



Evaluating the Effectiveness of Teaching the Topic "Energy" in Science Subject According to The STEM Education Model to Develop the Ability to Apply Learned Knowledge and Skills for Primary School Students

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ABSTRACT: This paper presents the findings of a study on the implementation of teaching the topic “Energy” in Grade 5 Science using the STEM education model, with the aim of developing primary school students’ competence in applying acquired knowledge and skills. Based on a competency-based approach and integrated teaching theories, the study designed a specific instructional process that combines scientific knowledge with practical experiential activities. The research was conducted in the form of a pedagogical experiment involving two groups: an experimental class applying the STEM model and a control class taught using traditional methods. The results indicate that the STEM model not only improved academic performance but also significantly enhanced students’ ability to apply knowledge in real-life contexts and fostered a more positive attitude toward learning. The study thus affirms the feasibility and practical value of applying the STEM education model to teaching Science at the primary level, contributing to the innovation of teaching methods aligned with the new general education curriculum.

KEYWORDS: Competence of Applying Learned Knowledge and Skills, Interdisciplinary Integration, Primary School Students, STEM, Teaching Science.

1. INTRODUCTION

In the current trend of educational reform, competency-based teaching models are receiving increasing attention, especially at the primary education level. STEM education, which integrates four disciplines—Science, Technology, Engineering, and Mathematics—is considered an advanced approach that emphasizes interdisciplinary connections and real-world applications. This approach helps students develop essential competencies needed in modern society. According to the orientation of the new General Education Curriculum, one of the core competencies to be developed is the ability to apply acquired knowledge and skills to solve practical problems. At the primary level, the Science subject, with its content closely related to everyday life, provides a solid foundation for developing this competency.

Among the various topics in Grade 5 Science, the topic “Energy” stands out for its high applicability and potential for integrating STEM elements. It encourages students to explore, experiment, and create practical products that serve daily life. However, in reality, the implementation of STEM education in primary schools still faces many limitations, particularly in designing specific instructional processes that effectively connect theoretical knowledge with students’ practical experiences.

In response to this situation, the present study focuses on evaluating the effectiveness of teaching the topic “Energy” in Grade 5 Science using the STEM education model, with the aim of developing students’ competence in applying knowledge and skills. Based on both theoretical and practical foundations, this paper proposes a feasible and structured instructional process, supported by evidence from a pedagogical experiment. The research clarifies the impact of the STEM model on students’ learning outcomes, while also contributing scientific evidence for effectively implementing STEM education at the primary level.

2. RESEARCH RESULTS

2.1 Competence and the Ability to Apply Learned Knowledge and Skills

Some researchers define competence based on the elements that constitute the ability to act. For example, F.E. Weinert (2001) considers competence as the skills and techniques acquired by each individual and defines it as: Competence is the learned or inherent

skills and techniques of an individual to solve specific situations, as well as the readiness in motivation and the ability to apply problem-solving methods responsibly and effectively in flexible situations. According to X. Roegiers (2000), Competence is the integration of skills that naturally influence the content in a given type of situation to solve the problems posed by that situation.

According to Nguyen Minh Giam (2024) defines competence as the synthesis of knowledge, skills, and attitudes that are either learned or inherent in an individual, enabling responsible actions to quickly and easily achieve high efficiency in a specific field. Competence is formed and developed through education, training, self-improvement, and practical experiences of each individual.

According to Nguyen Thi Thu Hang and Phan Thi Thanh Hoi (2018), the application of learned knowledge and skills is the ability of individuals to identify real-world problems, mobilize relevant knowledge, or explore and discover new knowledge to effectively solve practical problems. Le Thanh Huy and Le Thi Thao (2018) state that "The ability to apply knowledge is the learner's ability to independently solve posed problems quickly and effectively by applying acquired knowledge to practical situations and activities to explore and transform the surrounding world.

Based on these perspectives, the ability to apply learned knowledge and skills can be understood as the learner's capacity to flexibly combine acquired knowledge and skills to effectively solve real-life situations. In the context of the Science subject, this ability involves solving learning tasks in new contexts or situations related to real life, appropriate to the capacity of students. It creates opportunities for students to connect and apply knowledge and skills learned from various fields.

From the above perspectives, STEM and STEM education can be understood as concepts that embody the integration of the four disciplines—Science, Technology, Engineering, and Mathematics—into teaching and real-life applications. STEM education aims to develop learners' competence in integrating knowledge, skills, critical thinking, and problem-solving abilities through diverse experiential activities. This is a progressive educational trend that meets the demands of the modern era and is increasingly being adopted and implemented worldwide.

