JPII 14 (2) (2025) 364-377

Jurnal Pendidikan IPA Indonesia

https://journal.unnes.ac.id/journals/jpii

FACTORS AFFECTING THE IMPLEMENTATION OF STEM EDUCATION: A CASE STUDY IN VIETNAM

N. T. Nguyen*[1] and T. V. Thai[2]

[1]Faculty of Natural Science Education, Saigon University, 273 An Duong Vuong, HoChiMinh City, Vietnam
[2]Nghe An Department of Education and Training, Vinh City, Nghe An, Vietnam

DOI: 10.15294/jpii.v14i2.23453

Accepted: April 13th, 2025. Approved: June 29th, 2025. Published: June 30th 2025

ABSTRACT

In recent years, STEM education has garnered significant attention globally, particularly in Vietnam. This research aims to investigate the factors influencing the implementation of STEM education in Vietnam. This study aims to identify key factors influencing the adoption of STEM education in Vietnamese schools. A survey was conducted with 865 teachers from 120 schools across Vietnam to examine these influencing factors. The methodology employed both qualitative and quantitative approaches, including surveys and data analysis, to determine the impact of various factors on the successful implementation of STEM education. The results revealed that the national general education program is the most significant factor influencing the implementation of STEM education in schools. Other contributing factors include the qualifications and awareness of teachers regarding STEM education, limited school facilities, and the content of assessment tests in teaching, all of which play important roles in the implementation process. In conclusion, this study presents recommendations and policy suggestions aimed at enhancing the implementation of STEM education in schools in Vietnam. The novelty of this research lies in its comprehensive examination of multiple factors influencing STEM education at the school level in Vietnam, offering new insights for educators and policymakers.

Keywords: STEM education; school; Vietnam; teachers; implementation

INTRODUCTION

While STEM—Science, Technology, Engineering, and Mathematics—education has garnered global attention for its potential to foster interdisciplinary thinking and innovation (Davis et al., 2019; Brečka & Monika, 2023; Galimova et al., 2024), its implementation in developing countries, particularly Vietnam, remains unexplored. Despite a growing emphasis from Vietnam's Ministry of Education and Training, schools continue to face systemic challenges in integrating STEM effectively into their curricula. Globally, STEM education is recognized for equipping learners with essential skills such as problem-solving, creativity, and applied knowledge (Avery & Reeve, 2013; Zuza et al., 2024; Sun et al., 2025), making it highly relevant in addressing complex issues like climate change and digital transformation. However, the majority of studies are based in Western contexts; only 8.5% of current STEM education research focuses on Asia, with Vietnam being notably underrepresented (Nguyen et al., 2019). This research addresses a critical gap by examining the local factors that influence the implementation of STEM education in Vietnam. It aims to move beyond general discussions of STEM to provide context-specific insights that can guide effective policy and practice within the Vietnamese education system.

Students exposed to STEM education enjoy numerous benefits, including enhanced aca-

***Correspondence Address**
E-mail: ntnhi@sgu.edu.vn

demic performance, logical thinking, and creativity (Daher & Shahbari, 2020; Astawan et al, 2023; Rogoza et al., 2024). Moreover, such exposure contributes to future career readiness and reduces anxiety in science and math-related fields (Wongsila & Yuenyong, 2019; Komalasari et al, 2024; Nordlöf et al., 2025). In Vietnam, where academic pressure and curriculum overload are persistent concerns (Le et al., 2021), identifying how STEM can be effectively and sustainably integrated becomes a pressing issue. STEM education also plays a significant role in advancing the United Nations Sustainable Development Goals (SDGs), especially in areas such as Quality Education (Goal 4), Clean Energy (Goal 7), and Climate Action (Goal 13) (Davis et al., 2019; AlAli & Yousef, 2024; Almughyirah, 2024). By equipping students with scientific and technological competencies, STEM enables the development of innovative solutions to local and global environmental challenges. This is particularly relevant for Vietnam, a country vulnerable to climate change and environmental degradation.

In addition, STEM education is closely linked to SDG 9 – Industry, Innovation, and Infrastructure (Wahyuni & Batuseng, 2024). The development of sustainable industries and modern infrastructure depends on a highly qualified workforce in science, technology, and engineering fields (Jones & Smith, 2023; Hakim et al., 2023). Countries such as Singapore and South Korea have incorporated STEM education into their national strategies; Vietnam's adaptation of similar models requires a contextual understanding and evidence-based planning. Despite policy-level efforts, the implementation of STEM in Vietnamese classrooms remains fragmented, facing barriers such as a lack of teacher training, inadequate infrastructure, and limited interdisciplinary collaboration (Le et al., 2021; Hossain et al., 2024). This study investigates the key factors that influence the success or failure of STEM implementation in Vietnamese schools. It specifically explores: (1) What are the contextual and systemic factors affecting STEM adoption in Vietnam? (2) How can these factors inform a practical model for policy and curriculum development?

By emphasizing the Vietnamese context and presenting a locally adapted model, this research contributes a novel perspective to the international discourse on STEM education. The findings are expected to support policymakers, educators, and curriculum designers in enhancing STEM integration in Vietnam, thereby narrowing both local and global education gaps.

METHODS

An exploratory sequential mixed-methods design was employed in the present study. This design was chosen because the use of both quantitative and qualitative data collection methods complements each other, enabling a more complete and comprehensive understanding of the perceptions of Vietnamese high school teachers regarding the factors affecting the implementation of STEM education in Vietnam. By combining both approaches, a deeper and more validated insight into the research problem was obtained compared to using only one method (Creswell & Plano Clark, 2018). The use of mixed methods research has become increasingly popular in educational studies, as it provides a more holistic understanding of phenomena by exploring both numerical data and descriptive insights, making it more effective than relying on just one method (Creswell & Plano Clark, 2018; Irma et al, 2023).

The implementation of STEM education is context-dependent (Bong & Chen, 2024), meaning that factors influencing STEM education in one context may not be applicable in another. It is important to seek opinions from stakeholders within the specific context of STEM education implementation. Therefore, the exploratory mixed methods approach was deemed suitable for this study.

