

Research Article

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Developing Opportunity-Expanding Schools' (OES) STEM Education in Thailand

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Abstract

Background/purpose: This study is an experimental research project aimed at exploring and enhancing the implementation of integrated STEM (Science, Technology, Engineering, and Mathematics) education in opportunity-expanding schools (OES), which are defined here as schools serving economically and socially disadvantaged communities to provide equitable access to quality education. The research focuses on three main objectives: 1) to investigate the challenges and needs associated with organizing integrated STEM education in these schools, 2) to evaluate the effectiveness of integrated STEM learning activities delivered through academic services, with a target efficiency rate of 75%, and 3) to assess the satisfaction levels of stakeholders with the implementation of these integrated STEM learning activities.

Materials/methods: The sample group used in the research was 98 individuals, selected through purposive sampling. The research instruments consisted of 1) a set of 10 integrated STEM education learning activities, 2) a questionnaire on the problems and needs in organizing integrated STEM education learning in the opportunity expansion schools, 3) a problem-solving skill assessment form, and 4) a satisfaction assessment form.

Results: The research found that the important OES problems in organizing integrated STEM education learning are: 1) teachers' understanding and readiness in organizing integrated STEM education learning, 2) resources and equipment, and 3) policy support. Additionally, a clear advantage of the activities was that participants achieved a high level of engagement and interest (4.7), content accessibility (4.6), content understanding (4.5), and activity participation (4.5).

Conclusion: The results of evaluating the integrated STEM education learning activity set can develop students' problem-solving skills (PSS) in 4 components: 1) problem identification, 2) finding alternatives, 3) problem-solving planning, and 4) decision-making and implementation. The mean was 81.67%, higher than the 75% criterion. The satisfaction assessment results for the integrated STEM learning activities were at the highest level (4.6).

1. Introduction

Education is an essential element in a nation's human resource development. However, education in Thailand still faces many obstacles affecting educational quality and inequality, which must be systematically analyzed and solved. Educational inequality can reflect the disparity of access, which is unequal to the general population's access (Billon et al., 2021). Educational inequality in Thailand reflects disparities in access to education, particularly in rural areas and among low-income groups (Chairassamee et al., 2024). Additionally, there are gaps in laws and regulations concerning education for persons with disabilities, which results in inequality of educational opportunity. This is consistent with Shaeffer (2018), who reported that children from disadvantaged groups can still not access equity education. Therefore, ways must be found to find resources for these groups while simultaneously developing policies to address these issues. Developing these skills is essential to prepare students for real-life challenges and the rapidly changing demands of the modern workforce.

Improving the quality of Thai education in the digital era has also become a critical priority across all levels of education (Muangchan et al., 2024). Numerous papers and studies have noted the importance of this process and detailed multiple methods to achieve it, especially its use during the massive disruption during the COVID pandemic, under which online education was mandated (Aroonsrimarakot et al., 2023).

Mostly implemented using smartphones through Internet connections and some version of a learning management system (LMS) (Veluvali & Suriseti, 2022; Wannapiroon & Pimdee, 2022), the online 'digital age' became a matter of educational necessity and national survival in Thailand's many other nations and economies. Simultaneously, educators were expected to develop new forms of curricula and teaching methods, usually with little to no training in how to do so (Boonmoh et al., 2022; Boonmoh & Sanmuang, 2024). They were also expected to do this development on their own time and at their own expense. Expectations were high, but unfortunately, results were far less than expected in too many instances, leading many stakeholders, including the students, to question the methods used and the time it took.

Additionally, the farther the student moved from the traditional (bricks and mortar) classrooms; it seemed the problems increased. These problems included the limited and sometimes costly price of the Internet connection, its limited bandwidth and slowness, device age and cost (usually a smartphone or tablet), and thus speed and processing limitations (Aroonsrimarakot et al., 2023; Özüdoğru, 2021). Students also complained about excessive online classroom time and physical limitations in attending these classes. Finally, many felt distanced or isolated in their online course experience (Imsa-ard, 2020).

The problems and their hurdles were no less daunting for teachers and administrators. Teachers often complained about their lack of training in digital classroom development. They were also expected to come up to speed on newer pedagogies and techniques like problem-based learning (PBL), flipped classrooms (DeLozier & Rhodes, 2017; Wannapiroon & Petsangsri, 2020), blended learning (Banyen et al., 2016) and their use in enhancing student problem-solving skills (PSS) (Kantathanawat et al., 2025), analytical thinking skills (ATS) and critical thinking skills (CTS). These processes became entrenched in national policy plans and directives to make matters even more crucial.

