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Apply mathematical modeling in steam education at high schools

Abstract

In mathematics instruction, mathematical models are one of the powerful tools for promoting effective learning. However, it must be used properly. Teachers need to use mathematical models as part of their teaching methods.STEAM education represents a paradigm shift from a traditional education based on standardized test scores to modern ideas that focus on the valuation of learning process. In essence, we allow our students to be wrong, try many ideas, listen to alternative ideas and create a knowledge base that can be applied to real life. In this paper, the researcher studied the application of modeling in STEAM education projects.

Keywords: experience learning, STEAM Education, 21st century skills

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Introduction

The problem-solving experience that students encounter in schools is no longer relevant to today's world. Mathematical Problem- solving relates to the solution to start from a particular situation where the goals and solutions are clearly defined. The most challenging aspects of the problems encountered in many industries today relate to the development of useful ways of mathematical thinking in relation to relationships, models and rules. From the point of view of Lesh&Doer,[1,2] with the increasing importance of mathematics in the global market change, there is greater demand for mathematically capable and technologically innovative workforce. Activities such as: building, describing, explaining, predicting, representing,in addition to quantifying, coordinating and organizing data provide a basis for the development of capabilities.It is increasingly important because the ability to collaborate on multi-dimensional projects, make plan, monitor communication results is essential to success.

STEAM stands for Science (S), Technology (T), Engineering (E), Art (A) and Mathematics (M). STEAM is essentially intended to equip learners with the necessary knowledge and skills related to the fields of science, technology, engineering, art and mathematics. These knowledge and skills must be integrated and complementary to help students not only understand the principles but also be able to practice and create products in daily life.

We state that the introduction of mathematical models and applications in STEAM education in high schools has a positive influence on students' learning, technical skills, mathematical competence, creativity in thought. Therefore, STEAM education should be considered in the teaching of mathematics in high schools.

Research methods

Objectives of the study

This study utilizes mathematical modeling in STEAM education projects for high school students. From there, develop STEAM skills for the students helping to train the high-quality workforce of the 21st century.

Research questions

This study aims to answer the following questions:

a. What is mathematical modeling?

b. How to model mathematics in STEAM education in high schools?

This study was conducted through theoretical and practical studies. Survey on teaching activities of mathematics at Xuan Gianghigh school, Soc Son district, Hanoi city.Interview students and teachers after participating in this STEAM education project.Specifically: survey of 30 students, 6 teachers of mathematics at Xuan Gianghigh school.

Data analysis

The results of the survey were statistically and proportionally evaluated, from which the research team analyzed and made conclusions.

Mathematical modeling

Perspectives on mathematical modeling

According to Maab,[3] modeling is one of a number of fact-based learning activities that involve simplifying a complex real-world situation, creating a mathematical model and explaining the result in that actual situation.Fox (2005), Watters (2006) showed the mathematical model used to explain real-world situations or non-mathematical situations in mathematical formats. For example, charts, tables, and equations are used to model and interpret complex relationships between different phenomena.[4,5] Modeling is a cyclical process of creating and modifying empirical case models to understand them better and improve decisions. The role of modeling and teaching mathematical models in school mathematics has received attention as a matter of creating authentic learning and revealing the ways of thinking that produce it.[6,7] The distinction between the model and the world is not merely a matter of identifying symbols.The process of modeling from the real world is an interesting task because this

process is intended to solve problems arising in life, modelers need to mobilize their knowledge, practical experience and human knowledge. Models often involve a lot of repetitions in a cycle as in the following diagrams I mentioned, different stages of the pattern cycle appear to be connected to one another, requiring more interaction between small tasks.By looking at the views of Maass,[3–9] I suppose that "modeling is one of the practical learning activities that represent and solve problemsIn real world, students learn to use a variety of representations of mathematics to choose and apply appropriate mathematical methods, tools in solving real world problems".

A number of proposed mathematical modeling

Diagram of Hermann Schichl

The model proposed by Hermann Schichl is described in Figure 1, which is a description of the traditional modeling process, the different stages of the model cycle appearing interconnected, requiring more interaction between small tasks.