The competence to apply knowledge and skills refers to a learner's ability to independently and effectively solve problems. This ability is demonstrated through the flexible application of learned knowledge and skills to explore the world and respond to changes. It also reflects personal qualities and character traits, as individuals engage in activities that satisfy their need for learning and development. Among the core competencies that STEM education seeks to develop, the ability to apply acquired knowledge and skills stands out—namely, the capacity to use knowledge flexibly to address real-world problems. For primary school students, this competence serves as a foundation for developing creative thinking, initiative, and adaptability.

2.2 Instructional Process for Teaching the Science Topic “Energy” Based on the STEM Education Model to Develop Primary Students’ Competence in Applying Acquired Knowledge and Skills

The instructional design and implementation process for teaching the Grade 5 Science topic “Energy” based on the STEM lesson model, with the goal of developing students’ competence in applying knowledge and skills, consists of four main steps:



Figure 1. Instructional Process for Teaching the Science Topic “Energy” Based on the STEM Education Model to Develop Students’ Competence in Applying Acquired Knowledge and Skills

Step 1: Selecting the Teaching Content on Energy

Core knowledge on energy is identified from the Grade 5 Science curriculum, including concepts such as the definition, types, transformation, sources, and applications of energy. At the same time, real-life phenomena and processes are incorporated to enhance students’ engagement and demonstrate the practical value of the subject. For example, specific cases such as solar panels, electric



lights, wind turbines, and hydroelectric dams can be used to illustrate content and help students connect what they learn to real-world contexts. In addition, attention should be paid to modern technological systems that apply energy knowledge, such as solar or wind power plants and clean energy vehicles. Selecting content that is relevant and practical not only stimulates student interest but also enables them to see the real-world significance of energy-related knowledge.

Step 2: Defining the Energy-Related Problem to Be Solved

A specific, real-life problem should be chosen that is suitable for students' abilities and has interdisciplinary characteristics, requiring them to integrate knowledge and skills to solve it. This fosters scientific thinking and competence in applying what they've learned to real-life situations.

For instance, teachers can assign a task requiring students to design and build a smart house model powered by solar energy, integrating a lighting system and fan operated by solar-charged batteries. To complete this task, students must draw on knowledge of how solar panels work, electrical circuits, and mechanical systems such as fan motors. They must also apply mathematical and engineering skills such as calculation, design, assembly, and measurement. Through this, students gain a deeper understanding of solar energy's nature and usage, and learn how to use energy economically and efficiently.

Step 3: Establishing Criteria for Energy Problem-Solving Products or Solutions

A clear and comprehensive set of evaluation criteria should be developed for the products or solutions students are expected to create. These criteria guide the problem-solving process, helping students understand the objectives and plan their work effectively. In the example of designing a solar-powered smart house, the product evaluation criteria might include:

- (1) The model correctly demonstrates the working principle of solar panels and electrical circuits;
- (2) The lighting and fan systems operate stably and efficiently;
- (3) The model is structurally sound and aesthetically pleasing;
- (4) The project report clearly explains the scientific basis and operational principles of the model;
- (5) The project proposes a creative and feasible real-world application of solar energy.

Step 4: Designing the Teaching and Learning Activities on Energy

This is the final and most critical step in the STEM lesson design process. A detailed teaching plan should be developed to ensure students can effectively acquire and apply knowledge while fostering active, engaged, and creative learning. The lesson should follow basic steps of the engineering design process and may incorporate digital tools or e-learning components to support learning beyond the classroom.

Each activity should include clearly defined goals, content, expected student outputs, and specific methods of organization. For example, in a field trip to a wind power plant, the objective may be to help students observe the structure and operating principles of wind turbines. Students are expected to produce a report and a model illustrating the wind energy harvesting mechanism. This activity could be organized as a group-based field study at the plant.

It is evident that designing a STEM lesson on energy requires careful investment and planning, but it is a crucial condition for developing high-quality lessons. Such lessons unlock students' potential for application, integration, and innovation, while empowering teachers to confidently implement and adapt the instruction in flexible classroom settings.

2.3 Research Methodology

This study was conducted using a quasi-experimental design, involving two selected groups: an experimental group and a control group. Both classes were chosen based on equivalent criteria in terms of class size, academic level, and learning conditions. They were taught by the same teacher and covered the same topic—"Energy"—from the Grade 5 Science curriculum. However, the teaching methods differed between the two groups.

