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The status of teachers' implementation of STEM education at some high schools within the Mekong Delta

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Abstract

The extensive general education program introduced in 2018 is currently being rolled out across all levels of education, and it has proven to bring forth a myriad of benefits by seamlessly integrating the STEM education model into various subjects and topics. It intends to conduct a comprehensive examination into the present status of STEM teaching practices within educational institutions in the Mekong Delta, alongside an in-depth assessment of teachers' proficiency in employing active teaching methodologies and practical STEM pedagogical approaches. The results obtained show that teachers use many different teaching methods and techniques to apply to STEM lessons, but these methods and techniques still lack uniformity and standardization in application. When evaluating the responses of the 30 participating teachers, it became clear that traditional teaching methods and techniques were more popular than modern methods. This trend may be due to the need to accommodate different objective factors to tailor the choice of methods and techniques to different groups of students.

Introduction

STEM represents the acronym for Science, Technology, Engineering, and Mathematics outlined by Sanders and Wells (2005). STEM education embodies an instructional approach that fosters interdisciplinary learning, drawing from at least two disciplines: Science, Technology, Engineering, and Mathematics. This methodology integrates these diverse fields within the educational process, promoting the practical application of acquired knowledge. In the context of Vietnam, the essence of STEM education is evident within the broader framework of general education programs through several notable indicators: (1) The contemporary general education curriculum includes a comprehensive array of STEM-oriented subjects such as Mathematics, Natural Sciences, Technology Informatics, Physics, Chemistry, and Biology; and (2) The position and role of Informatics Education and Technology Education in the newly enhanced general education program (Ministry of Education and Training, 2018).

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To effectively steer students towards synthesizing knowledge across STEM disciplines for comprehensive problem-solving, we can set our sights on contemporary educational methodologies. Several of these approaches encompass: (1) Project-based learning propels students to delve into real-world projects, encouraging them to unravel and address challenges fostering creative thinking and teamwork as they collaboratively engage in these projects; (2) Collaborative learning: Through collaborative efforts, students jointly tackle activities, problems, model-building, and experiments, honing their ability to function effectively in teams, sharing insights, deliberating, aiding one another, and fostering knowledge exchange; (3) Hands-on learning: This experiential approach allows students to intimately grasp STEM concepts, procedures, and practical applications, thus deepening their understanding; (4) Problem-based learning: This technique stimulates critical thinking, logical reasoning, and innovation, nurturing students' ability to tackle complex problems; and (5) Technology-enhanced learning: Leveraging technology, students can access learning resources, conduct virtual experiments, interact with educational software and tools, and partake in online courses, enhancing their educational experience.

Engaging in STEM lessons entails deploying a design and construction framework to solve challenges, following the engineering process, and applying scientific methods to test hypotheses. Thus, adopting these instructional methods can significantly bolster the effective execution of STEM lessons.

Literature Review

Deploying STEM education-oriented teaching has been attracting many scientists interested in research. Bybee (2010) is one of the prominent authors researching STEM education who has pointed out several directions and challenges in STEM teaching, including (1) the need to promote Technology and Engineering in the program learning by expanding the scale of Technology and Engineering courses, integrating Technology and Engineering into Science and Math education as a reasonable way to do it; (2) promote teaching methods that develop capacity in solving situations and problems, not just focusing on conceptual and procedural knowledge in STEM subjects; and (3) STEM education needs to put issues in the context of the times such as energy efficiency, climate change, natural resources, environmental quality, risk reduction, etc. into a central position. These are problems that students, as global citizens, have to face. The problems must be related and require knowledge and skills in STEM fields to solve. Bybee (2010) also provides a STEM lesson model framework that shows the connection between STEM subjects to solve problems according to the context in the center.

One of the integration efforts in the STEM field includes the promulgation of the US Next Generation Science Standards (NGSS), which helps promote the integration of Technology and Engineering standards into US standards. Science subjects are taught through Disciplinary Core Ideas and Crosscutting Concepts, especially Science and Engineering Practices. Science and engineering practices include eight skills that clearly demonstrate the integration of Technology and Engineering standards into Science teaching; therefore, these are also called STEM practices. STEM practice guides two popular approaches in STEM education: (1) inquiry-based, which involves asking questions, conducting investigations, and developing models and theories to understand the natural world better; and (2) engineering design-based, which requires students to apply crosscutting concepts and core scientific knowledge to design tasks; shifting the focus from memorizing detailed knowledge to understanding big ideas (National Academies Press, 2012; NGSS Lead States, 2013; Terry et al., 2017). These STEM practices can be taught individually and appropriately in different content or can be combined in a complete scientific research or engineering design project. The US NGSS is used in many countries and is considered key to integrating STEM subjects.

