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Enhancing problem-solving skills for primary students through interdisciplinary STEM activities

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Abstract--This study investigates the impact of simple interdisciplinary STEM activities on the development of problem-solving skills among primary students in Hanoi, Vietnam. A twelve-week intervention was implemented across three primary schools, involving 186 students in grades 4 and 5. Using a mixed methods design, the study collected both quantitative and qualitative data through pre-tests, post-tests, observations, student products, questionnaires, and interviews. The quantitative results showed a significant improvement in the experimental group, with a gain score of 2.08 points compared with 0.42 points in the control group. Qualitative findings revealed that students became more engaged, confident, and persistent, demonstrating enhanced abilities in identifying problems, generating ideas, testing prototypes, and explaining their reasoning. Teachers also observed notable improvements in communication, collaboration, and attitudes toward learning. The study concludes that simple, low-cost STEM activities are highly effective in promoting problem-solving skills and can be feasibly implemented in primary schools with limited resources.

Keywords--STEM education, problem solving, primary education, hands-on learning, interdisciplinary learning, Vietnam.



1. Introduction

Problem-solving is one of the core competencies required of learners in the twenty-first century, and it plays a particularly central role in primary education, where foundational cognitive abilities and dispositions toward learning are first formed. In recent years, the shift from content-based instruction to competency-based education has placed greater emphasis on involving students in authentic, inquiry-driven, and interdisciplinary learning environments. Within this context, STEM education has emerged as a promising pedagogical approach for cultivating students' analytical thinking, creativity, and problem-solving capacities. Numerous studies have demonstrated that interdisciplinary STEM activities create opportunities for students to encounter real-world challenges, collaborate with peers, engage in engineering design processes, and apply knowledge from multiple domains to construct meaningful solutions (Güven & Alpaslan, 2022; Lansiquot et al., 2011; McCrum, 2017).

International and regional educational reforms increasingly recognize the importance of providing primary students with opportunities to engage in design-based problem-solving tasks. Integrated STEM education fosters such opportunities by allowing students to connect scientific inquiry, mathematical modeling, and technological creativity within a coherent learning environment. Research shows that interdisciplinary approaches not only strengthen students' conceptual understanding but also stimulate creativity and flexible thinking, which are essential for solving open-ended problems (Sheth & Pathak, 2023; Bicer et al., 2017). In addition, assessment systems for STEM problem-solving have been developed to capture learners' collaborative cognitive processes and engineering design strategies, showing the multidimensional nature of problem-solving in contemporary classrooms (Lin et al., 2015; Amalina & Vidákovich, 2022).

In Vietnam, the general education curriculum reform emphasizes competency development and encourages schools to implement STEM-oriented learning activities. Recent studies indicate that STEM-integrated programs can enhance Vietnamese students' critical thinking, problem-solving tendencies, and motivation to participate in scientific inquiry (Chen et al., 2021; Linh et al., 2019). However, despite the growing adoption of STEM activities in Vietnamese primary schools, there remains a need for empirical studies examining how interdisciplinary STEM tasks specifically contribute to strengthening primary students' problem-solving skills. Many existing studies focus on secondary or university-level learners, while the primary level remains underexplored.

To address this gap, the present study investigates the effectiveness of interdisciplinary STEM activities in enhancing problem-solving skills among primary students. The research aims to analyze the improvements in students' abilities to identify problems, generate solutions, collaborate with peers, and apply interdisciplinary knowledge within structured STEM learning tasks. This study contributes to the current literature by offering evidence-based insights into how integrated STEM instruction can be designed and implemented effectively at the primary level, particularly within the context of emerging educational reforms in Vietnam. The findings are expected to support teachers, curriculum designers,

and school leaders in promoting STEM-based problem-solving practices that align with broader competency-based educational goals.

2. Literature Review

2.1. Problem-Solving Skills in Primary Education

Problem solving is an essential cognitive and metacognitive competence for primary learners, forming the basis for later academic achievement and the ability to deal with real-life situations. In the primary years, problem solving usually involves several connected processes such as identifying the problem, proposing possible strategies, selecting appropriate solutions, and evaluating the results. These processes help build higher-order thinking and enable students to approach unfamiliar tasks with confidence.

Young learners develop problem solving skills more effectively when they are given opportunities to manipulate objects, test ideas, collaborate with peers, and discuss their thinking. With suitable scaffolding, primary students can demonstrate creativity, logical reasoning, and flexible thinking. Research has highlighted that early engagement in problem solving activities supports the development of key competencies belonging to the twenty-first century, including communication, collaboration, and creativity (Güven and Alpaslan, 2022). Primary education therefore plays an important role in fostering problem solving dispositions that promote long-term learning.

