niyazi Galipogullari [29] elaborated that VE applications can significantly contribute to potential savings in early project stages. The authors also mentioned that when VE is implemented later, resistance to changes and the amount of money needed to implement increase.

Companies compete by offering innovations, conveniences, low prices, and quality to customers, with VE application directly impacting each element in the quality-time–cost triangle (Senay Atabay & Niyazi [29]). Over the past decade, VE has been applied to various construction projects, focusing on value assessment in relation to project lifecycle costs and other project value aspects [19].

A research study conducted by Senay Atabay and Niyazi Galipogullari [29] in Croatia aimed at assessing the application of value engineering (VE) principles in construction projects. The VE team achieved satisfactory time and cost savings, saving over 43,000,000 dollars and 12 months of time by applying VE principles during the project preparation phase and project revision phase. This resulted in a reduction of work time by 17% and financial savings by 6%. Another research by Ellis et al. [14] confirmed that VE, when implemented correctly early in the project, could save capital costs by 10–25% in building projects. Subsequently, VE was used by Kim et al. [21] as an affordable alternative design tool for road construction. Another case study conducted by Parakhiya and Patel [27] suggests that using value engineering can maximize profits without compromising product reliability. By changing materials, project costs can be reduced by around 8%, especially for complex construction projects, which can result in significant savings compared to the overall project cost. In fact, project costs were reduced from ₹ 5,92,31,721 to ₹ 5,47,16,558 after implementing VE.

Following an analysis of the state of VM research in particular construction projects, Lin et al. [22] found that large-scale projects and building projects are the subjects of VM research that have received the greatest attention to date. It is very effective to apply VM to large, expensive, complex, repetitive, budget-restricted projects and projects with compressed design programs, as per Coetzee [9] which claims that VM application can save up to 5–15% of the total costs involved in the project.

Enhancing value engineering in the construction industry

Perpetua [28] mentioned the significant benefits of value engineering in the construction industry, highlighting its potential to promote sustainable construction principles, optimize project development, and ensure quality throughout its life cycle. As noted by Senay Atabay and Niyazi Galipogullari [29], value engineering in construction projects offers several benefits, including reduced production costs, timely completion, quality improvement, and reduced mistakes and deficiencies in project drawings.

Empirical evidence indicates that every technique has limitations, and those limitations must be addressed by taking the appropriate steps [17]. According to findings by Thneibat et al. [32], the majority of practitioners admitted to having limited knowledge of VM stages. Kim et al. [21] examined and categorized 12 of the 18 hindrance factors into four components: (1) lack of qualified personnel to implement VM, (2) inherent difficulties in VM workshops, (3) lack of awareness of VM, and (4) lack of VM application documents.

Analyzing the obstacles to VM application aids in the development of suitable implementation procedures [21]. A study conducted by Mahinkanda et al. [24] proposed strategies to enhance VM application, including developing VM education, selecting suitable procurement methods, improving project planning, motivating investors and professionals, training VM facilitators, and governing knowledge sharing, to deliver value for clients' money. Othman et al. [26] recommended that clients, both public and private, need to be educated on the advantages and possibilities of using VM in construction projects. Gahlan [16] suggested that focus should be on staying updated with advancements in building materials, technologies, and new techniques. Senay Atabay and Niyazi Galipogullari [29] suggested that the highest performance in VE is achieved when the primary goal is value enhancement rather than cost reduction.

Theory and practice of value engineering in Egypt

Most developing countries, like Egypt, do not give VM techniques, activities, and stages the same consideration [21]. Practitioners compromise performance and elementary functions for cost reduction. Due to uncoordinated teams, they lack creative alternatives, which are crucial for the success or failure of a VM study [26]. The same author also stated that VM implementation in building and construction industry is still quite low in Egypt. Nevertheless, Atia et al. [4] highlighted the importance of VM implementation for Egyptian decision-makers to optimize project costs, as they have not yet converted costs from Egyptian pounds to dollars due to the recent price changes and currency fluctuations.

According to Abdelghany et al. [2], no systematic research has been done in Egypt to examine the comprehension and application of VM by stakeholders. Furthermore, no studies have assessed the VM phases and their construction field activities [31]. However, based on the experience of Abdelghany et al. [2], it can be concluded that the majority of Egyptian stakeholders lack sufficient knowledge about VM, which makes VM designs significantly ineffective, and that Egypt cannot implement the SAVE International VM methodology due to lack of comprehension of the methodology. In addition, Othman et al. [26]'s findings revealed that VM implementation in Egypt in building and construction sector is still at a very low level. Therefore, bridging the VE theory–practice gap will offer new insights to improve understanding of VE use in the construction industry and will result in cost savings [20]. This supports the goal of Egypt's government of implementing a strategy to become a global economic powerhouse, aiming to achieve a ranking among the top 30 countries by 2030 [11].

Methods/experimental

Research methodology

The main aim is to identify the level of VE application in the Egyptian construction industry, explore the roadblocks facing its implementation, and suggest ways to minimize these obstacles and enhance the use of VE in Egypt through bridging the theory–practice gap of VE. To accomplish its goal, this study employed both qualitative and quantitative research approaches. Initially, a thorough literature review was conducted to determine the application of the VE approach in the local and international construction industries. Based on the literature review, two gaps were identified and two research questions were established:

1. What is the extent of the current state and application of VE in Egypt?
2. How to bridge the gap between the theory and practice of VE in the Egyptian construction industry?

Consequently, a web-based survey was chosen as a suitable data collection technique to collect the different viewpoints of the perception of the role of VE and evaluate the current practice of VE for construction projects in Egypt. Informed consent was obtained from all individual participants in the study.

The questionnaire was distributed via email, Facebook groups dedicated to project and construction management, LinkedIn, and direct messaging. The entire distribution procedure took almost 2 months. All responses from participants who have little or no experience of working in Egypt were excluded. Afterward, Microsoft Excel was used to analyze each question's responses independently. Multiple data analysis techniques were used such as thematic analysis, descriptive analysis, and the Relative Importance Index (RII). Data was then validated using Cronbach's alpha test. The value of Cronbach's alpha coefficient was 0.84, indicating a good level of reliability.