Moreover, integrating Science, Technology, Engineering, and Mathematics (STEM) education into these online and classroom educational pedagogies has also become a national imperative, focusing on improving PSS, ATS, and CTS. These imperatives are further supported by studies from authors such as Hebebcı and Usta (2022), who have reported that STEM education positively affects learner problem-solving, scientific creativity, and CTS. Darling-Hammond et al. (2020) have also reported that student development of *higher-order thinking skills* (HOTS) is best achieved by

investigation and inquiry, applying knowledge to new situations and problems, idea and solution production, and collaborative problem-solving. However, implementing integrated STEM education faces many challenges (Khan, 2023; Suhirman & Prayogi, 2023), including resource limitations, limited professional development opportunities (Dare et al., 2021), and overcoming traditional teaching methods (e.g., chalk and talk) (Kanawapee et al., 2021).

It has been shown in previous studies that integrated STEM education improves students' problem-solving skills (PSS) (Dewi et al., 2023; Griffiths et al., 2021). Previous research also highlights that integrated STEM education can improve learner-collaborative PSS and that positive benefits exist across diverse students, including students from different age ranges and socio-economically disadvantaged backgrounds. Despite these benefits, opportunity-expanding schools (OES) face significant barriers to successfully implementing integrated STEM education.

A primary challenge is a lack of resources and teaching knowledge for effective implementation (Sangnapaboworn, 2018; Yangkeaw & Siputta, 2023). Most OES lack appropriate funding, materials, and specialized staff to lead STEM initiatives. Moreover, many teachers working in OES already complain that they have excessive workloads as schools require teachers to teach multiple subjects. This leaves teachers little time to integrate their knowledge across disciplines, an important constituent of STEM education (Margot & Kettler, 2019).

It also has to be acknowledged that although active learning pedagogies in STEM education have been documented to improve students' ATS and CTS, schools that extend learning opportunities for socially and educationally disadvantaged learners are often struggling to implement them. To harness the potential of integrated STEM education for all, barriers, such as resources, professional development of teachers, or their workload, need to be overcome in these schools.

These issues are supported by a recent study from Jarupunphol et al. (2025) who report how the economic segregation of schools in Thailand seriously affects the educational performances of students in OES. Furthermore, these schools face persistent challenges in resource allocation and teacher training, reinforcing the need for tailored academic support. Integrating STEM education with PBL can bridge this gap by fostering essential 21st-century skills such as analytical reasoning, problem-solving, and collaboration (Metpattarahiran, 2021; Srirakul, 2018). This research provides an asset by providing a data-driven STEM approach and implementation through an integrated academic service in an OES.

A recent article by Mendez (2023) highlights that integrating PSS in STEM education through team-based learning greatly strengthens the adaptability and student involvement of the underprivileged school, illustrating a way of enriching OES with approaches where students develop skills needed in the 21st century. The evident socioeconomic disparity in the Thai education system (Jarupunphol et al., 2025) also indicates the desperate need for STEM-based integration into students' lives. These previous studies used data-driven approaches, which emphasize the importance of equally targeted educational policies, strong teacher training, and proper resource support in overcoming challenges faced by schools lacking resources.

However, most studies indicate that interdisciplinary, collaborative approaches are crucial to a positive STEM outcome in underprivileged schools. Furthermore, using various networks between schools and organizations from different sectors is essential (Eugenijus, 2023). Bridging various schools and organizations compensates for the lack of poor infrastructure and teacher training in opportunity-expanding schools (Pimdeet et al., 2023). As these schools face persistent challenges in resource allocation and teacher training and the need for reinforcing the need for tailored academic support, integrating STEM education with PBL can bridge this gap by fostering essential 21st-century skills such as analytical reasoning, problem-solving, and collaboration (Metpattarahiran, 2021;

Sritrakul, 2018). This research underscores the urgency of implementing data-driven strategies and integrated academic services to enhance STEM learning in OES settings.

Recent research from Mendez (2023) suggests integrating PSS into STEM education through team-based learning significantly enhances adaptability and student engagement in underprivileged schools. This aligns with efforts to equip OES with strategies for 21st-century skill development. Socioeconomic disparities in Thai education (Jarupunphol et al., 2025) demonstrate the urgent need for STEM-based interventions. Studies using data-driven approaches emphasize targeted educational policies, improved teacher training, and resource support as crucial factors in overcoming the challenges faced by OES. Interdisciplinary, collaborative approaches are key to STEM success in disadvantaged schools (Eugenijus, 2023). Establishing networks between schools and external organizations helps compensate for inadequate infrastructure and teacher training in OES settings (Pimdeet et al., 2023).

