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Integrating STEM-S and Design Thinking in Primary Science Education: A Lesson Design for Fourth Grade

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ABSTRACT: In the context of global education shifting strongly towards competency development and integrated education, the STEM-S model (Science – Technology – Engineering – Mathematics – Society), combined with design thinking, is being viewed as a potential approach to foster scientific, technical, and creative skills, as well as social responsibility among students. This article presents the process of designing an integrated STEM-S lesson based on the design thinking model. Based on that, a specific lesson plan was developed from the content "Good thermal conductors, poor thermal conductors" in the 4th-grade Science curriculum, with the theme "Keeping Warm – Protecting Health." The results show that the lesson model not only helps students gain a deeper understanding of scientific knowledge but also develops problem-solving skills related to real-life situations, collaboration abilities, and civic awareness. The lesson has a clear structure, is suitable for elementary school teaching conditions, and can be used as reference material in training and professional development for elementary school teachers in line with educational innovation.

KEYWORDS: competency development, design thinking, STEM-S, student, Science, lesson plan

I. INTRODUCTION

In the context of a rapidly changing global education landscape, the development of core competencies and 21st-century skills for students has become the focus of curriculum reform efforts. The increasing demand for a workforce capable of critical thinking, practical problem-solving, and effective collaboration has led to a shift in educational orientation – from content-based teaching to a competency development approach (Voogt & Roblin, 2012). On that basis, STEM education – integrating Science, Technology, Engineering, and Mathematics – has emerged as an effective pedagogical model that promotes interdisciplinary thinking and problem-solving related to real-world applications (English, 2016).

Recently, the integration of social factors into STEM education has led to the development of the STEM-S model (Science – Technology – Engineering – Mathematics – Society). This is a comprehensive approach aimed not only at equipping learners with technical knowledge but also at fostering a sense of social responsibility. STEM-S encourages students to design solutions that are both technically feasible and environmentally sustainable, while also meeting community needs. This approach helps develop scientific thinking linked to civic awareness from an early elementary level (Hwang et al., 2023) (Kreth et al., 2024). This model is particularly suitable for elementary education, where students begin to form attitudes towards science and develop foundational skills for lifelong learning.

An effective approach to implementing STEM-S in elementary classrooms is to use design thinking as a teaching strategy. With a five-step process – empathize, define the problem, ideate, prototype, and test – design thinking provides a specific framework that helps students engage with, explore, and solve real-world problems (Pinasa et al., 2018). When applied to learning activities, this model encourages students to pay attention to user needs, apply scientific knowledge in specific contexts, and develop creative solutions with social responsibility. The intersection of STEM-S education and design thinking opens up great potential for cultivating scientific competence, creativity, and civic spirit in students – starting from their early years (Gözen, 2016).

In Vietnam, the 2018 General Education Program marks an important shift towards a competency-based approach, emphasizing interdisciplinary learning, practical application, and problem-solving (Ministry of Education and Training, 2018). In this context of innovation, teaching science in elementary school is no longer just about imparting knowledge. Instead, teachers are encouraged to create authentic learning experiences that connect scientific content with everyday life and broader social issues. However, the effective implementation of STEM or STEM-S education in elementary schools in Vietnam still faces many challenges, such as limitations in resources, and a scarcity of practical lesson designs that align with learning outcomes and the local context.

This article focuses on designing and implementing a STEM-S oriented learning activity for 4th-grade students, based on the content of the lesson "Good Thermal Conductors, Poor Thermal Conductors" in the Vietnamese elementary science curriculum.

This is a topic that is often taught in a traditional way – conceptually and experimentally – but has great potential to be transformed into a meaningful STEM-S experience. The lesson opens up opportunities to connect knowledge about thermal conductivity with practical challenges in life: keeping food and drinks warm – especially important for students in high mountainous areas or cold regions, where there is a lack of specialized thermal insulation equipment. When scientific content is integrated into a product design task, students not only acquire knowledge but also develop empathy, design thinking, and civic responsibility. The main objective of the research is to explore how to integrate the STEM-S model and design thinking into an elementary science lesson in order to enhance student engagement, promote interdisciplinary thinking, and develop problem-solving skills related to the community.

II. METHODOLOGY

This study is conducted as qualitative research, aiming to design and propose an integrated lesson based on the STEM-S model for elementary school students, drawing on theoretical analysis and Vietnam's current educational program framework. Instead of collecting and analyzing experimental data, the research focuses on synthesizing the theoretical framework, analyzing the content of the curriculum and textbooks, and developing a detailed teaching plan as a pedagogical product that can be applied in practice. This method aligns with the research objective of proposing a model lesson that illustrates an integrated approach to science, technology, engineering, mathematics, and social factors (STEM-S).