The experimental group was instructed following the STEM education model, incorporating experiential activities, product creation, and problem-solving tasks. In contrast, the control group was taught using traditional methods, primarily lectures and teacher-led questioning.

This design enabled a comparative analysis of the effectiveness of the two teaching approaches, allowing for objective conclusions to be drawn regarding the impact of the STEM model on students' competence in applying acquired knowledge and skills.



The study sample included Grade 5 students from Trung Trác Primary School, Ho Chi Minh City, during the 2024–2025 academic year. A total of 71 students participated in the study, with 36 students assigned to the experimental group (Class 5/6) and 35 students to the control group (Class 5/7).

The experimental lesson focused on the topic “Solar, Wind, and Flowing Water Energy,” part of the "Energy" unit in the Grade 5 Science curriculum issued by the Ministry of Education and Training of Vietnam (2022).

Following the experimental teaching phase, students’ competence was assessed through a 10-point written test, and the results were analyzed using SPSS statistical software.

2.4 Experimental Results

To evaluate the effectiveness of the proposed instructional process, we formulated the following experimental hypothesis: H1: There is a significant difference in Science learning outcomes between the experimental class—taught using the STEM education model aimed at developing competence in applying acquired knowledge and skills—and the control class—taught using traditional textbook-based instruction.

In SPSS, descriptive statistics were conducted using the Explore procedure to examine the mean, confidence intervals, median, minimum–maximum values, as well as Skewness and Kurtosis, which provide information on the normality of data distribution.

The descriptive statistics results are presented in Table 1 below.

Table 1. Descriptive Statistics for Science Learning Outcomes of Experimental and Control Groups
Descriptive

| Grouping Variable | | Statistic | Std. Error | | |
|---------------------|--------------------|---|------------|------|--|
| Scores | Control Group | Mean | 7,06 | ,246 | |
| | | 95% Confidence Interval for Lower Bound | | 6,56 | |
| | | Mean Upper Bound | | 7,56 | |
| | | 5% Trimmed Mean | 7,12 | | |
| | | Median | 7,00 | | |
| | | Variance | 2,114 | | |
| | | Std. Deviation | 1,454 | | |
| | | Minimum | 3 | | |
| | | Maximum | 10 | | |
| | | Range | 7 | | |
| | | Interquartile Range | 2 | | |
| | | Skewness | -,592 | ,398 | |
| | | Kurtosis | ,955 | ,778 | |
| | Experimental Group | Mean | 9,14 | ,155 | |
| | | 95% Confidence Interval for Lower Bound | | 8,82 | |
| | | Mean Upper Bound | | 9,45 | |
| | | 5% Trimmed Mean | 9,21 | | |
| | | Median | 9,00 | | |
| | | Variance | ,866 | | |
| Std. Deviation | | ,931 | | | |
| Minimum | | 7 | | | |
| Maximum | | 10 | | | |
| Range | | 3 | | | |
| Interquartile Range | 2 | | | | |
| Skewness | -,741 | ,393 | | | |
| Kurtosis | -,451 | ,768 | | | |

The descriptive statistics indicate that the mean score of the experimental group was 9.14 ± 0.155 (with a 95% Confidence Interval [CI]: 8.82 to 9.45; 5% trimmed mean: 9.21), which is higher than the mean score of the control group, 7.06 ± 0.246 (95% CI: 6.56 to 7.56; 5% trimmed mean: 7.12). The median score of the experimental group was 9.0, while that of the control group was 7.0, indicating a difference of 2 points.

The score range for the experimental group extended from a minimum of 7 to a maximum of 10 (Range = 3), whereas the control group had a wider range from a minimum of 3 to a maximum of 10 (Range = 7). The standard deviation was 0.931 for the experimental group, lower than 1.454 in the control group, suggesting that not only were the learning outcomes higher in the experimental group, but also more consistent.

The Skewness and Kurtosis values for the experimental group were -0.741 and -0.451 , respectively; while those for the control group were -0.592 and 0.955 , indicating that both distributions were slightly left-skewed with moderate kurtosis.

These descriptive results suggest a trend in which the experimental group outperformed the control group in Science learning outcomes. However, this observed difference needs to be statistically tested in the next section.