Questionnaire design

The questionnaire is divided into three parts: a summary of the study's goal, a statement of confidentiality and anonymity, and background information about the researcher. The second section focuses on participant and company information, aiming to sort the organizations surveyed, justify answers based on participant experience, and rate responses based on knowledge. The third section aims to gather insights about the current state and application of value engineering techniques in different organizations. It gathers insights about the VE environment, process, duration, type of projects applied, and effectiveness, providing a comprehensive overview of Value Engineering in Egypt. It also reviews case studies done by companies, providing an overview of how VE is applied and the common factors behind its application. Open-ended questions are asked about participant rating of the VE application, challenges faced, and suggestions to improve the VE application in Egypt.

Sample size

The target population for this study is all people working in the construction field in Egypt, regardless of their stakeholder type or knowledge level of VE in Egypt. The sample size was determined using the sample size equation introduced by Cochran (1977). Basic sample size determination for categorical data for the unknown population is calculated using Eq. 1 as shown (Cochran's (1977) sample size):

$$n_o = \frac{(t)^2 * (p)(q)}{(d)^2} \quad (1)$$

where.

- t = value for selected alpha level in each tail = 1.65
- $(p)(q)$ = estimate of variance = 0.25
- d = acceptable margin of error for proportion being estimated = 0.05

From the equation, the calculated minimum sample size is 272 participants, where the margin of error the researcher is willing to accept is 5% and the confidence level is 90%. A total of 312 responses were collected, and 299 were included in the analysis.

Results and discussion

Respondents' characteristics

The study categorized respondents based on their experience levels, with 33% having 5–10 years of experience, 31% having 0–5 years, 29% having 10–20 years, and 7% having more than 20 years as shown in Fig. 1. This balanced distribution ensures a comprehensive overview of various professional backgrounds and perspectives. Sixty-nine percent of respondents have more than 5 years of experience, indicating that applying

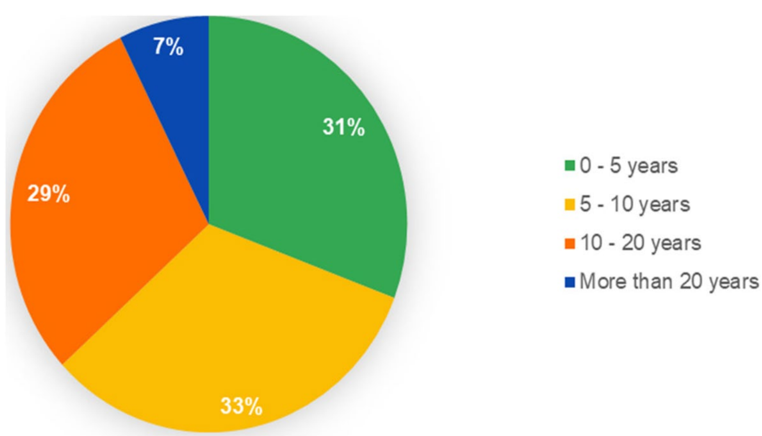

Fig. 1 Respondents' years of experience

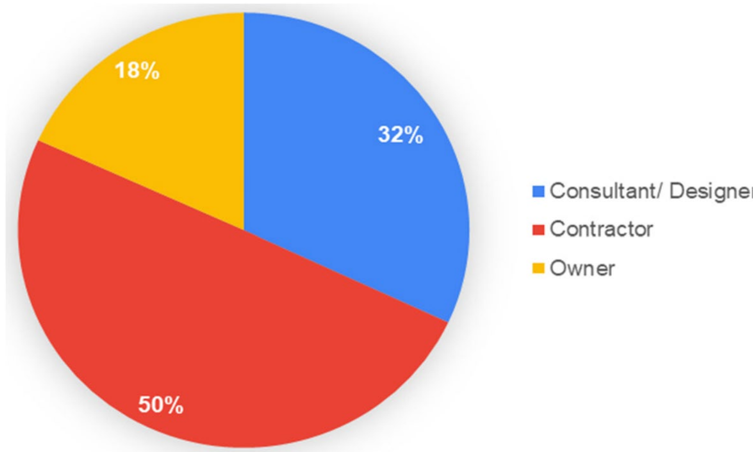

Fig. 2 Respondents' company size

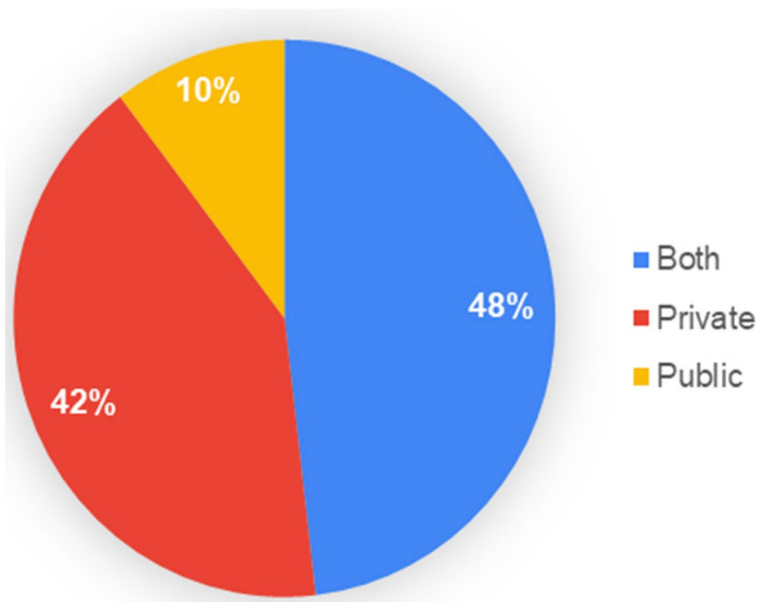

Fig. 3 Respondents' company sector

value engineering requires experience for valuable insights and a deeper understanding of various industries and projects.

The study also assessed the current state of VE in relation to respondents' firms, revealing that 72% work at large sized companies, 23% work at medium sized companies, and 5% work at small sized companies, as shown in Fig. 2. The study revealed that 48% work in both private and public sectors, 42% in private, and 10% in public as shown in Fig. 3.

