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Experiential STEM education as a pathway to enhancing problem-solving skills in primary schools

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***Abstract*---**Experiential STEM education has become an important educational approach for developing problem-solving skills and learner competencies in primary education. This study examined the role of experiential STEM activities in enhancing problem-solving skills among primary school students in Vietnam. The research employed a mixed-methods approach combining classroom observation, semi-structured interviews, and a survey involving 115 primary school teachers in Hanoi. The findings indicate that experiential STEM education positively influences students' creativity, critical thinking, collaboration, and learning engagement. Teachers reported that interdisciplinary STEM activities created more active and learner-centered classroom environments in which students could apply knowledge to practical situations and participate directly in problem-solving processes. The study also identified several challenges affecting STEM implementation, including limited teacher training, insufficient instructional resources, and large class sizes. The findings suggest the importance of strengthening teacher professional development and institutional support in order to improve the effectiveness of experiential STEM education in Vietnamese primary schools.

***Keywords*---**STEM education, experiential learning, problem-solving skills, primary education, interdisciplinary learning, educational innovation.

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1. Introduction

The rapid development of science and technology in the twenty-first century has created significant changes in educational goals and teaching approaches worldwide. Modern education increasingly emphasizes the development of learners' competencies rather than the simple transmission of knowledge. Among the competencies considered essential for students in contemporary society, problem-solving skills play a particularly important role because they help learners analyze situations, think critically, make decisions, and apply knowledge to practical contexts. In primary education, developing problem-solving skills is especially necessary because this stage forms the foundation for students' future learning and cognitive development.

In recent years, STEM education has become an important trend in educational innovation because it integrates science, technology, engineering, and mathematics into interdisciplinary learning experiences. Unlike traditional subject-based instruction, STEM education encourages students to apply knowledge from different disciplines to solve real-world problems through exploration, experimentation, and collaborative learning activities. According to Sheth and Pathak (2023), STEM education promotes integrated and interdisciplinary learning that supports creativity, analytical thinking, and active student participation. Through STEM-oriented learning, students are provided with opportunities to connect theoretical knowledge with authentic situations and practical problem-solving tasks.

Experiential learning is another important characteristic of STEM education. Instead of receiving information passively, students participate directly in designing models, conducting experiments, building products, and solving practical challenges. Such learning experiences encourage curiosity, creativity, and independent thinking among learners. Güven and Alpaslan (2022) found that interdisciplinary STEM activities positively affect students' creative problem-solving abilities and twenty-first-century skills. Similarly, Topsakal et al. (2022) reported that problem-based STEM education contributes significantly to students' critical thinking tendencies and perceptions of problem-solving competence. These findings suggest that experiential STEM learning can create effective conditions for developing higher-order thinking skills in primary education.

In Vietnam, STEM education has received increasing attention as part of educational reform and competency-based curriculum implementation. Vietnamese schools are gradually integrating STEM-oriented activities into teaching practices in order to improve students' creativity, collaboration, and practical learning abilities. Chen et al. (2021) emphasized that STEM education in Vietnam is closely connected to human resource development and the preparation of future learners for science and technology-related careers. In addition, Linh et al. (2019) highlighted that STEM-oriented educational programs support the development of students' critical thinking and active learning capacities within Vietnamese educational contexts.

Despite these positive developments, the implementation of experiential STEM education in Vietnamese primary schools still faces several challenges. Many teachers have limited experience in interdisciplinary instructional design and STEM-based teaching methods. In addition, schools may encounter difficulties related to learning materials, technological resources, and classroom organization for experiential activities. Traditional teaching approaches that emphasize memorization and examination performance also continue to influence instructional practices in some educational settings. These challenges indicate the need for further investigation into the educational value and implementation of experiential STEM learning in primary education.

2. Literature Review

2.1. STEM Education and Interdisciplinary Learning

STEM education has become one of the most influential educational approaches in contemporary teaching and learning because it integrates science, technology, engineering, and mathematics into meaningful and practical learning experiences. Unlike traditional subject-separated instruction, STEM education encourages students to apply interdisciplinary knowledge to solve authentic problems and participate actively in inquiry-based learning activities. Sheth and Pathak (2023) emphasized that STEM education is fundamentally interdisciplinary because it combines different academic fields to create integrated and collaborative learning experiences.

