

## INTEGRATING THE 5E INSTRUCTIONAL MODEL AND STEM TO DEVELOP REPRESENTATION COMPETENCY IN THE TOPIC OF “SUBSTANCES AND THEIR TRANSFORMATIONS” FOR THE 8TH-GRADE NATURAL SCIENCE STUDENTS

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**Abstract.** Representation competency is one of the three components of natural science competence (according to the high school curriculum in 2018) that needs to be emphasized for students' development. To foster this competency in learners, innovation in teaching methods is essential. In this article, we investigated the current status of applying the 5E teaching model and STEM education to develop the representation competency that learners have acquired. Through the results obtained from this investigation, we aim to construct a teaching plan that integrates the 5E teaching model and STEM in the theme 'substance and changes in matter' for 8th-grade natural science class and conduct pedagogical experiments to assess the feasibility of developing the representation competency in students. Teachers can apply the research findings to various topics and subjects to develop the representation competency acquired in students.

**Keywords:** 5E instructional model, STEM education, representation competency, Substances and Changes in matter, 8th-grade Natural Sciences.

### 1. Introduction

The 5E instructional model was developed to enhance learners' understanding and engagement in the teaching and learning process through five phases: engage, explore, explain, elaborate, and evaluate. Each step, represented by the letter "E" in the 5E instructional model, focuses on assisting students in learning through experience, connecting existing knowledge with relevant new concepts [1]. Learners are taught to employ methods, attitudes, and skills similar to those of scientists while conducting research, thereby honing their abilities and skills through the 5E instructional model [2]. Numerous studies worldwide have examined the application and effectiveness of the 5E instructional model in practice. For instance, a study by Salyani and colleagues in 2020 explored the application of the 5E instructional model to correct misconceptions and positively engage learners [3]. In 2021, Puspita and Fardillah investigated the effectiveness of both the 5E and 7E instructional models in developing learner competencies [4]. In Vietnam, there is also considerable interest among researchers in the 5E instructional model, such as Vu Thi Minh Nguyet's 2016 study on applying the 5E instructional model to lesson planning [5]; and Ninh Thi Bach Diep's 2020 research on developing investigative and exploratory abilities in students through the 5E instructional model [2]. Author Phan Thi Hong The has conducted a study on the application of the 5E teaching model in experimental teaching of natural sciences at secondary schools in 2021 [6].

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Teaching STEM (Science, Technology, Engineering, and Mathematics) is an instructional approach that integrates scientific, technological, engineering, and mathematical knowledge to help individuals solve real-world problems within specific contexts. Additionally, the four domains of STEM provide learners with analytical thinking and decision-making skills, aiding in career choices and readiness [7]. Through STEM education, learners gain opportunities to learn and succeed, benefiting from an education aligned with society's workforce demands [8]. Numerous studies globally, including in Vietnam, have investigated STEM education and its impacts. For instance, explored educators' attitudes toward STEM across different education levels [9]; while Nguyen Lan Phuong and colleagues analyzed STEM education implementation using Scopus data [10].

Representation competency (RC) is demonstrated when learners apply their scientific knowledge and skills to explain common natural phenomena, address environmental protection and sustainable development issues, and appropriately respond to simple problems in their personal lives, families, and communities [11]. The capacity to apply learned knowledge and skills is pivotal, as it represents the final step in students' process of transforming theoretical knowledge into practical activities through educational products. Studies on enhancing this skill abound. Tran Thai Toan's 2018 research focused on developing strategies for applying knowledge to practice in teaching high school biology [12]. In 2019, Le Thanh Oai and Phan Thi Thanh Hoi investigated using exercises to cultivate the application of learned knowledge and skills in high school biology education [13]. Additionally, studies like Cao Cu Giac's research contribute to the development of assessment frameworks for natural science competencies [14].

Of special importance is the 8th-grade natural science curriculum's theme "Substances and Changes in Matter". This theme aims to introduce learners to chemical changes and familiar concepts in chemistry such as chemical reactions, acids, bases, and more. It underscores the necessity of connecting knowledge to practical experiences to deepen understanding-learning by doing. To achieve this, the development of representation competency is crucial in linking students' theoretical knowledge with practical content. Furthermore, natural science is interdisciplinary, so the application of knowledge should also be interdisciplinary, fostering creativity and linking knowledge strands, which is where STEM plays a pivotal role. Alongside this, the 5E instructional model acts as the second supportive element, enhancing comprehension and positivity in students' learning process. This research thus identifies the alignment between the 5E instructional model and STEM education within the "Substances and Changes in Matter" theme in the 8th-grade natural science curriculum, serving the current educational context to foster the application of learned knowledge and skills in students.