The study classified respondents' firms by stakeholder type, revealing that contractors comprise 50%, consultants/designers 32%, and owners 18%. Contractors have a higher response rate, indicating greater awareness of VE for cost optimization and

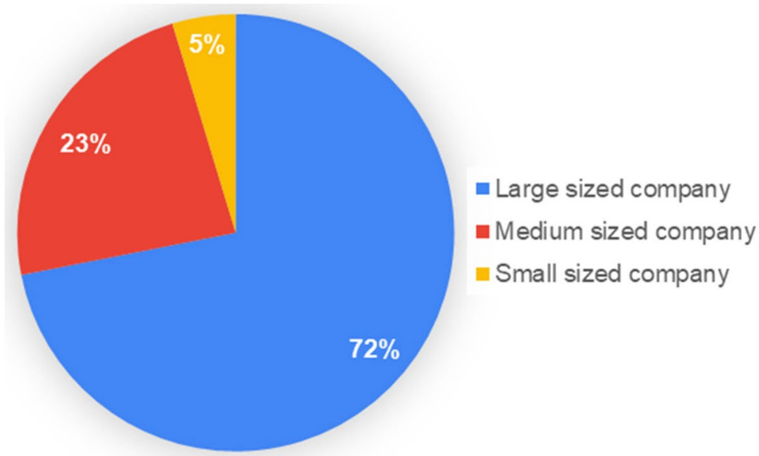

Fig. 4 Respondents' stakeholder type

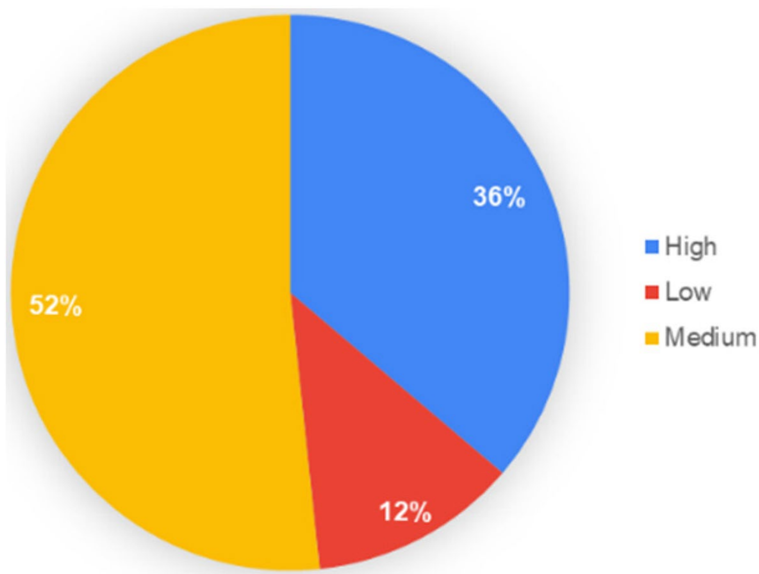

Fig. 5 Respondents' level of knowledge about VE

quality standards, enhancing their chances of securing project bids, as shown in Fig. 4.

The study aimed to evaluate respondents' knowledge of VE by assessing their level of knowledge. As shown in Fig. 5, results show that 52% of respondents rated their knowledge as medium, 36% as high, and 12% as low. This high level of knowledge aligns with the current trend of project optimization in the construction industry, which seeks cost-saving opportunities without compromising functionality in the global economy.

Figure 6 shows that the largest group of respondents were from Project Control (28%), followed by Engineering and Design (26%), and Project Management (22%). These three areas, which are essential for VE studies in terms of design optimization