Obstacles in Thai education include budgets, centralized management of teachers and educational personnel, and policies and curricula. Additionally, educators and administrators must be digitally enabled and prepare for technological changes. PSS is a primary focus in today's educational environment as it is considered a prerequisite in 21st-century education. This is especially true for educators in opportunity-expanding schools (Grusky et al., 2019), where educating students from economically disadvantaged areas in 21st-century skills such as PSS is seen as meeting real-world challenges of modern work (Nakornthap, 2018).

Integrated academic services are crucial in addressing OES challenges and obstacles in implementing effective STEM education. These challenges stem from limited educational resources, insufficient teacher training, and a lack of collaboration between schools and external organizations (García-Martínez et al., 2021). To overcome these barriers, it is essential to establish collaborative professional networks, facilitate teacher training workshops, and provide support for essential learning resources.

One practical approach to enhancing students' PSS is through contextualized learning activities designed around local issues and incorporating appropriate technological tools. By grounding STEM education in real-world applications, students can develop essential 21st-century skills and bridge the gap between theoretical knowledge and practical problem-solving (Jarupunphol et al., 2025).

Given the importance of integrated academic services in fostering STEM education, this research aims to develop effective learning management strategies that enhance students' PSS in OES. Specifically, this study focuses on the following objectives:

1. Identifying the challenges and requirements for implementing integrated STEM education in OES, considering teacher preparedness, student engagement, and available resources.
2. Assessing the effectiveness of integrated STEM learning activities ensures that at least 75% of students improve their PSS.
3. Evaluating student satisfaction with STEM learning activities delivered through academic services to determine their impact on engagement and motivation.

By addressing these objectives, this research contributes to developing structured, sustainable strategies for implementing STEM education in OES, ensuring that students in disadvantaged settings receive quality learning experiences that prepare them for future challenges.

2. Methodology

The researchers conducted experimental research and analyzed quantitative data. Data were collected using a questionnaire to survey the problems and needs, a satisfaction assessment form,

and an examination of the results that occurred with students after participating in the activities using 75% criteria.

2.1. Population and Sample

The population and sample used in this research were collected from eight teachers and students in primary and secondary schools, divided into 61 primary and 29 secondary students, totaling 98 individuals. The sample was selected by purposive sampling because they wanted to receive academic services.

2.2. Experimental Design

This study employed an experimental research design to evaluate the effectiveness of integrated STEM education activities in enhancing students' problem-solving skills (PSS) and satisfaction levels. The experiment involved 98 participants, comprising 61 primary and 29 secondary school students, selected from Opportunity-Expanding Schools (OES) in Nakhon Si Thammarat, Thailand.

The study did not include a control group because the primary objective was to compare students' performance against a predefined benchmark of 75% rather than comparing outcomes between experimental and control groups. This approach was chosen to align with the study's focus on assessing whether the integrated STEM activities met the minimum performance threshold required for educational effectiveness.

The experiment was conducted over a total duration of 6 hours, divided into multiple activities tailored to the grade levels of the participants. For secondary school students, the activities included:

1. Take Me Home (1.5 hours),
2. Coding Game: Rabbit Game (1.5 hours),
3. Balloon-Powered Car (1.5 hours), and
4. Microbit-Controlled Car (1.5 hours).

For primary school students, the activities included:

1. Find Your Way (1 hour),
2. Blindfolded Drum Game (1 hour),
3. Egg Tapping Game (1 hour),
4. Fun with Sequences (1 hour),
5. Algorithms and Flowcharts (1 hour), and
6. Scratch Bingo Game (1 hour).

Each activity was designed to foster problem-solving skills through hands-on, collaborative learning experiences. After completing each activity, students' problem-solving abilities were assessed using a standardized rubric, and their satisfaction levels were measured through post-activity surveys.

2.3. Research Instrument

The research instruments used were: 1) A set of 10 integrated STEM learning activities, 2) A questionnaire on the problems and needs in organizing integrated STEM learning at extended opportunity schools, 3) A PSS assessment form, and 4) A satisfaction assessment form.

2.3.1. Integrated STEM Learning Activity Sets

The researchers developed a set of learning activities that focused on integrating STEM concepts, which were designed to be consistent for OES schools. This set of activities focused on training PSS in real situations. The activity sets were divided into 10 sub-activities, including six activities for primary school students and four for lower secondary school students. Figure 1 details the ten STEM-related activities designed for elementary and lower-secondary school students. Each activity was crafted to promote learning through play, creativity, and collaboration. The activities range from games enhancing social skills to projects introducing basic coding and engineering concepts. These activities foster learning and encourage creativity, teamwork, and critical thinking among learners. Each activity is designed to be engaging and educational, making learning a fun experience.