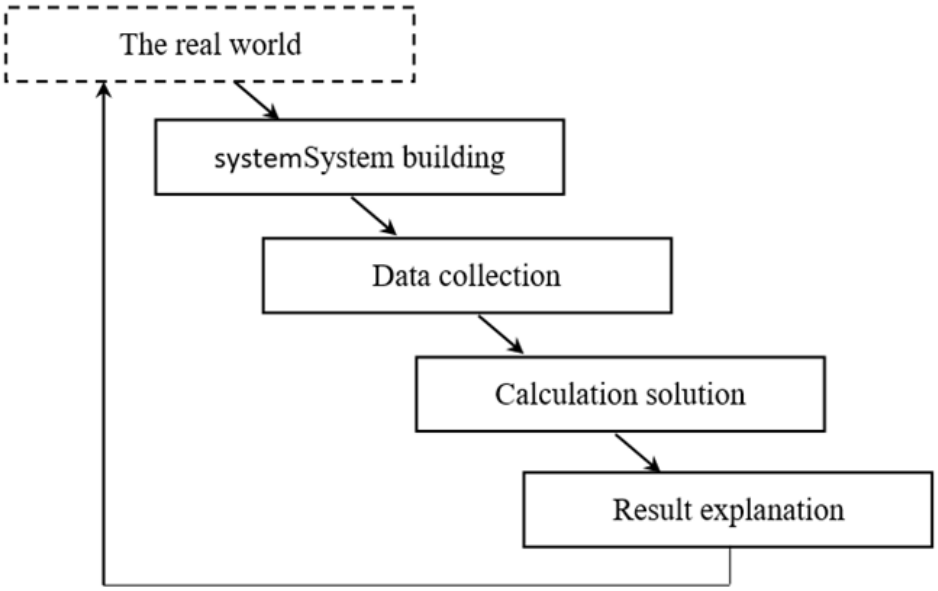

Figure 1 Cycle model (proposed by Hermann Schichl).

Diagram of Mette Sofie Olufsen (2003)

According to Mette Sofie Olufsen (2003), teachers begin with some observations about the real world. The teachers want to make some conclusions, predictions about observed reality. One way to proceed (E) is to conduct some experiments and record the results. Then the teachers will modelin different ways. Firstly, teachers summarize or compile some of the important features of the real world into a mathematical system. Then, by logical reasoning (L) the teacher derives some mathematical conclusions. These conclusions are then explained (I) as predictions about the real world. To be useful, the mathematical system should predict the real world conclusions to be actually observed when appropriate experiments are performed. If the predictions from the model are less similar to what actually happens in the real world, then that model is not the best. Model designers should take into account important features that will not be manipulated in the context of research or other views about the relationship between these features. On the other hand, if there is a good deal between what is observed and what the model predicts, then there are some reasons to believe that the mathematical system does not really grasp the important facets of precision of the actual situation (Figure 2).

Diagram of Bblum

The author proposes the mathematical modeling process

From the review of modeling from the studies of Pollak,[3,4] we have found that each process has its own advantages which are suitable for each teaching context. In the process of conducting model 4 in Vietnam, the author has found that mathematical modeling practice is not much and students need help to get familiar with the steps in the rules to understand and apply the mathematical manipulation on solving the problem of the real world. From there, the author strives to demonstrate the specificity of each step in the process, then summarize a real-world problem to apply mathematical knowledge, mathematical results, the results obtained from the practical, theoretical explanation of the results and the results from the mathematical theory, and finallyto continue to expand the real world problem.We propose a mathematical model for teaching in Vietnam (Figure 3&4). A summary of its meaning is a mathematical conceptual process by which rules and concepts are derived from the use and classification of specific features. It Identifies the variables in the situation and selects the ones that represent the necessary features.

Introduction: From the practical problems need to be solved, the student understands the relationship between the objects in the problem, the information and the nature of the objects. From there, the systematized mathematical knowledge needs to be used, transforming the practical problem into a problem to be solved.

Apply mathematical knowledge: Students build effective links between mathematical knowledge that is used to solve problems (this problem is transformed from a practical problem). By analyzing the relevant mathematical framework, activities on the mathematical relationship will be implemented to draw conclusions; If the implementation can not be completed, then modify the selection of variables used to build the model. From that, we have a mathematical conclusion.These conclusions are then explained for better understanding the result of the problem; results from experiments of reality (1).