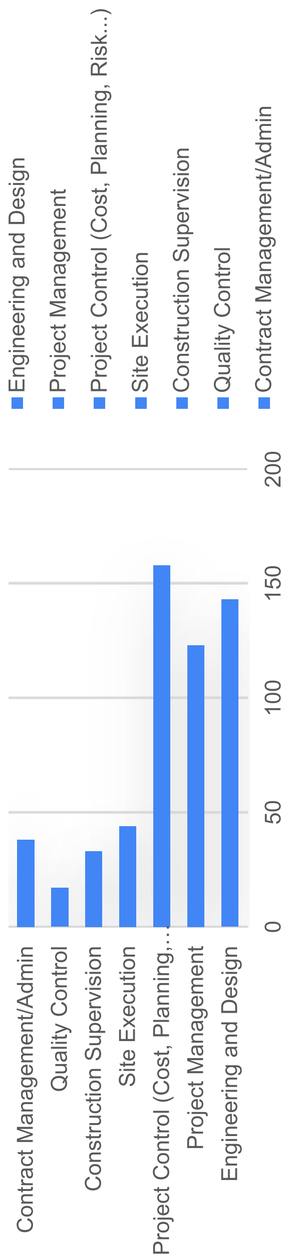

Fig. 6 Respondents area(s) of expertise

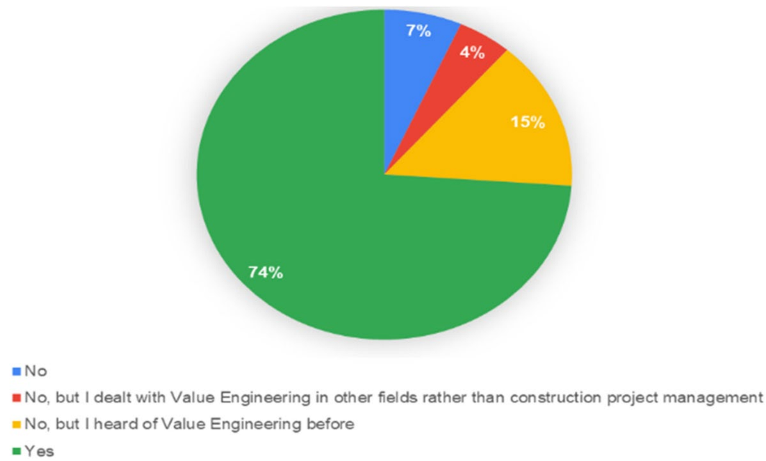

Fig. 7 Classification according to office using VE

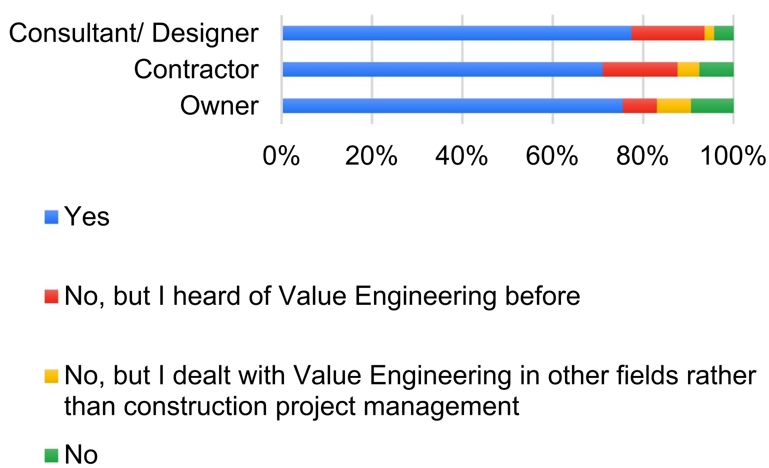

Fig. 8 VE implementation across stakeholders

and cost estimation, account for nearly 75% of the participants. Other areas of expertise included Site Execution (8%), Contract Management (7%), Construction Supervision (6%), and Quality Control (3%).

Questionnaire findings

1. Office applying VE

As shown in Fig. 7, a majority of respondents (74%) indicated their offices use (VE) approach in construction projects. However, 15% had familiarity with VE but had not used it, 7% had no knowledge, and 4% had experience in other fields.

Figure 8 shows that over 50% of respondents use the VE approach across all stakeholders. For consultants, 77% of respondents indicated that they use VE, constituting a majority of responses. This shows that the highest percentage of stakeholders

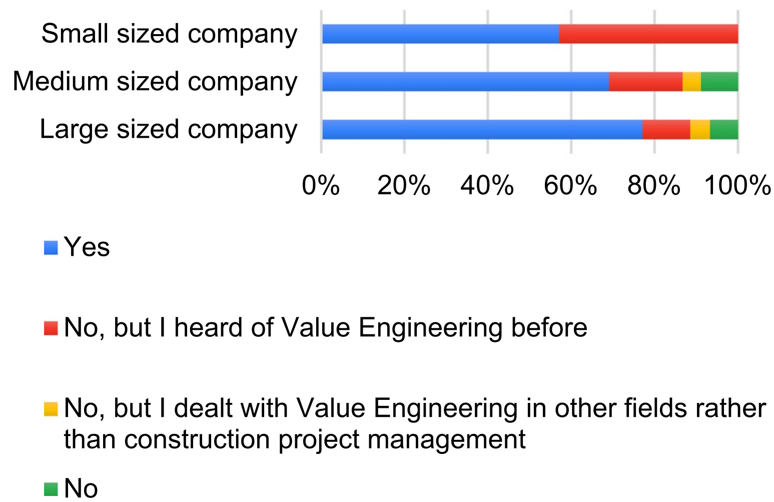

Fig. 9 VE implementation across size of the company

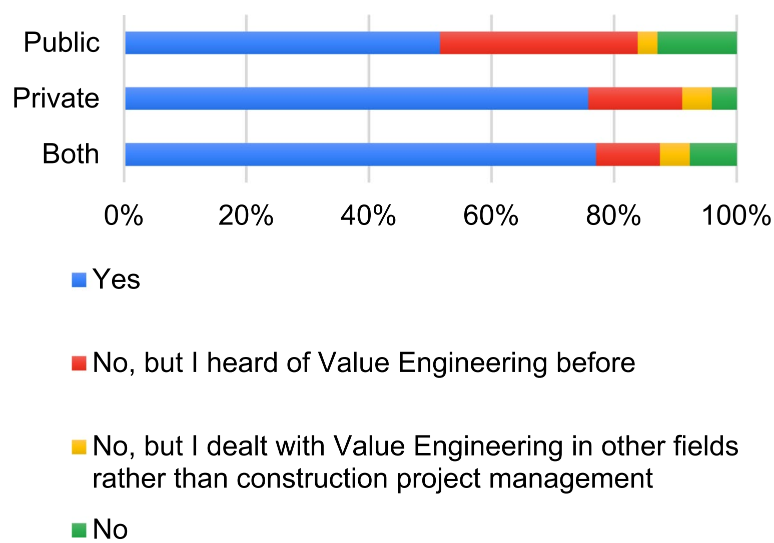

Fig. 10 VE implementation across sector types

applying VE are consultants/designers, who play a crucial role in design processes, seeking optimal designs and alternative solutions.

Figure 9 shows that large companies are the most likely to utilize the VE concept, with a higher percentage of respondents compared to medium and small companies. Large companies often have more resources, leading to higher cost savings and functionality retention in large-scale projects.

Figure 10 reveals a significant disparity in the usage of VE between private and public sectors, with the public sector comprising a smaller proportion due to strict regulations and prioritizing time minimization over cost considerations. Private sectors prioritize efficiency and cost savings, giving VE an edge in construction projects.