To determine the appropriate statistical test for evaluating the difference between the two group means (experimental: $M = 9.14 \pm 0.155$; control: $M = 7.06 \pm 0.246$), it is essential to first assess the normality of the score distribution. To examine normality, the author employed a combination of methods, including Histograms, Normal Q-Q Plots, and the Shapiro-Wilk test, given that the sample size in each group was less than 50.

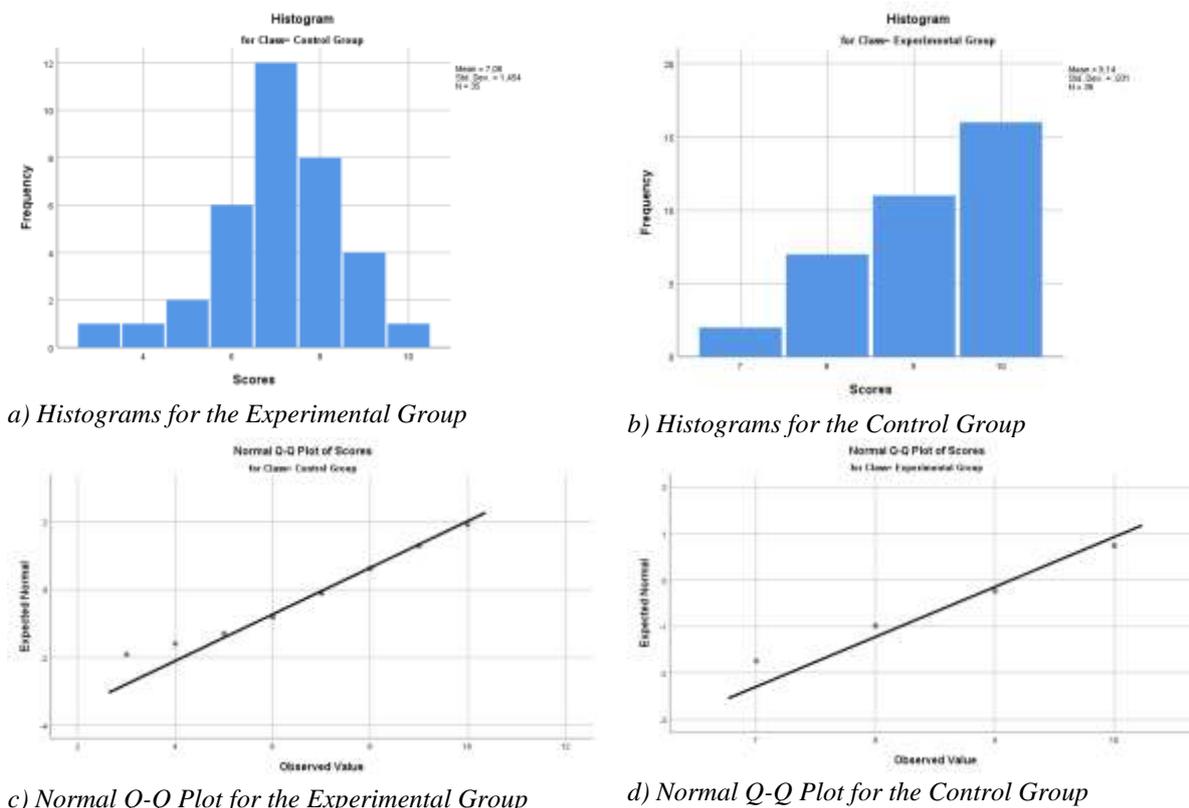


Figure 2. Results of the Normality Test for Student Scores

Observing the Histograms in Figures 2a and 2b reveals that the score distribution of the experimental group does not resemble a bell-shaped curve, while that of the control group appears closer to a normal distribution. These observations raise doubts about whether the data follow a normal distribution.

When examining the Normal Q-Q Plots for both the experimental and control groups, the observed scores and the expected scores do not consistently align along the theoretical Q-Q line of a normal distribution. This further suggests a potential violation of the assumption of normality.



To confirm this suspicion, the Shapiro–Wilk test was conducted, as it is suitable for small sample sizes. The results of the Shapiro–Wilk test are presented in Table 2 below.