Integrating engineering design and technology in STEM education continues to be emphasized in several other studies (Guzey et al., 2016; Margaret et al., 2014). An engineering design-based activity can take many forms. However, looking at current learning programs and projects, the technical element tends to take on a single form, such as modeling or design activity. Learning science content through engineering lessons shows moderate or large gains in test performance, impacting students' motivation, engagement, and attitudes toward science and engineering. However, these results need further research. Besides, integrating engineering practices into science teaching faces major obstacles for teachers in many countries, including the United States. A survey study of 98 science teachers (in the United States) showed that all were unfamiliar with and lacked understanding about teaching according to the engineering design process (Al Salami et al., 2017). STEM teaching initiatives through problem-based learning have also been researched. Using complex real-world problems creates a context for students to apply knowledge and experience from many disciplines. Problem-based teaching in STEM education programs also stems from engineering and technology education (Fortus et al., 2004).

Biology, based on the level of abstraction and complexity of the knowledge content, allows the integration of the technical design process within a narrow range of relevant, meaningful issues such as human biology, genetic engineering, neuroengineering, bioprocessing, agriculture, environmental science, building sustainable biological systems, designing and building vehicles inspired by human bodies and movements animals (Tipmontiane & Williams, 2022). Another study on the principles of integrating STEM education in teaching Biology includes principles of integration (maximum integration of STEM knowledge in the teaching process so that students can apply biological knowledge to solve practical problems in the learning process) (Zhou, 2022). In particular, the principle of practice is emphasized as beneficial for building abstract concepts and developing students' interest in learning biology, suitable for implementation in teaching science and design subjects. Elaborate hands-on activities in teaching are essential; letting students try something for themselves often leads to deeper memories. The author also mentions a variety of activities that can be used in STEM education-oriented teaching such as: investigation, experimentation, data analysis, problem discussion, model building, and test sample design. However, the integrated teaching of Science, Technology, Engineering, and Mathematics in Biology also faces many challenges, such as Teachers' lack of expertise in STEM; and time constraints because students need a lot of time to discuss and communicate to come up with solutions, or repeat designs to improve products; Inadequate facilities (lack of teaching aids and practice rooms); Students' attitudes in the classroom are not positive and proactive while it is necessary to promote student-centered learning activities and promote student initiative in the classroom (Wahid & Talib, 2017).

The trend of integrated teaching is not a new problem in Vietnam. A number of research works by domestic authors have clarified STEM-oriented teaching typically. In recent years, research on teaching and applying STEM education in various subjects is gradually being carried out. Studies on teaching and developing capacity by a number of authors in Vietnam have given a common view that: "Research on teaching and applying STEM education in various subjects has gradually been carried out in recent years. Studies on teaching and developing capacity by several authors in Vietnam have given a standard view: STEM education is a teaching perspective with an interdisciplinary approach to equip students with knowledge and skills related to Science, Technology, Engineering, and Mathematics. This knowledge and skills must be taught in an integrated way so that learners can apply that knowledge in different contexts, specifically" (Le, 2017; 2022; Nguyen, 2021). These have researched the theoretical basis and application of STEM education at secondary school and university levels in a number of subjects such as Technology, Chemistry, and STEM education robotics. In Biology, research on STEM education-oriented teaching can include: "Designing STEM education topics in teaching the section "Material and energy metabolism in plants", biology grade 11 – High School" (Tran et al., 2018), and "Designing and organizing teaching on the topic "Growth of microorganisms - yeast breeding" (biology grade 10) according to STEM education orientation for students continuing education system" (Pham & Ngoc, 2019). These studies have provided biology teachers with reference support materials in designing STEM lessons. However, research has not yet built a STEM education-oriented teaching model that demonstrates the relationship between elements in STEM education and the processes, teaching measures, or assessment methods in STEM-oriented teaching. STEM education, so teachers are still confused and left open to implementing STEM education in subjects in general, and STEM education in Biology in particular, has not been promoted.

Based on the research above, it becomes evident that the STEM education paradigm in Vietnam is gaining heightened prominence and is emerging as a novel instructional trend. Teachers actively explore, apply, and enhance STEM teaching techniques to augment their efficacy. Nevertheless, using STEM pedagogical approaches remains an inadequately investigated and unresolved matter within the Mekong Delta region. To grasp this landscape, the present study endeavors to accumulate insights into implementing STEM teaching methodologies by teachers within Mekong Delta schools.