Research has shown that interdisciplinary STEM learning contributes positively to students' academic achievement, creativity, and higher-order thinking skills. Through STEM activities, students are encouraged to investigate problems, design solutions, test ideas, and reflect on learning outcomes. Such processes support active learning and help students connect theoretical knowledge with real-life situations. Lansiquot et al. (2011) also argued that interdisciplinary problem-solving approaches contribute to STEM success by encouraging collaboration, communication, and practical application of knowledge across disciplines.

Experiential learning is considered a key characteristic of STEM education. Students learn more effectively when they participate directly in hands-on activities, experiments, engineering design projects, and collaborative learning tasks. STEM-oriented experiential learning environments therefore promote learner engagement, curiosity, and independent thinking. These educational experiences help students become more confident in exploring ideas and solving unfamiliar problems in flexible ways.

In primary education, interdisciplinary STEM learning is particularly important because young learners often understand concepts more effectively through practical experiences and integrated activities. STEM activities such as model construction, scientific exploration, coding games, and engineering challenges provide opportunities for primary students to interact actively with knowledge rather than passively receive information. Consequently, STEM education is increasingly viewed as an effective strategy for improving educational quality and promoting competency-based learning in primary schools.

2.2. Problem-Solving Skills in Primary Education

Problem-solving skills are widely recognized as essential competencies for students in the twenty-first century. These skills involve the ability to identify problems, analyze information, generate possible solutions, evaluate alternatives, and apply appropriate strategies to resolve challenges effectively. In educational contexts, problem-solving competence supports not only academic learning but also creativity, adaptability, and decision-making abilities.

Research indicates that primary school is an important stage for developing problem-solving skills because children begin to form logical thinking patterns and independent learning habits during this period. Educational activities that encourage exploration, questioning, experimentation, and collaboration help students strengthen analytical thinking and develop confidence in solving practical problems. According to Amalina and Vidákovich (2022), STEM-based problem-solving assessment has become increasingly important because it measures students' ability to apply interdisciplinary knowledge in authentic contexts rather than simply recalling information.

Several studies have demonstrated the relationship between active learning approaches and problem-solving skill development. McCrum (2017) found that interdisciplinary problem-based learning contributes positively to students' creative problem-solving abilities by encouraging critical thinking, experimentation, and collaborative learning processes. Similarly, Topsakal et al. (2022) reported that problem-based STEM education improves students' perceptions of their own problem-solving competence and supports the development of critical thinking tendencies. These findings suggest that student-centered instructional methods are highly effective for strengthening problem-solving skills.

Problem-solving competence is also closely connected to collaborative learning and communication abilities. In STEM learning environments, students frequently work in groups to discuss ideas, design solutions, and complete interdisciplinary projects. Such collaborative activities help learners develop communication skills, teamwork, and flexibility in addressing challenges. Lin et al. (2015) emphasized that collaborative problem-solving assessment systems in STEM education provide opportunities to evaluate students' interaction, reasoning, and joint decision-making processes during learning activities.

2.3. Experiential STEM Education and Skill Development

Experiential STEM education refers to learning approaches in which students acquire knowledge and skills through direct participation in practical and interdisciplinary activities. Instead of relying solely on textbook-based instruction, experiential STEM learning encourages students to investigate real-world problems, design products, conduct experiments, and apply scientific and mathematical concepts in authentic situations.

The reviewed studies indicate that experiential STEM activities contribute significantly to the development of creativity, innovation, and problem-solving skills. Güven and Alpaslan (2022) found that interdisciplinary science activities positively influence students' creative problem-solving abilities and twenty-first-

century skills. Similarly, Bicer et al. (2017) reported that informal STEM learning activities combined with 3D printing technologies support creativity and problem-solving development among learners. These findings suggest that practical and experiential learning environments create favorable conditions for higher-order thinking and innovation.

Experiential STEM education also supports learner motivation and engagement. Students participating in hands-on STEM activities often demonstrate greater curiosity, active participation, and interest in learning because they can directly observe the practical relevance of knowledge. Such learning experiences encourage students to become active problem-solvers rather than passive recipients of information. As a result, experiential STEM education is increasingly considered an effective strategy for improving both learning outcomes and learner competence development.

In addition, experiential STEM learning contributes to the development of twenty-first-century competencies such as communication, collaboration, adaptability, and digital literacy. Students involved in STEM projects frequently work in teams, use technological tools, and present solutions to authentic challenges. These experiences strengthen both academic and social competencies that are important for future learning and professional development.