Elementary Level Activities EL Activity 1: Your way-my way Game Description: A fun game where learners pair up and take turns giving directions to each other to navigate an obstacle course. 	Lower-Secondary School Activities LSS Activity 1: Take Me Home Game Description: A strategic game where learners must navigate a maze to find their way home, enhancing PSS. 
EL Activity 2: Blind-folded Bucket Hitting Game Description: Learners are blindfolded and must hit a bucket, relying on their teammates' verbal cues. 	LSS Activity 2: Rabbit Coding Game Description: An interactive coding game where learners program a rabbit to complete various challenges, introducing them to basic coding concepts. 

EL Activity 3: Go Break Some Eggs/Pok Pok Egg Cracking Game

Description: A playful activity where learners try to crack eggs using various methods while learning about force and motion.



LSS Activity 3: Balloon Powered Car

Description: Learners design and build a car powered by a balloon, learning about physics and engineering principles.



EL Activity 4: Fun Steps

Description: A movement-based activity where learners follow fun steps to improve coordination and teamwork.

EL Activity 5: Algorithm and Flowchart EL Sequence



Description: Learners learn algorithms' basics by creating flowcharts representing simple tasks or games.

EL Activity 6: Bingo/Scratch Game



Description: A bingo game where learners scratch off items while learning new vocabulary or concepts.

LSS Activity 4: Micro: bit Remote Control Car

Description: Using a Micro: bit, learners create a remote-controlled car, integrating technology with hands-on learning.



Figure 1. STEM learning activities

There were four steps used in creating and checking the quality of the STEM education integrated learning activity tool set:

Step 1: Planning

The researcher studied literature related to the STEM education concept and academic service studies to understand the principles and methods of designing activities appropriate for the context of the opportunity expansion school. The objectives of each activity were clearly defined, focusing on developing problem-solving thinking skills.

Step 2: Analyze and Design Activities

The researchers designed the content and sequence of activities to cover and relate to real-life situations that students encounter daily. Participation in the activity was divided into sub-steps to provide a variety of situations.

Step 3: Activity Appropriateness

Activity appropriateness was validated from a simulation class using 52 first-year students from the Faculty of Education's Computer Science program.

Step 4: Activity Improvement

Improve the activities and visit the field to test the activities with sample students.

2.3.2. OES STEM Questionnaire

The researchers used a questionnaire to collect data on the problems and needs of STEM education management from teachers and students in the OES about the obstacles and challenges the school faced using the STEM education concept to integrate learning management in the classroom. The steps in creating and checking the quality of the tools were as follows:

Step 1: Activity Improvement

Improve the activities and visit the field to test the activities with sample students.

Step 2: Objective Identification

Set the objectives. Identify the objectives of the questionnaire.

Step 3: Item Design

Prepare questions according to the research objectives using closed-ended and open-ended questions.

Step 4: Content Validity Check

The researchers took the questionnaire to three experts to check the content validity (IOC). Their assessment returned an IOC=0.8.

Step 5: Reliability Testing

Take the questionnaire to test with a non-sample experiment to assess its reliability using Cronbach's Alpha statistical formula. Before the questionnaire is used, the test results must have a reliability of 0.7 or more.

Step 5: Questionnaire Item Refinement

Based on input from the experts' input and the pilot test, items were reviewed and edited for clarity and accuracy.

2.3.3. PSS Assessments

There were three steps in creating and checking the quality of the tool. They are:

Step 1: PSS Identification

Identification of PSS revealed four aspects. These were: 1) problem identification, 2) thinking of alternatives, 3) problem-solving planning, and 4) decision-making and implementation.

Step 2: PSS Assessment

Create a problem-solving skill assessment list as a Rubric score with three scores from 1 to 3 respectively. Each score has the following meanings: 3 = High ability, 2 = Moderate ability 1 = Low ability.

Step 3: Content Validity Check

Check the content validity by having three experts check the PSS assessment form to assess the appropriateness and validity of the content by calculating the content validity index (IOC) and adjusting according to the recommendations.

2.3.4. Satisfaction Assessment Form (SAF)

There were three steps in creating and checking the SAF. They are:

Step 1: SAF Aspects

A participant satisfaction evaluation form was developed. It measured four aspects. These were 1) access to content, 2) understanding of content, 3) stimulating interest, and 4) activity participation.

Step 2: Item Design

The design of the items in the SAF used a five-level Likert-type scale to allow respondents to indicate their level of satisfaction in the specified areas. Additionally, open-ended questions were used to allow respondents to provide additional comments on the strengths and areas for improvement of the activity.

Step 3: Content Validity Check

The questionnaire was given to three experts to assess the appropriateness and comprehensiveness of the questions using the content validity index (IOC). The test results showed a reliability of 0.7 or higher for each of the items.

