STEM PRODUCTS OF MECHANICAL SUBJECTS MAKING WATER FIRE MODEL

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Abstract

STEM education has been long implemented in high schools and junior high schools in Dong Thap province in general and Cao Lanh city in particular. On the basis of the classification of STEM, the paper aims to present its role and needs in teaching to improve students' skills in applying interdisciplinary knowledge. It is very necessary to apply an effective combination of learned theories and knowledge to solve real-life problems in order to consolidate, improve knowledge and help students develop their character either creativity problem solving or subject-specific competencies. This article surveys students' understanding of STEM summaries of knowledge related to the "Mechanics" section and details on how students apply STEM product design processes from scratch implementation plan to the design and presentation of their "Water Rocket Model" product as well as their actual product.

Keywords: *Conservation of momentum, model, momentum, water rocket.*

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SẢN PHẨM STEM CHỦ ĐỀ CƠ HỌC CHẾ TẠO MÔ HÌNH TÊN LỬA NƯỚC

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Tóm tắt

Giáo dục STEM đã được triển khai vào các trường trung học phổ thông và trung học cơ sở trên địa bàn tỉnh Đồng Tháp nói chung và thành phố Cao Lãnh nói riêng trong một thời gian dài. Trên cơ sở của việc phân loại STEM, vai trò và ý nghĩa của nó trong dạy học cũng như nhu cầu tham gia loại hình hoạt động này để nâng cao kỹ năng vận dụng kiến thức liên môn của học sinh. Đối với học sinh, việc vận dụng phối hợp tốt các lý thuyết, kiến thức học tập trên lớp vào giải quyết các vấn đề thực tế cuộc sống là rất cần thiết nhằm củng cố, nâng cao kiến thức và giúp học sinh phát huy tính sáng tạo, năng lực giải quyết vấn đề hoặc các năng lực chuyên biệt của các môn học. Bài viết chia sẻ thông tin khảo sát mức độ hiểu biết của học sinh về STEM, tóm tắt kiến thức liên quan đến phần "Cơ học" và chi tiết cách học sinh áp dụng quy trình thiết kế sản phẩm STEM từ khâu triển khai ban đầu đến thiết kế và trình bày sản phẩm "Mô hình tên lửa nước" của mình thông qua sản phẩm thực tế.

Từ khóa: *Bảo toàn động lượng, động lượng, mô hình, tên lửa nước.*

1. Introduction

Both teachers and students have an understanding of STEM, its roles and benefits in the teaching process. There are many different forms of STEM activities with different levels that teachers can guide students to participate in depending on the ability and actual conditions of each school unit as well as the professional ability of teachers and students' skills.

Although STEM education has been long implemented in middle and high schools, the percentage of students actually participating in STEM activities is still low. Therefore, allowing students to participate in STEM activities to enhance their ability to apply knowledge, creativity, and problem-solving skills. The design of the "Water Rocket Model" incorporates knowledge of the laws of conservation of momentum and energy of water into the operation of the rocket. The model can work and students can experiment and perform in extracurricular activities or experiential activities in the school yard.

This approach is to implement the policy of synchronously innovating teaching forms, teaching methods and testing and evaluating educational results; to strengthen the connection of this with real life and contribute to the formation of problem-solving capacity of high school students. Since 2012, the Ministry of Education and Training has annually organized the competition "*Applying interdisciplinary knowledge to solve practical situations for learners*" and the competition "*Educating based on integrated topics for the teachers*". The competition is an opportunity to encourage students to apply knowledge of different subjects to solve real-life situations; enhance their ability to apply synthesis, self-study and self-research ability; promoting the connection of theoretical and practical knowledge in school with real life; promote the implementation of teaching according to the motto "learning goes hand in hand"; contribute to the renewal of forms and methods of it and the innovation of examination and assessment of learning results; promote the participation of families and communities in education. For teachers, this is also an opportunity to encourage creativity conduct teaching by topic with content related to many subjects and associated with practice; increasing the effectiveness of using educational equipment; create opportunities to exchange experiences between high school teachers nationwide and around the world. In particular, the annual high school contest "*Innovation in Science and Technology*" organized by the Ministry of Education and Training has become a positive bright spot in competency-oriented one. These competitions are an example of the educational goal to develop students' capacity to form study and work skills in the 21st century that is also the goal that education STEM aims. (Ministry of Education and Training, 2020; Nguyen, 2023a; Nguyen et al., 2019)

In the research projects on designing STEM topics in Physics as mentioned above, the authors have built models, instructions and organized experiments at several grade school levels. On this ground, organizing pedagogical experiments is to obtain evaluation data and comments for the feasibility of the research more effectively.