## **2. Content**

### **2.1. Theoretical foundations of the 5E instructional model combined with STEM education in the topic of "Substances and Changes in substances"**

#### **2.1.1. Concept of the 5E instructional model**

In 1967, Robert Karplus introduced a learning cycle model with three phases: exploration, invention, and discovery. Later, in 1980, the learning cycle model evolved into the 5E model (engagement, exploration, explanation, elaboration, evaluation). The concept of the 5E model remains consistent with the original learning cycle model. The 5E instructional model is designed to create conditions for learners to engage in a sequence of activities to acquire knowledge and develop skills by actively assuming the role of learners [4].

The 5E instructional model is built upon constructivist theory, wherein learners are encouraged to explore, experience, and construct knowledge. In the 5E instructional model, learners collaborate to solve problems and investigate new concepts through questioning, observation, analysis, and conclusion [1].

According to Rodger W. Bybee and colleagues, the 5E instructional model is a popular educational approach used for teaching science, characterized by the following components [1].

- *Engage*: It begins by stimulating the curiosity and interest of students. Teachers create a situation or initial question to make students interested in the learning topic.

- *Explore*: Students engage in hands-on activities and exploration to learn more about the topic. They have the opportunity to observe, collect data, and discover knowledge on their own.

- *Explain*: After conducting exploratory activities, the teacher explains and guides students so that they can gain a deeper understanding of the knowledge, theories, and related concepts.

- *Elaborate*: In this phase, students are encouraged to apply their knowledge to real-life situations and solve complex problems. They can work individually or in groups.

- *Evaluate*: Finally, the assessment and evaluation of student's understanding and skills related to the learning topic occur. This may include tests, assignments, or assessment projects.

According to this study, the 5E instructional model shifts the role of learners compared to traditional teaching through five stages: First is engagement to stimulate and arouse learning motivation; Second is exploration, which involves the natural process of exploration; Third is explanation of the discoveries made in the second stage; Fourth is application in practical contexts; Fifth is evaluation to gather feedback on the learner's knowledge discovery process.

### **2.1.2. Concept of STEM education**

Model STEM education emerged in the United States in 1990 to foster individuals with a strong foundation in basic science and the ability to research and solve problems. STEM education combines the four disciplines of Science, Technology, Engineering, and Mathematics to prepare students for post-graduation careers [7].

Prominent STEM education research began around 2006 and has significantly developed in recent years (2019-2023). Key trends in STEM education include: Firstly, focusing on analyzing prominent STEM education research in higher education (issues related to gender, career development, and experiential learning). Secondly, expanding STEM to STEAM (adding the Arts component). Lastly, directing research toward STEM education activities in K-12 education, including curriculum, integrated teaching, and pedagogical content knowledge [15].

STEM lesson design follows a technical design process with five primary activities: establishing foundational knowledge, researching foundational knowledge, selecting solutions, prototyping and evaluating, and sharing, discussing, and refining [16].

### **2.1.3. Some theoretical issues regarding the application of acquired knowledge and skills**

According to the Ministry of Education and Training, "Competence is a personal attribute formed and developed through inherent qualities and the process of learning and training. It allows individuals to synthesize various knowledge, skills, and other personal attributes such as interest, confidence, and determination, to successfully carry out a specific activity and achieve desired outcomes under specific conditions". Representation competency in practice is the learner's capacity to effectively use and integrate knowledge, experiences, skills, and attitudes to solve real-world issues related to the learned content [11, 17].

The structure of representation competency consists of three components, and the expressions of this ability are depicted in Table 1 [18].

**Table 1. Components and manifestations of lower secondary school students' representation competency**

Components of Competence	Expressions
1. Identifying Issues and Asking Directed Questions to Mobilize Knowledge and Skills for Resolution (TP1)	Identify and formulate questions for issues within learning and practical contexts. Gather information and identify relevant knowledge and skills related to the issue
2. Planning and Problem-Solving (TP2)	Plan, propose, and select problem-solving approaches. Execute the plan, draw conclusions, and evaluate problem-solving options
3. Self-Evaluation and Adjustment (TP3)	Generate meaningful new insights for oneself and propose practical applications. Demonstrate attitudes and behaviors that align with addressing environmental protection, natural resource conservation, and sustainable development issues