A purposive sample of ten teachers was selected for semi-structured interviews. The targeted sample includes: two primary school teachers, two secondary school teachers, three high school teachers, and three university lecturers. These participants were selected because they are teachers of STEM-related subjects and have achieved significant accomplishments in their field. The qualitative interviews aimed to identify key factors that affect the implementation of STEM education in schools across the primary, secondary, and high school levels. To ensure a broad representation of the three education levels, the stratified purposive sampling technique was used. The interviews were conducted with teachers who were well-versed in STEM subjects, as well as university lecturers involved in STEM education.

Demographic information for the qualitative semi-structured interviewees is summarized in Table 1, while the demographic information for the quantitative questionnaire respondents is presented in Table 3.

Table 1. Summary of Demographic Information of the Interviewees

Participants	Workplace	Subject	Age	Years of service	Qualification
Interviewee number 1	Primary school	Math	40	20	Master
Interviewee number 2	Secondary school	Natural Sciences	36	16	Master
Interviewee number 3	University	Math	45	25	Doctor
Interviewee number 4	High school	Chemistry	37	17	Master
Interviewee number 5	Primary school	Math	35	15	Master
Interviewee number 6	Secondary school	Technology	39	19	Master
Interviewee number 7	High school	Biology	42	22	Master
Interviewee number 8	High school	Biology	37	17	Master
Interviewee number 9	University	Technology	43	23	Doctor
Interviewee number 10	University	Physics	46	26	Doctor

Interviewees were contacted via email to obtain their consent for participation at a specified time and date. The interviews were audio-recorded, and notes were taken during the sessions. Open-ended questions were used to allow participants to freely discuss the factors they believed were influential in the implementation of STEM education in Vietnamese schools. The interviews were conducted in Vietnamese and then translated into English for thematic analysis.

Following the qualitative interviews, a questionnaire was designed to explore factors affecting the implementation of STEM education in schools. These factors were identified through the interview results and a review of the literature. The questionnaire consisted of two parts:

Part 1: 6 questions related to the personal information of the teachers, including gender, workplace, years of service, qualifications, subjects, and current role.

Part 2: 22 items addressing five influencing factors identified from the interview data. The questionnaire was designed using the Likert Scale ranging from 1 to 5, where: 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree.

A survey was administered to teachers from 120 schools across Vietnam, including primary, secondary, and high schools, from urban, rural, and mountainous areas. The teachers were selected from courses in subjects related to STEM education, including mathematics, physics, technology, natural sciences, chemistry, and biology. Teachers in these courses were chosen on a preferential basis. The survey was conducted in December 2024.

Qualitative Data: The interviews were analyzed using thematic analysis as described by Braun and Clarke (2006). Thematic analysis involves identifying and analyzing patterns or themes within qualitative data. This method enables a comprehensive understanding of the factors influencing STEM implementation in Vietnamese schools.

Quantitative Data: The quantitative data were analyzed using statistical software SPSS (version 26). Descriptive statistics were used to summarize the data, and regression analysis, ANOVA, and correlation analysis were employed to examine the relationships between variables and their influence on STEM education implementation.

A questionnaire has then been designed to include factors affecting the implementation of STEM education in schools. These factors were identified through the results of interviews and a literature review. The questionnaire was designed in two parts. Part 1 consisted of 6 questions related to the personal information of teachers, including gender, workplace, years of service, qualifications, subject, and current mission. Part 2 consisted of 22 questions related to 5 influencing factors obtained from the interview results. The questionnaire was designed using a Likert Scale from 1 to 5, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree.

Regarding the subjects of the survey, we surveyed teachers from 120 schools in Vietnam (including Primary, Secondary, and high schools) in cities, rural areas, and mountainous areas. Teachers in these schools often attend universities for subject-specific professional development training. We have selected training courses in subjects at all three levels related to STEM education, such as math, physics, technology, natural sciences, chemistry, and biology. Teachers in those classes can be chosen arbitrarily (preferentially). The survey time was December 2024.

RESULTS AND DISCUSSION

The data collected from the semi-structured interviews were copied and analyzed using thematic analysis, which required identifying the main themes from the answers. The analysis process involved transcribing interviews verbatim and coding responses based on emerging categories. Regarding the research objectives and related research questions, four topics were identified as factors affecting the implementation of STEM education in high schools in Vietnam: teacher awareness and qualifications, Conditions of facilities in high schools, education programs, and content of assessments in the teaching process. These topics represent the major challenges in implementing STEM education in Vietnam.

Seven out of ten interviewed teachers stated that bringing STEM education into high schools holds significant meaning and aligns with the current orientation of basic and comprehensive reform of general education. However, the implementation of STEM education also comes with several challenges and limitations. This includes limitations in the awareness of management staff, teachers, students, and the community regarding STEM education. The concept of STEM education is still understood differently across schools. STEM education is a new issue for many schools and teachers. Some regions and schools are not fully aware of the purpose and meaning of STEM education activities, which has led to a lack of enthusiasm for its implementation and delayed encouragement for teachers and students to engage in scientific and technical research. One teacher (Interviewee No. 10) shared:"Currently, each teacher has a different perspective, and there is no consensus on STEM education. Although the Ministry of Education and Training has many documents presented in a relatively general and easy-to-understand manner related to this content, a consensus has yet to be reached. Therefore, in order to implement STEM education effectively in high schools, the first thing that teachers need to do is to understand STEM education properly, sufficiently, and deeply."

The interview results also indicated that all the participants agreed that the lack of professional training was a factor negatively affecting the effective implementation of STEM education. Most teachers have been trained in traditional, single-subject teaching, making it challenging to implement interdisciplinary teaching methods, such as those required for STEM education.

One participant (Interviewee No. 3) commented: "I have been trained to teach Mathematics. I have also attempted to self-study and research the organization of teaching according to the STEM education model, but implementing it in the subject remains challenging, as I am unsure of the best approach. We need to have training/retraining sessions that focus on how to organize the implementation of the STEM education model, especially STEM education in specific subjects."