2. Methodology

Theoretical research methods: Resolution of the Party, Law on Education, directives of the Ministry of it and Training; STEM one model; problem solving/experimental capacity; high school physics program,...

Practical research methods:

- Observational method: observing how STEM education activities are organized in Mechanics section at some high schools in Dong Thap province to assess the feasibility of the activity design topics; fostering and developing natural science capacity.

- Survey method by questionnaire: build questionnaires and conduct a survey about STEM education activities in Mechanics at some high schools in Dong Thap province.

- Method of pedagogical experiment: Conduct pedagogical experiments in some high schools in Dong Thap province to check the feasibility of the topic.

- Mathematical statistical method: using mathematical statistical method

- Analyzing the results obtained and draw conclusions.

Steps to conduct research:

- Theoretical research overview of research situation at home and abroad.

- Identifying research objects conduct surveys on students of some high schools in Dong Thap province.

- Analyzing and discussing survey results Summary of theory in Mechanics section.

- Allowing students design products according to the specified topic with all the prescribed requirements.

- Synthesizing images of students participating and evaluate the effectiveness of activities.

3. Student participation in STEM activities

3.1. Students' knowledge about STEM

STEM is an abbreviation of the words Science, Technology, Engineering and Mathematics as shown in Figure 1. Students participating in the survey clearly understood the role of STEM in teaching in general and teaching Physics in particular.

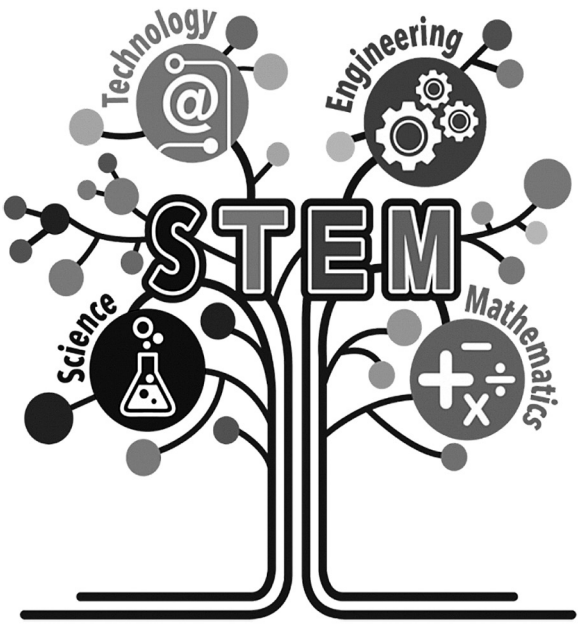

Figure 1. Fields in STEM Education (Source: Internet: https://robotsteam.vn/giao-duc-stem-la-gi)

In addition to the ideas chosen by many students in Figure 2, there are some other ideas about the role or benefits of STEM for students when participating. As follows:

- Developing thinking ability to master decisions to formulate the right decisions so that students can be tough in the future to become the pride of the nation;

- Developing ingenuity and creativity, quick problem solving, increase knowledge or teamwork spirit;

- Developing ingenuity and creativity in each lesson, the ability to apply what students have learned to their life.

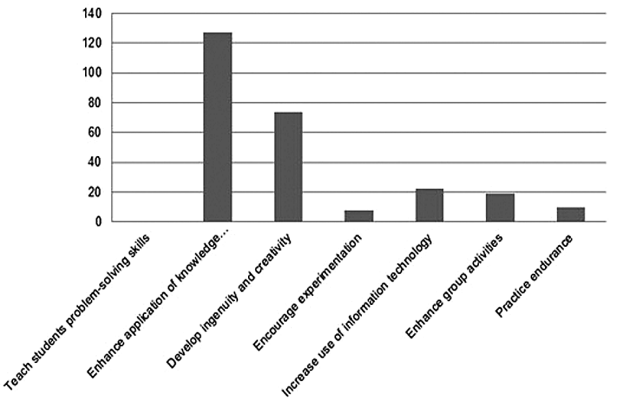

Figure 2. Student survey opinions about the benefits of participating in STEM activities

Over 300 high school students participated in the internet survey involving grades 10, 11 and 12 from 05 high schools in Dong Thap province which is shown in Table 1.