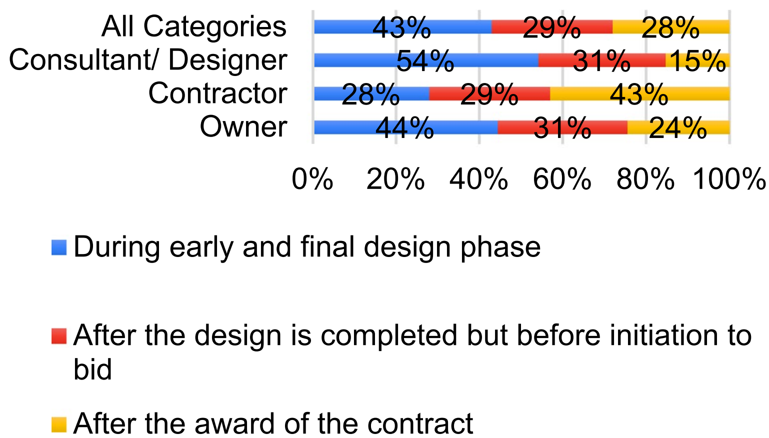

Fig. 11 Best timing for VE implementation

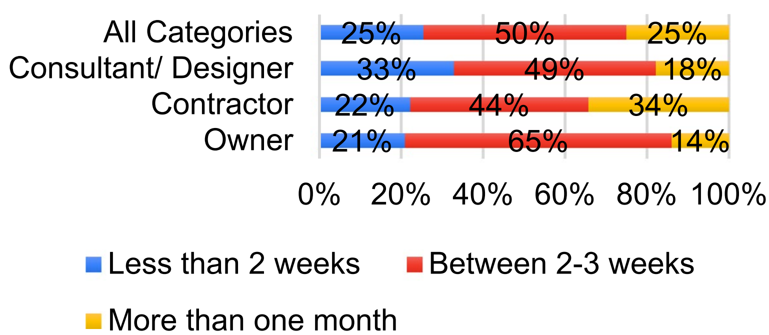

Fig. 12 Duration to perform VE study: stakeholders' perspective

2. Best timing and duration for VE study implementation

Figure 11 shows that 43% of all stakeholders believe conducting a VE study during early and final design phases is the best time. This is common among consultant/designer and owner firms, as the cost of construction time outweighs the benefits of early design changes. On the other side, contractor firms recommend VE study after contract award, as they are not involved in the project before this stage.

The results show that the study typically takes 2 to 3 weeks. This trend is observed to be consistent across all stakeholders, as shown in Fig. 12. Furthermore, this trend is observed in relation to the best time to implement the study, as shown in Fig. 13.

3. Cost optimization studies

Thematic analysis was applied to responses on cost optimization methods, categorizing them into seven main themes, as shown in Fig. 14. This comprehensive overview included respondents who applied or did not apply VE to determine the methods used in cost optimization, including other methods. The most used method is alternative solutions and redesign, while the least used method is risk management and forecasting.

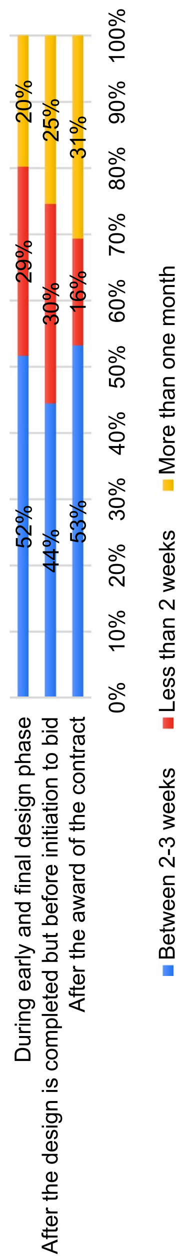

Fig. 13 VE study duration relative to best efficient timing

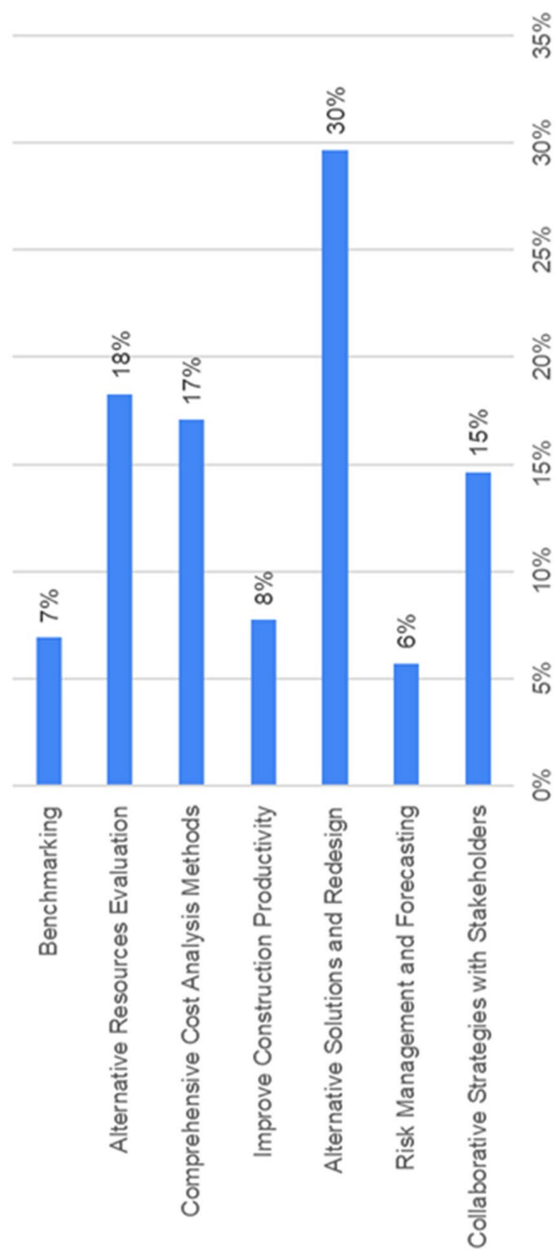

Fig. 14 Other methods used in cost optimization studies

4. Number of VE studies

The cross-tabulation analysis of stakeholder type and annual volume of work variables reveals patterns in the number of studies conducted and the annual volume of work done by firms, as shown in Fig. 15. It also reveals trends between stakeholder types and the number of studies conducted. For projects with an annual volume less than L.E 20 M, most studies were less than five, regardless of stakeholder type. Smaller projects may have fewer VE studies due to the cost of time, resources, and expert engineers, as well as limited resources for firms with smaller annual work volumes. Additionally, smaller projects are generally less complex, so they may not require VE studies.

Another observed trend is that consultants/designers conducted more studies than other stakeholders for projects with an annual volume less than L.E 20 M, as they had more design alternatives to choose from, initiating solutions.

Taking a deeper look at firms with an annual volume of work above L.E 20 M, Fig. 15 shows that firms across all stakeholders with an annual volume of work above L.E 20 M have a diverse range of number of VE studies conducted. Owner and consultant/designer firms conducted higher number of studies, ranging from 5 to over 30 studies, compared to contractor firms, where half of the studies are less than 5 studies.

