DESIGNING EXPERIENTIAL-BASED PROCESS OF STEM LEARNING SITUATIONS FOR SOLVING MATH QUESTIONS ON AREA THEME FOR GRADE 5

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Article history

Received: 17/02/2023; Received in revised form: 10/3/2023; Accepted: 13/3/2023

Abstract

The article analyzes the experiential-based process of STEM. Accordingly, some learning situations and activities are introduced so that students could find the minimum area for the constant perimeter rectangles. Upon exploration activities, Scratch software, and the hypothetical garden in the schoolyard, students are deemed to develop their competencies in Mathematics, information, technology, and critical thinking. At the same time, the article also suggests strategies to motivate students to compare the optimality and limitations of square, rectangular and circle categories embracing many practical applications and uses. In this way, students are likely to develop a comprehensive competence.

Keywords: *Area theme, competence, STEM.*

DOI: https://doi.org/10.52714/dthu.12.3.2023.1044

Cite: Phan Thi Hiep. (2023). Designing experiential-based process of STEM learning situations for solving math questions on area theme for grade 5. *Dong Thap University Journal of Science, 12*(3), 38-45.

THIẾT KẾ TÌNH HUỐNG VẬN DỤNG CHỦ ĐỀ DIỆN TÍCH TOÁN LỚP 5 THÔNG QUA GIÁO DỤC STEM THEO HƯỚNG TRẢI NGHIỆM

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Lịch sử bài báo

Ngày nhận: 17/02/2023; Ngày nhận chỉnh sửa: 10/3/2023; Ngày duyệt đăng: 13/3/2023

Tóm tắt

Bài viết phân tích quy trình giáo dục STEM theo hướng trải nghiệm. Từ đó, chúng tôi đưa ra một tình huống tìm cực tiểu diện tích cho lớp các hình chữ nhật có chu vi không đổi. Thông qua các hoạt động khám phá, sử dụng phần mềm Scratch, thực thi khu vườn trên sân trường học. Học sinh sẽ phát triển được năng lực toán học, tin học, kỹ thuật và phản biện. Đồng thời, bài viết còn gợi thêm động cơ cho học sinh so sánh về tính tối ưu và hạn chế của lớp hình vuông, hình chữ nhật và hình tròn. Đây là các đối tượng hình học có nhiều ứng dụng và phổ biến trong cuộc sống. Thông qua đó, học sinh sẽ phát triển được năng lực toàn diện.

Từ khóa: *Chủ đề diện tích, năng lực, STEM.*

1. Introduction

STEM education is an interdisciplinary approach to teaching at least 2 subjects of Science, Technology, Engineering, and Mathematics upwards. Its learning contents are associated with practices, and teaching methods under the action-oriented approach. Thereby, STEM education is a method that equips and develops students' necessary competencies. They are natural inquiry abilities such as the ability to observe, ask questions, gather information, and apply scientific knowledge to interpret and improve reality; modeling capacity, computing power such as mobilizing initial understanding of simple arithmetic, measurement, geometry, and statistics; apply thinking manipulations, calculate, use calculation tools such as gauges; technology and material capacity to design products; collaborative communication skills such as group work, presentations, and debates.

The area theme in 5th-grade Mathematics is associated with some practical problems. Skillfully combining Scratch software, engineering skill, and natural science software, the teacher is able to design situations for teaching topics under STEM education, developing learners' comprehensive capacity.

The article presents the experiential STEM education process, thereby designing a teaching situation using the formula for calculating the area of a rectangle in the area theme 5th-grade Mathematics by the experiential-based process of STEM. This design can be similar to the volume themes, and problems related to quantities.

2. Results

2.1. Proposing the experiential-based STEM educational process

Currently, many authors offer differential design procedures for STEM education themes. For example, according to Nguyen Thanh Nga *et al.* (2017), the criteria for STEM education themes are knowledge in the field of STEM with practical problem-solving, practice orientation, and teamwork. Designing STEM themes consists of 5 steps: Practical problems → STEM topic ideas → Identifying STEM knowledge to be solved → Define STEM topic goals → Build a set of topic-oriented questions STEM. Meanwhile, Le Xuan Quang (2017) suggests 5 steps: Selecting specific content in the subject → Connecting with products and ideas applied in reality → Application analysis → Indicate relevant knowledge in STEM subjects → Form the topic. However, Ministry of Education and Training (2018) proposes 4 steps: Selecting lesson topics → Identifying problems to be solved → Developing criteria for equipment or solutions for the issues → Designing the process of organizing teaching activities.

With the experiential activities, Dinh Kim Thoa *et al.* (2020) offer 5 activities in a plan: exploratory activities → Activities related to contemplation, experience connection → Skills training activities → Application and extension activities → Valuation activities.