Methodology

The research instrument employed in this study takes the form of a questionnaire for the purpose of collecting information effectively (Pham & Nguyen, 2011). The Likert scale was utilized to assess responses, which permits the measurement ofagreement/satisfaction/response, as established by Allen & Seaman (2007). For a relatively precise evaluation of levels, the Likert scale is configured with five points and an interval of (5-1)/5= .8, following the insights of Narli (2010) and Yavuz et al. (2013). Accordingly, the significance of the rankings is determined as follows: $1.0 \leq M < 1.8$: Never/Very undifficult; $1.8 \leq M < 2.6$: Rarely/Undifficult; $2.6 \leq M < 3.4$: Sometimes/Normal; $3.4 \leq M < 4.2$: Often/Difficult; $4.2 \leq M \leq 5.0$: Very often/Very difficult.

Survey target: Teachers instructing the STEM education model within high schools in the Mekong Delta region.

Survey methodology: After the survey's completion, a preliminary round of questioning was conducted with a select group of teachers to refine and validate the survey structure, as documented by Dinh et al. (2011a, 2011b).

Assessment of Questionnaire Reliability: To gauge the questionnaire's dependability, Cronbach's alpha coefficient, as introduced by (Cronbach, 1951), was employed.This method was successfully applied by Nguyen et al. (2024a, 2024b, 2024c) and Vo et al. (2024).

Data analysis: The amassed data underwent coding and processing using SPSS v.21 software. Employing a significance threshold of $p < .05$, the Mann-Whitney U test was employed to scrutinize distinctions between male and female teachers, as well as teachers with two categories of experience (< 10 yrs and ≥ 10 yrs).

Results and Discussion

Reliability of the Questionnaire

Cronbach's Alpha is a measure used to evaluate the internal consistency of a set of items or questions in a questionnaire. It assesses how closely related the items are to each other and provides a coefficient that ranges between 0 and 1. A higher value signifies better internal consistency among the items. The Cronbach's Alpha analysis findings indicate that the questionnaire is well-suited for assessing reliability. This is evidenced by the calculated Cronbach's Alpha coefficient of .893, which surpasses the conventional threshold of .6, suggesting a high level of internal consistency among the questionnaire items, further affirming its reliability.

General Information about Survey Participants

To examine the present state of integrating STEM within educational institutions to enhance students' practical application of knowledge, the survey primarily focused on inquiries related to the training process, teachers' utilization of STEM, and the underlying causes of challenges faced within STEM organizations. The survey was conducted among a random selection of 30 participants, comprising both male and female teachers. Among the sampled individuals, 56.7 percent were female teachers, while the remaining 43.3 percent were male teachers. All respondents were actively employed within educational establishments in the Mekong Delta region. Notably, a substantial proportion of the participants possessed extensive professional tenure and significant teaching experience. For a comprehensive breakdown of the demographics of the respondents involved in the study, please consult Table 1.

Table 1 Information about survey participants

Category		Numbers	Percent (%)
Sex	Female	17	56.7
	Male	13	43.3
Seniority	< 10 yrs	14	46.7
	≥ 10 yrs	16	53.3

Teaching Methods Used to Organize STEM Teaching Activities

The analysis of the survey responses regarding the instructional techniques employed for organizing STEM education reveals that teachers predominantly utilize the Project-based learning method significantly, with an average score of 3.67±0.80 standard error (SE). Conversely, the other instructional methodologies are employed intermittently, as indicated in Table 2. Notably, the Collaborative learning approach is widely favored among teachers due to its familiarity, simplicity, ease of implementation, suitability for class durations, and notable efficacy. On the contrary, the remaining approaches necessitate a substantial investment of time for research and lecture preparation, along with heightened resource requirements. As a consequence, these methods are less frequently adopted by teachers.

The survey findings concerning the utilization of various teaching methods in STEM showcase the method preferred by teachers (Project-based learning) and the reasons underlying the prevalent use of a particular method (Collaborative learning). It also sheds light on the

Table 2 Teachers' viewpoint on the application of teaching methods

Code	Content	Mean±*SE*	Viewpoint
Q121	Project-based learning	2.83±0.79	Sometimes
Q122	Collaborative learning	3.67±0.80	Often
Q123	Hands-on learning	2.83±0.99	Sometimes
Q124	Problem-based learning	3.37±0.93	Sometimes
Q125	Technology-enhanced learning	3.17±1.05	Sometimes