5. Savings due to VE implementation

Figure 16 shows the effectiveness of the VE approach in the construction industry, revealing average savings ranging from 6 to 10% of the project's total cost. Furthermore, The VE study was found to be useful and effective in identifying savings of less than 1% of the project total cost among all firms. However, firms with an annual volume of work exceeding L.E 20 M reported higher percentages of savings over 20% of the total project cost, indicating that a 10% savings for volume exceeding L.E 20 M is more valuable than a 30% savings for volume less than L.E 20 M.

Consultants and owners indicated the average expected savings most frequently ranged from 6 to 10% and 11 to 20% taking the highest percentage regardless volume of work conducted by these firms. However, contractors indicated that the highest average expected savings ranged at 2–5% and 6–10% of capital costs. The study reveals that consultants and owners achieve more savings compared to contractors due to their involvement in the early stages of the project, allowing them to explore multiple alternatives and define the scope of work with a broader perspective.

6. Types of projects where VE is implemented

Table 2 shows that the Egyptian construction industry employs a diverse range of project types using VE, with the highest ranking being residential. However, the research did not anticipate residential projects to be the most common type of VE application, as commercial or infrastructure projects were expected to be more common. The results show that priority nowadays is on faster return on investment, making residential projects the most common type with faster returns. Commercial and infrastructure projects remain the top three ranked projects where VE is implemented

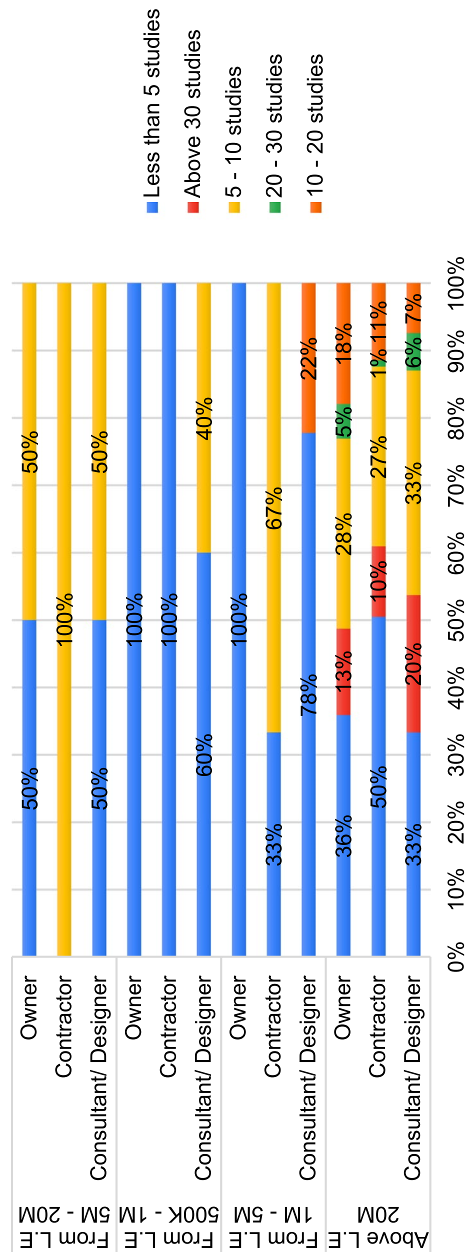

Fig. 15 VE studies

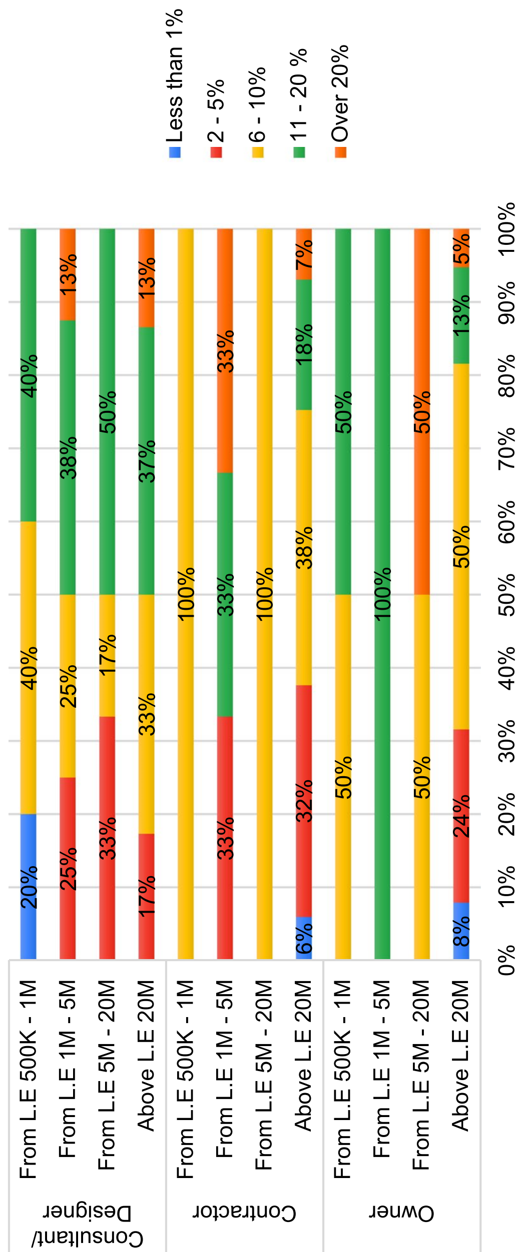

Fig. 16 Savings due to VE study: stakeholders' insights

Table 2 Types of projects where VE is implemented

Project type	RII	Rank	Item mean
[Residential]	0.754	1	3.017
[Office buildings]	0.709	2	2.834
[Health care]	0.499	7	1.996
[Educational]	0.543	5	2.170
[Industrial]	0.601	4	2.404
[Infrastructure]	0.653	3	2.613
[Power plants]	0.535	6	2.140
[Agricultural]	0.447	9	1.787
[Touristic]	0.479	8	1.915

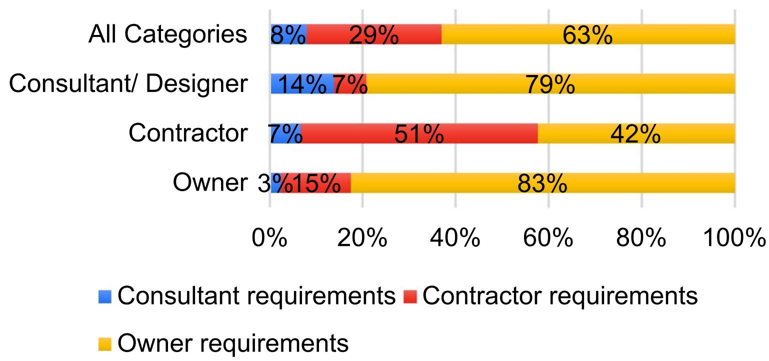

Fig. 17 Personnel involved in a VE study

due to their complexity and high cost-saving potential. The results are realistic as they depict the current state of projects in the Egyptian construction industry.