Despite this importance, traditional classroom practices in many education systems remain teacher centered and focused on content delivery. These practices limit opportunities for students to explore and reason independently. As a result, contemporary education models emphasize inquiry, project based learning, and integrated tasks that require students to apply reasoning and creativity. These models have strong connections with STEM education, which has been shown to enhance problem solving through meaningful and hands-on learning.

2.2. Interdisciplinary STEM Education

STEM education focuses on the integration of science, technology, engineering, and mathematics to create authentic learning environments that resemble real-world challenges. Instead of teaching the four disciplines in isolation, interdisciplinary STEM instruction highlights the relationships among them and encourages students to apply knowledge across domains. This integrated approach helps learners understand how inquiry, technological tools, mathematical reasoning, and engineering design reinforce one another when solving complex problems.

According to Sheth and Pathak (2023), the interdisciplinary nature of STEM supports cognitive flexibility and promotes sustainable learning by enabling students to view a challenge from multiple perspectives. Lansiquot et al. (2011) also emphasize that interdisciplinary problem solving strengthens conceptual understanding and supports academic progress for diverse learners. The interdisciplinary structure of STEM aligns with the modern labor market that increasingly requires workers who can synthesize knowledge and adapt quickly.

Interdisciplinary STEM instruction often uses inquiry activities, project based learning, and engineering design cycles. These approaches promote questioning, experimentation, collaboration, and continuous improvement. When applied in primary classrooms, interdisciplinary STEM activities help young children develop foundational scientific reasoning and technological awareness while maintaining motivation and interest. For this reason, STEM has become an important component of primary education reforms in many countries, including Vietnam.

2.3. STEM Activities and Problem-Solving Development

There is substantial evidence that STEM activities contribute positively to the development of problem solving skills. STEM activities create conditions in which students must identify a challenge, collect information, generate possible solutions, evaluate alternatives, and revise their ideas. This process mirrors scientific and engineering practices and helps students understand the iterative nature of problem solving.

Güven and Alpaslan (2022) reported that interdisciplinary STEM activities improved students creative problem solving and strengthened competencies related to the twenty-first century. Topsakal et al.(2022) found that problem based STEM activities had a positive effect on learners critical thinking tendencies and their perceptions of their own problem solving abilities. Research in informal learning environments also supports these findings. For example, Bicer et al. (2017) noted that using three-dimensional printing in STEM activities enhanced students creativity and problem solving performance by allowing them to design and visualize prototypes.

Assessment is an important dimension of STEM-oriented problem solving. Amalina and Vidákovich (2022) highlight the need for multidimensional tools that capture cognitive, collaborative, and technological aspects of STEM problem solving. Lin et al. (2015) further developed an assessment system for collaborative problem solving that reflects the complexity of students interactions and decision making in STEM tasks.

Collectively, these studies show that STEM activities play an important role in strengthening primary students problem solving abilities through hands-on learning, creativity, and collaborative engagement.

2.4. Framework for Developing Problem-Solving Skills

Frameworks for developing problem solving skills in STEM education often provide structure for both instruction and assessment. One widely used framework is the engineering design process, which includes identifying a problem, proposing ideas, planning, constructing a prototype, testing the prototype, and refining the solution. This cyclical model teaches students that problem solving requires trial and improvement rather than completing a task in a single step.

Another important framework comes from research on collaborative problem solving, which focuses on communication, coordination of ideas, shared understanding, and collective decision making. Lin et al. (2015) emphasize that

effective problem solving in STEM settings often occurs in group activities that require negotiation, justification, and reflection.

Systematic reviews of STEM assessments indicate the need for frameworks that capture cognitive, emotional, and behavioral components of problem solving (Amalina and Vidákovich, 2022). These frameworks usually include indicators such as creativity, perseverance, self regulation, and the use of evidence in decision making.

In primary schools, frameworks must be developmentally appropriate and carefully scaffolded. Teachers play a crucial role in designing open-ended tasks, guiding student reflection, and connecting concepts across STEM areas. When effectively implemented, these frameworks help students transfer knowledge, generate solutions, and build confidence in addressing complex challenges.

3. Methodology

Research Design

A twelve-week intervention with simple interdisciplinary STEM activities was carried out to explore how primary students developed problem solving skills. Data were collected through pre-tests, post-tests, observations, questionnaires, and interviews.

Participants

The study was conducted at three primary schools in Hanoi: Quynh Loi Primary School, Kim Dong Primary School, Dong Da District; Hanoi Star Primary, Lower Secondary and High School.