Note: $1.0 \leq M < 1.8$: Never; $1.8 \leq M < 2.6$: Rarely; $2.6 \leq M < 3.4$: Sometimes; $3.4 \leq M < 4.2$: Often; $4.2 \leq M \leq 5.0$: Very often challenges that might hinder the adoption of other methods in STEM education. Dang (2011) also highlighted several analogous benefits. These include fostering an environment where students can actively engage, exchange ideas, explore concepts, nurture positivity, creativity, independence, and self-reliance, and cultivate collaboration, communication, and Normal interaction skills. This approach also creates an advantageous learning atmosphere where students are motivated to share, elucidate, and support one another, bolstering unity, cooperation, and collective awareness. Nevertheless, cooperative group teaching comes with its set of constraints. Some group members might lean excessively on others, contributing little effort themselves. There's also the risk of time wastage during preparation and execution and potential disruptions. Excessive and rigid incorporation of group activities, or overextending the duration of such activities, can lead to diminishing returns. Moreover, novices might find it challenging to control the process and maintain order, particularly when they lack prior experience executing these approaches (Dang, 2011).

When analyzing gender differences, the average ratings of male and female teachers for Q121 – Q125 exhibited no statistically significant disparities (Mann Whitney U, $p > .05$ for all instances), indicating that teachers' selection of teaching methods remains unaffected by gender (Table 3).

When considering seniority, the average evaluations provided by teachers with < 10 yrs of experience and those with 10 yrs of expertise are as follows: For Q123 (Hands-on learning) and Q125 (Technology-enhanced learning), a statistically significant distinction exists between the average evaluations of teachers with < 10 yrs of experience and those with ten or more years. Expressly, teachers with < 10 yrs of expertise sometimes incorporate the Hands-on learning method into their teaching (3.21 ± .26 *SE*), whereas teachers with a decade or more of experience tend to use this method less frequently (2.50 ± .22 *SE*) (Mann Whitney U, $Z = -2.064$, $p = .039$). Concerning the Technology-enhanced learning method, teachers with < 10 yrs of experience often integrate this approach into their teaching (3.71 ± .24 *SE*). In contrast, teachers with ≥ 10 yrs of expertise occasionally employ this method (2.69 ± .24 *SE*) (Mann Whitney U, $Z = -2.612$, $p = .009$). This discrepancy can be attributed to more experienced teachers' hesitancy towards embracing innovation, typically adhering to conventional teaching methods. Their familiarity with accessing information technology might also be restricted, limiting their ability to seamlessly incorporate technology into their teaching practices. Conversely, teachers with < 10 yrs of experience, being generally younger, tend to be more dynamic and adaptable to change, enabling them to readily create lessons in line with the requisites of STEM education. For Q121 (Project-based learning), Q122 (Collaborative learning), and Q124 (Problem-based learning), no statistically significant differences were found in the mean assessments (Mann Whitney U, $p > .05$). Both groups of teachers utilize these assessment methods with similar frequency due to their simplicity, accessibility, ease of application, and efficiency in terms of time consumption (Table 4).

Table 3 Teachers' viewpoint on the application of teaching methods concerning gender

Code	Content	Mean±*SE*		Mann Whitney U
		Female	Male	
Q121	Project-based learning	2.76±0.16	2.92±0.26	$Z = -0.629$, $p = .529$
Q122	Collaborative learning	3.59±0.12	3.77±0.30	$Z = -1.069$, $p = .285$
Q123	Hands-on learning	2.94±0.20	2.69±0.33	$Z = -0.685$, $p = .493$
Q124	Problem-based learning	3.35±0.19	3.38±0.31	$Z = -0.110$, $p = .912$
Q125	Technology-enhanced learning	3.18±0.23	3.15±0.34	$Z = -0.110$, $p = .913$

Note: 1.0 ≤ *M* < 1.8: Never; 1.8 ≤ *M* < 2.6: Rarely; 2.6 ≤ *M* < 3.4: Sometimes; 3.4 ≤ *M* < 4.2: Often; 4.2 ≤ *M* ≤ 5.0: Very often

Table 4 Teachers' viewpoint on the application of teaching methods concerning seniority

Code	Content	Mean±*SE*		Mann Whitney U
		< 10 yrs	≥ 10 yrs	
Q121	Project-based learning	2.71±0.24	2.94±0.17	$Z = -0.509$, $p = .611$
Q122	Collaborative learning	3.86±0.18	3.50±0.22	$Z = -1.062$, $p = .288$
Q123	Hands-on learning	3.21±0.26	2.50±0.22	$Z = -2.064$, $p = .039$
Q124	Problem-based learning	3.71±0.27	3.06±0.19	$Z = -1.900$, $p = .057$
Q125	Technology-enhanced learning	3.71±0.24	2.69±0.24	$Z = -2.612$, $p = .009$