This reflects the practical challenges in adapting to interdisciplinary teaching in Vietnamese educational institutions, where most teachers follow a mono-disciplinary training path.

Moreover, teachers are often reluctant to share knowledge or collaborate with colleagues, which further limits the exchange of ideas between teachers of STEM-related subjects. As a result, the qualifications of teachers play an important role in the success of implementing STEM education. Teachers expressed the need for well-designed and focused professional training programs that help them integrate various subjects into their teaching.

All interviewed teachers stated that the condition of school facilities has a significant impact on the implementation of STEM education. The large number of students per class also made it difficult to organize activities and hindered the innovation of teaching methods.

One of the interviewees (Interviewee No. 4) explained: "The fact that high schools do not have STEM classrooms or practice rooms for students to have places for teamwork, research, and experiments is also a problem that greatly affects the implementation of this model in practice."

Additionally, teachers noted that subjects such as computer science, robotics, and programming require substantial investment in infrastructure and teaching materials. Therefore, these factors create substantial difficulties in implementing STEM education effectively. These limitations are particularly significant in many Vietnamese provinces, especially in rural or underfunded areas. Interview results showed that eight out of ten teachers believed that, although the 2018 general education program in Vietnam has created more favorable conditions for STEM education, there are still challenges in organizing the content and topics in a way that both meets the requirements of the curriculum framework and promotes students' creativity.

Interviewee No. 7 stated:"When implementing the 2018 general education program in Vietnam, it is necessary to have guidance on STEM topics in subjects and fields of study to facilitate teachers in teaching. Together with 'Programming' in STEM education, there should be policies, regulations, and frameworks attached. Without specific regulations and policies, the implementation of STEM education will not have a firm foundation and will remain superficial."

This highlights the gap between curriculum goals and real classroom implementation, a challenge frequently encountered in the Vietnamese context.

In the interviews, six teachers said that the content of testing and assessment in teaching still poses significant barriers. The assessment system, particularly the national high school exam, focuses on multiple-choice tests that measure knowledge and skills, while STEM education requires process-oriented and product-based assessment.

One teacher (Interviewee No. 2) pointed out: "Currently, in high schools that still focus on studying for exams, the slow innovation of testing and assessment in teaching will be the biggest barrier to the implementation of STEM education."

Currently, students spend most of their time preparing for exams, leaving little room for STEM activities, which are mostly extracurricular or after-school activities. This examination-oriented environment in Vietnamese high schools creates a structural obstacle to integrating STEM into the mainstream curriculum.

Based on the interview results combined with document analysis, four factors were identified, each represented by multiple topics, that affect the implementation of STEM education in schools. These factors are shown in Table 2.

Table 2. Factors and Topics Affecting the Implementation of STEM Education

Factors	Topics
Teachers' qualifications and awareness	I only know briefly about STEM education methods (GV1)
	I mainly self-study, self-research through books, newspapers, the internet, or learn from colleagues (GV2)
	I am used to the old teaching method that mainly imparts knowledge in one way (GV3)
	I am afraid to change teaching methods (GV4)
	I am not ready for STEM education (GV5)
Facilities in the school	Implementation of STEM education requires many facilities in schools (CS1)
	Implementation of STEM education requires functional classrooms (CS2)
	The school's current facilities are not synchronized (CS3)
	Tables and chairs in the classroom are not suitable for teamwork (CS4)
General education program	Currently, the study program is in the form of a single subject (CT1)
	Time spent on STEM education is not clear in the program (CT2)
	The 2018 general education program has an orientation for STEM education (CT3)
	The 2018 general education program in the direction of developing the students' quality and competencies should have a positive effect on the organization of STEM teaching (CT4)
Contents of testing and assessment in the teaching process	Testing and assessment are now mainly based on scores (ND1)
	Assessment is now mainly performed through a test (ND2)
	It is necessary to conduct a practical skills assessment (ND3)
	It is necessary to conduct a competency assessment through the assessment of the student's work process and products (ND4)
Implement STEM education	STEM education is an integrated education method following an interdisciplinary approach (ST1)
	STEM education emphasizes collaborative learning (ST2)
	STEM education implements strategic problem-solving learning (ST3)
	Implement STEM education towards developing learners' capacity (ST4)
	Deploying STEM education aligns with the global trend in education development (ST5)

Based on the above results, we have identified factors that are likely to impact the implementation of STEM education in schools and constructed a research model, as shown in Figure 1.

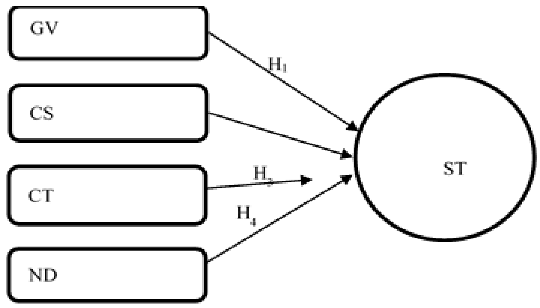

Figure 1. Research Model

In which, ST is the dependent variable corresponding to the factor of implementing STEM education; GV (qualification factors, teachers' awareness of STEM education); CS (factors of physical facilities for the implementation of STEM education); CT (factors on educational program); ND (factor of testing & assessment in teaching) are respectively the independent variables that affected the ability to implement STEM education in schools. With the above research model, we have carried out an exploratory study to test the hypothesis H1 (level factors, teachers' awareness of STEM education have a positive effect on the implementation of STEM education in school); H2 (factors of physical facilities have a positive effect on the implementation of STEM education in schools); H3 (factors of educational program have a positive effect on the implementation of STEM education in schools); H4 (factors of testing & assessment in teaching have a positive effect on the implementation of STEM education in schools). The results of testing the hypothesis will contribute to answering the two questions posed by the study:

Q1: What factors will affect the implementation of STEM education in schools?

