Designing “Saving Pig” STEM activity for Vietnamese primary schools

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Abstract. The paper presents teachers’ STEM education skills as well as teachers’ and students’ awareness of STEM education at primary schools. The research has concentrated on investigating the potentials of STEM education and integration approach in teaching mathematics at primary schools. We also designed and organized “Saving Pig” STEM activities that integrated knowledge of mathematics, sciences, technology, and other social science subjects. The research results have shown that the STEM approach is appropriated for primary education. Our teaching strategies have also contributed to develop teachers’ STEM education skills and raised students’ interest in learning.

1. Introduction

STEM is important because it is around our lives. STEM stands for Science, Technology, Engineering, and Mathematics. STEM education is essentially understood as equipping learners with the necessary knowledge and skills related to the fields of science, technology, engineering, and mathematics [3], [4], [9]. This knowledge and skills (called STEM skills) must be integrated and complementary in the classroom to help students not only understand the principles but also apply knowledge into practice and create new products in everyday life.

The global urgency to improve education from a STEM perspective can be affected by environmental and social impacts. The 21st century illustrates the complexities of a global society, and educators must help students prepare for change to face these challenges. This is considered as a breakthrough educational reform of the United States to firmly establish the position of the world’s leading economy, science, and technology with a high-quality labor force of STEM field [10]. Besides, it continues to increase the influence of the United States on the world through inventions. So far, many countries have pursued the STEM education program because they realize that it is the right way and indispensable in the context of economic competition among countries around the world.

STEM education is an important solution in the fundamental renovation of Vietnamese education in the direction of capacity development in learners to meet the requirements of modern society. To build that human resource, education needs to prepare a proficient force in the fields of science, technology, engineering, etc [4], [9]. Therefore, in the process of extensive international integration, opportunities access to new trends, new educational models, and the experience of countries with advanced education are needed to fundamentally change general education in Vietnam.

Science has grown rapidly since the 18th century, the humans know how to replace human/animal labor with machines and produce more, how water and wind power have can be converted into electricity, we can share our knowledge with many people by using communications technology and equipment. Almost every field benefits from science. All of this is part of everyday life, every second counts by science [7], [11]. Scientific skills are needed, in which students are equipped with the knowledge of the concepts, principles, laws, and theoretical foundations of scientific education.
Through scientific education, students can connect this knowledge and at the same time be practiced and trained to use that knowledge in practice to solve real problems.

Technology makes our lives multi-dimensional, making the world a “global community”. Communicating with a remote person within seconds, making a trip around the world in cyberspace, all of this is possible with advanced technology. Technology is making multitasking functions available in a device. Technology can be seen from everyday items like conical hats, pencils to complex systems of use such as the internet, national electricity network, satellites. All of the changes of the natural world that serve the needs of people are being applied by technology a lot [9], [10], [11]. Technology helps solve problems more effectively through the application of theories and principles of science, technology, and mathematics to research and develop solutions to solve problems. The life sciences and engineering fields are often separated by great distances. But now, the growing interest from both fields together addresses the common challenges that contribute to the creation of a new scientific and technological era. Students need technical skills to solve real-world problems, by designing objects, systems, and building production processes to create objects. Students equipped with technical skills can produce an object and understand the process to make it. Students must be able to analyze, synthesize and combine to know how to balance-related factors (such as science, art, technology, engineering) to get the best solution in designing and building processes. Besides, students also can recognize the needs and responses of society in technical issues.

Mathematics is the science of law and relationships [1], [3]. Mathematics provides a precise language for technology, science, and engineering. Technology development, such as computer technology, is also very helpful for mathematics, as well as the development of mathematics that often creates innovations in technology [8], [9], [10]. Mathematics skills are the ability to recognize and grasp the role of mathematics in all aspects of the world. Students with mathematical skills will be able to express ideas correctly, able to apply mathematical concepts and skills to everyday life [5].

STEM is understood as the combination of four disciplines of science, technology, engineering, and mathematics into a new subject, where learners have the opportunity to reach out to the world in many ways rather than just being taught individually separate knowledge and practice about it. By allowing students to explore related STEM concepts, they will develop a passion for students and hope to pursue a job in a STEM field. A STEM-based curriculum with real-world situations to help students learn. This program combines multiple classes to provide the opportunity to see how life-related concepts are, through the program to inspire passion for future careers in an area. STEM activities provide hands-on and thinking lessons for students and make mathematics fun and interesting helps students do more than just study [9], [10], [11]. Today science and technology are becoming more important as we face the benefits and challenges of both the globalized economy and the knowledge economy. To succeed in the future, students need to develop their competencies in STEM fields to a level that exceeds what is considered acceptable at present. However, relevant fields in STEM education do not just appear when teachers teach in the classroom, but they are everywhere. Some activities show the practical meaning of STEM that can combine the ideas presented in schools and help them express the benefits of our society and the world [5], [6].