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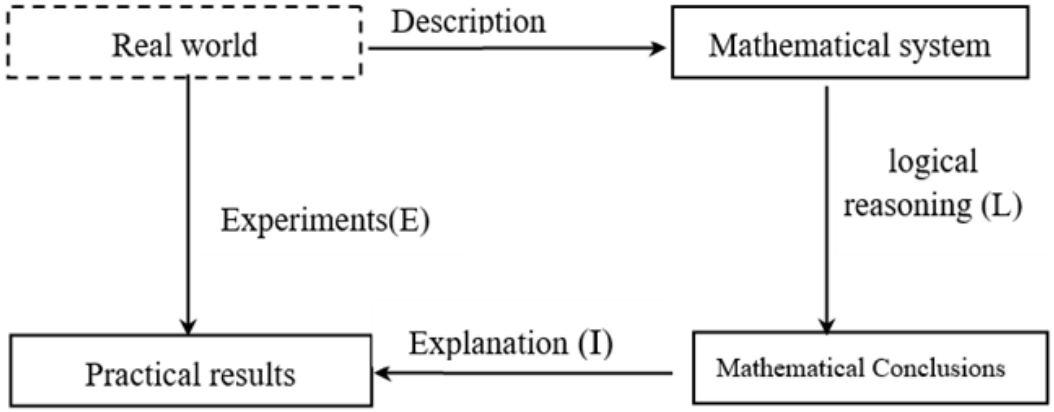

Figure 2 Model (proposed by Mette Sofie Olufsen).

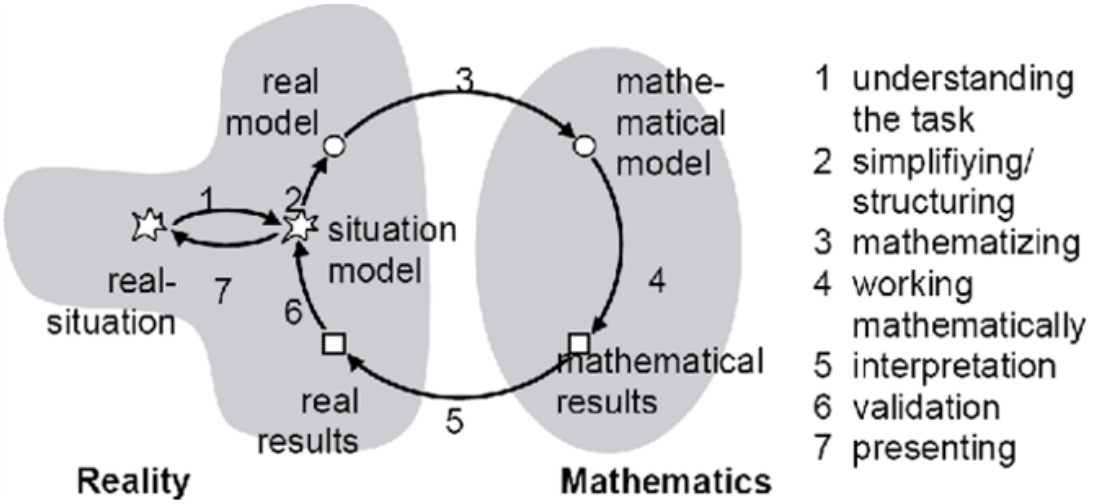

Figure 3 Blum's Model.

