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RESEARCH ARTICLE

APPLYING DESIGN THINKING IN TEACHING PHYSICS THROUGH STEM ACTIVITIES

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Abstract

The new general education curriculum has set obvious goals for developing the competencies needed for students in the 21st century. Design Thinking is a new educational approach that aims to maximize students' abilities and direct students to solve real-life problems. The flexible application of Design Thinking in STEM activities helps students to approach and come up with clear solutions to the problems posed. The article presents research results on the approach Design Thinking in teaching Physics in general, teaching STEM topics in particular, and how to implement it in teaching in high schools.

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Introduction:-

In the general education curriculum 2018, at the high school level, the structure of the Physics subject has changed a lot, reducing the load on some content and increasing teaching according to the topics associated with real-life and career orientation. The new Physics curriculum structure will set requirements for Physics teachers and students to change teaching and learning methods and forms. STEM-oriented Physics teaching is one of the practical teaching forms to help improve teaching quality and develop students' competencies. In Vietnam, STEM education is increasingly promoting its advantages and receiving attention from the Government, relevant ministries, educators, schools, teachers and students. Besides STEM education, the term Design Thinking has appeared in many discussion forums recently, and there are also many research works on Design Thinking and the potential of applying Design Thinking in the teaching process. This article presents the application of Design Thinking approach in teaching Physics through STEM activities, from understanding Design Thinking to its application to building specific lesson plans.

Research Results:-

Teaching Physics in the direction of STEM education

Modern life presents people with many new challenges. The challenges that require unique and universal problem-solving approaches today are the use of knowledge and skills that integrate science, technology, engineering, and mathematics. STEM is an abbreviation of Science, Technology, Engineering, and Mathematics (Vietnam Ministry of Education and Training, 2019). STEM is often mentioned in the scientific and technological development of countries and today is used in the teaching process in high schools to connect knowledge and real-life contexts. Life events that learners experience will give rise to problems that need to be solved, and then they need to be allowed to apply STEM knowledge and practice effectively, that is, to analyze, reflect, and evaluate their own experience based on the learning space and the background knowledge of science, technology, engineering, and mathematics (Nadelson & Seifert, 2017).

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There needs to be a straightforward implementation process to implement STEM-oriented Physics teaching. In order to organize Physics teaching in the direction of STEM education, it is necessary to put students in front of real-world problems related to Physics knowledge and ask students to solve those problems. The problem-solving process requires students to explore and apply knowledge to come up with a solution to that problem. (Vietnam Ministry of Education and Training, 2019). Each STEM teaching topic in Physics teaching will refer to real issues and ask students to thoroughly solve them according to the scientific solving process, from "defining problems", "providing solutions", "choosing an alternative", and "solving the problem". Because STEM topics are the connection of many knowledge, students must approach interdisciplinary expertise to implement STEM topics in the learning process.

Design Thinking

The concept of Design Thinking

For decades, researchers have had to work to define Design Thinking and document its various expression (Diefenthaler et al., 2017).

Design Thinking is an approach to learning that focuses on developing children's creative confidence. (Maureen Carroll, 2010).

Design Thinking is a methodology that provides a solution-based approach to solving problems. It's extremely useful in tackling complex problems that are ill-defined or unknown, by understanding the human needs involved, by re-framing the problem in human-centric ways, by creating many ideas in brainstorming sessions, and by adopting a hands-on approach in prototyping and testing (RikkeFriis Dam, 2021).

Nowadays, it is not difficult to see the appearance of the phrase "Design Thinking" in discussions about working methods in many different industries. Design Thinking has been taught in many top universities such as Stanford with D.School, MIT with Design Lab and many others. Like creative, design, logical, and strategic thinking, design thinking is commonly used in life. It should be equipped for students in school before they step into the reality of work and life.

Design Thinking can be understood as a learning, human-centered approach to creative problem solving that is appropriate for all levels and ranges from the classroom to a more significant extent in schools. Applying this method to the teaching process, students have the opportunity to learn, think, and develop reflexes quickly. Students will gradually accumulate knowledge and skills by identifying real-world problems multi-dimensionally, working effectively in groups, researching methods, testing, and analyzing to develop effective ways to solve problems.