Table 1. Information about the number of students participating in the survey

High School /Grade	10th	11th	12th
Thap Muoi Nguyen Du Lai Vung 1 Thien Ho Dương Thong Linh	88	143	92

Link: https://docs.google.com/forms/d/1-4Q1QpRrwnb0c8RUCDq-035YLMTu29VCVtjIio-hnAmg/viewform?ts=61792396

They participated in answering 14 different questions about issues related to STEM teaching or types and roles of STEM or the benefits that STEM brings to them who participated in commenting on the level and form of STEM application in schools, most of them wanted to be organized in the form of experiential activities with nearly 150 options and organized as a scientific and technical research activities with over 100 options.

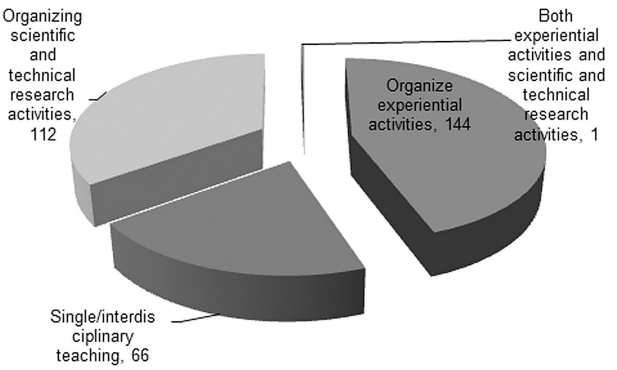

Figure 3. Form and level of organization of STEM activities in schools

According to the statistics in Figure 3, there are also students who choose the level of application in single or interdisciplinary.

3.2. Actual participation in STEM activities of students participating in the survey

Students also learn and know which skills can be better equipped when participating in STEM education. With the above survey subjects and through the opinions received from the survey, over 100 students think that problem solving skills are trained and improved the most, in addition to others such as critical thinking skills or Mathematic and teamwork skills or communication gifted. This result is depicted in Figure 4.

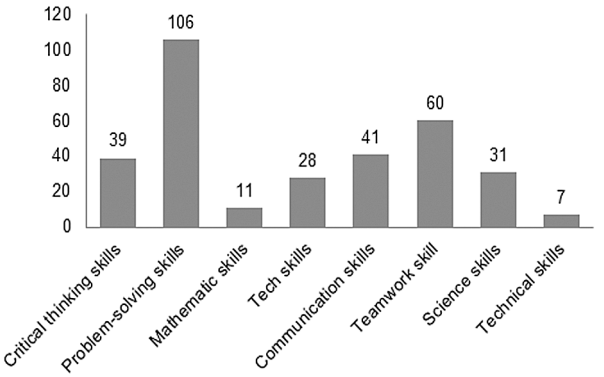

Figure 4. Students' skills are enhanced when participating in STEM activities

Although understanding about STEM from concepts, roles to benefits and skills that students can improve by participating in this activity. However, in fact, the number of students who have participated in this activity is not large. For example, over 70% of students participating in the survey have never participated in a STEM activity (according to the statistics in Figure 4).

Survey results showed that students obtained:

-Understanding about STEM, concepts and components of STEM activities;

- The benefits and role of STEM that when participating students can get;

- The skills that participating in STEM activities will be formed or enhanced;

- It also noted that many of them have not been able to participate in STEM activities at their schools.

For these reasons, it is necessary to organize for students to participate in STEM activities at school from simple to complex levels with different forms. Through this activity, students can form and practice problem-solving skills or teamwork skills and planning ability, logical thinking, calculation ability. (Nguyen et al., 2017; Nguyen et al., 2018a; Nguyen et al., 2018b).