2. STEM education at the primary schools

The key to preparing primary teachers for STEM education is to start by building a conceptual understanding of STEM education by teaching key learning theories, pedagogical and advanced methods. Through numerous studies, we have found that high-quality STEM education programs must include: integrating technology and engineering into scientific and mathematical theory; promote scientific research and technical design, including mathematics and scientific instruction; collaborative approach to learning, connecting students and teachers with STEM fields and professionals; incorporate strategies such as project-based learning, providing formal and informal learning experiences; incorporate appropriate technologies to enhance learning; finally, more research and discussion on STEM education is needed so that primary teachers can implement effective teaching methods.

Through conducting a survey, we classified primary teachers’ qualifications into four levels: (i) try some small science experiments for students; (ii) take part in a science project that attracts teachers
and students to work together; (iii) build a club-like STEM class with regular scientific activities; (iv) teachers in different subjects write the curriculum for each subject so students can experience STEM in any subject. Effective teaching requires good content knowledge so that teachers can highlight the link between subjects. However, teachers are not experts in all subjects. Instead, teachers can identify knowledge constraints related to their content and overcome this limitation by teachers/content experts or resources. In this way, teachers can gain expertise in some aspects of the content but need to collaborate with others in areas where they do not have a solid qualification.

Teachers at primary schools are also promoting the STEM education movement by activities such as clubs, festivals, STEM ambassadors, days of visiting laboratories, factories,... teachers do not carry out the whole of the STEM education process. Parents must also encourage their children to pursue STEM activities and to raise awareness and interest at home and in extracurricular activities on the achievement of STEM education. The factor that teachers need to consider when using the STEM approach is a matter of factual context, meaning it relates to the student’s life, community, or culture. In this way, we see STEM teachers as effective as those who can use students’ problem-solving skills and exploratory nature by providing them with opportunities to solve problems. In Vietnam, many organizations and individuals are participating in STEM education and gradually investing in facilities for STEM education, but the process is slow with STEM education in developed countries [1], [3].

STEM education in primary schools is important to stimulate the pursuit of discovery ideas in students. The reality is that Vietnam’s primary education has a rigid, inflexible program structure with programs, requirements, content standards, and year-end exams. If these barriers remain in education in Vietnam, they may limit the successful implementation of STEM education. The STEM approach will inspire and stimulate students’ curiosities and discoveries, putting students to think like scientists about real-life issues. Developing STEM education will help create a generation of good, creative, and curious researchers who can contribute to building a prosperous country in the future. The proposed measures are based on the current situation of STEM educational activities at primary schools, which are aimed at overcoming the weaknesses in the current STEM education. As a result, creating a premise for the successful implementation of educational activities in the schools.

From the primary teacher survey, the research has shown that 44.1% of teachers would love to learn about STEM, 16.9% of teachers are already learning about STEM and only 1.7% are conducting research about STEM. These are important foundations for making teaching proposals STEM-oriented mathematics teaching at schools. Some of the benefits we can mention are when applying the STEM educational perspective to teaching: forming and developing students’ competencies; equipping students with the knowledge, conceptual understanding, thinking skills through experience of STEM educational content; contributing to forming a passion for science and career orientation for students; helping students apply knowledge in the areas of science, technology, engineering and mathematics to the real-life; contributing to creating new knowledge for students themselves; discovering and fostering talents in the fields of STEM; promoting the creative potential in many different areas of the student; contributing to building a quality future human resource, meeting the professional supply related to STEM field; enhancing teachers’ understanding of STEM knowledge content, as well as STEM teaching strategies [7], [9].

3. Designing “Saving Pig” STEM activity

3.1. Purpose of teaching STEM-oriented mathematics

Through teachers’ interviews, we have summarised that teaching STEM-oriented mathematics at primary schools aims to forming and developing students’ competencies and qualities under the new general education orientation; equipping students with knowledge, understanding, thinking skills through content of STEM education; helping students apply their knowledge in the areas of science, technology, engineering and mathematics to real-life; fostering and discovering, creating conditions and promoting creative potentials in various fields of students; building human resources for career orientation related to STEM field in the future; creating opportunities for students from disadvantaged areas to show their abilities in the fields of science and technology; creating new knowledge for students; establishing qualities of love, self-control, and responsibility in students.
3.2 The process of developing STEM educational topics in mathematics

**Step 1: Select specific content in mathematics**

The specific content of the mathematics was chosen for STEM-oriented teaching can be a text, a topic, or a section. This selection ensures that the knowledge will be applied to solve the practical problems of STEM education.