Table 2. Shapiro–Wilk Test Results for Score Data

Tests of Normality

| | Grouping Variable | Kolmogorov-Smirnov ^a | | | Shapiro-Wilk | | |
|--------|--------------------|---------------------------------|----|------|--------------|----|------|
| | | Statistic | df | Sig. | Statistic | df | Sig. |
| Scores | Control Group | ,199 | 35 | ,001 | ,939 | 35 | ,053 |
| | Experimental Group | ,267 | 36 | ,000 | ,812 | 36 | ,000 |

a. Lilliefors Significance Correction

Since the sample size in each group is less than 50, the Shapiro–Wilk test was employed to assess normality. The test results show a p-value less than 0.05 for the experimental group ($p = 0.000$) and greater than 0.05 for the control group ($p = 0.053$). This indicates that the score data from the experimental group do not follow a normal distribution, while those from the control group are approximately normally distributed.

These findings confirm that although the control group data meet the assumption of normality, the experimental group data violate this assumption. This violates a key prerequisite of parametric tests such as the Independent Samples t-test, which require both groups to be normally distributed when the sample size is relatively small.

Therefore, to ensure reliability and objectivity in the statistical analysis, this study adopts the non-parametric Mann–Whitney U test, which does not require the assumption of normality. This test is appropriate for comparing medians or overall distributions between two independent groups when at least one group does not meet the normality condition. This approach adheres strictly to the principles of inferential statistics and enhances the validity of research conclusions in subsequent chapters.

The Mann–Whitney U test results for comparing Science learning outcomes between the experimental and control groups are presented in two key tables: the Ranks Table and the Test Statistics Table. These are essential for objectively assessing the difference between the two teaching approaches.

Table 3. Ranks for Science Learning Scores Between Experimental and Control Groups

| Ranks | | | | |
|--------|--------------------|----|-----------|--------------|
| | Grouping Variable | N | Mean Rank | Sum of Ranks |
| Scores | Control Group | 35 | 22,06 | 772,00 |
| | Experimental Group | 36 | 49,56 | 1784,00 |
| | Total | 71 | | |

The ranking results show that the experimental group had a significantly higher mean rank than the control group (49.56 vs. 22.06). The sum of ranks for the experimental group was nearly twice that of the control group, indicating a clear difference in learning outcomes between the two groups. This serves as an initial indication that students in the experimental group achieved better academic performance.

Table 4. Mann–Whitney U Test Statistics for Science Learning Scores

Test Statistics^a

| | Scores |
|------------------------|---------|
| Mann-Whitney U | 142,000 |
| Wilcoxon W | 772,000 |
| Z | -5,730 |
| Asymp. Sig. (2-tailed) | ,000 |

a. Grouping Variable: Grouping Variable



As shown in Table 4, the value of Asymp. Sig. (2-tailed) = 0.000 indicates a highly statistically significant difference between the experimental and control groups ($p < 0.001$). This result is further supported by the absolute Z-value ($|Z| = 5.730$), which exceeds the critical value of 1.96 (with $\alpha = 0.05$), allowing us to accept the alternative hypothesis (H_1).

In other words, there is a clear and significant difference in Science learning outcomes between the two student groups: The experimental group, which was taught using the STEM education model designed to enhance students' competence in applying acquired knowledge and skills. The control group, which followed the traditional lecture-based approach, mainly focusing on direct instruction and teacher-led questioning.

This advantage is not only statistically meaningful but also holds substantial pedagogical value. The proposed instructional model created an interactive learning environment, encouraging student engagement and autonomy through hands-on activities, product creation, and problem-solving tasks. These experiences effectively strengthened students' learning capacity and led to a marked improvement in their Science performance.

3. CONCLUSION

This study focused on evaluating the effectiveness of implementing the Grade 5 Science topic "Energy" using the STEM education model, with the goal of developing primary students' competence in applying acquired knowledge and skills. Grounded in a competency-based approach, the study developed a detailed instructional process that ensures interdisciplinary integration, practical relevance, and developmental appropriateness for primary school learners. The process not only adheres to the core principles of STEM education but also provides meaningful opportunities for students to explore, design, and create through authentic learning tasks.

The experimental results demonstrated that the proposed instructional model significantly enhanced students' ability to apply knowledge, solve problems, think creatively, and develop a positive learning attitude. Furthermore, the model's feasibility and effectiveness were confirmed under actual teaching conditions in primary schools. However, for broader implementation, additional investment in infrastructure, instructional materials, and teacher professional development will be necessary.

This study contributes both theoretically and practically to the integration of STEM education into primary Science instruction. It also opens up new directions for developing similar instructional models across other topics and subjects aligned with the new general education curriculum.

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