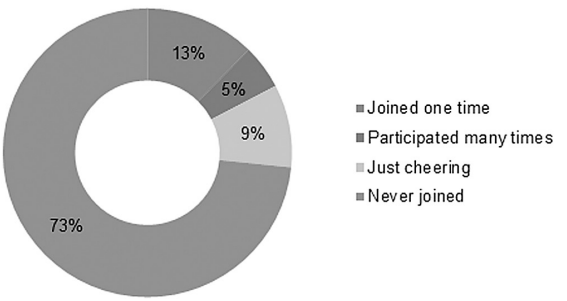

Figure 5. Percentage of students participating in STEM activities at schools

3.3. Students' participattion in the design of a water rocket model

On the basis of learning about STEM and the topic of mechanics - the momentum part and the law of conservation of momentum that students use to participate in the design of the water rocket model.

a. Target

Applying learned knowledge about momentum, the law of conservation of momentum as applied products.

Each team makes a detailed plan for the design and completion of the product.

Design drawings of water rocket models.

Complete a water rocket model from simple and easy-to-find items.

b. Request

According to the organization and requirements, students will perform as a miniature STEM project, including the following requirements:

Learn relevant theory;

Drafting drawings, dimensions, preparing materials;

Use simple and easy-to-find materials or reuse materials to formulate;

Manufacturing products according to the design and evaluation plan;

Reporting and presenting product results.

c. Duration

Within 2 weeks after the student receives the assignment.

d. Participants

Students in grade 10 at Thien Ho Duong High School, Cao Lanh city.

e. Process

Details of sudents' activities are shown in Table 2.

Table 2. Student Activities

Order	Activity name	Job Content	Notes
First activity	Product name: Water rocket model	Planning Assigning tasks Carry out, conduct, commence Expected product: water rocket model with soft drink bottles, water pipes, …	Groups of students discuss and work in groups
Second activity	Researching the knowledge, determine implementation plan	Synthesizing the theory of momentum and the law of conservation of momentum Outlining or sketches, model drawings of water rockets Choosing an implementation plan	Each division group implements the options to finally compare, evaluate and choose the optimal one
Third activity	Designing and completing the product according to the selected plan	Basing on the defined drawing, select the appropriate material Designing the product, testing, editing and finalizing the product	Large capacity soft drink bottle dawn water pipe drawstring, parachute cord Hardcover,…
Fourth activity	Displaying Presentating Reporting the products	Preparing presentations on powerpoint or canvas software	Teachers evaluate and comment on products

3.4. Actual product of a group of students

Students are divided into groups by the teacher to design water rockets. Each group has different ideas about the design of the product model. The following article shares in detail the steps taken by one of the student groups Pham et al. (2023).

3.4.1. Synthesizing both knowledge about momentum and the law of conservation of momentum

Momentum concept: "Momentum of a particle is a physical quantity determined by the product of the mass and velocity of the particle. Momentum is a vector quantity, in the same direction as velocity.

Recipe: $p = m.\upsilon$

Sign: p

Unit of measure: kg.m/s

Momentum of Force: The change in momentum equal to the impulse of force F during the time interval Δt (or time variation) over which force F acts on the object.

$$\Delta p = F.\Delta t$$

In there:

F : applied force (N)

Δt : duration of action (s)

Δp : momentum variation (kg.m/s)

Isolated System: Any system is said to be isolated if and only if there are no external forces acting on the system or the total external forces are equal. In an isolated system, only internal forces exist, and these interacting forces exist in pairs that are orthogonal to each other.

Law of Conservation of Momentum: Momentum of an isolated system is a quantity that is conserved.

For an isolated system consisting of only two bodies with respective masses is m_1, m_2 .

The respective velocities of the two bodies before and after the interaction are $\vec{\upsilon}_1, \vec{\upsilon}_2$ and $\vec{\upsilon'}_1, \vec{\upsilon'}_2$.

The expression of the conservation law in this case:

$$\vec{p} = \vec{p'}$$

$$m_1.\vec{\upsilon}_1 + m_2.\vec{\upsilon}_2 = m_1.\vec{\upsilon'}_1 + m_2.\vec{\upsilon'}_2$$

The problem of soft collision and elastic collision

A soft collision is a collision where after that the two bodies stick together and move with the same velocity (same direction, direction and magnitude).

An elastic collision is that after the collision each object moves with a specific velocity (in both direction, direction and magnitude).

Based on the nature and type of motion and the frame of reference, convert the equation of the law of conservation of momentum to a scalar form to solve.

Practical applications of the law of conservation of momentum

Motion by reaction: In any closed system, if part of it moves in any direction, the rest one will move in the opposite direction - this is called jet motion.