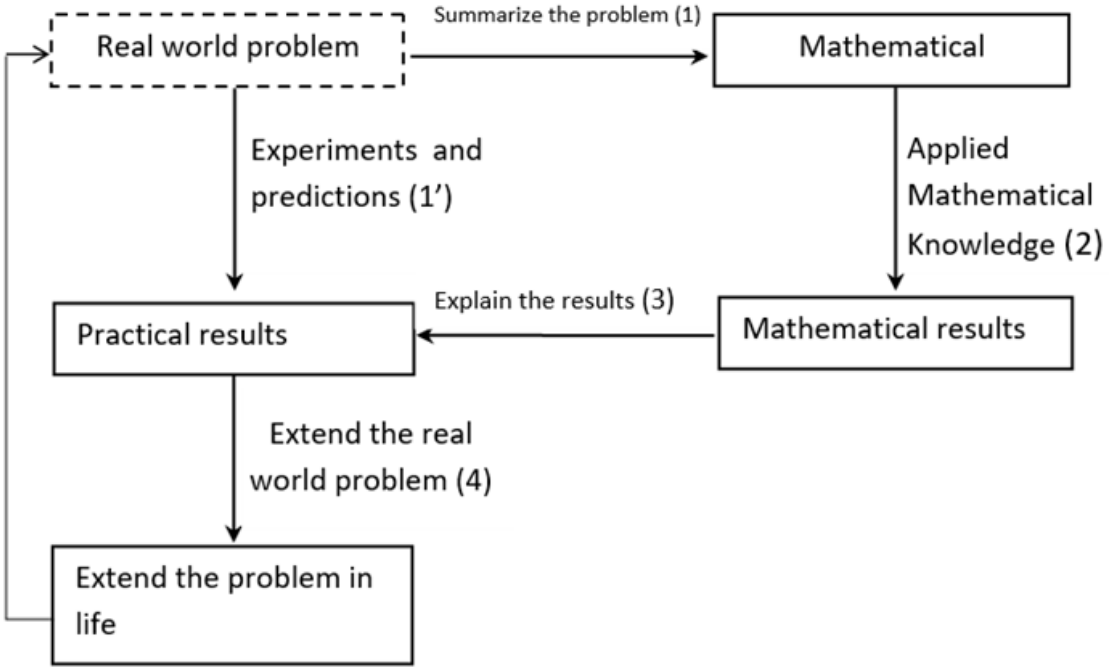

Figure 4 Cycle Model.

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Expanding the real world: Addressing real world issues can make the issue more sustainable and meaningful for students. Practical examples provide specific applications for mathematical knowledge and skills learned in the classroom that relate to students themselves and society. Practical examples also encourage students to be aware of the choices they make and how they fit into a larger social context. Real world examples prove the complication and unpredictability of real problems, and as such, can stimulate critical thinking. They also emphasized the need for an interactive and multidisciplinary approach to problem solving. Moreover, using examples from the real world proves that sometimes there is no perfect solution to a given problem. However, students still think about solutions, instead of just focusing on the problem.

Mathematical modeling in steam education

STEAM education

STEAM is a curriculum based on the idea of equipping learners with knowledge, skills related to fields of science, technology, engineering, art and mathematics according to the interdisciplinary approach, then learners can apply to solve problems in everyday life. Rather than teaching separately four subjects, STEAM combines them into a cohesive learning model based on practical applications.

STEAM education through teaching mathematics is usually approached in terms of exploring practical elements through teaching a number of topics in mathematics or mathematical experiential activity. It aims to develop the capacity of students to become aware of the role of mathematics in the world, to rely on mathematics to make the underlying assumptions that meet the needs of personal life. It is the capacity to analyze, reason and transfer ideas effectively through the design, formation and resolution of mathematical problems in different situations and circumstances. Research on the characteristics of mathematics, many researchers believe that besides abstract logic, mathematics also has practical and universal characteristics. Most of the mathematics knowledge at senior high school is derived from real world. Many researchers have shown that students are really attracted to math lessons if they are working in a learning environment that focuses on mathematical discovery. Mathematical experience is the process of studying, solving mathematical situations through mathematical games, mathematics, and mathematical applications. When taking part in the experience process, students will be attracted by math problems, the game requires the student to ask questions, collect data and conduct research.

Mathematical modeling process in STEAM education

Based on studies of Mette Sofie Olufsen,[2,4] we proposed a mathematical modeling process in STEAM education (Table 1).

Table 1 The steps of the process

Step	Content
Introduction	It is important that students understand the nature of the problem and its related goals.
	Encourage students to solve problems themselves.
Describe the difficulties of real-world problems	Students should be aware of any difficulties that may prevent them from successfully completing the STEAM project. What is the immediate problem?
	Encourage students to report, analyze difficulties. This is an important step.
Propose and implement solutions	After understanding the nature and parameters of a problem, students will need to choose one or more appropriate strategies to implement the project. Students need to understand that they have many available strategies and that there is no strategy to address all STEAM project issues.
A solution test	Test a solution. When working through a strategy or a combination of strategies, it will be very important for students.
	Write accurate and up-to-date logs of group thoughts and activities. Recording collected data, predictions, and used strategies are an important part of the STEAM education process.
	Try to follow a chosen strategy or combination of strategies until it becomes clear that it does not work, it needs to be modified, or it supplies no suitable data. When students become more competent problem solvers, they will feel comfortable refusing strategies they think are not appropriate in the search for solutions.
	Observe carefully the steps. Encourage students to carefully evaluate and monitor their progress, give results.
	Taking time to think about the problem. Scientists rarely come up with solutions when they first approach the problem.
Result evaluation	It is extremely important that students have many opportunities to evaluate their working skills and the solutions they create when using the STEAM skills. Students are often too dependent on teachers to evaluate their performance in the classroom. However, the self-assessment process is not easy. It includes risk acceptance, self-assurance, and a degree of independence. The results also depend on environmental factors, so activities in STEAM education help students have a good connection between theory and practice.
Extend the real world problem	STEAM education can make the problem more sustainable, clearer and meaningful for students. Practical work activities provide specific applications to make mathematical knowledge and skills learned in the classroom be related to the student and society itself.