For designing and implementing an activity, managers and administrators often use the PDCA cycle, being a continuous loop of planning. The PDCA cycle is evaluated as an effective problem-solving method, continually improving processes in a quality management system consisting of a four-step model: Plan - Do - Check - Act (Plan, Perform, Monitor, and Improve). PDCA cycle provides a simple and effective approach for solving problems and managing change. It enables problems to develop hypotheses about what needs to change, test these hypotheses in a continuous feedback loop, and gain valuable learning and knowledge. While implementing it, the organizations not only understand the PDCA method but also can repeat the PDCA cycle to make it a standard operating procedure in the organization. The PDCA cycle can be applied to:

- Starting a new improvement project;
- Developing a new or improved design of a process, product, or service;
- Defining a repetitive work of a process;
- Planning data collection and analysis in order to verify and prioritize problems or root causes;
- Implementing any change;
- Working toward continuous improvement.

From the process analysis in combination with the PDCA continuous improvement cycle, we propose a 5-step experiential-based STEM education process as shown in Figure 1.

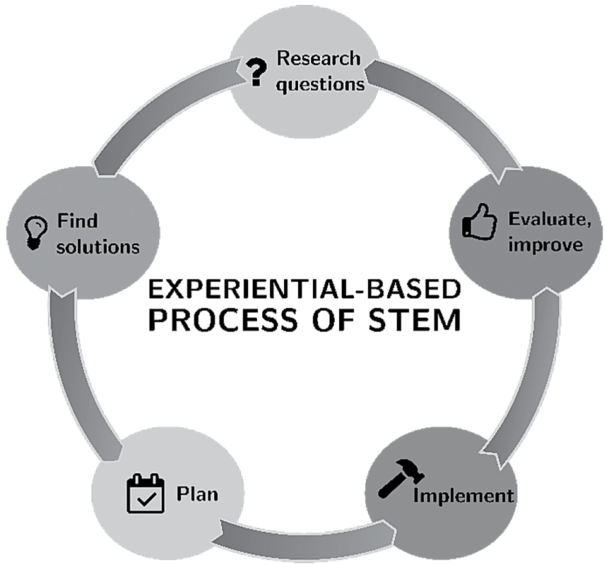


Figure 1. The experiential-based process of STEM

Step 1: Proposing the theme for the experiential-based process of STEM

Based on the competency requirements to be assessed in the themes and products associated with that knowledge in real life... select themes, determine the problems to be performed, and the expected products of students.

Step 2: Finding solutions and ideas for implementation

To enhance teamwork participation, discuss ideas to solve problems. This step should use the "brainstorm" teaching technique, giving as many ideas as possible, without commenting on right and wrong, and evaluating ideas. After listing out a range of ideas aimed at solving problems, the teacher directs students to evaluate the ideas, selecting the ones on which many members agree and that are deemed capable of being completed, and suitable for the task. knowledge, skills, and performance conditions of the group.

Step 3: Setting up a plan

Based on the solution identified in Step 2, the teams plan to implement that solution. During the implementation stage, the groups must develop criteria for the product, the implementation process, the duration of each step, and the expected product. The teacher must guide the groups by providing missing criteria and ensuring that the appropriate criteria are met. This guidance is crucial for students to successfully design, manufacture and improve products during their experience activities-based process of STEM education.

Step 4: Implementing the plan

Teachers organize students to implement the established plan, monitor, and correct students' mistakes. This implementation can be done on paper, on the computer, in the lab, or in the real world. In this step, teachers need to direct the students into experiential activities based on the outlined plan. The product of this step is evaluated against the plan, the product may not have achieved the expected or optimal results. In case the product does not meet expectations, the teacher allows students to evaluate, learn and improve the solution in the next step.

Step 5: Evaluating, improving, and developing

- Once the students have completed the outlined plan and have a product, the teacher organizes the group to report, self-assess, and learn from their experience. Next, the groups cross-check each other's product. The teacher, then, summarizes the success points, good points, and limitations of the student's product if any providing constructive feedback to facilitate further learning.

- Through evaluations and summaries, students are able to generate better solutions and plans. Additionally, they can generalize and expand on the original question or problem, arriving at more effective and comprehensive solutions. The teacher can also highlight any necessary capacity requirements, as well as any limitations in the students' knowledge. Further experimentation, practice, and the use of software can help students continue to improve their solutions, though there may be limitations to the scientific basis for solution optimization.

2.2. Designing experiential-based process of STEM learning situations for application in the area of rectangle formula

2.2.1.The outcome of the design

The following knowledge and skills can be formed through activities aimed at helping students develop the ability to apply the formula for calculating the area of a rectangle to solve real-life problems.

- Apply formulas to calculate the area of rectangles and squares; detected the square that has the largest area in the class the rectangles with the same perimeter.

- Use Scratch software to calculate the area of a rectangle when the length and width are known, and determine the maximum value of the area when the length and width are changed.