**2.1.4. Introduction to the topic of "Substance and Its transformation" in Natural Sciences grade 8**

The topic of "Substance and changes of matter" in Natural Science grade 8 includes a variety of content and specific time allocation as follows [11]:

**Table 2. Time allocation distribution within the topic of "Matter and Changes in Matter" in the 8th-grade natural sciences subject**

Ordinal number	Content	Proportion
1	Chemical Reaction	12%
2	Reaction rate and catalysts	3%
3	Acid-Base – pH – Oxide – Salt; Chemical fertilizers	14%

The objective of this topic is to provide learners with a brief overview of chemical reactions in real-life situations, along with the presence and interplay of factors influencing reaction rates. In addition, the topic helps learners become acquainted with familiar concepts in chemistry such as acids, bases, pH, oxides, and salts. Furthermore, this topic serves as a foundation for developing biological knowledge through an exploration of chemical fertilizers, the correlation between using chemical fertilizers, and their impact on organisms, soil, and humans.

**2.2. Scientific basis for integrating the 5E teaching model and STEM to develop the application of learned knowledge and skills**

The 5E teaching model focuses on stimulating learners' curiosity and exploration, encouraging interaction with knowledge to acquire understanding and develop thinking skills and competencies. Simultaneously, STEM is a teaching model that integrates students' knowledge and skills into practical contexts through topics derived from real-life ideas and projects intertwined with daily life. This demonstrates a reciprocal relationship between the 5E teaching model and STEM. STEM provides the origin of practical issues to initiate the first step (stimulation) of the 5E model, and the subsequent steps of the 5E model support the refinement of STEM topics: The Exploration step involves students researching foundational knowledge from reality to enhance comprehension of concepts; the Explanation step entails constructing arguments to select solutions for STEM topics; the Application step involves transforming concepts into STEM products, and the Evaluation step entails feedback and improving the effectiveness of what students gather from the STEM learning process. Thus, the 5E teaching model and STEM exhibit a strong correlation as both emphasize interaction, exploration, and application of knowledge to reality.

The 5E teaching model can be employed as an organizational method for structuring the learning process within STEM to aid students in developing scientific thinking skills, creative thinking, and problem-solving abilities.

**Table 3. Correlation between the 5E teaching model, STEM teaching, and the representation competency**

<b>5E Instructional Model</b>	<b>Teaching STEM</b>	<b>Representation competency</b>
Engage	Establishing Fundamental Knowledge	Problem Discovery and Guiding Questions Mobilizing Knowledge and Skills to Solve (TP1)
Explore	Background Knowledge Research	
Explanation	Solution Selection	Problem Planning and Resolution (TP2)
Elaborate	Prototype Fabrication and Test Process Evaluation	
Evaluate	Sharing, Discussion, Adjustment	Self-Assessment and Self-Adjustment (TP3)

To assess the manifestation of knowledge and applied skills development based on the correlation with the 5E teaching model and STEM, the research team proposes criteria through Table 4, specifically in the form of three assessment levels via the link <https://bom.so/9RZ2bv>.

**Table 4. Criteria for assessing representation competency through the integration of 5E and STEM teaching frameworks**

<b>Competency Components</b>	<b>Criteria</b>
1. Problem identification and focused questioning to mobilize knowledge and skills for resolution (TP1)	1.1. Identifying issues within the STEM subject
	1.2. Showing interest and posing questions about STEM-related issues
	1.3. Researching materials to gather information from various sources and identify relevant knowledge and skills related to the STEM subject
2. Planning and problem-solving (TP2)	2.1. Planning to address the tasks related to the STEM subject, proposing different approaches
	2.2. Selecting an approach for designing the STEM subject and explaining the reasoning behind the choice
	2.3. Implementing the plan to create the STEM product
	2.4. Engaging in discussions to draw conclusions and evaluate the testing process of the STEM product
3. Self-assessment and self-adjustment (TP3)	3.1. Assessing equivalences and self-evaluating the ability to apply knowledge to the STEM subject
	3.2. Providing suggestions for improving the recently created STEM product
	3.3. Demonstrating attitudes and behaviors aligned with environmental protection, natural resource conservation, and sustainable development concerns

Developing the capacity to apply acquired knowledge and skills based on the 5E and STEM teaching models will create conditions that deeply integrate the acquired knowledge. This approach provides a multi-dimensional perspective on real-world problems and engages learners actively in learning. By bridging these two teaching models and the application of acquired knowledge and skills, learners will undergo comprehensive development, equipping them with the necessary knowledge and abilities to meet the demand for a high-quality young workforce.