III. RESULTS

A. The process of designing STEM-S lessons.

Step 1: Identify the STEM-S theme.

The topic needs to be selected from the current curriculum/textbook, with the potential to connect interdisciplinary knowledge (Science, Technology, Engineering, and Mathematics) and the ability to relate to practical issues in social life. The selection criteria include:

+ Alignment with the goal of developing competencies;
+ Inclusion of elements of exploration and practice;
+ Connection to real-life contexts or the student community;
+ Feasibility in terms of classroom organization.

Step 2: Determine the objectives of the lesson.

The lesson should focus on simultaneously developing the following skill sets:

+ Scientific skills (observation, explanation, reasoning);
+ Problem-solving and engineering thinking skills;
+ Collaboration and presentation skills;
+ Awareness of social responsibility (the "S" factor in STEM-S).

From there, learning objectives are constructed in the form of specific competencies and observable behaviors.

Step 3: Analyzing the classroom context and organizational conditions.

This includes: the number of students, their cognitive levels, available learning resources, allocated duration, teacher capabilities, and classroom space. This analysis helps to determine the appropriate level of integration and implementation methods (such as group teaching, station-based learning, short projects, etc.).

Step 4: Design a learning activity sequence based on design thinking + the 5E Model.

Integrating two models:

+ 5E (Engage – Explore – Explain – Elaborate – Evaluate): Ensures pedagogical logic, moving from elicitation to mastery and application of knowledge.

+ Design Thinking (Empathize – Define – Ideate – Prototype – Test): Linked to the process of solving real-world problems. The sequence of activities needs to be specified at each step: the products students need to create, the role of the teacher, and how students interact.

Step 5: Develop a Diverse Assessment Tool

Not only evaluating the results but also assessing the process of competency development. This includes:

+ Evaluation criteria table for products (rubric);
+ Observation sheets;
+ Self-assessment questions;
+ Peer reviews.

B. Illustrative example.

Based on the five-step process mentioned above, the research team has developed a STEM-S lesson plan with the theme "Keeping Warm – Protecting Health", derived from the lesson "Good Heat Conductors, Poor Heat Conductors" (4th-Grade Science Textbook).

STEM-S Theme: "Keeping Warm – Protecting Health" (4th Grade Science).

I. Lesson Objectives

After completing the lesson, students will be able to:

* Regarding natural science skills:

Identify good thermal conductors (metals, etc.) and poor thermal conductors (wood, plastic, wool, foam, air, etc.).

Explain why it is necessary to use poor thermal conductors to retain heat (thermos bottles, warm clothing, bedding insulation, insulated roofs, etc.).

State the applications of heat retention / heat resistance in family and community life.

Conduct a simple experiment to compare heat transfer between different materials.

Apply the engineering design process to create a model of a thermal insulation box/wrap for a hot cup of water.

* About general abilities

Team collaboration, presenting ideas and products.

* About qualities

Concern for personal health, family, and the people in cold regions.

Awareness of energy conservation (maintaining heat well → reducing the need for reheating multiple times).

Cooperation, sharing, and responsible behavior towards the living environment.

II. Teaching Materials

* Teacher: hot water, metal spoon, plastic/wooden spoon; materials: foam, cloth, newspaper, cardboard, fabric scraps, rubber bands, scissors, tape; thermometer (if available) or use hot-cold perception; worksheets, design sheets, product evaluation criteria chart.

* Students: Prepare some thermal insulation materials from home as suggested by the teacher; notebook, colored pens, safety scissors.

III. Teaching activities

Teacher's activities	**Student's activities**
STEP 1. ENGAGE – EMPATHIZE	
- Show images of highland farmers eating cold food and drinking cold water in the winter while working in the fields. - Raise the question: "What do you feel when you see people having to use cold food/drinks in the winter?"	- Observe the images - Share feelings and personal experiences about eating cold food or drinking cold water in winter.
STEP 2. EXPLORE	
- The teacher distributes the experiment tools to the students: metal spoon, plastic/wooden spoon, hot water cup. - Guide the students on how to conduct the experiment to determine which material conducts heat well and which does not. - Ask the students to identify: which spoon handle is colder/hotter? Why? - The teacher concludes: Poor thermal conductors are materials that transfer heat slowly. They prevent heat from moving quickly from one place to another. Examples include wool, cotton, foam, plastic, wood, and air. Good thermal conductors are materials that can transfer heat quickly from areas of high temperature to areas of low temperature.	- Conduct a group experiment: place a metal spoon and a plastic spoon into a cup of hot water. Touch the handle of the spoon and feel the heat. - Report the group's results. - Record on the learning sheet: which material conducts heat well/poorly. For example: Good heat conductors: metals (silver, copper, aluminum, iron, etc.); Poor heat conductors: wood, plastic, wool, cotton, foam, air, etc.
STEP 3. EXPLAIN – DEFINE	
- The teacher asks the question: "How can we keep food warm for a long time in winter?" - Students are required to create some specific heat-retaining products. - Introduce the design criteria: keep warm for a long time, easy to make, safe, and use recycled materials.	- Student: To keep food and drinks warm, it is necessary to minimize heat loss to the environment by using insulating materials to wrap or protect them.