7. VE team

Knowing who requires VE to be implemented shows who is aware of the importance of VE. Figure 17 illustrates that owners are the primary initiators of value engineering (VE) implementation due to their project decision-making authority and budget concerns. Consultants/designers and owners themselves also exhibit this trend. However, contractors conduct VE studies primarily for their own benefit, either before or after the contract award. This finding reinforces previous insights on the optimal timing for VE implementation, highlighting the critical importance of owners' awareness of VE.

8. Phases followed in VE studies

Figure 18 illustrates the sequential phases of VE studies, from pre-study to post-study, following the SAVE International Job Plan. Adherence to all phases is crucial for a successful VE study. However, there are notable variations in the percentages of passing through each phase, indicating deviation from the expected adherence. Respondents selected 76 different options for VE phases, despite all phases being essential for a comprehensive and effective study. This highlights a common misapplication of VE

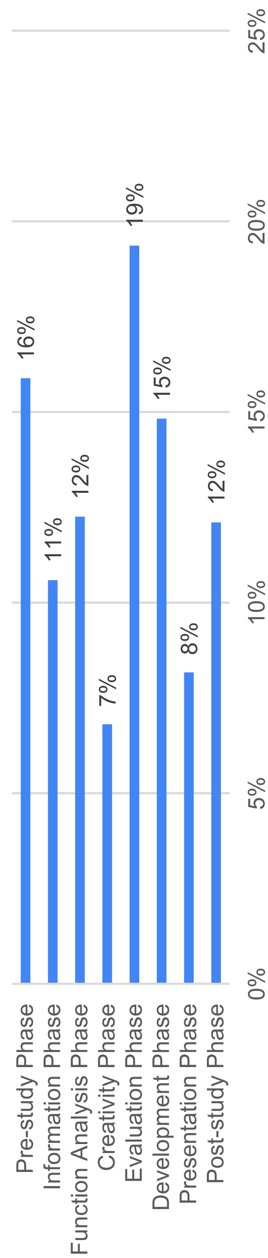

Fig. 18 Phases followed in VE studies

methodology, where studies are conducted without adhering to all phases. Factors contributing to deviation include time constraints, lack of VE experts, and the misconception that VE is merely a cost reduction method.

The evaluation and pre-study phases are the most common phases implemented. While function analysis phase forms the essence of VE, it is not selected among the top common phases implemented, validating the results that VE technique is seen as a merely cost reduction technique disregarding functional requirements. The creativity and presentation phases are less frequently applied due to the time-consuming nature of generating creative ideas. This lack of proper implementation is attributed to the lack of qualified personnel for the 40-h job plan, leading to VE studies being conducted without proper methodology.

9. Objectives improved by VE studies

Figure 19 illustrates a consistent trend across stakeholders, indicating that cost savings are the primary objective improved by value engineering (VE) studies, while quality and performance are least emphasized. Despite focusing on eliminating unnecessary costs, VE is not solely a cost-cutting method, challenging the misconception in Egypt that VE is solely about reducing costs, evident from the significant disparity in emphasis between cost and quality/performance objectives. The VE concept in Egypt needs a reevaluation to focus on optimizing project performance, quality, and cost-effectiveness while preserving its intended functionality. This requires a shift in perspective from solely focusing on cost reduction to focusing on project functional requirements.

10. VE theory–practice gap of VE

Determining the VE theory–practice gap is one of the research's goals. Table 3 is a summary of the specific VM practices found when analyzing the questionnaire in comparison to the theoretical elements.

The study reveals that despite the benefits and increasing interest in the VE approach, the Egyptian construction industry lacks a comprehensive understanding of the VE concept and how to use it correctly. This suggests that the implementation of VE in Egypt lacks both theory and practice, necessitating further investigation to bridge the theory–practice gap in VE.

11. Strategies to bridge VE theory–practice gap

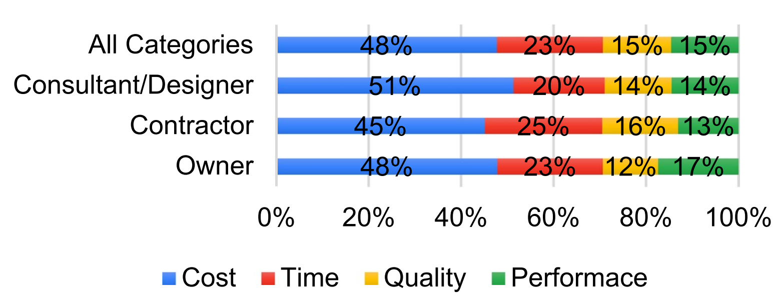

Fig. 19 Objectives improved by VE study

Table 3 VE application in theory and practice

	VE application in theory	VE application in practice
Methodology	Adheres to following standards such as VE job plan. VE workshop is systematically conducted	Misapplication and incomplete standards are followed. Discussion meetings conducted rather than formal VE workshop
Team	Includes VE experts, design/project team, and owner. VE experts mainly responsible for making decisions	Includes mainly design/project team. The proposal of VE mainly responsible for decision-making
Stakeholders engagement	Active collaborative engagement of all stakeholders including owner, consultant/designer, contractor, and VE experts	Limited collaboration involvement
Focus	Optimizing costs, accelerating time, enhancing quality, maintaining project functionality, and enhancing performance	Purely reducing cost and accelerating time
Implementation timing	During early project stages for best results. A time is specified in the project schedule for VE implementation	During design phase, after award of the contract, or during construction stage to solve over-budget issues or time issues. No time is specified for VE implementation
Process evaluation	Various systematic evaluations of alternatives to achieve optimum results	Limited evaluation of alternatives due to resistance to change and limited resources
Value considerations	Long-term value considerations, including life cycle cost assessment	Short-term value considerations, focusing on short-term cost savings and time acceleration
Monitoring measurements	Continuous monitoring throughout project stages	Limited monitoring of progress throughout project stages
Implementation review	Assessment of VE studies conducted and lessons learned	Assessment of VE studies is often ignored

Thematic analysis categorized respondents' main challenges and obstacles in implementing value engineering study in Egypt and suggestions to enhance its application, including those who applied or did not apply VE. Determining the challenges is crucial for examining the theory and practice gap of VE in Egypt's construction industry. Based on the analysis of the questionnaire, the study outlines and maps strategies for overcoming the challenges found as shown in Fig. 20.