For example, the movement of rockets or jets and archery.

Gun recoil when firing: Based on the law of conservation of momentum to explain the phenomenon of gun recoil when doing. The momentum of the system including the gun and the bullet before firing is zero. Immediately after firing this total momentum is also zero, based on the bullet's firing velocity to calculate the gun's recoil velocity and give advice when practicing shoots.

3.4.2. Sketch and select the water rocket model (as shown in Figure 6)

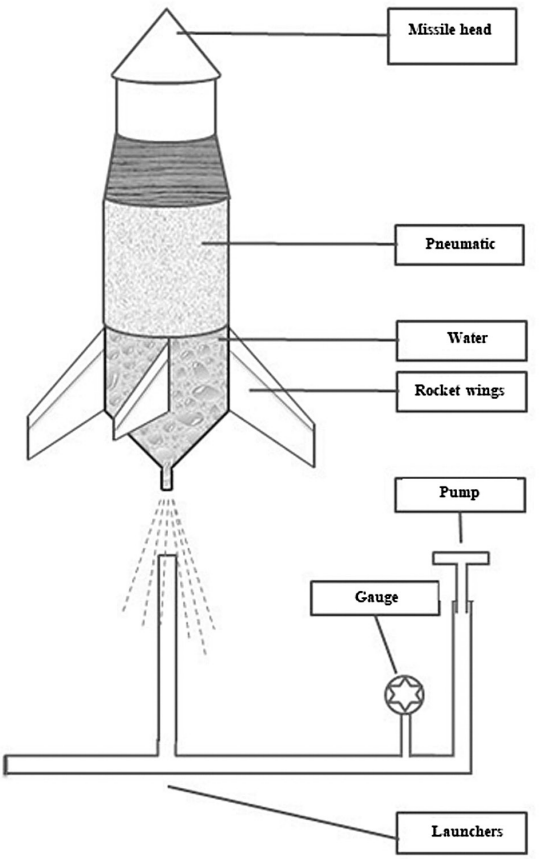

Figure 6. Sketch of water rocket model

3.4.3. Prepare materials with expected quantity and size according to table 3

Table 3. Students' list of materials

Order	Materials	Sample Specifications	Quantity	Note
	Plastic bottles for soft drinks	1.25-liter capacity type	2	
		1.5 liter or 2-liter capacity type	2	
	Cardboard	A_0 size roki paper	1 sheet	
		A3 multicolored cardboard paper	4 sheets	
		Cardboard boxes of cakes, soft drinks,…		Depending on the box size
	Color paper	A3 color decal paper	4 sheets	
		Colored craft paper in A4 or A5 size	6 sheets	
	Bicycle pump needle valve	Bicycle pump needle valve	1	
	dawn plastic tube	Ø 21	2 m	
	T-joint	Ø 21	3	
	L coupling	Ø 21	2	
	Plastic pipe cap	Ø 21	4	
	Tape	Big size	1 roll	
	Gauge		1 cái	
	Glue Guns		1 bar	
	Plastic glue		5 bar	
	Plumbing glue		1 tube	
	Scissors, ruler			Enough to use
	Clay		1 box	

3.4.4. The steps for processing and making water rocket products are according

Table 4. Details of students' steps to make water rockets

Order	Implementation content	Detail	Note
1	Making the rocket head	Choose cardboard or cardboard processed into a cone	If useing decal paper, you don't need to stick the tape outside
2	Missiling fuselage	Cover the outside with adhesive tape to prevent water	The body can change shape and size depending on the bottle used
3	Connecting the rocket's head and body	Select soft drink bottles, processed according to the sketch pattern	
4	Making rocket wings	Glue the top to the bottom of the bottle	Noticing the 4 wings are the same
5	Attaching the air intake valve	Punching a small hole in a wooden cork	Pay attention to the hole that fits the needle valve, to avoid gas leakage
6	Making a launch pad	Attaching the bicycle pump needle valve to the wooden button	Make sure the size of the platform is suitable for the rocket (when water is added to the rocket body
7	Experiment	Putting water in the rocket body	Depends on the missile body size
		The rocket is kept at the neck of the bottle, below the wing	Pay attention to the direction of observation and manipulation. Avoid the missile's flight direction for safety
		Place the rocket vertically	
		Pumping gas into the rocket body	
8	Completing products	Reinforce the joints, rocket wings for sure	
		Redecorate the water rocket	
9	Preparing reports, presenting products	Make report file	