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Discussion

Describe the steps in the project "Making lanterns"

Introduction

The main task is to build a lantern model, main material is bamboo sticks, or plastic straws (drinking straws). What are the materials needed to build two lanterns model? How much is funding? The system provides lighting for lanterns.

Describe the difficulties of the lantern project

Funding is limited, so the cost of materials needs to be minimal

Estimating materials is difficult (apart from the materials collected, it is not easy to find other materials in the market).It is difficult to assign work because the capacity and skills of each individual are unclear.

Propose and implement solution

Proposals for building lanterns by model, design drawings, application of mathematical knowledge into calculations. Refer to market prices for materials required to purchase: colored paper, glue, LED, AC power to DC.Debate on proposed solutions for solving tasks.

A solution test

Test a seemingly viable solution on the model for specific calculations: product safety, cost of materials acquisition, construction time, formality, durability.

Result evaluation

Evaluate the test results, overcome the limitations of the test solution. Search for a good solution (probably a combination of solutions).Carrying out the project to make lanterns.

Extend the real-world problem

Making lantern is mainly based on the mathematical model, and the mathematical knowledge of the area, finding the optimal solution to use colored paper or art paper for low cost but high aesthetic.If the problem is to design a different lantern model, or decorative painting on the statue, or design the generator model using the form of energy such as wind, water, heat.

Making lanterns for the Mid-Autumn festival

Objectives

a. To reinforce the concept of area of circle, triangle, hexagon, cubic ...

b. To develop imagination of space, aesthetics.

c. To recognize the efficient conversion of electrical energy into light.

d. To design and build models using different materials and to test the functionality of the construction model with the selected materials.

Knowledge link

The project is related to:

a. Mathematic: Learn about units, scales, area formulas, some figures

b. Physical: Relationship between the tension of bamboo sticks, steel rods, plastic rods to the curvature of rods, ...

c. Technique: Assemble the details of the lantern

d. Technology: Using safe, simple materials easy to use, environmentally friendly ...

e. Art: Students need to be creative in every detail to design products that are user-friendly, user- and attract students and users; Experimental design of some sample lanterns

f. Prerequisites:Understanding the relationship between cubes in space, the tolerance of materials.

Resources required

Spreadsheet, bamboo stick, wooden stick, plastic rod, ... computer, scissors, pliers, small steel wire, rubber wire, glue, small wires with two intestines, led or Incandescent type 6V to 12V.

Activity description

Activity 1:

To reinforce the lantern model, students and teachers raise questions, discuss ideas.

Discussion questions

Identify the basic structure of some lanterns?Recommend material to make some parts of lanterns?materials should be easy to find, inexpensive and safe.Outline the design of each model on the drawing.

Notes for teachers: Students are divided into groups and provide relevant links. They can prepare and make frames for lanterns.

Activity 2:

Groups outline models and details on paper, on the floor. Each group is given a work table. Students complete Worksheet 1 and present the results.Students collect data and complete part 2 of the worksheet.

Discussion questions

For models using plastic rods, plastic tubes, we need to note the problems in the design? For models using bamboo sticks, what issues do we need to address in designing, assembling?

Activity 3:

Discuss with students to convert one-way electrical energy to light for lanterns; Uisng colored paper, glossy paper to glue the sides of the lantern and create a beautiful light.

Discussion questions

Design the pattern on the sides of lanterns by combining colored paper or art paper, painting art.

Estimate the amount of art paper, art color paper (can be many different color paper), avoid wasting paper. What is the relationship between the design, animation, color paper, art paper color?

Notes for teachers

In order to save time, teachers can allow students to complete part 2 of the worksheet by using a computer.

Teachers can remind students how to use rulers for measurement.

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Integration and application:

a. Science: Convert electrical energy to light.

b. Technology: Sample design and appropriate material selection.

c. Technique: Making technical products, assemble them into lantern models following the design.

d. Mathematics: Calculate the area of the models in two-dimensional and three-dimensional space; estimate the cost of materials.

e. Art: Remain innovative design, minimal components, aesthetics materials, friendly with the environment, creating the inspiration for the user.