A total of 186 students in grades 4 and 5 participated. 95 students formed the experimental group that joined the STEM activities, and 91 students formed the control group. Twelve teachers supported lesson implementation and data collection.

Instruments and Materials

The study used the following tools:

A simple problem solving test with eight open-ended items

Observation checklists focusing on engagement and collaboration

Student products such as paper models, simple prototypes, drawings, and worksheets

Teacher and student questionnaires

Interviews with four teachers and twelve students

Procedures

The intervention focused on very simple and age-appropriate STEM activities suitable for primary students. The study followed four steps.

First, twelve STEM modules were designed with teachers. Each activity used everyday materials, such as paper cups, straws, rubber bands, cardboard, and recycled items. Examples included:

Making a paper bridge that can hold small objects

Creating a simple water filter using sand and cotton

Building a mini windmill from paper

Testing different paper planes to see which flies farther

Creating a basic pulley system with string and a plastic cup

Second, both groups took the pre-test.

Third, the experimental group participated in two forty-minute simple STEM sessions each week for twelve weeks. Students worked in small groups, discussed ideas, and built simple models. The control group continued with the normal curriculum. Observations were carried out during the sessions.

Finally, the post-test, questionnaires, interviews, and collection of student products were completed.

Data Analysis

Quantitative data were analyzed using descriptive statistics and t tests to compare pre-test and post-test results for both groups. Mean scores and effect sizes were calculated. Qualitative data from observations, interviews, and student work were coded to identify evidence of improved reasoning, creativity, and teamwork. The combined results provided a clear picture of how simple STEM activities supported problem solving skill development.

4. Findings

The findings of the study are presented through both quantitative and qualitative results. Overall, the twelve-week implementation of simple interdisciplinary STEM activities resulted in clear improvements in primary students problem solving skills, learning behaviors, and engagement in hands-on tasks.

4.1. Quantitative Findings

Improvement in Problem Solving Scores

Results from the pre-test and post-test showed a significant improvement among students in the experimental group. Table 1 shows the comparison of test scores between the experimental and control groups.

Table 1. Pre-test and Post-test Problem Solving Scores

Group	n	Pre-test Mean	Post-test Mean	Gain Score
Experimental	95	5.84	7.92	+2.08
Control	91	5.79	6.21	+0.42

The experimental group showed a gain score of 2.08 points, indicating substantial improvement after participating in the STEM activities. In contrast, the control group showed an increase of 0.42 points, representing only slight natural progression. Statistical comparisons confirmed that the difference in gain scores between the two groups was significant. This result suggests that simple STEM activities were effective in enhancing students ability to identify problems, generate ideas, and justify solutions.

Changes in Sub-skills of Problem Solving

Further analysis of the test responses showed improvement across specific problem solving sub-skills in the experimental group:

Identifying the problem: increased from 54 percent to 87 percent

Generating at least two ideas: increased from 38 percent to 76 percent

Testing ideas with simple evidence: increased from 41 percent to 82 percent

Explaining reasoning with simple sentences: increased from 35 percent to 78 percent

These improvements indicate that even very simple tasks can support the development of structured thinking in primary students.

4.2. Qualitative Findings

Qualitative Findings from Student Work

Analysis of student products revealed progressive improvement in how students approached hands-on tasks. At the beginning of the study, many students completed activities such as building paper bridges or designing paper planes without careful planning. Their designs were often simple, and written explanations typically contained only short statements.



Figure 1. Primary students building simple STEM models during the activity

By the middle and end of the intervention, student work showed greater creativity and reasoning. For example, several groups testing paper plane designs experimented with wing length and folded angles, noting that wider wings created more stability. In the water filter activity, students adjusted the order of cotton, sand, and gravel to compare water clarity. Their written reflections demonstrated increasing ability to link actions with outcomes, even in simple language such as “We changed the layers to make the water cleaner.”

Overall, student products reflected a growing ability to record ideas, test solutions, and modify designs based on results.

Qualitative Findings from Classroom Observations

Classroom observations conducted throughout the twelve weeks provided strong evidence of changes in learning behaviors. In the early sessions, many students relied heavily on the teacher for instructions and hesitated to test their ideas. As the weeks progressed, students became increasingly independent and confident. Observation notes recorded several positive shifts:

Active participation increased from 58 percent in week 1 to 89 percent in week 12.

Effective group cooperation rose from 62 percent to 91 percent.

Students asked more questions and engaged in more exploratory behavior.

Students displayed greater perseverance when prototypes failed.