### **2.3. The reality of applying 5E and STEM teaching in developing students' representation competency**

The research team conducted a quantitative survey using a questionnaire method and a qualitative survey through recorded interviews (12/46 teachers agreed to record, audio recording) in the provinces of Ninh Thuan, Phu Yen, Binh Dinh, and Gia Lai. By employing a stratified random sampling technique, the research team randomly selected 407 students and 46 teachers from middle schools across the four aforementioned provinces. The table describes the survey sample characteristics and survey content, which are presented through the following link: <https://bom.so/o9RRJM>

Survey results show that most teachers have a relatively good understanding of the 5E instructional model and STEM education. They recognize the purposes of these models in teaching natural science subjects. However, the application of these teaching models is not frequent among teachers in Region III (on average once per semester) and is rare for teachers in Region IV (on average once per school year). The reasons cited are the difficulty in designing and organizing lesson plans and the low level of active student participation. Additionally, there is a lack of tools to support STEM education due to insufficient teaching materials that do not meet practical needs. Most of the surveyed teachers are interested in developing representation competency learned to their students but have difficulty choosing the right method.

Most students reported that they have participated in STEM topics within subjects like natural science, technology, and mathematics through experiential and hands-on activities. They express enthusiasm for natural science subjects and feel more motivated to learn when studying STEM-related topics. Male students generally show more interest in technology and technical activities within STEM topics compared to female students, while female students are more interested in researching and seeking information related to practical applications. However, according to students, STEM topics can sometimes be complex and require a significant amount of time for research, exploration, and experimentation.

The current situation highlights the necessity of designing lessons that combine the 5E instructional model and STEM education to develop representation competency, especially during the ongoing challenges in educational programs.

### **2.4. Illustration of the lesson plan**

Building upon the three main content areas of the 'Substance and the Transformation of Matter' topic in Grade 8 natural science, as presented above, the research team has developed a series of lessons that integrate the 5E instructional model and STEM through **Table 6** available via the following link <https://bom.so/4WpoMQ>

Illustration of the lesson plan of “Container for transforming food waste into organic fertilizer”:

+ Duration: Consists of 4 in-class periods and 45 days of at-home implementation.

Below is a summary of the lesson plan that combines the 5E instructional model and STEM, titled "Transforming Excess Food into Organic Fertilizer Bin" (the 8th-grade Natural Science). The plan is designed based on the engineering design process.

- Identifying the STEM topic:

+ Content: The "Chemical Fertilizers" in 8th-grade natural science helps students understand the role, components, and usage of various fertilizers and reduce pollution caused by fertilizers. These are the basic knowledge in life that students need.

+ Real-world Issue: The daily excess food we generate leads to wastage and requires effort for collection and disposal. Additionally, land resources are limited, and the use of chemical fertilizers can harm the soil and reduce arable land.

⇒ Implementing the 5E and STEM approach for the topic of "Transforming Excess Food into Organic Fertilizer Bin" to enable students to apply fertilizer knowledge in building a device that converts excess food into organic fertilizer at home.

STEM Knowledge: Science (S): Influence of nutrients on plant development; Technology (T): Fertilizer production process; Engineering (E): Connect electrical devices; Mathematics (M): Calculating balanced dimensions of the device and its components.

Applying the 5E Instructional Model: E1-Engage: Igniting curiosity and interest in the lesson; E2-Explore: Researching the foundational knowledge of the topic; E3-Explain: Presenting ideas, constructing the product, and explaining the rationale; E4-Elaborate: Creating the organic fertilizer bin; E5-Evaluate: Reflect, discuss, evaluate the cognitive level of learners.

- Learning objectives for the topic:

Natural Science Understanding (NT): Presenting the role and impact of fertilizers on plants and soil.

Investigative Skills (TH): Identifying potential materials for transformation into organic fertilizer, proposing solutions, planning, and executing suitable methods for substance separation.

Representation competency (RC): TP1. Identifying problems and orienting questions using fertilizer-related knowledge and skills; TP2. Planning, proposing, and selecting solutions; carrying out plans, drawing conclusions, and evaluating selected solutions; TP3. Peer assessment, self-assessment, suggesting improvements for STEM products. Displaying appropriate attitudes and behaviors aligned with sustainable development issues.

General Skills: Communication and Collaboration (HT): During discussions and group work; Problem Solving and Creativity (GQ): Selecting suitable solutions for transforming excess food into organic fertilizer.