Q2: How are factors affecting the implementation of STEM education in schools shown?

Survey data were collected, analyzed using mathematical statistical methods, and processed with SPSS 20 software.

After filtering and cleaning the data, we conducted descriptive statistical analysis for six questions about teachers' personal information to determine the characteristics of the sample obtained. Frequency analysis of the six main characteristics of the studied sample (n = 865 teachers) yielded the results presented in Table 3.

Table 3. Descriptive Statistics of the Teacher Survey Sample

Parameters of the Sample		Frequency	Percent (%)
Gender	Male	377	43.6
	Female	488	56.4
Workplace	Primary school	33	3.8
	Secondary school	176	20.3
	High school	656	75.8
Years of service	less than 5 years	93	10.8
	From 5 to 10 years	260	30.1
	From 10 to 15 years	321	37.1
	Over 15 years	191	22.1
Qualification	college bachelor	7	0.8
	Bachelor	486	56.2
	Master	372	43
	Doctor	0	0

Subject	Math	202	23.4
	Physics	256	29.6
	Chemistry	131	15.1
	Biology	102	11.8
	Natural Sciences	59	6.8
	Technology	115	13.3
Current mission	Teaching	844	97.6
	Manage	21	2.4
Total survey sample		865	100

The proportion of distributed surveys was not balanced at any level, as subjects were assigned due to the convenience of the research approach. However, we do not intend to compare among levels of education, so this did not affect the study's purpose. Particularly, in terms of working qualifications, teachers with a doctorate accounted for 0% of the research sample. Regarding the questionnaire provided to the participants, Table 4 shows the average value and standard deviation of the survey data. All average values are higher than the midpoint of 2.5 (ranging from 3.73 to 3.98), implying that teachers have a positive perception of the implementation of STEM education. The standard deviation between 0.375 and 0.561 indicates the normal prevalence of the data around the average value.

Table 4. Descriptive Statistics

	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
GV1	865	1	5	3.75	.506
GV2	865	1	5	3.77	.496
GV3	865	1	5	3.85	.423
GV4	865	1	5	3.79	.468
GV5	865	1	5	3.85	.446
CS1	865	1	5	3.81	.507
CS2	865	1	5	3.85	.476
CS3	865	2	5	3.90	.397
CS4	865	1	5	3.93	.375
CT1	865	1	5	3.72	.511
CT2	865	1	5	3.73	.567
CT3	865	1	5	3.76	.536
CT4	865	1	5	3.84	.519
ND1	865	1	5	3.88	.447
ND2	865	1	5	3.85	.434
ND3	865	1	5	3.89	.453
ND4	865	1	5	3.99	.469
ST1	865	1	5	3.78	.503
ST2	865	1	5	3.76	.499
ST3	865	1	5	3.76	.498
ST4	865	1	5	3.79	.483
ST5	865	1	5	3.98	.561

Next, we conducted a reliability analysis to preliminarily test the scale. The following table presents the final results obtained (Table 5).

Table 5. Cronbach's Alpha Coefficient Analysis Results

	Factor	Observed variables	Coefficient Cronbach's Alpha	Coefficient total variable correlation min-max
1	Factors of qualification, teachers' awareness of STEM education (GV)	GV1, GV2, GV3, GV4, GV5	0.928	0.740 to 0,888
2	Factors of physical facilities for the implementation of STEM education (CS)	CS1, CS2, CS3, CS4	0.839	0.656 to 0.708
3	Factors in the educational program (CT)	CT1, CT2, CT3, CT4	0.909	0.769 to 0.882
4	Factor of testing & assessment in teaching (ND)	ND1, ND2, ND3, ND4	0.860	0.631 to 0.787
5	Factors of implementing STEM education (ST)	ST1, ST2, ST3, ST4, ST5	0.932	0.671 to 0.775

Cronbach's Alpha reliability test method was used to assess the reliability of each scale; any observed variables that failed to meet the criteria will be removed. According to Peterson (1994), any scale with a Cronbach's Alpha coefficient greater than 0.6 will be accepted. Observed variables with a total correlation coefficient less than 0.3 are considered poor variables and will be removed from the scale. The results from Table 2 show that all scales have Cronbach's Alpha coefficients ranging from 0.839 to 0.932, indicating a reliable level. The loading coefficients of the items on each scale were greater than 0.6, and the correlation coefficient of the sum of the observed variables was greater than 0.3. Thus, it was demonstrated that the observed variables in the factors are consistent, the factor scale has high reliability, and no observed variables were excluded from the scale. Next, we used exploratory factor analysis EFA for a study model consisting of 04 hypotheses H1, H2, H3, H4 corresponding to 04 independent variables and 01 dependent variable to test the convergence and discrimination of the observed variables with the factor extracted in the theoretical model. With the following conditions: (1) The factor loading of the observed variables is greater than 0.5; (2) Satisfactory KMO coefficient $0.5 \leq KMO \leq 1$ (Hair et al., 1998); (3) The Sig value of Bartlett's test is less than 0.05; (4) Value of extracted or cumulative variance > 50% (Glaser & Strauss, 1967); Eigenvalue is used to determine the number of factors to be extracted from a value greater than 1.

Table 6. Exploratory Factor Analysis

Parameter	EFA Independent Variables	EFA Dependent Variable
KMO	0.909	0.855
The Sig value of the Barlett test	0,000	0,000
Eigenvalue	1.138	3.985
Total variance extracted	74.678%	79.705%
Minimum load factor	0.780	0.902
Number of extracted factors	4	1
Number of variables eliminated	0	0

In Table 6, the KMO coefficient of the independent variable and the dependent variable is respectively 0.909 and 0.855, satisfying the condition 0.5 ≤ KMO ≤ 1, showing that factor analysis is suitable with the research data file; The Sig value of the Barlett test of the independent variable and the dependent variable is equal to 0.000 < 0.05, showing that the observed variables in the factor are correlated with each other and the factor analysis is statistically significant; The Eigenvalue is all greater than 1, the data extracted 04 independent factors with the total variance extracted is 74.678%, 01 dependent factor with the total variance extracted is 79.705% (satisfy the condition greater than 50%; The minimum factor loading is 0.780, satisfying the minimum condition for the observed variable to be retained and no variable to be excluded.