For example, during the pulley activity, students repeatedly tested how much force was needed to lift objects and adjusted their designs accordingly. Instead of giving up when designs failed, students showed excitement in trying alternative solutions. These behavioral changes indicate increased engagement and a more positive attitude toward problem solving.

Findings from Student Interviews

Interviews with twelve students highlighted the influence of simple STEM activities on their learning. Students described the lessons as enjoyable and interesting because they could “make things by hand,” “experiment with materials,” and “see what happens.” Many students reported that the activities helped them feel more confident because they could try ideas freely and learn from mistakes.

Several students explained that working in groups made problem solving easier because “friends have different ideas” and “we help each other think.” Students also expressed pride in creating physical products such as windmills or bridges, which motivated them to stay engaged in the tasks.

Overall, students felt that the STEM lessons made science easier to understand and encouraged them to think more carefully before making decisions.

Findings from Teacher Interviews

Interviews with teachers supported the positive effects observed in the classroom. Teachers noticed that students were more enthusiastic during STEM lessons than during traditional subjects. They observed that even shy students participated more actively because the materials were simple and non-threatening.

Teachers also highlighted improvements in students communication skills. Students learned to explain their ideas more clearly and listen to their peers during group discussions. Teachers reported that students became more persistent, often wanting to try multiple solutions before completing a task.

One teacher commented that simple STEM materials such as paper, plastic cups, and cardboard were easy to prepare and suitable for large primary classes. Teachers agreed that the activities created a supportive environment in which students were comfortable exploring ideas and learning from trial and error.

5. Discussion

The findings of this study indicate that simple interdisciplinary STEM activities can significantly enhance problem solving skills among primary students. The quantitative results demonstrated a clear increase in test scores in the experimental group, with students showing substantial progress in identifying problems, generating ideas, testing solutions, and explaining their reasoning. These improvements were supported by qualitative evidence that students became more active, collaborative, and persistent throughout the twelve-week intervention.

One important factor contributing to these outcomes is the simplicity and accessibility of the STEM tasks. The activities used everyday materials such as paper, cardboard, straws, and plastic cups, allowing students to focus on understanding the problem and testing ideas rather than struggling with complex tools or unfamiliar concepts. This approach helped reduce cognitive load, making problem solving more approachable for young learners. By working with simple materials, students were able to explore ideas freely, take risks, and build confidence in their abilities.

The study also showed that simple STEM activities encouraged students to engage in systematic thinking. Students gradually learned to plan their work, experiment with variations, and make decisions based on observed outcomes. This aligns with the developmental characteristics of primary students, who benefit from hands-on exploration that links concrete actions with observable results. The repeated cycle of building, testing, and revising supported the gradual internalization of basic problem solving processes.

Collaboration played a major role in strengthening students problem solving abilities. Students worked in small groups, discussed ideas, and made joint decisions about their designs. Over the course of the intervention, their communication and teamwork improved significantly. The qualitative data showed that students gained new ideas from peers and learned to respectfully negotiate differences. These experiences helped reinforce social aspects of problem solving, including listening, sharing responsibilities, and supporting group success.

Teacher interviews also highlighted improvements in students motivation and persistence. When prototypes failed, students became more determined to try again instead of feeling discouraged. This shift in mindset suggests that simple STEM activities can help develop resilience, an essential component of problem solving. Teachers appreciated the practicality of the activities, noting that they were easy to prepare and effective for large primary classes.

Overall, the discussion suggests that simple interdisciplinary STEM tasks provide an effective and developmentally appropriate approach to building foundational problem solving skills in primary education. The combination of simplicity, hands-on engagement, group collaboration, and repeated experimentation contributed to meaningful learning gains that may not occur through traditional instructional methods.

6. Conclusion

This study examined the impact of simple interdisciplinary STEM activities on the problem solving skills of primary students in three schools in Hanoi. Using a mixed methods design, the study collected both quantitative and qualitative data over a twelve-week period. The findings consistently demonstrated that the STEM intervention led to significant improvements in students ability to identify problems, generate ideas, test prototypes, and explain their reasoning.

The quantitative data revealed a much higher gain score in the experimental group than in the control group. Qualitative observations, student products, and interview responses confirmed that students became more active, curious, cooperative, and confident in solving problems. Teachers also reported that students developed stronger communication skills and a more positive attitude toward mistakes.

These findings indicate that simple, low cost, and age appropriate STEM activities can be a powerful tool for supporting problem solving development in primary education. The results are especially meaningful for schools with limited resources, as the activities require minimal preparation and rely on readily available materials. The study demonstrates that meaningful STEM learning does not depend on complex technology or advanced tools but can be achieved through thoughtful design and facilitation of simple tasks.

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