Characteristics: Honesty (TT): In reporting product outcomes; Responsibility (TN): Being accountable during task execution; Diligence (CC): Being proactive in studying at home and school, determined to complete assigned tasks.

- Establishing Product/Solution Criteria and Guiding Questions: + Criteria: Effective activity, transforming excess food into fertilizer in less time compared to natural decomposition, technically viable, low cost, and creative. + Guiding Questions: How can we efficiently address excess food in households and benefit the environment? Outline the primary steps in organic fertilizer production. How can the decomposition process be facilitated? What are the key tools and equipment for designing a solution in this topic? + Instructional Equipment and Materials: Teacher: PHT 1, 2; Checklists 1, 2, 3; Rubrics 1, 2, 3, 4; Laptop, whiteboard, markers; Videos about organic fertilizer production, videos of similar organic fertilizer bins in the market (<https://bom.so/HKCQvI>). Students: Tools, materials, and resources required for building the STEM product.

- Lesson Organization Process

Activity 1. Engagement (10 minutes)

Objective: Generate interest, identify issues, and stimulate student curiosity (E1) about the topic; NT, TP1, TN.

Content: The necessity of using organic fertilizers for plants and soil.

Outcome: Help students recognize that there are simple ways to create organic fertilizers and that using organic fertilizers brings benefits to the soil and plants.

Implementation: Students watch a video about the benefits of organic fertilizers and their production at the link (<https://youtu.be/YMYVdc-4XLM>). The teacher presents the question: What are the advantages of organic fertilizers compared to other types of fertilizers? In the video, what are the materials used to produce organic fertilizers? How does your family handle leftover food and unused parts (roots, stems) of plants during food preparation? Based on these questions, students provide initial insights and express their personal opinions; The teacher guides students to fill in the missing content using the suggested images in Handout 1; Through student answers, the teacher connects responses to conclude: "Creating a device capable of transforming food waste into fertilizer for plants is necessary".

Assessment method: Based on student responses and the answers in Handout 1.

This activity aims to create students' interest and curiosity in the topic according to E1 of the 5E instructional model. It also helps students develop the ability to ask questions about the topic and enhance TP1 of applying learned knowledge and skills.

Activity 2. Research, Knowledge Exploration, and Solution Proposal

- *Stage 1: Knowledge Systematization (25 minutes)*

Objective: NT, TH, TP1, E2, TN, CC, HT.

Content: Research on various methods of food waste treatment.

Outcome: Mind map summarizing the explored content (using the app Mindomo).

Implementation: The teacher divides students into expert groups and assigns Handout 2. Students work in groups, and after completing Handout 2, they create a mind map.

*\* While students are discussing, the teacher moves around the groups to support and assess using Rubric 1 and the answers to Handout 2.*

- *Stage 2: Synthesis of Background Knowledge (20 minutes)*

Objective: NT, TH, TP1, E2, TN, CC, HT.

Content: Synthesizing necessary background knowledge from researched sources.

Outcome: Presentation content combined with a general mind map (using the app Mindomo).

Implementation: Students work in mosaic groups, and study Handout 3, the group leader assigns presentation content to the "experts," and they create a mind map. After student presentations, the teacher summarizes the content of food waste transformation into fertilizer.

Assessment plan: The teacher evaluates Handout 3. Students peer-evaluate presentations and mind maps using Rubric 2. This activity applies E2 of the 5E instructional model to develop TP2, representation competency.

- *Solution Proposal (15 minutes)*

Objective: NT, TH, TP2, E3, TN, CC.

Content: Proposing solutions to design bins to convert food waste into fertilizer.

Outcome: List of design proposals presented on the Google Doc at <https://bom.so/eBjAhk>

Assessment method: Teacher evaluation using Check Sheet 2. This activity employs E3 in the 5E model to develop TP2, representation competency.

Activity 3. Explanation (45 minutes)

Objective: TH, TP2, E3, GQ, TN, TT, CC.

Content: Proposing suitable solutions, selecting a solution, and planning task assignments.

Outcome: Proposed solutions from student groups; students create a task list, outline the process, and assign tasks.

**Implementation:** - Students observe images/videos of real-life devices that transform food waste into fertilizer (<https://bom.so/BI8Bxx>). After viewing, students discuss to finalize the design solution. The group leader records opinions and synthesizes them. Students discuss to determine the steps for creating the device and assign tasks on the task assignment board. The teacher observes, supports, and guides groups during class discussions

**Assessment method:** The teacher monitors student work through Check Sheet 3, along with observation, support, and guidance during group discussions. Additionally, the teacher uses Rubric 1 to assess group discussions. This activity effectively applies E3 of the 5E instructional model to develop TP2, representation competency.