Note: 1.0 ≤ *M* < 1.8: Never; 1.8 ≤ *M* < 2.6: Rarely; 2.6 ≤ *M* < 3.4: Sometimes; 3.4 ≤ *M* < 4.2: Often; 4.2 ≤ *M* ≤ 5.0: Very often

Regarding professional training, the average evaluations provided by teachers without training and those with training are presented as follows: Concerning Q125 (Technology-enhanced learning), a statistically significant disparity exists between the average assessments of teachers lacking formal training and those who have undergone training. Teachers without training tend to infrequently incorporate the Technology-enhanced learning approach into their teaching (2.17±0.31 SE), while trained teachers more frequently utilize this method (3.42±0.20 *SE*) (Mann Whitney U, $Z = -2.687$, $p = .007$). For Q121 (Project-based learning), Q122 (Collaborative learning), Q123 (Hands-on learning), and Q124 (Problem-based learning), there were no statistically significant differences in the mean evaluations ($p > .05$). Both groups of teachers employed these assessment methods with similar frequency (Table 5).

Teaching Techniques Used to Organize Stem Teaching

Based on the outcomes of the survey on teaching methodologies employed to structure lessons according to the STEM model, it is evident that the mind map technique (Q138) is frequently utilized by instructors, with a mean score of (3.80 ± .76 SE). Elaborating on the significance, benefits, and drawbacks of mind maps, Nguyen emphasizes that their implementation in education aids in honing students' analytical and synthetic skills, cultivating a deeper understanding of lessons, and facilitating longer knowledge retention. This contrasts with the conventional method of rote memorization, which instead encourages a more holistic comprehension of knowledge in diagrammatic form (Nguyen, 2016). The role of mind maps in education encompasses several aspects: fostering independent and creative learning methods, enhancing students' initiative and thinking abilities, promoting active learning, optimizing brain potential, tailoring knowledge presentation to individual students, and instilling a sense of appreciation for self-designed mind maps. Additionally, mind maps prove to be an effective note-taking tool. However, the traditional paper-based mind map design has limitations, making it cumbersome to maintain, modify, and edit. This constraint can be overcome using software solutions such as Free Mind, Mindmap, and Visual Mind (Tran, 2019).

Furthermore, the research findings reveal that instructors only occasionally utilize the remaining teaching techniques. Specifically, Q131 - Tablecloth (3.13±0.86 *SE*), Q134 - Puzzle pieces (3.33 ± .88 SE), Q136 - Lightning (2.83±0.95 *SE*), and Q137 - Brainstorming (3.10±0.92 *SE*). However, certain teaching techniques are applied relatively infrequently by teachers, earning low scores and are as follows: Q132 - Painting room (2.60±0.89 *SE*), Q133 - Ball circle (2.17±0.79 *SE*), and Q135 – KWL (2.57±0.97 *SE*) (Table 6).

When examining gender as a factor, the average evaluations of male and female teachers do not exhibit any statistically significant differences for Q131 – Q138 (Mann Whitney U, $p > .05$ for all cases) (Table 7).

When evaluating seniority as a variable, the mean evaluations of teachers with < 10 yrs of experience and those with ≥ 10 yrs of expertise do not demonstrate any statistically significant differences for Q131 – Q138 (Mann Whitney U, $p > .05$ for all cases) (Table 8).

Considering professional training, the average evaluations of teachers without and those with training demonstrate no statistically significant differences for Q131 – Q138 (Mann Whitney U, $p > .05$ in all cases) (Table 9).

Table 6 Teachers' viewpoint on the application of teaching techniques

Code	Content	Mean±*SE*	Degree evaluation
Q131	Tablecloth	3.13±0.86	Sometimes
Q132	Painting room	2.60±0.89	Rarely
Q133	Ball circle	2.17±0.79	Rarely
Q134	Puzzle pieces	3.33±0.88	Sometimes
Q135	KWL	2.57±0.97	Rarely
Q136	Lightning	2.83±0.95	Sometimes
Q137	Brainstorming	3.10±0.92	Sometimes
Q138	Mind Map	3.80±0.76	Often

Note: $1.0 \leq M < 1.8$: Never; $1.8 \leq M < 2.6$: Rarely; $2.6 \leq M < 3.4$: Sometimes; $3.4 \leq M < 4.2$: Often; $4.2 \leq M \leq 5.0$: Very often

Table 5 Teachers' viewpoint on the application of teaching methods concerning the professional development process