Step 4: Data Collection

Collect data from the respondents' questionnaire.

2.4. Data Collection and Analysis Methods

Data were collected through three main instruments:

2.4.1. Problem and Needs Assessment Questionnaire

This questionnaire was administered to identify the challenges and requirements for implementing integrated STEM education in OES. Data were collected both onsite and online.

2.4.2. PSS Assessment

Students' problem-solving abilities were evaluated after each activity using a standardized rubric. The rubric assessed four components:

- Problem Identification (maximum score: 6),

- Generating Alternatives (maximum score: 6),
- Planning for Problem-Solving (maximum score: 6), and
- Decision-Making and Execution (maximum score: 6).
- Each component was scored on a scale of 1 to 3, which was then multiplied by 2 to yield a maximum score of 6 per component. The total score across all components was 24, and the success benchmark was 75% (18 out of 24).

2.4.3. Satisfaction Assessment Form (SAF)

After completing all activities, students' satisfaction levels were measured using a 5-point Likert scale questionnaire. The SAF evaluated four dimensions:

- Content Accessibility,
- Content Understanding,
- Engagement and Interest, and
- Activity Participation.

2.4.4. Data Analysis

Descriptive statistics (means, percentages, and standard deviations) were used to summarize the data and evaluate performance against the 75% benchmark. The analysis focused on determining whether students met or exceeded the benchmark for problem-solving skills and assessing their overall satisfaction with the activities.

3. Results

3.1. Respondent Characteristics

The total number of participants was 98 (Table 1), with a nearly equal gender distribution (47.96% male, 52.04% female). Most participants were students (91.84%), while teachers comprised 8.16% of the sample. Most participants fell into the 7-12 age group (62.24%), followed by 13-18 (29.59%). Regarding education, 62.24% were in primary school, 29.59% were in secondary school, with the eight educators (8.16%) holding either a bachelor's or master's degree.

Table 1. Sample group general characteristics ($n=98$)

Characteristics	Participants	%
Gender		
Male	47	47.96
Female	51	52.04
Total	98	100.00
Status		
student	90	91.84
teacher	8	8.16
Total	98	100.00
Age		
7-12	61	62.24
13-18	29	29.59
19-24	0	0.00
25-30	2	2.04
31-36	2	2.04
37-42	3	3.06
43-48	0	0.00
49-54	1	1.02
Total	98	100.00
Education Level		
Primary education	61	62.24
secondary education	29	29.59
Bachelor's degree	4	4.08
Master's degree	4	4.08
Total	98	100.00

3.2. STEM Education Problems and Needs

The study identified four key issues in managing integrated STEM education in Opportunity-Expanding Schools:

3.2.1. Issue 1: Teachers' Understanding and Readiness Challenges

Many teachers do not know what STEM education entails regarding integrating science, technology, engineering and mathematics. Teachers hold misconceptions about connecting (integrating) members of the STEM disciplines with one another (Aslan-Tutak et al., 2017). To successfully implement integrated learning, there is a need for a deep understanding of the STEM approach. In this sense, teachers have difficulty creating appropriate interdisciplinary classroom activities meeting the STEM approach (Breiner et al., 2012). Thus, they cannot create opportunities for students

The best STEM teachers use their knowledge and experience, integrate concepts between disciplines, and organize content around real-world problems while ensuring students can build on their knowledge and solve problems themselves. Limited access to professional development in STEM knowledge and skills denies teachers basic skills and encourages reliance on outdated practices. Furthermore, STEM education is advancing rapidly, leaving professionally isolated teachers unaware of the latest techniques and resulting in slower adoption of innovative and effective methods.

3.2.2. Issue 2: Challenges in Resources and Equipment

Opportunity-expanding schools (OES) face significant shortages of essential equipment and resources for effective STEM education. The lack of science experiment kits, modern technology tools, and quality learning materials limits the ability to conduct hands-on learning activities, making achieving the intended educational outcomes difficult.

Furthermore, these resource constraints hinder students' skill development in experimentation, exploration, and innovation, core STEM learning components. The issue is particularly severe in small and remote schools, where budget limitations prevent institutions from acquiring high-quality teaching materials and keeping pace with technological advancements.

3.2.3. Issue 3: Inadequate Policy Support and Implementation

While there are national policies promoting STEM education, their implementation lacks clarity, consistency, and systematic monitoring. Many schools do not receive clear guidelines or structured support to integrate STEM effectively into their curriculum.

- The lack of concrete action plans and standardized learning management manuals makes it difficult for teachers to design and conduct structured STEM activities.
- Monitoring and evaluation mechanisms are weak, leading to slow progress in improving teaching and learning quality.
- Schools struggle to apply STEM education principles systematically without sustained institutional and governmental support, resulting in inconsistent teaching practices across different institutions.