**Activity 4. Application, Prototyping, Testing, and Evaluation (Homework)**

**Objective:** NT, TP2, E4, TN, TT, CC.

**Content:** Develop the process of operation for the 'food waste transformation into organic fertilizer container' based on the selected equipment plan and proceed with device fabrication.

**Product:** Conceptual diagram (illustrated in Figures 1 and 2 on <https://bom.so/Cp3xa6>) and the actual 'food waste transformation into organic fertilizer container' product.

**Implementation:** Students apply the technical design process to create a STEM product by constructing design drawings, manufacturing, and testing the device at home. Team leaders update progress to teachers via Microsoft Sway using images/videos. Teachers supervise, update, and address students' queries during the research and manufacturing phases.

*\* Product Requirements: (1) Ability to transform food waste into organic fertilizer; (2) Ensure technical safety requirements; (3) Use easily available and cost-effective materials.*

*\* Teacher Observation (through students' progress reports) and student support.*

In this way, through this activity, the competency of TP4 in applying the learned knowledge and skills has been concentrated on development.

**Assessment Method:** Teacher observation (through students' progress reports) and assessment using a rubric; students perform a preliminary self-assessment of their group's product based on the required criteria. Thus, the E4 of the 5E instructional model has been employed to develop TP2 competency of applying learned skills and knowledge in students.

**Activity 5. Evaluation (45 minutes)**

**Objective:** TP3, E5, HT, CC, TT, TN.

**Content:** Students share the results of product fabrication through PowerPoint presentations, group discussions, and refinement of the product.

**Product:** PowerPoint presentation and the "Food Waste Transformation Bin into Organic Fertilizer" project by the group of students.

**Implementation:** Present the achievements of the group of students.

**Evaluation method:** Individual students self-assessed using a scale and Rubric 3, while group members assessed each other using Rubric 4. This allowed for the application of the E5 in the 5E instructional model to the STEM topic.

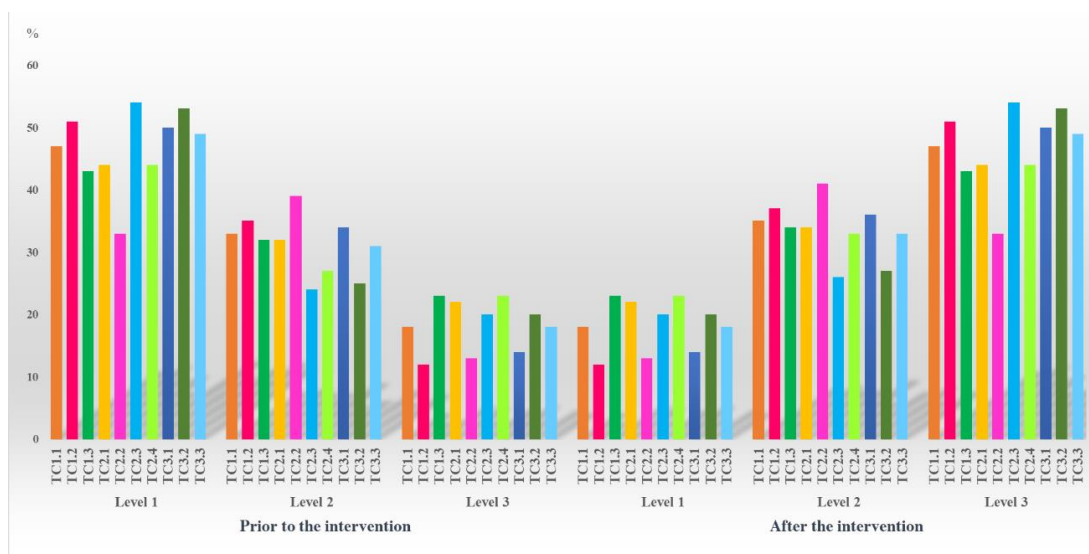
The above teaching plan combining 5E and STEM teaching methods is built to focus on making learners the center of the learning process. At the same time, teaching activities are designed to form and develop the components of representation competency. Additionally, the lessons provided opportunities to cultivate and develop natural scientific cognitive abilities, independent inquiry skills, STEM knowledge, and qualities for the learners.