Implementing the factor rotation, the observed variables of the factors converge.

At the end of the EFA step, we had the five factors: GV, CT, ND, CS, and ST, which are the most suitable with the 22 best observed variables (Hair et al., 1998). Therefore, to change the measurement of observed variables to account for the factors being tested, we perform the steps of creating representative factors and conducting a Pearson correlation assessment and linear regression analysis.

We performed the Pearson correlation test between the independent and dependent variables. The results from Table 7 showed that all variables had a quite close linear relationship (correlation coefficients were all greater than 0), and the results were positive. The results were statistically significant (sig < 0.05).

Table 7. Correlation Analysis Results

Variable		GV	CS	CT	ND	ST
Pearson correlation coefficient	GV	1				
	CS	0.604	1			
	CT	0.515	0.496	1		
	ND	0.559	0.594	0.518	1	
	ST	0.592	0.604	0.810	0.613	1
Sig	GV	0.000				
	CS	0.000	0.000			
	CT	0.000	0.000	0.000		
	ND	0.000	0.000	0.000	0.000	
	ST	0.000	0.000	0.000	0.000	0.000

Analyzing to test the four hypotheses of the theoretical model. The results of multivariable regression analysis in Table 7 showed that the sig value of the F test < 0.05, so the regression coefficient was significant, the regression model was suitable with the obtained data file; Durbin-Watson value is 1.808 satisfying the condition in the range of 1.5-2.5, indicating that the model does not occur autocorrelation; The significance test value of the regression coefficients sig < 0.05 showed that the effects of the independent variables on the dependent variable are significant. At the same time, the VIF coefficients of the independent variables are all less than 10, so the data does not violate the assumption of multicollinearity (Hair et al., 1998; Prabowo et al, 2021). The values of the beta-normalized regression coefficients in Table 8 are all positive, indicating that the independent variables have a positive effect on the dependent variables. This means that the hypotheses H1, H2, H3, and H4 have all been accepted. The research model is rewritten according to the normalized regression equation as follows:

$$ST = 0.106*GV + 0.151*CS + 0.602*CT + 0.152*ND$$

The valuable equation, with an Adjusted R-Square value of 0.734, showed that the independent variables GV, CS, CT, and ND explained 73.4% of the change in the dependent variable ST, while 26.6% was attributed to out-of-model variables and random error.

Table 8. Regression Results

Variable	ST			
	Std. Error	**Normalized Beta coefficient**	**sig**	**VIF**
(Constant)	0.095		0.019	
GV	0.026	0.106	0.000	1.846
CS	0.030	0.151	0.000	1.906
CT	0.021	0.602	0.000	1.563
ND	0.028	0.152	0.000	1.824
Number of observations	865			
Adjusted R Square	0.734			

The above-mentioned regression equation also showed the impact level of the independent variables on the dependent variable. Specifically, with the most significant Beta coefficient of 0.602, the educational program factor had the most significant influence, and the least influential factors were the qualification and awareness of teachers (Normalized Beta coefficient 0.106). This result also suggests that researchers conduct more specific studies on educational programs that incorporate STEM education into schools.

From the test results, analysis and linear regression equations, it showed that the research model with four hypotheses (H1, H2, H3, H4) corresponds to four factors of level, teacher's awareness, and school's facilities, the educational program, the content of testing and assessment in the teaching process all have a positive impact on the implementation of STEM education in secondary schools and high schools.

The factor of educational program (CT) is reflected in four basic matters: currently, the program is in a single-subject form that is not conducive to implementing STEM education, and the duration of STEM education is unclear in the programs. New general education programs have orientations for STEM education, and these programs are designed to develop students' quality and competence, which has a positive impact on the organization of STEM teaching. In the normalized regression equation, the educational program factor has the highest Beta coefficient (Beta = 0.602), indicating that this factor has the most significant effect on the implementation of STEM education in schools. This result was consistent with James (2013). "To attract and retain a new generation of learners, engineering and technology programs need to be innovated to optimize suitable skills today," James said. More importantly, all new teaching materials must provide clear guidelines for all expected workloads and classroom activities. STEM educators and students will benefit from precise results for courses, lessons, and projects. This result also suggested that educational managers and researchers should pay more attention to integrated programs when developing general education programs. This result is also consistent with Le et al. (2021). Specifically, it was necessary to integrate STEM education into a national educational program, promote its development in schools to support career guidance and classification of students, and foster their passion for scientific research, ultimately orienting them to pursue careers in high-tech scientific industries in the future. Additionally, it is essential to create a favorable legal and policy environment that encourages foreign investors to establish high-quality STEM educational institutions in Vietnam.

The factor of content of testing & assessment in the teaching process (ND) is showed in 4 contents: currently, assessment is mainly based on scores, tests mainly perform assessment, it is necessary to conduct an assessment of practical skills, it is necessary to evaluate the capacity through the assessment of the student's work process and products. In the normalized regression equation, the ND factor has the second-highest Beta coefficient (Beta = 0.152), indicating that the effect of the ND factor on the implementation of STEM education is ranked second, after the effect of the educational program factor. This result is quite similar to Nadelson et al. (2012) and Van Hoe et al. (2024). Accordingly, he suggested that a major challenge for teachers' implementation of STEM integration is the lack of quality assessment tools, planning time, and knowledge of STEM subjects. Accordingly, teachers feel that there are not enough standardized assessments for STEM programs, making STEM assessment a challenging task for teachers. This was also mentioned by the teachers who participated in the interviews, specifically the current traditional practice of assessment (through the test, the result is mainly the score, not carefully assessed). Hands-on skills, not interested in the implementation of students' products. It is a common habit among teachers, and it presents one of the challenges to implementing STEM education. This result suggested that it is necessary to innovate assessment in the teaching process in schools. Testing and assessment play a crucial role in determining the selection of content and methods, as well as promoting teaching and learning in general. With STEM education, testing and assessment play an even more crucial role, as using outdated methods (written exams, memorization, and exercises) can hinder access to STEM education. In STEM education, students are placed in real-life situations and asked to solve problems in authentic contexts using their interdisciplinary knowledge and social understanding. At the end of each such problem, students often create a product through self-discovery and targeted research, which serves as the basis for assessment.