3.2.4. Development Needs Based on the Findings

To address these issues, the study highlights three key areas for development:

1. Teacher Development – Providing comprehensive professional training to enhance educators' understanding and ability to implement integrated STEM learning.
2. Equipment and Resource Procurement – Securing adequate funding for schools to obtain modern teaching tools and laboratory equipment necessary for STEM activities.
3. Continuous Policy Support and Implementation – Strengthening policy execution, monitoring, and evaluation to ensure effective STEM education management across all OES.

3.3. Ethical Consideration

This study adhered to ethical research practices to ensure all participants' safety, privacy, and well-being. Although formal ethics committee approval was not sought, the research complied with ethical standards for educational research.

1. **Parental Consent:** Written consent was obtained from the parents or guardians of all primary and secondary school students participating in the study.

2. Participant Anonymity: All personal identifiers were removed from the data to protect participants' privacy. Additionally, any images or videos captured during the activities were edited to ensure that students' faces were not visible.

3. Voluntary Participation: Participation in the study was voluntary, and students were informed that they could withdraw at any time without penalty.

4. Data Security: All data were stored securely and accessed only by the research team.

3.4. STEM Education Activity Results

The research results are presented in Table 2, indicating that the overall average of all problem-solving components was 19.6 out of 24 (81.67%), above the minimum benchmark score limitation of 75% in total. All components scored above the established minimum benchmark scores at 4.5 out of 6, with the highest being Problem Identification (5.2 out of 6, 86.67%). This means that students could understand and define problems effectively, and vice versa for the lowest Problem-solving component, which scored 4.6 out of 6, or 74.67%, which was Planning for Problem-Solving. This lower score indicated students needed more proficiency to achieve a greater degree of problem-solving, although it was above the benchmark.

These results align with Constructivist Learning Theory, which underlines that learning is most effective when learners are actively engaged in constructing knowledge, with understanding and learning best occurring when learners construct meaning and knowledge by problem-solving (Almulla, 2023). STEM integration encourages students to construct their knowledge in the real world through hands-on activities, group work, and real-life problem-solving. High scores on problem identification and decision-making indicate the effectiveness of STEM integration in enhancing critical thinking and PSS by encouraging students to identify problems in the real world, develop proper solutions, and think critically when making decisions or assumptions during the learning process. The relatively low score on planning indicates that students can benefit further from scaffolding, guidance, or support in developing more structured or systematic problem-solving methods through STEM integration.

Table 2. Comparison of students' PSS against the 75% benchmark

Problem-Solving Component	Mean (Out of 6)	%	Met Benchmark?	Standard Deviation (SD)
Problem Identification	5.2	86.67%	Yes	0.45
Generating Alternatives	4.8	80.00%	Yes	0.50
Planning for Problem-Solving	4.6	76.67%	Yes	0.60
Decision-Making and Execution	5.0	83.33%	Yes	0.55
Total Score (Out of 24)	19.6	81.67%	Yes	1.65

3.5. Satisfaction Assessment Form (SAF) Results

The SAF results revealed that the participants overall were delighted (mean = 4.6 out of 5.92%). The breakdown of the components is as follows (Table 3):

- **Content Accessibility:** Participants expressed the highest level of satisfaction (mean = 4.6, 92%, SD = 0.40), indicating that the materials and resources were well-designed and easy to access.

- **Content Understanding:** Participants rated their understanding highly (mean = 4.5, 90%, SD = 0.47), demonstrating that the activities effectively facilitated comprehension of STEM concepts.
- **Engagement and Interest:** This component received the highest score (mean = 4.7, 94%, SD = 0.35), highlighting the activities' success in capturing and maintaining students' interest.
- **Activity Participation:** Participants reported a high level of participation (mean = 4.5, 90%, SD = 0.47), reflecting their active involvement in the learning process.

Table 3: Satisfaction with Integrated STEM Education Activities

Evaluation Component	Mean (Out of 5)	%	Satisfaction Level	Standard Deviation (SD)
Content Accessibility	4.6	92%	Very High	0.40
Content Understanding	4.5	90%	Very High	0.47
Engagement and Interest	4.7	94%	Very High	0.35
Activity Participation	4.5	90%	Very High	0.47
Overall Mean	4.6	92%	Very High	0.45

These findings are supported by the Self-Determination Theory (SDT), which posits that students are more motivated and engaged when their needs for competence, autonomy, and relatedness are met (Chiu, 2022). The high satisfaction scores suggest that the integrated STEM activities successfully addressed these needs by providing meaningful, engaging, and collaborative learning experiences. The emphasis on hands-on activities and real-world applications likely contributed to each participant’s sense of competence and autonomy. At the same time, group work and interactive tasks fostered a sense of relatedness.