Code	Content	Mean±*SE*		Mann Whitney U
		Untrained	Trained	
Q121	Project-based learning	2.50±0.22	2.92±0.17	$Z = -1.473$, $p = .141$
Q122	Collaborative learning	3.83±0.31	3.63±0.17	$Z = -0.432$, $p = .666$
Q123	Hands-on learning	2.50±0.34	2.92±0.21	$Z = -1.018$, $p = .309$
Q124	Problem-based learning	3.50±0.34	3.33±0.20	$Z = -0.545$, $p = .586$
Q125	Technology-enhanced learning	2.17±0.31	3.42±0.20	$Z = -2.687$, $p = .007$

Note: $1.0 \leq M < 1.8$: Never; $1.8 \leq M < 2.6$: Rarely; $2.6 \leq M < 3.4$: Sometimes; $3.4 \leq M < 4.2$: Often; $4.2 \leq M \leq 5.0$: Very often

Table 7 Teachers' viewpoint on the application of teaching techniques concerning gender

Code	Content	Mean±*SE*		Mann Whitney U
		Female	Male	
Q131	Tablecloth	3.06±0.18	3.23±0.28	$Z = -0.651, p = .515$
Q132	Painting room	2.88±0.21	2.23±0.23	$Z = -1.923, p = .054$
Q133	Ball circle	2.29±0.17	2.00±0.25	$Z = -0.895, p = .371$
Q134	Puzzle pieces	3.47±0.17	3.15±0.30	$Z = -0.808, p = .419$
Q135	KWL	2.65±0.24	2.46±0.27	$Z = -0.503, p = .615$
Q136	Lightning	2.94±0.22	2.69±0.29	$Z = -0.926, p = .335$
Q137	Brainstorming	3.18±0.18	3.00±0.32	$Z = -0.697, p = .486$
Q138	Mind Map	3.71±0.17	3.92±0.24	$Z = -0.675, p = .500$

Note: $1.0 \leq M < 1.8$: Never; $1.8 \leq M < 2.6$: Rarely; $2.6 \leq M < 3.4$: Sometimes; $3.4 \leq M < 4.2$: Often; $4.2 \leq M \leq 5.0$: Very often

Table 8 Teachers' viewpoint on the application of teaching technology concerning seniority

Code	Content	Mean±*SE*		Mann Whitney U
		< 10 yrs	≥ 10 yrs	
Q131	Tablecloth	3.14±0.17	3.12±0.25	$Z = -0.045, p = .964$
Q132	Painting room	2.50±0.20	2.68±0.25	$Z = -0.489, p = .625$
Q133	Ball circle	2.21±0.23	2.12±0.17	$Z = -0.422, p = .673$
Q134	Puzzle pieces	3.28±0.19	3.37±0.25	$Z = -0.736, p = .462$
Q135	KWL	2.85±0.23	2.31±0.25	$Z = -1.652, p = .099$
Q136	Lightning	2.85±0.27	2.81±0.22	$Z = -0.482, p = .630$
Q137	Brainstorming	3.28±0.28	2.93±0.19	$Z = -1.270, p = .204$
Q138	Mind Map	3.71±0.19	3.87±0.20	$Z = -0.536, p = .592$

Note: $1.0 \leq M < 1.8$: Never; $1.8 \leq M < 2.6$: Rarely; $2.6 \leq M < 3.4$: Sometimes; $3.4 \leq M < 4.2$: Often; $4.2 \leq M \leq 5.0$: Very often

Table 9 Teachers' viewpoint on the application of teaching techniques concerning professional training

Code	Content	Mean±*SE*		Mann Whitney U
		Untrained	Trained	
Q131	Tablecloth	3.16±0.30	3.12±0.18	$Z = -0.083, p = .933$
Q132	Painting room	2.83±0.47	2.54±0.17	$Z = -0.776, p = .438$
Q133	Ball circle	2.00±0.25	3.20±0.17	$Z = -0.693, p = .488$
Q134	Puzzle pieces	3.33±0.21	3.33±0.21	$Z = -0.167, p = .867$
Q135	KWL	2.16±0.40	2.66±0.19	$Z = -1.247, p = .212$
Q136	Lightning	2.50±0.34	2.91±0.19	$Z = -0.147, p = .452$
Q137	Brainstorming	2.83±0.16	3.16±0.20	$Z = -0.806, p = .420$
Q138	Mind Map	3.66±0.21	3.83±0.16	$Z = -0.334, p = .738$

Note: $1.0 \leq M < 1.8$: Never; $1.8 \leq M < 2.6$: Rarely; $2.6 \leq M < 3.4$: Sometimes; $3.4 \leq M < 4.2$: Often; $4.2 \leq M \leq 5.0$: Very often

The outcomes derived from the survey indicate that factors such as gender, seniority, and professional training do not exert any discernible influence on the choices made by teachers concerning the adoption of specific teaching techniques for STEM education activities within high school settings in the Vietnamese Mekong Delta region. Despite variations in gender representation, levels of experience, and professional development, these factors do not seem to play a significant role in shaping teachers' preferences regarding the methods employed for facilitating STEM learning experiences, suggesting a certain level of consistency and universality in the pedagogical approaches teachers use in this specific educational context.