**Step 2: Connect the application in practice**

With the selected content, teachers consider the knowledge from that content has been applied in practice and the application of that knowledge in real life. How was that knowledge applied? This is an important practical basis for developing STEM education topics.

**Step 3: Analysis and application**

When connecting the application in practice, teachers conduct analysis and application to learn the processes, stages, and knowledge used to create the application/product. On that basis for teachers to build learning activities and tasks in the topic that ensure fit with students. Identify the challenges students will have to address.

**Step 4: Identify relevant knowledge in the field of STEM**

The teacher considers what knowledge contributes to creating applications with STEM subjects. Providing relevant knowledge using STEM is the basis for selecting the right knowledge for the student’s study program.

**Step 5: Form the topic**

Topic structure includes: topic name (a product-oriented activity); goals or objectives (based on the standard of knowledge and skills of the subject); content of topic (general description of knowledge in STEM fields, the knowledge that students will apply or be formed in solving the tasks of STEM topic); the competencies that need to be formed and developed (problem-solving capacity, creative ability, cooperation ability, communication capacity).

Example: Designing “Saving Pig” from plastic bottles.

**Part 1: Required purpose**

We see that the number of plastic bottles used in modern life is increasing, from spring water, soft drinks, bottles of cooking oil, milk cartons ... After use, we can do it. What about those bottles? We put it in the trash, or we can keep it to store water or other food. And almost everyone has a small amount of savings for themselves, so instead of buying a traditional piggy bank, why do not we make a showy pig with our personality? Recycling these old plastic bottles is not only a way to protect the environment but also a way to save yourself and your family. But this amount of recycling is not much. STEM teaching topic with the theme “Design of saving pig from plastic bottles” is set for the purpose like: (i) students recognize the important role of recycling plastic products for life; (ii) students apply the knowledge they have learned from subjects such as mathematics, science, engineering, fine arts, etc. to make some applied products from plastic bottles in life such as: real trays products, pen boxes, toys for children.

To complete a “Saving Pig” product, students need to use the knowledge of the following subjects:

* Science subject (5th grade): Provide students with knowledge about some environmental protection measures. The main material is plastic bottles, combined with other materials and with different techniques have created products with many applications such as food trays, toys, pen boxes, etc.

* Handcrafting subject (3rd grade): Some techniques of paper folding, manual collage, etc. are needed in manufacturing. Ensuring the practicality, manufactured products that can be used in life.

* Mathematics (5th grade): Provide knowledge about cylinders and spheres, technical drawing, folding, cutting pictures in mathematics.

* Arts: Ensuring aesthetics.

**Part 2: Teaching process**

*Activity 1: Identify a real-world problem*

Objectives: Students will learn about the important role of recycling products from plastic bottles in life. Students apply the knowledge of science subjects learned in the school to make appliances used in life, minimize waste to the environment.
Teachers will create interest in exploration, passion, and creativity to explore and discover new and innovative models, tools, and everyday items that can be replaced by recycled products from plastic bottles, to contribute part of environmental protection, community health protection. From the practical application of plastic bottles in life, students have a passion for creativity with the art to make many useful products.

Groups of students report research using specific photos or videos. Teachers provide students or students with self-study in books, newspapers, mass media. On that basis, it is proposed to make a product “Saving Pig”.

**Activity 2: Background theory research**

Objectives: From the main materials are plastic bottles, students will learn to combine with other materials and with different techniques, create many products with applications such as food trays, containers, pens, toys for children. Students are actively learned knowledge about science, mathematics, fine arts,... and developed their self-study, creative, and teamwork skills.

Teachers organize group activities for students to discuss knowledge and skills related to the process of product selection and manufacturing by answering the following questions: Please list the role of plastic bottles in daily life? What are the ideas to implement your team’s product? What materials and tools will you choose to make your group’s product? Discuss and comment on formulating evaluation criteria for the product “Saving Pig”.

Students are expected to complete the study survey of knowledge related to the topic. Teachers develop an evaluation criteria table for student products. Students discuss in groups to answer the questions. Teachers provide support when children encounter difficulties and organize for groups to report the results of the discussion via learning cards. Students comment, evaluate about the topic, and then teachers introduce new knowledge.

**Activity 3: Proposing implementation solutions**

Objectives: Ask the group of students to find possible solutions and design an experiment that describes the phenomenon following the group theory they have just learned. Orientation for students after choosing solutions will implement the design process: (i) determining necessary materials, tools, and equipment; (ii) identify details, patterns; (iii) build drawings, complete editing in groups.
Figure 2. Designing process of “Saving Pig”

Teachers help students to discuss in groups to complete the following table:

| Real thing | Created from recycling | Picture, size | Material group choice |
|------------|------------------------|---------------|-----------------------|
|            |                        |               |                       |

Teachers allow students to discuss and finish the board, then organize for students to report the results of the discussion in the group: explain the reason for choosing the products, the drawings are full-sized and the appropriate material selection, how the organization works. After surveying and researching relevant knowledge, students will work in groups to design products based on their ideas.