2.4. STEM Education and Educational Innovation in Vietnam

In Vietnam, STEM education has gradually become an important component of educational reform and competency-based curriculum development. Vietnamese educational policies increasingly encourage schools to integrate interdisciplinary and experiential learning activities into teaching practices in order to improve students' creativity, critical thinking, and practical learning abilities. STEM education is therefore viewed as an important strategy for preparing learners for the demands of the digital economy and modern labor markets.

Chen et al. (2021) emphasized that STEM education in Vietnam contributes not only to science and technology learning but also to career orientation and human resource development. STEM-oriented activities provide students with opportunities to explore scientific inquiry, engineering design, and technological applications from an early age. Similarly, Linh et al. (2019) found that STEM educational orientation programs positively influence Vietnamese students' critical thinking development and active learning engagement.

Despite these positive developments, several challenges continue to affect STEM implementation in Vietnamese primary schools. Many teachers still have limited experience in interdisciplinary instructional design and experiential STEM teaching methods. In addition, schools may encounter difficulties related to educational materials, technological infrastructure, and classroom organization for STEM activities. Traditional teaching approaches emphasizing memorization and examination performance also continue to influence instructional practices in some educational settings.

Another important challenge concerns teacher professional development. Effective STEM education requires teachers to possess interdisciplinary knowledge,

collaborative instructional skills, and the ability to organize experiential learning environments. However, many primary school teachers have not received sufficient training in STEM pedagogy or project-based instructional design. These conditions highlight the importance of strengthening teacher training programs and institutional support for STEM implementation in Vietnamese primary education.

3. Methodology

This study was conducted using a mixed-methods research approach to investigate the role of experiential STEM education in enhancing problem-solving skills among primary school students. The research combined qualitative observation with quantitative survey methods in order to obtain a comprehensive understanding of STEM teaching practices and their educational impacts in primary schools in Hanoi, Vietnam.

The study was implemented through several stages. First, classroom observations and experiential investigations were conducted in primary schools where STEM-oriented learning activities had been integrated into teaching practices. The researchers observed how teachers organized interdisciplinary STEM activities, guided students in solving practical problems, and encouraged collaboration, creativity, and experiential learning during classroom instruction. Particular attention was given to students' participation, interaction, analytical thinking, and problem-solving behaviors throughout STEM learning activities.

Following the observation stage, a survey was conducted with 115 primary school teachers from schools in Hanoi. The participants included teachers who had experience implementing STEM-related educational activities in primary education. The survey focused on teachers' perceptions of experiential STEM education, the development of students' problem-solving skills, instructional effectiveness, and challenges encountered during STEM implementation.

The collected data were analyzed using both qualitative and quantitative methods. Observational data were examined through thematic content analysis to identify recurring educational practices and instructional patterns related to experiential STEM learning. Quantitative survey data were summarized using descriptive statistical analysis in order to evaluate teachers' perceptions and experiences concerning STEM-oriented teaching and problem-solving skill development among students.

4. Findings

4.1. Quantitative Findings

The quantitative data were collected from a survey involving 115 primary school teachers in Hanoi who had experience implementing experiential STEM activities in teaching practices. The survey focused on teachers' perceptions of the effectiveness of STEM education in developing students' problem-solving skills, improving learning engagement, and supporting interdisciplinary learning in primary education.

Table 1. Teachers' Perceptions of the Effectiveness of Experiential STEM Education in Developing Problem-Solving Skills

Evaluation Criteria	**Very High (%)**	**High (%)**	**Moderate (%)**	**Low (%)**	**Mean Score**
Enhancing students' problem-solving skills	48.7	39.1	10.4	1.8	4.35
Promoting critical thinking	45.2	41.7	11.3	1.8	4.30
Increasing creativity in learning activities	52.2	34.8	11.3	1.7	4.38
Encouraging collaboration among students	49.6	37.4	10.4	2.6	4.34
Improving student engagement and motivation	56.5	31.3	9.6	2.6	4.42
Supporting interdisciplinary learning	44.3	40.0	13.0	2.7	4.26

The findings in Table 1 indicate that most teachers evaluated experiential STEM education positively in relation to students' competency development. The criterion receiving the highest mean score was "Improving student engagement and motivation" (M = 4.42), with 56.5% of teachers selecting the "Very High" level. Teachers reported that STEM activities created more dynamic classroom environments and encouraged students to participate actively in learning processes.