Factors Leading to Challenges in Structuring Education While Implementing Stem

The survey findings regarding the challenges encountered while implementing the STEM educational model in teaching reveal that teachers' assessments of all the factors were consistently rated as "Normal." This implies a spectrum of perspectives, where some teachers perceive these reasons as posing difficulties, while others perceive them as less problematic (Table 10). This diversity in perception might stem from the fact that a significant portion of the surveyed teachers possess a seniority of ≥ 10 yrs. As a result, transitioning from conventional teaching methodologies to competency-based approaches becomes arduous due to their familiarity with traditional methods. This result is similar to the study of Nguyen (2021).

Table 10 Teachers' viewpoint on the difficulty in organizing teaching with the application of STEM

Code	Content	Mean±*SE*	Degree evaluation
Q171	Low quality/capacity of students	3.17±1.15	Normal
Q172	Students' activeness is still not high	2.97±1.13	Normal
Q173	Conditions and facilities have not been met	3.30±1.06	Normal
Q174	There is no specific instructional material available	3.23±1.10	Normal
Q175	It is difficult to identify effective teaching methods	2.80±1.06	Normal
Q176	Not enough time to organize life activities for students	3.37±1.22	Normal
Q177	Not trained in STEM teaching	2.67±1.21	Normal

Note: $1.0 \le M < 1.8$: Very undifficult; $1.8 \le M < 2.6$: Undifficulty; $2.6 \le M < 3.4$: Normal; $3.4 \le M < 4.2$: difficult; $4.2 \le M \le 5.0$: Very difficult

The shift from content-focused teaching to competency-driven education, particularly aligning with the guidelines of Official Letter 5512, introduces a significant transformation that many teachers find challenging to adapt to. Previously, they were well-versed in and accustomed to specific teaching methods, but the demand for updating pedagogical techniques, testing strategies, and assessment methods to suit individual students has posed difficulties. The time constraint to cultivate modern teaching techniques and models adds to the challenge, leading to problems in seamless implementation. Moreover, the monotonous format and content of training sessions, predominantly reliant on lecture-based methods, have failed to attract active engagement from teachers. Furthermore, factors such as student attitudes, collaboration with colleagues, adherence to school traditions, equipment availability, and the support framework of policies have not created an environment conducive for teachers to excel and enhance their expertise. However, despite these challenges, teachers still benefit from certain advantages. They experience professional enthusiasm, self-esteem, consistent attention, and insightful guidance from leaders. Investment in teaching equipment is also underway, aiming to fulfill the evolving teaching requirements of teachers.

When examining gender, the mean evaluations of both male and female teachers exhibit no statistically significant differences for Q171 – Q175 (Mann Whitney U, $p > .05$ for all cases) (Table 11).

Regarding experience level, the mean evaluations of teachers < 10 yrs of seniority and those with ≥ 10 yrs of seniority do not display any statistically significant differences for Q171 – Q175 (Mann-Whitney U, $p > .05$ for all cases) (Table 12).

Considering the professional training aspect, the mean evaluations of teachers who have not undergone training and those who have received training are as follows: For Q177 (Not yet trained in STEM teaching), a statistically significant discrepancy emerges between the average assessments of untrained teachers and their trained counterparts. Teachers without training perceive the reason for not being trained in STEM teaching as challenging (3.67 ± .33 SE), while trained teachers perceive it as less demanding (2.42 ± .24 SE) (Mann Whitney U, $Z = -2.306$, $p = .021$). However, for Q171 (Low quality/capacity of students), Q172 (Students' activeness is still not high), Q173 (Conditions and facilities have not been met), Q174 (There is no specific instructional material available), Q175 (It is difficult to identify effective teaching methods), and Q176 (Not enough time to organize life activities for students), the average ratings do not exhibit any statistically significant differences (Mann Whitney U, $p > .05$) (Table 13).