This project product relates mainly to the following general skills:

a. Collaborative skills.

b. Collaboration in groups.

c. Sharing responsibility and understanding the role of each member in building the lantern model.

d. Creation.

e. Improve and refine the design of the lantern.

f. Problem-solving skills.

g. Propose different solutions to increase the aesthetics and ease of making lanterns.

h. Put into trial the different designs of the lantern in order to improve usability, environmentally friendly to user.

i. Try and improve the solution through various experiments.

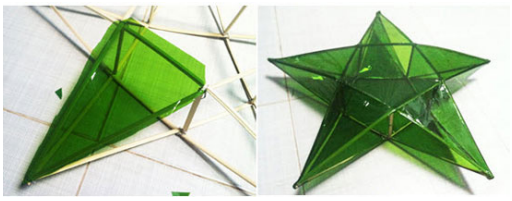
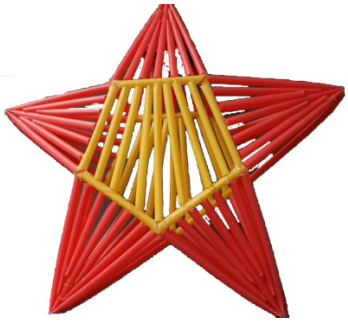
Worksheet

Student activity records of Group A and Group B are as follows:

	Ideas for the model	Drawing
Group A	Model of star-shaped lantern made of bamboo sticks	---
Group B	Model of lantern made of plastic straws	---

One student represents each of the groups describing the drawings, explaining the source of materials and how they are produced.

Student activity records of groupsA, B, and C are as follows:

	Model drawing	Products
Group A	The stars are made of bamboo sticks, pasted with glossy blue paper	
Group B	Lanterns are made of pink and gold yellow plastic straw	 

Explain the results

The survey was conducted at one high school for the purpose of exploring the relevance of the problem-solving learning process through experiential learning.According to our survey results, 26 students (86.6%) are interested in participating, and actively participate in mathematical modeling activities. Thanks to these activities they are active, acting as a researcher, scientist. Through their activities, they understand the mathematical knowledge involved and apply it well to the task of the STEAM education project. Only 4 students (13%) are not really enthusiastic about STEAM education activities. Through this study, we know that these 4 students are very interested in STEAM activities, however, they have visual limitations and personal mobility.

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Five teachers teaching Math, Physics, and Technology (83.3%) supposed that STEAM education through project implementation activities is in line with modern education, let them actively study, find new solutions, create new ones based on the knowledge they have learned in the school and what they have experienced in real life, thereby forming consciousness. quality, skills and capacity for themselves. Only 1older teacher of math (16.6%) think that it is not necessary to have to organize mathematical modeling activities through STEAM education because it takes too much effort and time for preparation. These teachers insist that traditional teaching meets the requirements, students understand the mathematical knowledge that teachers communicate in the classroom. However, they do not address the issue of whether students apply that mathematical knowledge to solving real life tasks.Thus, in general the surveyed educators, math teachers and students found that using mathematical modeling during STEAM education is indispensable. We believe that if the results of this study are applied to teaching in high schools in Vietnam, it will improve the mathematical understanding of students, contribute to improving the quality of education in high schools.

Conclusion

In Vietnam, the concept of mathematical modeling and STEAM education in general schools is practical education activities are carried out in parallel with teaching activities in schools. Through the activities of the STEAM education project, these activities are intended, organized within or outside the school to develop, enhance the quality and potential of the students themselves, encourage students to live independently. Through participation in STEAM education projects, students are given the opportunity to play their subject, dynamic, self-directed and creative role in solving problems. From then on, creating and developing the living values and the necessary capacities for students. STEAM education is part of the teaching process and has an organic relationship with mathematical modeling in which the teacher encourages learners to apply mathematics to solve project tasks, then reflect and revise to enhance understanding, develop skills, shape living values and develop oneself potential, and make positive contributions to the community and society.Survey results show the importance of mathematical modeling in STEAM education. If being applied well, the benefits of teaching Mathematics in high school are great, helping students develop problem solving skills, collaborative skills, the ability to apply mathematical knowledge, experience in solving practical tasks. We believe that the quality of mathematics education in high schools in Vietnam will be improved, meeting the requirements of the society in the fourth revolutionary period.

Acknowledgments

None.

Conflicts of interest

Author declares that there are no conflicts of interest.

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