3.4.5. Several pictures made by students

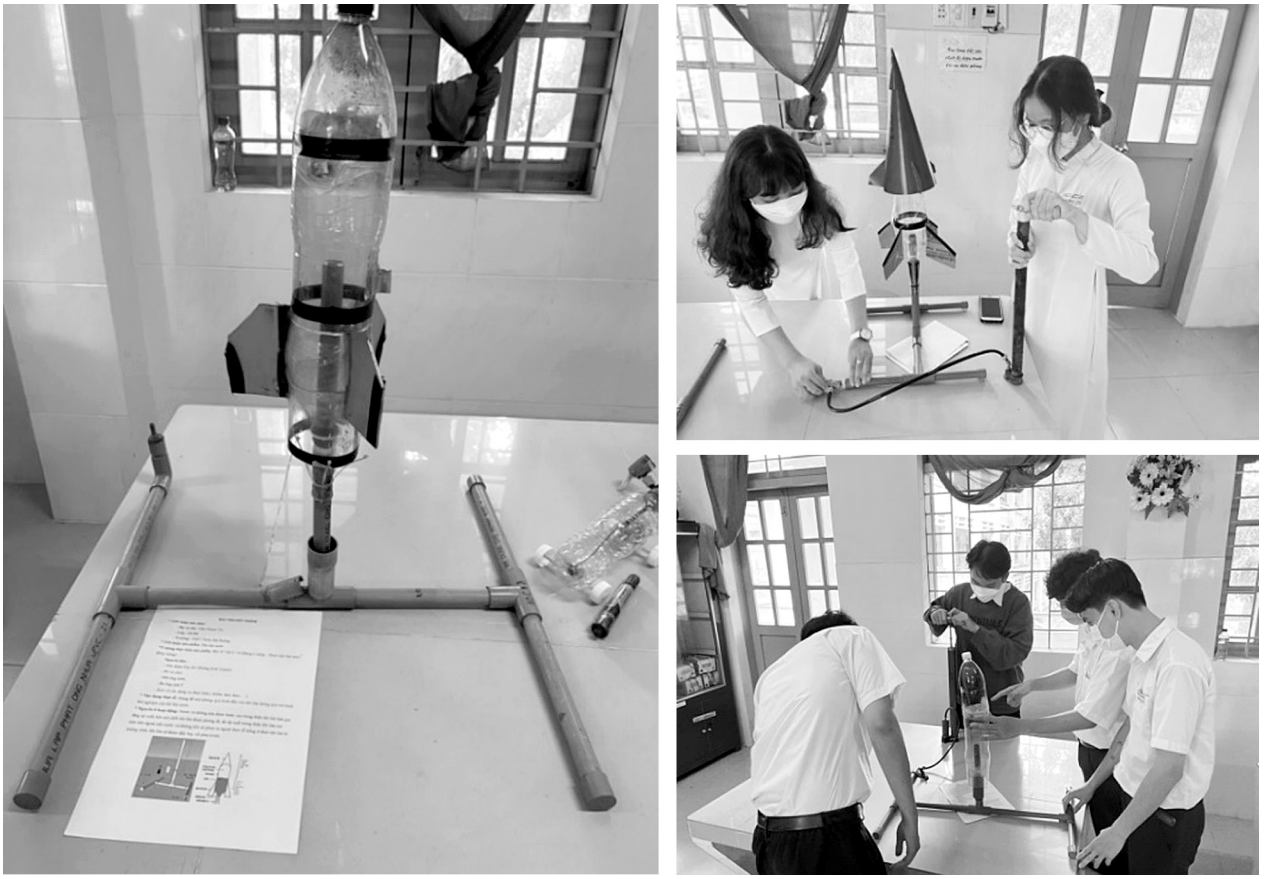

Figure 7. Several pictures made by students

4. Results and discussion

Organizing students to participate in STEM can be organized in many different forms and levels depending on the specific conditions of each school and each locality. Products of the same topic are also obtained very diversely depending on the ability and aptitude of students.

Teaching STEM has many advantages and develops students' specific skills and competencies. However, this form of teaching also encounters certain difficulties, both objectively and subjectively.