3.6. Importance of the Findings

The results in Tables 1–2 reveal the effectiveness of integrated STEM education on students' PSS and students' and teachers' satisfaction. The theoretical underpinnings of Constructivism and Self-Determination Theory provide strong theoretical grounds for explaining these results (Almulla, 2023; Chui, 2022). Constructivism posits that learners construct knowledge and derive meaning through hands-on engagement and problem-solving (Srikan et al., 2021), as evidenced by the highest scores in problem identification and decision-making. In another perspective, the Self-Determination Theory contextualizes the high level of student satisfaction given that the activities might have satisfied the students' psychological needs to feel competent, autonomous, and related.

The significance of these results is important given the implications for educational practice. Integrated STEM education enhances academic ability and develops essential 21st-century skills such as critical thinking, collaboration, and creativity. Relatively lower scores in planning for problem-solving suggest that future interventions target developing students' ability to create structured and systematic plans as an important aspect of practical problem-solving.

In conclusion, the integrated STEM education activities achieved high-level success in meeting academic and motivational goals. The results show the opportunity for integrated STEM education approaches to achieve a rewarding learning experience in settings with limited resources in an interesting, accessible, and affordable manner.

4. Discussion

This study's results suggest that integrated STEM education can be a successful academic model to increase learning outcomes in OES when it proposes context-based activities to develop 21st-century skills (Lynch et al., 2018). The results of this study show that the activities are appropriate in STEM education and satisfactorily fulfill the functional role necessary for both students and teachers (Roehrig et al., 2021).

Specifically, the ability of the activities to develop a high degree of engagement and interest (mean = 4.7), content accessibility (mean = 4.6), understanding of content (mean = 4.5), and participation in the activity (mean = 4.5) are indicative of the activity's success to allow them to access and understand the content. Similar results have been seen in other studies in which it has been determined that the main characteristic of integrated STEM education is the ability to connect knowledge to the real world (Dare et al., 2021; Li, 2022). This study's design, which focused on connecting knowledge to students' surroundings and real-world challenges, showed it could meet this goal (Ortiz-Revilla et al., 2022).

These high satisfaction ratings are consistent with other research findings that STEM activities fostering hands-on inquiry-based learning through collaborative work promote enjoyment and positive attitudes toward learning (Fang et al., 2021; Lin et al., 2024). Likewise, Jiang et al. (2021) found that STEM education builds students' systematic and logical thinking skills, which help students understand and solve complex and interdisciplinary problems. Similar findings are also reported in this study and highlight the transferability of integrated STEM education in various educational environments, including resource-constrained contexts (Nawaz et al., 2023).

One of the milestones of the activities was that they helped develop students' PSS (Parno et al., 2021), as evidenced by the student's overall mean score of 81.67% in the activity, surpassing the 75% criterion level set in this study. In particular, problem identification was the strongest component (mean = 86.67%), suggesting that the students could identify the problem's essence. This is in line with other studies where the role of constructivist models fortifies one's critical thinking and PSS (Almulla, 2023). Alkair et al. (2023) added that STEM models effectively engage learners in environmental sustainability programs through problem-solving.

However, the comparatively low score of planning for problem-solving (76.67%) implies that students might, albeit able to identify problems suitably, need further support to get better prepared in a structured and systematic problem-solving plan (Zamiri & Esmaeili, 2024). Similarly, Srikan et al. (2021) stated that learners tend to have great difficulty in the planning phase of problem-solving and, therefore, need specific teacher scaffolding.

Several considerations illuminate the ways activities and co-design practices were successfully implemented. Activities were designed to the current contextual realities of the OES, which are characterized by the lack of resources and workforce, by making the best use of what is available and supporting teachers to support learners. Likewise, Halawa et al. (2024) illustrated that STEM education in resource-constrained contexts could equip learners with the skills necessary in future contexts. Therefore, by offering a situated analysis of how to recognize barriers to equitable STEM education and respond to the idiosyncratic context of OES, this study contributes to a limited body of knowledge illustrating equitable STEM education.

5. Implications for Practice and Policy

The findings of this study also contribute to existing research on integrated STEM education by providing empirical evidence for the effectiveness of the proposed activities in enhancing student satisfaction and PSS. The high level of student engagement and satisfaction observed in this study is consistent with the First author's (Chiu, 2022) finding, which used the Self-Determination Theory to

depict how satisfying students' need for competence, autonomy, and relatedness fosters their active learning and motivation. The hands-on, real-world, authentic learning experiences suggested by Bybee (2013) are key to promoting STEM literacy.