The factor of school facilities (CS) is reflected in the following content: Implementing STEM education requires a range of school facilities, including functional classrooms. However, the current facilities of schools are insufficient, and the tables and chairs in the classrooms are not suitable for group work. Additionally, function rooms are limited. In the normalized regression equation, factor CS ranks third in terms of impact level (Beta coefficient = 0.151). This result is also quite consistent with Stark (2016). The conditions of facilities and teaching materials played a significant role in hindering the successful implementation of STEM education in schools. The classroom was the most important area in the school. Students spent most of their time, and stated that the number of students in the classroom can make it less effective for student activities. Research has confirmed that reducing class sizes can lead to higher academic achievement for students (Atmojo et al., 2020; Terzieva et al., 2024). Therefore, function rooms (such as classrooms and laboratories) need to be equipped to facilitate students' learning and academic pursuits. This result also suggests that it is necessary to enhance the synchronized facilities in schools that are suitable for STEM education. Saying that "without modern facilities, it is impossible to teach STEM" is not accurate. In fact, implementing STEM education in rural or mountainous areas, using recycled materials, has enabled students to learn. The important thing here is the teacher's choice of content and organization. However, in STEM education, many areas of content require investment in modern teaching facilities and equipment, such as robotics and computer science. Therefore, in order to implement STEM education comprehensively, it is necessary to gradually invest in appropriate facilities and teaching equipment (summarized according to the results of interviews with teachers).

The least influential factor (Beta coefficient is 0.106) is the factor that belongs to the qualification and awareness of teachers about STEM education, including the following specific issues: teachers only know briefly about education, teachers mainly self-research, self-learn through books, newspapers, the internet or learn from colleagues, teachers are familiar with the old teaching method which is mainly to impart one-way knowledge. This result aligns with Stark (2016), who noted that the shortage of qualified teachers in STEM education and the underinvestment in teachers' professional development are significant barriers to successfully promoting STEM education. This result suggests that it was necessary to improve the quality of STEM teachers. In STEM education, it is not a teacher who teaches multiple subjects simultaneously, but rather teachers who teach different subjects must collaborate and build lessons together so that students can apply the knowledge and skills from multiple subjects to solve a problem. Therefore, it is necessary to train teachers in groups or pairs, and to regularly organize training and retraining to improve pedagogical skills and teachers' ability to apply STEM educational methods in teaching, thereby enhancing the learning and practice capacity of students in STEM education in high schools.

The findings of this study revealed several key challenges in implementing STEM education in Vietnamese high schools: teacher awareness and qualifications, limited facilities, curriculum constraints, and inadequate assessment methods. These findings are consistent with recent research conducted in Vietnam, which highlights systemic difficulties in transitioning to STEM education at the school level (Hai et al., 2023; Thao et al., 2024).

First, the lack of understanding and professional preparation among teachers was identified as a major barrier. Teachers in this study reported confusion about the concept of STEM and the absence of practical strategies for integrating interdisciplinary content. This confirms Phuong and Hong (2024), who emphasized that while STEM is promoted in the 2018 General Education Curriculum, specific guidance for subject-based implementation remains insufficient. Furthermore, several studies demonstrated that without targeted teacher development, even strong curriculum intentions do not translate into effective classroom practice (Tuong et al., 2023;

Suprapto et al, 2021). This challenge is reflected in the broader theory of ”teacher professional capital” (Hargreaves & Fullan, 2015), where the success of any educational reform hinges on teacher collaboration, ongoing professional development, and a deep understanding of pedagogy. In the Vietnamese context, where many teachers are trained in a monodisciplinary fashion and rarely collaborate across subject areas, these conditions necessitate the implementation of integrated STEM education (Le et al., 2023).

Second, the limited physical infrastructure and facilities available in most high schools continue to be a structural challenge. As Van Dat et al. (2023) point out, many secondary schools in Vietnam lack dedicated STEM labs, maker spaces, or even basic technological resources, especially in rural or disadvantaged areas. In our study, participants also raised concerns about the limited physical space for teamwork and experimentation, making hands-on learning and project-based approaches challenging to implement. This barrier reinforces the argument made by Voogt and Roblin (2012) that 21st-century competencies cannot be cultivated without enabling learning environments.

Third, although the 2018 general education program formally supports competency-based and student-centered learning, teachers interviewed in this study expressed a need for clearer instructional models and policies for integrating STEM into existing subject curricula. This need for structural and policy-level support echoes the recommendations of Phuong and Hong (2024), who called for more substantial alignment between curriculum goals and practical guidelines.

Additionally, Tuong et al. (2023) found that well-structured STEM instruction can improve students' real-world problem-solving abilities, but such outcomes require not only curriculum integration but also administrative and pedagogical support. Without these, efforts often remain superficial and unsustainable.Lastly, the current assessment system in Vietnam remains incompatible with the goals of STEM education. Teachers reported that national examinations still emphasize standardized testing and theoretical knowledge, which discourages innovative approaches such as project-based learning or interdisciplinary assessments. This problem has also been documented by Hai et al. (2023), who found that testing pressure is one of the most significant factors deterring STEM integration. Teachers expressed concern that, under the current system, there is little motivation to implement process-oriented or product-based evaluation methods. In line with this, Le et al. (2023) emphasized that assessment innovation is a critical but underdeveloped component of successful STEM implementation, especially in systems that are historically exam-oriented.