Teachers have different working experience and different ages, so the traditional way of teaching will be limited in changing the implementation method, preventing change because it requires investment and preparation, especially, for STEM topics.

A few teachers still have the view that the teacher is the center, transmitting knowledge to students, not brave enough for students to take the initiative for fear of making mistakes, fear of losing time to adjust or observe and guide and support.

Some schools have not received the support or instructions from the school leaders, so the implementation is still limited.

Some schools in remote and isolated areas have limited means and facilities, so they do not actively allow students to participate in activities.

As for the topic of mechanics, in addition to the general difficulties when implementing STEM education into schools, there are also certain difficulties.

Mechanics is a content that has many practical applications, so putting STEM education into difficulty in finding implementation topics shows novelty and creativity.

The topic must be related between theory and practice or specific orientation to develop any capacity

for students after participating, whether the product can be used many times in different conditions.

It is safe for students to work and perform in front of a group.

It should be done or what parts of the physics program can be combined with it.

5. Conclusion

The study, design and completion of the water rocket model shows that students can well apply the theoretical knowledge they have learned to solve real-life problems. The product is a model designed from soft drink bottles, cardboard and other materials, simple, easy to find and low cost. This approach is an opportunity for students to become familiar with participating in STEM projects; hence, knowing how to incorporate learned theory into practice and becoming familiar with scientific research. Through this, students also learn more about designing skills, ensuring products that are safe, educational, aesthetically pleasing and highly applicable in real life./.

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References

Do, M. C. (2011). *Integrated implementation and teaching capacity in vocational training*. Institute for Professional Education Development Research.

Ministry of Education and Training. (2020). *Official Dispatch No. 3089/BGDDT-DGTrH on implementing STEM education in secondary education.*

Ngo, T. T. (2020). *Organize STEM teaching on mechanical topics associated with production and business*. Master's thesis in Physics Pedagogy. Vietnam National University, Hanoi.

Nguyen, M. A. T. (2023a). Current situation and propose solutions to improve the effectiveness of teaching organization towards developing the capacity of high school students in Tuyen Quang province. *Journal of Education, 23*(02), 34-40.

Nguyen, M. A. T. (2023b). Current situation of guiding students on science and technology research in high school in Tuyen Quang province. *Journal of Education, 23*(17), 18-25.

Nguyen, T. N. (Editor), Phung, V. H., Nguyen, Q. L., & Hoang, P. M. (2017). *Design and organize STEM education topics for middle and high school students*. Ho Chi Minh City University of Education Publishing House.

Nguyen, T. N., Hoang, P. M., & Le, H. M. N. (2018). Organizing teaching in direction of stem education The knowledge of physics 10 through creating simple toys. *UED Journal of Social Sciences, Humanities and Education Volume 8*(3B), 66-73. https://doi.org/10.47393/jshe.v8i3B.725.

Nguyen, T. N. (2018). *Designing and organizing the teaching of STEM topics for high school and high school students*. Ho Chi Minh City University of Education Publishing House.

Nguyen, V. B., Tuong, D. H. (Co-editor), Tran, M. D., Nguyen, V. H., Chu, C. T., Nguyen, A. T., Doan, V. T., & Tran, B. T. (2019). *STEM education in high schools*. Vietnam Education Publishing House.

Pham, H. M. (2020). *Organize teaching some knowledge of the chapter "Balance and motion of solid bodies" - Physics 10 according to STEM education orientation*. University graduation thesis, Ho Chi Minh City University of Education.

Pham, N. C. T., Tran. V. D., & Phan, N. T. (2022). The current situation of managing stem education-oriented experiential activities in teaching natural sciences in lower secondary schools. *Vietnam Journal of Educational Sciences, Volume 18*(11), 54-61.

Pham, T. T., Ha, T. T. L., & Nguyen, H. A. (2023). Teaching mechanical topics in STEM educational orientation. *Dong Thap University Journal of Science, 12*(01S), 56-65. https://doi.org/10.52714/dthu.12.01S.2023.1006.

Survey form "The current status of teaching stem in several hing schools in Dong Thap province. https://docs.google.com/forms/d/1-4Q1QpRrwnb0c8RUCDq035YLMTu29VCVtjIiohnAmg/viewform?ts=61792396.

What is STEM? What is stem education? 3 levels of deployment into the educational program. https://robotsteam.