- Developing measurement skills, creating realistic simulated drawings, and implementing basic designs.

- Developing teamwork skills, planning and delivering presentations, participating in experiential activities, and engaging in scientific critiques.

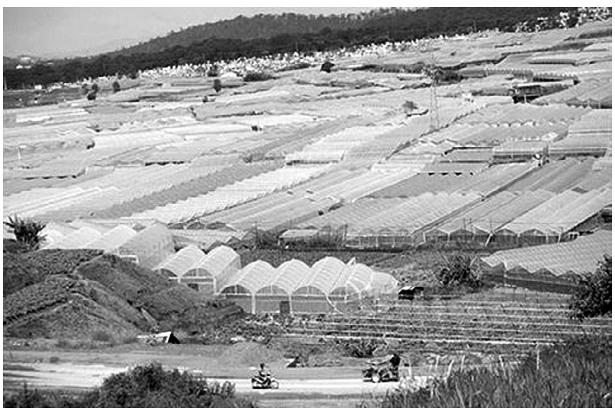
2.2.2. Designing experiential activities

Step 1: Identifying the research problem

- Duration: 0.5 hours.

- Organization form: Experience, teamwork.

- Motivating research from real problems.



When engaging in economic activities such as tree planting, owners often invest with the goal of minimizing material costs while maximizing profits. One popular and cost-effective method for home or garden fencing is using steel wire rope due to its high tension, durability, and aesthetic appeal. Students can observe "garden plots" in their school or local garden and recognize that these plots are typically rectangular. The teacher can then pose the problem of "how to fence a rectangular piece of land for vegetable or flower planting using a given length of wire rope while maximizing planting area with a fixed planting density". Solving this problem not only brings practical benefits to business owners, but also helps students understand Mathematical relationships and apply their knowledge about area, perimeter, and other concepts. Students will also benefit from developing their cooperation and teamwork skills while performing this task with confidence and creativity.

- The objectives of the activity:

+ Observe and identify the cross-sectional shape of "flower garden plots", sketching a real problem, and modeling the problem into research questions.

+ Analyzing the fixed factors in the problem, the circumference of the rope is given as 12 meters. Length and width will satisfy the requirements of the area optimization problem. The problem is as follows: use a rectangular fence fixed with a 12-meter perimeter in the schoolyard to maximize the vegetable area.

- Suggested activities: Let students observe through pictures or real gardens in the school, in the locality, and answer the questions:

1) What shape are the garden plots?

2) Estimate the perimeter and area of several "plots" in the garden?

3) Illustrate the observed "slices" on A4 paper.

4) Suppose that we take the fence of one "garden plot" and apply it to another "garden plot" that is of the same length. How does the illustration change? Which quantity is fixed and which quantity is variable? Also, what is the relationship between the rectangle area and the inside length?

- The achieved products: Illustrated drawing board, recognizing that the perimeter of the "garden plots" is fixed, the area is changed, the hypothesis and conclusion of the problem can be analyzed.

Step 2: Proposing ideas for designing "vegetable plots"

- Duration: 1.5 hours.

- Organization form: Group discussion, using brainstorming teaching techniques, using Scratch software to predict results.

- The objectives of the activity:

+ Use the formula perimeter and area of a rectangle to find out the formula for calculating the area of the rectangle in the problem is $S = (a - 6) \times a$ where $a < 3$ and $0 < a$ is the width of the rectangle.

+ Use Scratch software to calculate the area of the rectangle when changing, save the value a_0 with the largest area.

+ Design the shape of the "vegetable plots" on the drawing board.

+ Identify the tools needed to perform the drawing board.

- Suggested activities:

+ Ask the students to discuss the ways to find the largest area.

+ Orient students on using Scratch software for checking or estimating the relation of a rectangle's width, length, and area. The following system of prompting questions can be used.

Question 1: Calculate the area of the rectangular "vegetable plot" with the known length of width and the perimeter of a rectangle.

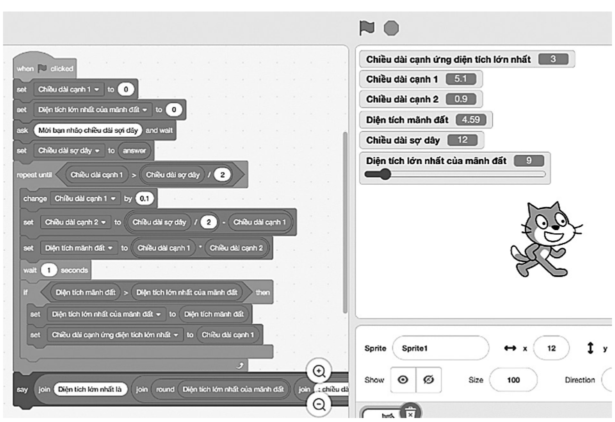
Question 2: When the length of the rope is given d, what is the relationship between the width, and length of the rope? What is the relationship between the perimeter and the area of a rectangle?