- Distribute design orientation sheets.	- Group discussion: + Who are the users? + What are their needs? + What conditions and materials are available? - Write down the group's ideas on a sheet.
STEP 4. ELABORATE – IDEATE / PROTOTYPE	
- Assign the task: create a thermal insulation product. - Remind the evaluation criteria (rubric): thermal insulation effectiveness, creativity, ease of use, social significance. - Observe and support groups that encounter difficulties. - Take photos to document the product.	- Students choose the product to design. - Sketch the model. - Divide the tasks: one person cuts the cardboard, another glues the fabric, another wraps the insulation layer, etc. - Finalize the product.
STEP 5. EVALUATE – TEST	
- Request students to present their products. - Suggested presentation: reasons for choosing materials, methods used, results of thermal insulation. - Guide feedback and peer evaluation among groups.	- Students report the results of their products. - Observe, reflect, and record data. - Appoint a group representative to present the product. - Evaluate peer groups using a form.

IV. DISCUSSION

The research results show that designing lessons according to the STEM-S model, combined with design thinking, not only contributes to innovating the organization of Science teaching in elementary schools but also opens up an effective approach to developing students' comprehensive abilities. Organizing teaching according to the 5E cycle and the design thinking process allows students to fully experience the constructivist learning process – from approaching real-world problems to exploring scientific knowledge, applying it in product design, and reflecting on society.

One of the important theoretical contributions of the research is to clarify how to transform a traditional science lesson – which focuses on basic concepts and experiments – into an integrated learning activity aimed at solving practical problems with social value. This is clearly demonstrated in the way students not only learn about thermal conductors but are also placed in meaningful situations: designing a thermal insulation product to support the health and well-being of themselves, their families, or their communities. In this way, the lesson demonstrates that the STEM-S model – with the "S" element emphasizing social responsibility – can be implemented within the elementary school curriculum, aligning with the cognitive characteristics and organizational conditions of general classrooms.

In the context of the 2018 General Education Curriculum shifting significantly towards integrated teaching and competency development, the demand from teachers for specific, feasible, and effective lesson models is very high. This study has provided a detailed example that is well-structured and readily applicable in the teaching of Science in the 4th grade. By using simple materials, an appropriate amount of time, and a variety of activities, the lesson is not only easy to implement in a regular classroom but can also be used as training material for teachers or education students. In particular, the lesson not only focuses on teaching scientific knowledge but also creates opportunities for students to develop technical thinking skills, collaboration, creativity, and civic awareness – essential competencies for the 21st century. This aligns with the direction of many countries in enhancing the quality of science education at the elementary level through integrated approaches such as STEM or STEAM (Schweingruber et al., 2014). A notable feature in the lesson design is the integration of social education elements within the content of the Science subject. Through the “empathy” step in the design thinking process, students are encouraged to become aware of the living conditions of others, thereby developing the ability to think from a community perspective, not just from personal interests. This is a valuable opportunity to integrate moral education, civic awareness, and social responsibility into the teaching of science – something that modern education programs are increasingly promoting (Lee et al., 2020).

However, the research also has some limitations that need to be viewed objectively. First, the study primarily focuses on lesson design and does not include experimental implementation or large-scale evaluation of its effectiveness. Second, the implementation of the STEM-S model requires teachers to have the ability to organize integrated activities, the capacity to connect interdisciplinary knowledge, and the skills to guide students in designing and evaluating products – skills that not all elementary school teachers are currently fully equipped with.

V. CONCLUSIONS

This study has proposed an integrated, STEM-S-oriented primary science lesson model that combines design thinking to enhance instructional effectiveness and develop students' scientific, technical, creative skills, and social responsibility. By applying the 5E cycle interwoven with the steps of design thinking, the lesson not only helps students actively acquire knowledge but also creates opportunities for them to apply that knowledge to solve practical, relatable problems. The results of the lesson development

show that transforming textbook content into tasks for designing socially relevant products not only increases student engagement but also expands educational goals beyond scientific knowledge to include civic qualities and competencies. The lesson model is built on a solid theoretical foundation, aligned with the orientation of the 2018 General Education Program, feasible under practical teaching conditions, and can be used as reference material for teachers or education students. However, to confirm its comprehensive impact, further research is needed on a larger experimental scale and in more diverse contexts. Training teachers in organizing integrated instruction and applying design thinking is also a key factor for the STEM-S model to be truly effective in elementary education.

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