## 2.5. Pedagogical experiments

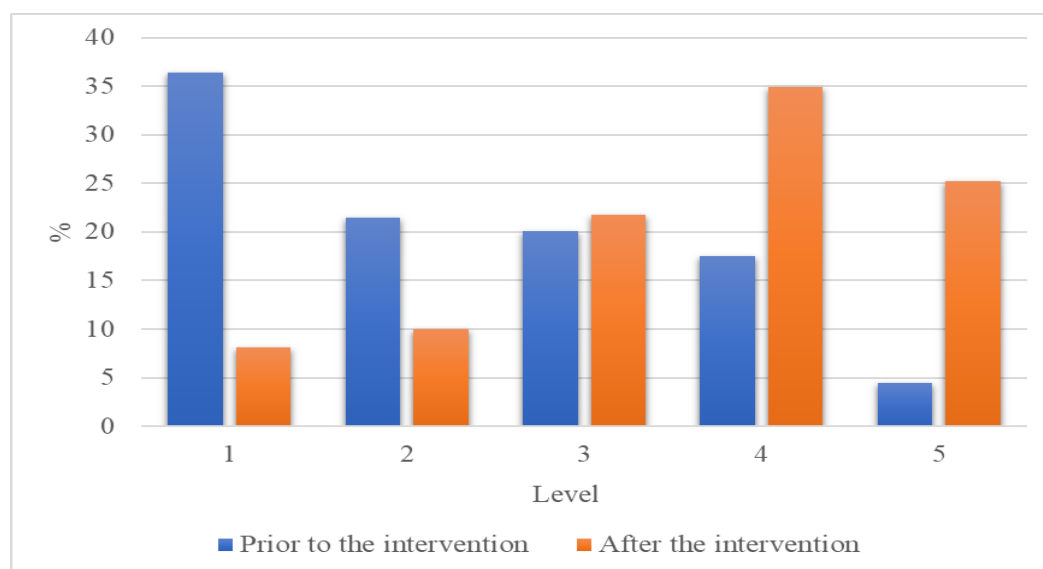
Sampling Method: Randomized Posttest-Only Control Group

Subjects and Location: 8th-grade students at Ly Tu Trong Secondary School, Phan Rang - Thap Cham City, Ninh Thuan Province.

Research Implementation: Randomly divide 60 students into 2 classes marked as the “control group” and the “experimental group”, with the overall scores in the 7th-grade Natural Science subject being 7.76 and 7.64 respectively.



**Figure 1. Assessment results of competency representation competency through assessment sheet 1 and rubric 3 for the 8th-grade students before and after the intervention**



**Figure 2. Results of the scale for assessing critical thinking skills of students before and after the intervention**

**Table 7. Summary Table of Test Results Parameters for the Control Group and the Experimental Group**

Tests	GPA ( $\bar{X}$ )	Variance ( $s^2$ )	Standard deviation (S)	Independent t-test	Impact (ES)
Control group	7,192	1,464	1,21	5,931.10 <sup>-6</sup>	0,95
Treatment group	8,342	0,746	0,864		

From the results of the pedagogical experiment above, we can observe that according to rubric 1 (by teachers) and rubric 3 (by students), the proportion of students reaching level 1 before the intervention is higher than after the intervention, and conversely, the proportion of students reaching level 3 after the intervention is significantly higher than before the intervention. Furthermore, the results of the competency representation competency scale before and after the intervention also indicate a difference in the student's skill levels, demonstrating progress in their competency representation competency. At the same time, the results of regular assessments after the lessons for the two groups show that the average score of the control group is lower than that of the experimental group. Additionally, the dependent t-test indicates statistical significance ( $<0.05$ ), with a large effect size (0.95). Therefore, based on these results, it can be said that the application of the combined 5E and STEM teaching model is effective in developing competency representation competency in learners. Additionally, through observation and evaluation based on assessment sheet 3, the study also recognizes an improvement in the students' qualities".

### 3. Conclusions

Through a survey on the necessity and application of 5E and STEM teaching models in four provinces in Vietnam, along with research on representation competency and the combined application of 5E and STEM teaching models, we have developed an illustrated lesson on the topic of "Substance and the transformation of substance" in grade 8 through content "Chemical fertilizers" to develop representation competency for students. By pedagogical experiments, it has been proven that the connection between the 5E teaching model and STEM in developing the representation competency learned to learners is appropriate and brings the expected results. Research is a source of additional options in terms of teaching methods for teachers. In addition, the combined application of 5E and STEM teaching models is not only encapsulated in natural sciences but also expanded in other subjects to develop comprehensive competencies for learners.