Question 3: Using Scratch software to calculate and find the largest area, how many variables are needed? What variables are those?

Question 4: Write an algorithm to find the largest area when the length or width of a rectangle changes.

Question 5: Design and programming with Scratch software.

Outcomes: A file Scratch programmed correctly the formula for calculating the area, determining the width and length corresponding to the optimal area.



Step 3: Setting up an implementation plan

- Duration: 01 hour.

- Organization form: Team-work and seminar.

- Objectives: Students should set up a plan to implement the results of the group's discussion. The plan should identify members' responsibilities and the estimated time needed to perform each step.

- Suggested activities:

+ The teacher provides instructions on dividing groups, allocating time, and specifying the necessary products to determine the rectangular garden with the largest area possible using the assigned 12-meter rope.

+ The representatives of each group present their plan for feedback and comments from both their fellow group members and teachers.

- The achieved products: the completed plan sheet meets the objectives of the activity.

Step 4: Simulating the "vegetable plots" on the schoolyard

- Duration: 01 hour.

- Organization form: Experience and "build on schoolyard".

- The objectives of the activity: Students correctly identify four stakes as the four vertices of a rectangle on the ground and align a rope, approximately 12 meters in length, accordingly.

- Suggested activities:

+ The team leader is responsible for mobilizing and directing team members to measure, locate and stretch ropes upon the garden plot's design.

+ The teacher observes and corrects mistakes during the implementation process.

+ The teacher supports students to use a square ruler, a rope measure to check the perpendicularity, length and width of the vegetable plots that they can do.

- The achieved products: The vegetable plots are created according to each student's garden plot design. It is possible that the groups will produce different products; however, there is no need to optimize the area.

Step 5: Evaluating and improving the results discovered and experienced

- Duration: 02 hours.

- Organizational form:

+ The group chooses a representative to present the product and self-evaluate it based on the product criteria set by the group.

+ Discuss to find the optimal solution, and analyze and expand the problem.

- The objectives of the activity:

+ Check the correctness of the calculations;

+ Assess which "vegetable plot" optimizes the area, identify any difficulties and obstacles that may arise during implementation, and propose solutions to overcome them;

+ Identify the situations in which it is appropriate to design with square, rectangular, or circle cross-sections.

- Suggested activities:

+ The teachers will organize groups to present and evaluate their experiences. During the class, it will be assumed that among all rectangles with the same perimeter, a square has the largest area. However, rigorous proofs will be introduced at a higher level using mathematical concepts such as Cauchy inequality or sum of squares equality.

+ The teachers will provide feedback on the process of working in groups, including both general observations and individual comments tailored to each group's performance.

+ The class will raise the question of when to design objects, buildings, and other structures with rectangular cross-sections, and when to use square cross-sections instead. Additionally, the class will explore the advantages and disadvantages of objects whose cross-sections are square, and consider how these factors can inform design decisions.

+ In school yards and parks, it's common to find rectangular flower plots and ornamental plants, but circles are a more uncommon sight, and squares are even rarer. One possible reason for this is that circles and curves in general are more visually appealing and less predictable than squares, which can create a more dynamic and interesting landscape. Additionally, circles have a more natural feel and can mimic the curves found in nature, whereas squares are more commonly associated with human-made designs and structures.

+ Provide an explanation for why sewage and manhole covers are commonly designed with a square shape.

- The achieved products:

+ Students have the ability to assess which products offer superior performance and features, and which ones have certain limitations based on the products used by their group and peers.

+ Survey some advantages and limitations of objects with cross-sections of rectangles, squares and circles.

3. Conclusions and recommendations

This article presents a 5-step process for organizing an experiential-based process of STEM learning situation. An example of its application in the context of the 5th-grade Mathematical curriculum is provided. The process starts by drawing motivation from local, real-life situations such as school grounds of familiar objects with certain sizes and shapes. Students then engage in discussion to identify a problem related to the largest area of rectangles with a fixed perimeter. In order to find a solution to the problem, students use Scratch software to test their predictions, while simultane-ously designing and implementing their designs. After completing the problem, students evaluate their work and learn from their experience, developing their skills and knowledge along the way.

By engaging in this approach to STEM education, students are likely able to develop their natural problem-solving abilities by integrating and applying various types of knowledge. This process can also generate excitement and motivation for students to continue learning about new topics, such as the area of a circle.

Through STEM education, students can develop important skills that enhance their ability to innovate and utilize technology and science as tools for solving real-world problems. In the current global landscape, where technology is rapidly evolving and changing, these skills are becoming increasingly valuable for success in many fields.

Acknowledgments: This research is supported by science and technology project, Dong Thap University. Code: SPD2019.01.40.

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