Similarly, "Increasing creativity in learning activities" received a high evaluation (M = 4.38), suggesting that interdisciplinary STEM projects helped students generate ideas, explore alternative solutions, and apply knowledge creatively in practical situations. The criterion "Enhancing students' problem-solving skills" also achieved a high mean score (M = 4.35), confirming teachers' perceptions that STEM-oriented experiential learning contributes significantly to analytical thinking and problem-solving competence among primary school students.

The survey results further demonstrate that experiential STEM education positively supports collaboration and interdisciplinary learning. More than 87% of teachers evaluated STEM activities as highly effective in encouraging teamwork and communication among students. Teachers explained that group-based STEM projects allowed students to exchange ideas, divide responsibilities, and cooperate in solving practical tasks.

Table 2. Teachers' Evaluation of Students' Problem-Solving Behaviors during STEM Activities

Problem-Solving Behaviors	**Frequently (%)**	**Occasionally (%)**	**Rarely (%)**	**Mean Score**
Identifying problems independently	62.6	31.3	6.1	4.21
Proposing multiple solutions	58.3	35.7	6.0	4.15

Applying interdisciplinary knowledge	60.0	33.0	7.0	4.18
Collaborating with peers to solve problems	71.3	24.3	4.4	4.43
Presenting and explaining solutions	55.7	36.5	7.8	4.09
Evaluating and adjusting solutions	49.6	40.9	9.5	3.98

The data in Table 2 reveal that students demonstrated positive problem-solving behaviors during experiential STEM activities. The highest mean score was recorded for "Collaborating with peers to solve problems" (M = 4.43), indicating that STEM learning environments strongly support teamwork and cooperative learning. Teachers observed that students became more willing to discuss ideas, share responsibilities, and support one another in completing STEM projects.

In addition, a large proportion of teachers reported that students frequently identified problems independently and applied interdisciplinary knowledge in learning tasks. These findings suggest that STEM education provides opportunities for students to connect scientific, mathematical, and technological knowledge when solving practical problems. However, the criterion "Evaluating and adjusting solutions" received a slightly lower mean score (M = 3.98), indicating that some students still experienced difficulties reflecting critically on their solutions and improving their approaches after completing activities.

Table 3. Challenges in Implementing Experiential STEM Education in Primary Schools

Challenges	**Agree (%)**	**Neutral (%)**	**Disagree (%)**	**Mean Score**
Lack of STEM teaching materials and equipment	69.6	20.0	10.4	4.12
Limited teacher training in STEM education	73.9	16.5	9.6	4.24
Difficulties in interdisciplinary lesson design	65.2	24.3	10.5	4.05
Limited instructional time	71.3	18.3	10.4	4.18
Large class sizes affecting STEM activities	68.7	19.1	12.2	4.10

The survey results show that teachers faced several challenges when implementing experiential STEM education. The most significant challenge was limited teacher training in STEM education (M = 4.24), with 73.9% of teachers agreeing that they needed more professional support and instructional guidance related to STEM pedagogy. Teachers also emphasized difficulties related to limited instructional time and lack of STEM learning materials.

Large class sizes and interdisciplinary lesson planning were additional barriers affecting STEM implementation in primary schools. Many teachers explained that organizing collaborative and experiential activities in crowded classrooms required extensive preparation and classroom management skills. These findings indicate the importance of strengthening teacher professional development and institutional support for STEM education in Vietnamese primary schools.

4.2. Qualitative Findings

The qualitative findings were collected through classroom observations and semi-structured interviews with 18 primary school teachers participating in experiential STEM teaching activities in Hanoi. The observations focused on students' participation, collaboration, and problem-solving behaviors during STEM lessons, while the interviews explored teachers' experiences and perceptions regarding STEM implementation in primary education.

The observations revealed that students were more active and engaged during experiential STEM activities compared with traditional lessons. Students participated enthusiastically in group discussions, experiments, model construction, and practical problem-solving tasks. Many teachers noted that STEM activities increased students' curiosity, creativity, and willingness to cooperate with peers. One teacher shared:

"Students become more confident and excited during STEM lessons because they can directly create products and test their own ideas." (Teacher 05)

Teachers also reported that experiential STEM learning helped students improve communication and collaborative problem-solving skills. During interdisciplinary projects, students discussed ideas, divided responsibilities, and worked together to complete learning tasks. Observational data further showed that students were able to apply knowledge from mathematics, science, and technology in practical situations more effectively through STEM activities.