In conclusion, the empirical data collected from Vietnamese teachers suggest that while national policies are increasingly supporting STEM education, significant implementation gaps remain. These include teacher capacity, infrastructure limitations, curriculum design challenges, and assessment practices. Addressing these issues will require multi-level reform—combining professional development, investment in facilities, more straightforward curriculum guidelines, and innovation in assessment systems. This study contributes to the ongoing discourse by offering context-specific insights from Vietnam, highlighting the disconnect between policy intentions and actual classroom practices in STEM education reform.

While this study offers valuable insights into the implementation of STEM education in Vietnam, several limitations need to be acknowledged. First, the study's sample size and geographic distribution were limited to 865 teachers from 120 schools. Although the survey covered various regions in Vietnam, the sample may not fully represent the diversity of schools across the country, particularly in remote or underserved areas. Future research could expand the sample size to include a broader representation of teachers and schools, especially in rural and isolated regions where STEM education may face additional challenges. Another limitation is the survey's cross-sectional nature, which captures only a snapshot of teachers' perceptions at a single point in time. This may not fully reflect the evolving challenges and changes in STEM education, especially in the context of rapid policy updates or shifts in educational priorities. Future studies could adopt a longitudinal approach to track changes over time and assess the impact of policy reforms or new government initiatives.

CONCLUSION

This study has identified key factors influencing the implementation of STEM education in Vietnamese high schools, namely: the general education program, content and assessment practices, teaching facilities, and teachers' awareness of STEM. While these findings provide a foundation, several important implications should be considered for practice and policy. From a policy perspective, the Ministry of Education and Training should consider revising the national curriculum to provide more flexibility for interdisciplinary STEM teaching. Simultaneously, it is recommended to align examination and evaluation criteria to encourage integrated learning approaches. At the school level, targeted investment in laboratory equipment and digital tools is essential. Professional development programs should be designed to improve teachers' understanding and confidence in implementing STEM lessons. This study has several limitations, including a restricted sample size and limited geographic coverage, which may not fully reflect the diversity of Vietnam's educational contexts. Future research should expand to include different regions, as well as comparisons between urban and rural areas, and longitudinal studies to track changes over time. In conclusion, strengthening STEM education in Vietnam requires not only recognizing influencing factors but also translating findings into context-specific actions. As STEM becomes increasingly vital for national development, in-depth and comprehensive research will be crucial to inform effective implementation strategies.

REFERENCES

AlAli, R., & Yousef, W. (2024). Enhancing student motivation and achievement in science classrooms through STEM education. *STEM Education*, *4*(3), 183–198.

Almughyirah, S. M. (2024). The degree of implementing STEM practices among mathematics teachers at the middle school level from the teachers' and educational supervisors' perspectives. *International Journal of Innovative Research and Scientific Studies*, *7*(3), 1182–1194.

Astawan, I. G., Suarjana, I. M., Werang, B. R., Asaloei, S. I., Sianturi, M., & Elele, E. C. (2023). STEM-Based Scientific Learning and Its Impact on Students' Critical and Creative Thinking Skills: An Empirical Study. *Jurnal Pendidikan IPA Indonesia*, *12*(3), 482-492.

Atmojo, S. E., Muhtarom, T., & Lukitoaji, B. D. (2020). The level of self-regulated learning and self-awareness in science learning in the COVID-19 pandemic era. *Jurnal Pendidikan IPA Indonesia*, *9*(4), 512-520.

Avery, Z. K., & Reeve, E. M. (2013). Developing effective STEM professional development programs. *Journal of Technology Education*, *25*(1), 55–69.

Bong, D. C. N., & Chen, C. J. (2024). Insights into science, technology, engineering and mathematics (STEM) achievement: A comprehensive review of factors and methodologies. *Review of Education*, *12*(3), e70018.

Brečka, P., & Monika, V. (2023). Applying STEM Strategies in the Context of Primary Education in Slovakia. *International Conference on Interactive Collaborative Learning*, 421–431.

Creswell, J., & Plano Clark, V. L. (2018). *51-Creswell & Plano Clark, 2018.pdf.*

Daher, W., & Shahbari, J. A. (2020). Design of STEM activities: Experiences and perceptions of prospective secondary school teachers. *International Journal of Emerging Technologies in Learning*, *15*(4), 112–128.

Davis, B., Francis, K., Friesen, S., Davis, B., Francis, K., & Friesen, S. (2019). STEM Education. In *STEM Education by Design*.

Galimova, E. G., Prokopyev, A. I., Aytuganova, J. I., Zakharova, V. L., Shindryaeva, N. N., & Kolomoets, E. N. (2024). Examining the relationships among anxiety associated with teaching science, interest in science, and self-efficacy. *EURASIA Journal of Mathematics, Science and Technology Education*, *20*(5), em2447.

Glaser, B. G., & Strauss, A. L. (1967). *The Discovery of Grounded Theory Strategies for Qualitative Research.* Aldine Transaction. New Brunswick (U.S.A.) and London (U.K.).

Hai, T. D., Linh, N. Q., & Bich, N. T. (2023). Obstacles and Challenges in Implementing STEM Education in High Schools: A Case Study in the Northern Mountains of Vietnam. *European Journal of Educational Research*, *12*(3).

Hair, J. F., Andreson, R. E., Tahtam, R. L., & Black, C. W. (1998). *Multivariate Data Analysis*. Prentice-Hall International Inc.

Hakim, A., Efwinda, S., Damayanti, P., Syam, M., Mutmainah, O., & Norsaputra, A. (2023). Improving Climate Literacy of High School Students Through Physics Teaching Materials Based on STEM. *Jurnal Pendidikan IPA Indonesia*, *12*(4), 526–536.

Hargreaves, A., & Fullan, M. (2015). *Professional capital: Transforming teaching in every school*. Teachers College Press.

Hossain, M. A., Deehan, J., & Gibbs, L. (2024). Unveiling the Pedagogical Approaches in STEM Classroom: A Scoping Review. *International Journal of Learning, Teaching and Educational Research*, *23*(12), 1–22.