### REFERENCES

- [1] R. W. Bybee et al., 2006. The BSCS 5E instructional model. Origins and effectiveness, Vol. 5, pp. 88-98.
- [2] Ninh Thi Bach Diep, 2020. Developing investigative and exploratory abilities for students through teaching by discovery in the 5E model in the teaching of the "Reproduction" chapter (Biology 11). *Journal of Education*, 20, (special issue 5), pp. 114-119.
- [3] R. Salyani, C. Nurmaliah, and M. Mahidin, 2020. Application of the 5E learning cycle model to overcome misconceptions and increase student learning activities in learning chemical bonding. *Journal of Physics: Conference Series*, Vol. 1460, No. 1.

- [4] W. R. Puspita and F. Fardillah, 2021. The Effectiveness of the Learning Cycle Model (5E and 7E) in Learning to Build Flat Side Sides Viewed From Student Self-Efficacy. *Journal of Physics: Conference Series*, Vol. 1764, No. 1, p. 012110.
- [5] Vu Thi Minh Nguyet, 2016. Applying the 5E teaching model in teaching science through exploratory lesson planning. *Journal of Education*, Vol. 384, No. 2, pp. 60-62.
- [6] Phan Thi Hong The, 2021. Applying the 5E model in the teaching of experiments in natural science in junior high school. *HNUE Journal of Science*, Vol. 66, No. 4G, pp. 171-180.
- [7] G. M. Rayner, T. J. J. o. T. Papakonstantinou, and L. F. G. Employability, 2015. Employer perspectives of the current and future value of STEM graduate skills and attributes: An Australian study. *Journal of Teaching and Learning for Graduate Employability*, Vol. 6, No. 1, pp. 110-115.
- [8] N. Tsybov, 2022. Didactic Peculiarities of the Use of Learning Systems in Technical Universities. *Education and Self Development*, Vol. 17, No. 4, pp. 267-287.
- [9] O. O. Martynenko, O. V. Pashanova, A. V. Korzhuev, A. I. Prokopyev, N. L. Sokolova, and E. G. Sokolova, 2023. Exploring attitudes towards STEM education: A global analysis of university, middle school, and elementary school perspectives. *Eurasia Journal of Mathematics, Science and Technology Education*, Vol. 19, No. 3.
- [10] Nguyen Lan Phuong, Le Thi Thu Hien, Nguyen Quang Linh, Trinh Thi Phuong Thao, Pham Hong Hanh, Nguyen Truong Giang and Vu Thi Thuy, 2023. Implementation of STEM education: A bibliometrics analysis from case study research in Scopus database. *Eurasia Journal of Mathematics, Science and Technology Education*, Vol. 19, No. 6.
- [11] Ministry of Education and Training, 2018. General Education Program - Natural Science Program (issued together with Circular No. 32/2018/TT-BGDĐT dated December 26, 2018, by the Minister of Education and Training).
- [12] Tran Thai Toan, 2018. Some measures to develop the application of knowledge into practice for students in teaching high school students in general education. *Journal of Education*, No. 440, pp. 44-48.
- [13] Le Thanh Oai and Phan Thi Thanh Hoi, 2019. Using exercises to enhance application skills and learned skills for students in teaching high school students in general education. *Journal of Education*, No. 452, pp. 57-60.
- [14] Cao Cu Giac, Le Danh Binh, and Nguyen Thi Diem Hang, 2019. Developing the natural science competence framework for junior high school students according to PISA assessment. *Journal of Education*, Vol. 463, No. 1, pp. 25-29.
- [15] T. a. V. E. R. C. (TVERC), 2022. Status and Trends of STEM Education in Highly Competitive Countries: Country Reports and International Comparison.
- [16] Ministry of Education and Training, 2020. Official Letter No. 3089/BGDĐT-GDTrH dated August 14, 2020, on implementing STEM education in secondary education.
- [17] Ministry of Education and Training, 2018. General Education Program - Comprehensive Program (issued together with Circular No. 32/2018/TT-BGDĐT dated December 26, 2018, by the Minister of Education and Training).
- [18] Vo Van Duyen Em & Nguyen Quy Bao, 2023. Assessing the process of teaching and learning in the STEM model with the theme of “Substances and Changes in matter” (Grade 6 Natural Science) to develop students' representation competency. *Journal of Education*, 23 (special issue 7), pp. 139-146. Retrieved from <https://tcgd.tapchigiaoduc.edu.vn/index.php/tapchi/article/view/888>.