In addition, teachers emphasized that STEM-oriented instruction encouraged more flexible and learner-centered teaching approaches. Several participants explained that STEM activities helped students understand lessons more deeply because learning was connected to real-life experiences rather than memorization-based instruction.

However, the interviews also revealed several implementation difficulties. Teachers reported challenges related to limited STEM teaching materials, insufficient professional training, and large class sizes. Some teachers expressed uncertainty regarding interdisciplinary lesson design and assessment of students' problem-solving performance during STEM activities. One participant stated:

"Organizing STEM lessons requires considerable preparation time and classroom management skills, especially in classes with many students." (Teacher 12)

Overall, the qualitative findings indicate that experiential STEM education contributes positively to students' engagement, creativity, collaboration, and problem-solving development. At the same time, the findings highlight the need for greater teacher training and institutional support to improve the effectiveness of STEM education in Vietnamese primary schools.

5. Discussion

The findings of this study demonstrate that experiential STEM education plays an important role in enhancing problem-solving skills among primary school students in Vietnam. Both quantitative and qualitative results indicate that STEM-oriented learning activities positively influence students' creativity, collaboration, critical thinking, and active participation in classroom learning. These findings are consistent with previous international studies emphasizing that interdisciplinary STEM education creates favorable conditions for developing higher-order thinking skills and learner-centered educational practices.

In the Vietnamese educational context, the positive impact of experiential STEM learning is closely connected to the current implementation of the 2018 General Education Curriculum, which emphasizes competency-based education and practical learning experiences. Vietnamese primary schools are gradually shifting from knowledge-transmission approaches toward teaching methods that encourage exploration, creativity, and application of knowledge in real-life situations. The findings suggest that experiential STEM activities support this transition effectively by allowing students to participate directly in interdisciplinary problem-solving tasks and collaborative learning processes.

Another important issue emerging from the findings concerns students' engagement and motivation. The survey results showed that "Improving student engagement and motivation" achieved the highest mean score among the evaluated criteria. This reflects an important reality in Vietnamese primary education, where traditional teaching methods focusing heavily on memorization and textbook-based instruction may reduce students' opportunities for active participation. Experiential STEM activities provide more flexible and interactive learning environments in which students can experiment, discuss ideas, and solve practical problems collaboratively.

The findings also highlight the growing importance of collaboration and communication skills in Vietnamese primary education. Teachers observed that STEM projects encouraged students to exchange ideas, divide responsibilities, and work together to complete interdisciplinary tasks. Such learning experiences are particularly valuable because Vietnamese educational reform increasingly emphasizes the development of twenty-first-century competencies, including teamwork, creativity, and critical thinking.

However, the study also reveals several challenges affecting STEM implementation in Vietnamese primary schools. One of the most significant difficulties concerns limited teacher training in STEM pedagogy and interdisciplinary instructional design. Many teachers reported uncertainty regarding how to organize experiential STEM activities effectively and assess students' problem-solving performance. This finding reflects a broader issue in Vietnam, where STEM education is still relatively new in many schools, especially at the primary level.

In addition, limited instructional time, insufficient STEM learning materials, and large class sizes continue to affect the effectiveness of experiential STEM teaching. In many Vietnamese public primary schools, classrooms often contain more than

40 students, making it difficult for teachers to manage collaborative and hands-on learning activities effectively. Financial limitations and unequal access to technological resources between schools may also reduce opportunities for implementing high-quality STEM learning experiences.

6. Conclusion

This study confirms that experiential STEM education provides meaningful opportunities for developing problem-solving skills among primary school students. Through interdisciplinary and hands-on learning activities, students are encouraged to explore ideas, collaborate with peers, and apply knowledge in authentic situations. The findings indicate that experiential STEM learning not only supports cognitive development but also contributes to students' creativity, communication abilities, and learning confidence.

The study also shows that teachers play a central role in organizing effective STEM learning environments. Successful STEM implementation requires teachers to possess interdisciplinary instructional competence, classroom management skills, and the ability to design experiential learning activities appropriate for primary students. In addition, supportive school environments and sufficient educational resources are important conditions for maintaining the quality of STEM-oriented teaching practices.

In the context of educational reform in Vietnam, experiential STEM education can contribute positively to the transition toward competency-based learning and learner-centered instruction in primary schools. However, improving the effectiveness of STEM implementation requires long-term investment in teacher training, instructional materials, and professional support systems. Future studies may further examine STEM learning outcomes among students in different educational contexts and explore innovative models for integrating experiential STEM education into primary school curricula.

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