Table 11 Teachers' viewpoint on the difficulty in organizing teaching with the application of STEM concerning gender

Code	Content	Mean±*SE*		Mann Whitney U
		Female	Male	
Q171	Low quality/capacity of students	3.12±0.30	3.23±0.30	$Z = -0.252$, $p = .801$
Q172	Students' activeness is still not high	2.71±0.29	3.31±0.26	$Z = -1.407$, $p = .159$
Q173	Conditions and facilities have not been met	3.29±0.27	3.31±0.29	$Z = -0.178$, $p = .858$
Q174	There is no specific instructional material available	3.18±0.30	3.31±0.26	$Z = -0.325$, $p = .745$
Q175	It is difficult to identify effective teaching methods	2.76±0.25	2.85±0.32	$Z = -0.261$, $p = .794$
Q176	Not enough time to organize life activities for students	3.47±0.29	3.23±0.36	$Z = -0.481$, $p = .631$
Q177	Not trained in STEM teaching	2.82±0.30	2.46±0.33	$Z = -0.779$, $p = .436$

Note: $1.0 \le M < 1.8$: Very undifficulty; $1.8 \le M < 2.6$: Undifficulty; $2.6 \le M < 3.4$: Normal; $3.4 \le M < 4.2$: difficult; $4.2 \le M \le 5.0$: Very difficult

Table 12 Teachers' viewpoint on the difficulty in organizing teaching with the application of STEM concerning seniority

Code	Content	Mean±*SE*		Mann Whitney U
		< 10 yrs	≥ 10 yrs	
Q171	Low quality/capacity of students	2.79±0.33	3.50±0.24	Z = -1.684, p = .092
Q172	Students' activeness is still not high	2.79±0.32	3.13±0.27	Z = -0.838, p = .402
Q173	Conditions and facilities have not been met	3.14±0.33	3.44±0.22	Z = -0.553, p = .580
Q174	There is no specific instructional material available	3.21±0.26	3.25±0.31	Z = -0.108, p = .914
Q175	It is difficult to identify effective teaching methods	2.71±0.29	2.88±0.27	Z = -0.433, p = .665
Q176	Not enough time to organize life activities for students	3.14±0.31	3.56±0.32	Z = -1.042, p = .297
Q177	Not trained in STEM teaching	2.43±0.29	2.88±0.33	Z = -0.968, p = .333

Note: 1.0 ≤ M < 1.8: Very undifficulty; 1.8 ≤ M < 2.6: Undifficulty; 2.6 ≤ M < 3.4: Normal; 3.4 ≤ M < 4.2: difficult; 4.2 ≤ M ≤ 5.0: Very difficult

Table 13 Teachers' viewpoint on the difficulty in organizing teaching with the application of STEM concerning professional training

Code	Content	Mean±*SE*		Mann Whitney U
		Untrained	Trained	
Q171	Low quality/capacity of students	3.50±0.50	3.08±0.23	Z = -0.936, p = .349
Q172	Students' activeness is still not high	3.17±0.48	2.92±0.23	Z = -0.349, p = .727
Q173	Conditions and facilities have not been met	3.50±0.34	3.25±0.23	Z = -0.497, p = .619
Q174	There is no specific instructional material available	3.50±0.34	3.17±0.23	Z = -0.644, p = .520
Q175	It is difficult to identify effective teaching methods	3.00±0.26	2.75±0.24	Z = -0.378, p = .706
Q176	Not enough time to organize life activities for students	4.00±0.26	3.21±0.26	Z = -1.326, p = .185
Q177	Not trained in STEM teaching	3.67±0.33	2.42±0.24	Z = -2.306, p = .021

Note: 1.0 ≤ M < 1.8: Very undifficulty; 1.8 ≤ M < 2.6: Undifficulty; 2.6 ≤ M < 3.4: Normal; 3.4 ≤ M < 4.2: difficult; 4.2 ≤ M ≤ 5.0: Very difficult

Conclusion and Recommendations

The research findings indicate that despite teachers engaging with the STEM education model and implementing a range of teaching methods and techniques, there remains a lack of uniformity and standardization in their application. Upon assessing the responses of 30 participating teachers, it becomes evident that conventional teaching methods and techniques are more prevalent than contemporary approaches. This trend can be attributed to the necessity of accommodating various objective factors to tailor the selection of methods and techniques for different student cohorts.

We recommend investigating the underlying reasons for difficulties using specific teaching methods and techniques to gain a deeper and more comprehensive understanding of this situation. This additional research would facilitate a more nuanced exploration of the factors that drive teachers' choices and help identify potential strategies to enhance the implementation of modern teaching methodologies in the context of STEM education.

Conflict of Interest

The authors declare that there is no conflict of interest.

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