Irma, Z. U., Kusairi, S., & Yuliati, L. (2023). STREM PBL With E-Authentic Assessment: Its Impact To Students' Scientific Creativity On Static Fluid. *Jurnal Pendidikan IPA Indonesia*, *12*(1), 80-95.

Jones, M., & Smith, C. (2023). The sustainable development goals and STEM education: Paradoxes and reframings. In *education and the UN sustainable development goals: Praxis within and beyond the classroom* (pp. 655–672). Springer.

Komalasari, Y., Nugraha, M. E., Danim, S., & Razak, A. Z. A. (2024). Implementation of STEM learning with a scientific approach to improving critical, creative thinking, and cadet learning outcomes. *Jurnal Pendidikan IPA Indonesia, 13*(2).

Le, H. C., Nguyen, V. H., & Nguyen, T. L. (2023). Integrated STEM approaches and associated out-

comes of K-12 student learning: A systematic review. *Education Sciences*, *13*(3), 297.
Le, L. T. B., Tran, T. T., & Tran, N. H. (2021). Challenges to STEM education in Vietnamese high school contexts. *Heliyon*, *7*(12), e08649.
Nadelson, L. S., Seifert, A., Moll, A. J., Coats, B., Nadelson, L. S., Seifert, A., Moll, A. J., & Coats, B. (2012). *i-STEM Summer Institute : An Integrated Approach to Teacher Professional Development in STEM i-STEM Summer Institute : An Integrated Approach to Teacher Professional Development in STEM*.
Nguyen, N. H., Hai, L., & Ngan, M. (2019). *Transformative Perceptions of In-service Teachers towards STEM Education : The Vietnamese Case Study Transformative Perceptions of In-service Teachers towards STEM Education : The Vietnamese Case Study*. *September*.
Nordlöf, C., Norström, P., Schönborn, K. J., & Hallström, J. (2025). Easier Said than Done: STEM Subject Integration Through Engineering Design in Swedish Upper Secondary School. *Canadian Journal of Science, Mathematics and Technology Education*, 1–15.
Phuong, P. N. T. P., & Hong, B. V. H. (2024). Science, Technology, Engineering, and Mathematics (STEM) Education in the New General Education Curriculum of Vietnam. *AsTEN Journal of Teacher Education*.
Prabowo, R., Bambang, A. N., & Sudarno, S. (2021). Water Quality Index of Well Water in the Converted Agricultural Land. *Jurnal Pendidikan IPA Indonesia*, *10*(4), 560-570.
Rogoza, V., Levchenko, F., Kalinina, L., Zasiekina, T. M., & Skulovatov, O. (2024). Implementation of STEM education in the framework of the New Ukrainian School reform. *Scientific Herald of Uzhhorod University. Series" Physics"*, *55*, 2064–2073.
Sreejesh, S., & Mohapatra, S. (2014). Mixed method research design: An application in consumer-brand relationships (CBR). In *Mixed Method Research Design: An Application in Consumer-Brand Relationships (CBR)*.
Stark, J. (2016). *Barriers to Successful Implementation of PDM*. 371–386. h
Sun, D., Zhan, Y., Wan, Z. H., Yang, Y., & Looi, C.-K. (2025). Identifying the roles of technology: A systematic review of STEM education in primary and secondary schools from 2015 to 2023. *Research in Science & Technological Education*, *43*(1), 145–169.
Suprapto, N., Prahani, B. K., & Cheng, T. H. (2021). Indonesian curriculum reform in policy and local wisdom: Perspectives from science education. *Jurnal Pendidikan IPA Indonesia*, *10*(1), 69-80.
Terzieva, V., Paunova-Hubenova, E., & Slavcheva, S. (2024). Trends, Challenges, Opportunities, and Innovations in STEM Education. *IFAC-PapersOnLine*, *58*(3), 106–111.
Thao, N. P., Huong, L. T. T., Dinh, N. V, Hang, N. T. T., Quyen, C. V, Cuong, L. M., & Thao, T. T. P. (2024). Current Situation of Primary School Teachers' Integrated STEM Teaching Competence: An Exploratory Study in the Northern Mountainous Provinces of Vietnam. *Jurnal Pendidikan IPA Indonesia*, *13*(1).
Tuong, H. A., Nam, P. S., Hau, N. H., Tien, V. T. B., Lavicza, Z., & Hougton, T. (2023). Utilizing STEM-based practices to enhance mathematics teaching in Vietnam: Developing students' real-world problem solving and 21st century skills. *JOTSE: Journal of Technology and Science Education*, *13*(1), 73–91.
Van Dat, T., Thach, P. N., & Tu, P. N. C. (2023). Proposing a Model for Developing Facilities to Support STEM-Oriented Natural Science Experiences in Junior High Schools in Vietnam. *International Journal of Secondary Education*, *11*(3), 55–62.
Van Hoe, A., Wiebe, J., Rotsaert, T., & Schellens, T. (2024). The implementation of peer assessment as a scaffold during computer-supported collaborative inquiry learning in secondary STEM education. *International Journal of STEM Education*, *11*(1), 3.
Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies*, *44*(3), 299–321.
Wahyuni, S., & Batuseng, I. (2024). Evaluating STEM-based Reform Teaching Observation Protocol to Enhance Students' Communication Skills in the Context of Sustainable Development Goals in Science Learning. *Jurnal Pendidikan IPA Indonesia*, *13*(3).
Wongsila, S., & Yuenyong, C. (2019). Enhancing grade 12 students' critical thinking and problem-solving ability in learning of the STS genetics and DNA technology unit. *Journal for the Education of Gifted Young Scientists*, *7*(2), 215–235.
Zuza, K., Portillo-Blanco, A., Iturbe-Zabalo, E., Gutierrez-Berraondo, J., Sirmakessis, S., Trombetti, L., Zoncheddu, S., & Barelli, L. (2024). PBL Application to STEAM Education Incorporating Sustainability and Gender Equality Axes: STEAM-ACTIVE Project Implementation in University and High School. *Conference Proceedings. New Perspectives in Science Education 2024*.