Findings indicate that the three key barriers are awareness and understanding, time constraints, and financial constraints. Furthermore, the three key recommendations are the role of educational institutions and training, continuous improvement, and public awareness and recognition. All barriers and strategies to prevent those barriers are mentioned and linked in an attempt to bridge the theory–practice gap of implementing VE to deliver value for client's money.

Conclusions

Egypt's construction industry faces major challenges due to the country's unstable economy, reflected by high employment, low incomes, currency fluctuations, and safety concerns. Despite the worldwide recognized importance of value engineering in theory, its practical implementation in the Egyptian construction industry remains limited. This research provided insights about the VE environment, process, duration, type of projects applied, and effectiveness, aiming to get a comprehensive overview of VE in Egypt.

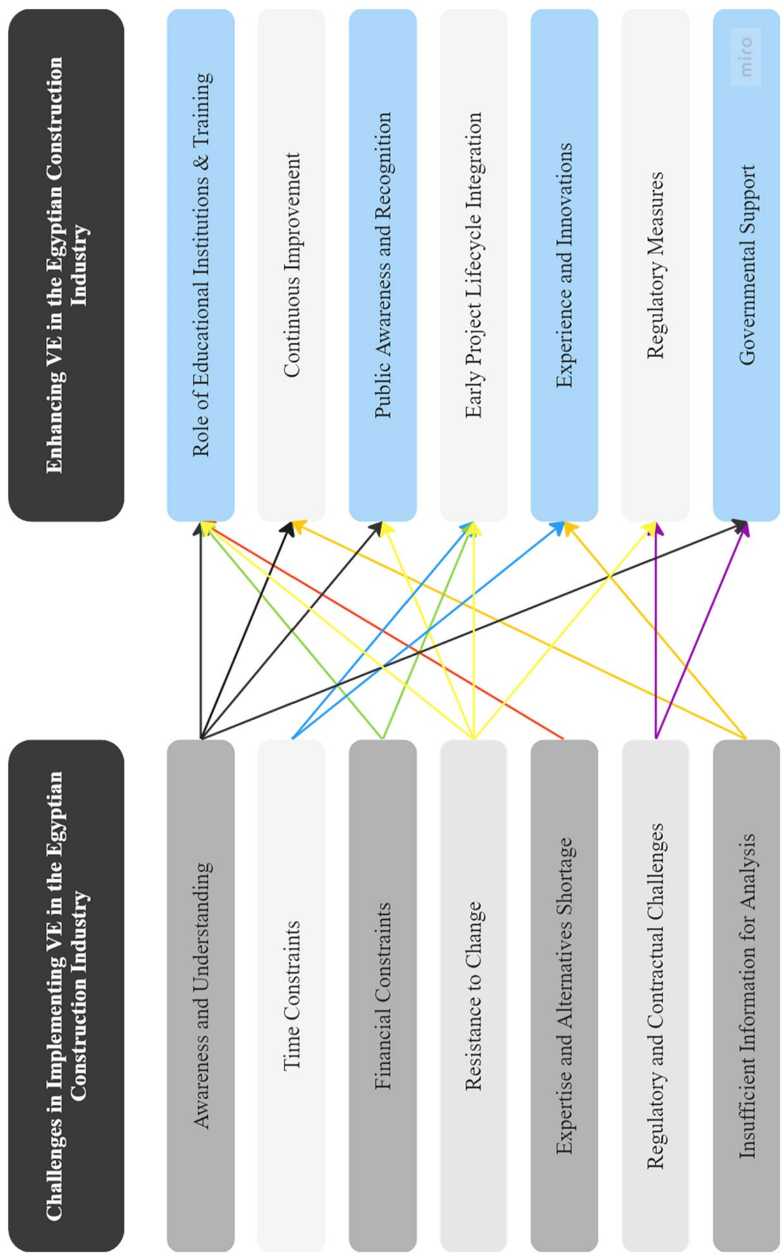

Fig. 20 Bridging the theory–practice gap of VE in Egypt

Furthermore, this research identified a significant gap between VE theory and practice in Egypt, due to many factors including lack of awareness, time and financial constraints, and resistance to change. To bridge this gap and enhance the implementation of VE in Egypt, strategies such as focusing on the role of educational institutions, increasing public awareness and recognition, and integrating VE approach early in the project lifecycle are suggested.

By addressing these challenges and applying strategies to enhance VE application, the Egyptian construction industry will benefit in terms of minimizing unnecessary costs, maintaining functionality, and ultimately delivering better value for client's money. While this study provides valuable insights for industry practitioners and educators to effectively promote the integration of VE practices in the Egyptian construction industry, it did not consider case studies and real-world examples of VE application; therefore, future research could add more value to the study through integrating case studies and examples to better provide a more comprehensive understanding of the current state and application of VE in the Egyptian construction industry. In addition, these case studies may be used to track the long-term impacts of VE on construction projects. This research contributes to the field by not only gaining key insights about VE application in Egypt but also proposing strategies for bridging the theory–practice gap, which adds to the knowledge in construction and promotes more efficient and valuable construction practices.

Abbreviations

RII	Relative Importance Index
SAVE	Society of American Value Engineers
VE	Value engineering
VM	Value management

Supplementary Information

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Supplementary Material 1.

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The corresponding author is SAA, who designed, analyzed the data, and wrote the paper. AHN provided valuable guidance and expertise and critically reviewed the paper. Both authors reviewed and approved the final manuscript.

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Declarations

Competing interests
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