However, the findings of this study are more consistent with existing studies that have iOMA scope and that more or less highlight the importance of contextual adaptation, making them less consistent with those of prior studies that have not considered this criterion, particularly in resource-constrained contexts, such as (Africa (Oladejo et al., 2025); Spain (Bartolomé, 2024); and South Africa (Tibane et al., 2024)).

6. Study Limitations

The study has several limitations. First, the study is based on a specific geographic and cultural context (opportunity-expanding schools in Nakhon Si Thammarat), resulting in limited generalizability of the findings to other regions or educational contexts. Second, the study relies mainly on self-report data for satisfaction and problem-solving skills, which are susceptible to response bias (Zhang, 2025) in that participants may provide socially desirable responses. Third, the study is limited in its cross-sectional design, limiting causal inferences regarding the extent to which the integrated STEM activities would evoke a long-term impact on student learning.

7. Future Research

Future research could overcome this limitation by adopting longitudinal designs, evaluating a broader range of contexts to include more diverse settings, and using more objective measures of student performance. Implications for Practice and Policy This study suggests several implications for educational practice and policy. Integrated STEM education can address inequities by providing appropriate opportunities for underserved students inadequately educated in opportunity-expanding schools. There is a need to implement targeted interventions by offering teacher professional development, resources, and policy support (e.g., teacher training programs that encourage teachers to learn to design context-appropriate STEM activities; policy decisions on prioritizing the distribution of resources such as experiment kits and laboratory access).

8. Conclusion

This study illustrates the benefits of integrated STEM interventions for learners from underserved and resource-constrained settings. This study has highlighted the role of contextual adaptation, participation, and real-world relevance in the design of STEM activities. Further, this study also contributes a process to contextualize STEM learning that directly addresses the opportunity-expanding school challenges educators are involved with. This study also provides a possible pathway to address educational justice by increasing access to high-quality STEM education. Taken together, the findings from this study suggest that integrated STEM activities that are contextual, participatory, and relevant real-world can benefit student attitudes and skills in ways that contribute towards solving local community problems and challenges issues. Future research in this area needs to focus on these interventions' longer-term impact, examining sustainable collaborations between academic institutions and schools that can benefit learners from underserved and resource-constrained settings.

9. Knowledge Contribution Novelty

This research provides new knowledge on successful approaches and elements of integrated STEM education activities for opportunity expanding schools. Specifically, these included linking STEM concepts to the rural student context, applying creative technologies and media to support learning, and motivating students with hands-on experiences. The study shows that integrated STEM

education has the potential to address educational inequity in opportunity expanding schools by providing engaging and effective learning opportunities for underserved students.

The research findings also highlight the importance of academic services in facilitating the development of problem-solving skills and student satisfaction. This research offers a framework that focuses on active participation, engagement, and practical implementation, contributing to reducing educational inequality. Future research may investigate how universities and opportunity-expanding schools can collaboratively develop these models. For instance, the basic education schools within the responsibility of Nakhon Si Thammarat Rajabhat University can serve as models for raising the quality of education and teacher capacity.

10. Recommendations

Teacher professional development opportunities that allow teachers to enhance their STEM education knowledge and skills should be provided and supported by government education agencies. Training should focus on helping teachers design context-appropriate learning activities that meet the needs of students and the resources available to them in their local context.

Provision of Resources: Concerned agencies should provide schools, particularly sciences and technical subjects, with modern and sufficient resources, especially experiment kits and learning materials, in order to have a feel of what they are taught and have practical knowledge about it. Also, they should make it available to the students; for instance, the laboratories should be made accessible to the students to maximize their intended impact.

Policy and Guidelines: Policy and related practical guidelines should be prepared to help teachers systematically integrate STEM education into classrooms. Continuous monitoring and evaluation of the implementation of STEM education should be conducted to identify any room for improvement and to ensure the sustainability of these implementations.

Partnerships: Universities should work together with the opportunity-expanding schools to develop and implement STEM education, as rural schools might be unable to meet all training expectations. Therefore, partnerships can serve as a bridge to STEM education.

By following these suggestions, educational stakeholders can help minimize educational disparities and better prepare students from opportunity-expanding schools with the skills they need to face future challenges. Integrated STEM education has the potential to impact student learning experiences and outcomes, provided that it is accompanied by the provisioning of resources and the building of teacher capacity.

Declarations

Author Contributions.

Rutchanee Sittisak: Writing – original draft, Investigation, Data curation. Writing – review editing, Methodology, Supervision, Resources

Nattakan Roekmongkol: Investigation, Data curation, Writing – original draft,

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