**Activity 4: Choose the best solution**

Objectives: Help students to analyze proposed solutions and find the best solutions that meet the initial set of target criteria.

Teachers ask students: draw the designs of the group on paper (using an auxiliary board or A3 paper and attach it to the board), list the materials and tools the group chooses to make the product, describe the practical use and meaning of the product.

Then students must analyze the optimization of the products to find the best product to propose performance, then complete the following table:

| Product names selection | Design form and construction process | Materials and essential tools |
|-------------------------|-------------------------------------|-------------------------------|
|                        |                                     |                               |

Students explain why this product is selected for execution. The group of students is expected to agree on the most reasonable solution with explanations attached. They discuss in groups and classify the proposed proposals which show the advantages and disadvantages of each solution. Finally, they choose the most optimal plan to conduct manufacturing.

**Activity 5: Manufacture of prototypes**

Objectives: After selecting the optimal model, students will prepare material conditions such as materials, processing tools, drawings of manufactured products. Teachers also prompt safety rules when making products.

Students: Discuss with teachers about how to do their group; assign work to members, collect necessary materials and tools; perform calculations to demonstrate practical and aesthetic practices; log activities (who does what, at what time, what difficulties, etc.), take pictures of workgroups (if possible); displaying products; write a description of what the product means.

Students are expected to complete products “Saving Pig” ensuring the criteria set out initially and a description of the meaning of the product. They assign jobs, collect necessary materials, and process products in groups.
Activity 6: Testing and evaluation

Objectives: Ask students to organize an activity to re-evaluate the group’s entire product, including manufactured products and the effectiveness of the original problem-solving solution.

Students present products and conduct the product testing in class. Teachers organize for cross-evaluation groups. An evaluation of the student team’s product according to the criteria on the table, activity log, and product presentation.

Teachers organize for students to present the meaning of the product and cross-evaluation discussion groups. The team leader reports the evaluation results.

Activity 7: Sharing and discussion

Objectives: The group of students is introduced to their products in the class, discussing the content of knowledge, case-handling situations, thereby perfecting their products.

Students are presenting their recycled products that can be optimized for this solution, introducing the teamwork process and sharing advantages as well as difficulties when making products.

![“Saving Pig” products](image)

After introducing the products, students discuss in groups, cross-comment, ask questions and criticize their ideas. The following product criteria table “Saving Pig” is given:

| Criteria   | Need to adjust (0-4 points) | Medium (4-6 points) | Rather (6-8 points) | Good (8-10 points) | Point evaluation                           |
|------------|-----------------------------|---------------------|---------------------|-------------------|-------------------------------------------|
| Form       | The product size is large, some arrangement details are not suitable | Some details in the product are not rational | Products are compact, but some small details are not reasonable | Compact product, designed to arrange the appropriate details, ensuring aesthetics | Short processing time, beautiful products, ensuring the technical requirements |
| Time       | It takes a long time to process products, does not meet the technical requirements | It takes time to process products, the technical requirements are relatively guaranteed | Processing time is relatively guaranteed, beautiful products | | |
| Materials  | Materials are expensive, not reasonable, some materials | Materials are relatively reasonable in price and quality | Using many simple materials, saving costs | All materials used are cheap, easy to find, safe, and | |
Activity 8: Modify the model

Objectives: Students evaluate the products of other groups and listen to the teacher’s comments. Teachers create an activity to develop students’ critical and creative thinking.

Teachers analyze the design of the groups to find the group with the most optimal products and draw experience for the groups. If the group changes the design, what factors will change to make the model of the group better? Teachers point out factors that should change in design to be more suitable in reality.

Students are in groups in the class: ask the teachers in charge of subjects such as science, fine arts to advise (if necessary). The groups self-adjust their products so that the products are of the best quality.

4. Conclusion

Mathematical knowledge in primary schools comes from real practices and practical services. Many researchers have shown that students be involved in mathematics classes if they work in the environment learning focuses on real-life exploration. Students explore and solve mathematical situations through activities, games, projects with mathematical applications. They have to ask questions, collect data, and conduct research. The study has shown that the ability to apply STEM education in teaching mathematics in elementary schools is feasible, suitable for teaching conditions in some primary schools in Vietnam. STEM activities contribute to the development of mathematical skills for students and help relate theoretical knowledge in school with real-life around children. The process consists of eight activities with STEM that are suitable for teaching in schools, the research results also show that students are very interested in the lessons with STEM topics, practice designing and report the design products of the group, thereby helping the children understand the knowledge they learned at schools more deeply and more meaningful.
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