The process of applying Design Thinking in teaching Physics

According to the five-step model proposed by Hasso-Plattner of the Design Institute at Stanford University (D.school), the five stages in Design Thinking include: Empathize, Define, Ideate, Prototype, Test.

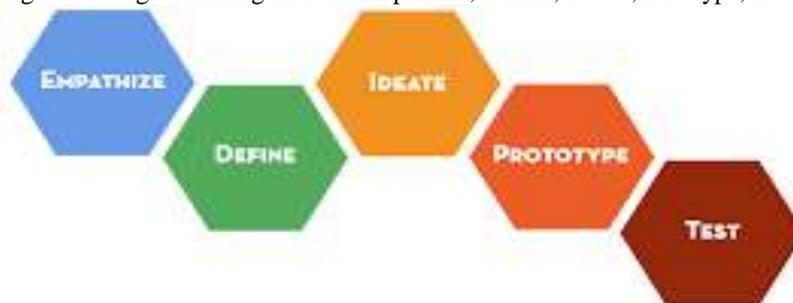


Figure 1:- Design Thinking Process by The Hasso-Plattner Institute of Design at Stanford.

Source: Retrieved from: <https://dschool.stanford.edu/>

Empathize.

Empathize is the first step of Design Thinking that aims to gain insight into the problem or situation that needs to be solved. This requires the discovery of the investigated phenomenon from different angles and from various stakeholders through observation, interviews, document analysis, or any other information that can be gathered around the problem. Empathy can be considered a core component of the process as it encourages the researcher or the design thinker to ignore their assumptions about the problem and focus more on the needs of the "user". From the

findings of this step, a large amount of information relevant to the situation is used to support the next efforts toward reaching a unique and meaningful solution.

Define.

In the second step, the problems identified in the first stage are put together to provide the design thought, the big picture of the status quo, from which they can locate the outstanding problem to be solved. While considering the issues, design thinkers need to be “user” centered and avoid letting their assumptions get in the way of their decisions.

Ideate.

At this step, design thinkers have an overview of the situation they are looking for a solution. Based on the identified problem from the previous step, they now imagine new solutions to their identified problem. This encourages them to think about as many solutions as possible. “Even the craziest ideas are welcomed because they can often lead to the most creative solutions” (Mulder, 2017).

Prototype.

When an idea is picked up from the previous stage, it is transformed into physical products or intangible services. At this step, creating a perfect or expensive version of the product we have devised is unnecessary. More importantly, it helps design thinkers connect their imaginations with the physical world and actually “see” their solution, so they can get feedback and create a more improved prototype. Several prototypes can be made at this stage to help design thinkers see different aspects of the solutions implemented to the initially identified problems until they arrive at the final solution.

Test.

For the final step, the prototype can be tested in a small group to test whether the proposed solutions meet the users' needs. Such prototypes may be accepted and requested for improvement, or they may be rejected. Through this process, design thinkers better understand how well their products and services maximize the needs of their users. At this point, design thinkers have the opportunity to look back at the previous stages to perfect their products or service. They can even add empathy to get more information they want and repeat the process until they are satisfied with their solution.

There are many different variations when it comes to applying Design Thinking methods. In this study, the author proposes a process of implementing Physics teaching according to Design Thinking approach, including five steps as follows:

Stage 1: Establish empathy - Discovery and understand the problem.

Empathy is when presented with a situation that requires students to put themselves in the shoes of others to understand their problems and contexts in order to seek empathy through their problem experiences; Asking survey questions to elicit empathy, thereby collecting student responses and synthesizing notes on issues and facts found.

Stage 2: Identify the problem.

Students reflect on the problem from what they learned in Stage 1 - Establish empathy by asking guiding questions. This question requires students to think, investigate and find solutions to problems”.

Stage 3: Ideate—Give ideas.

In this activity, students develop creative ideas/solutions to the problem they thought about in stage 2 – Identify the problem visually, clearly and systematically. The “Ideate” activity can help eliminate impractical, difficult-to-implement solutions and uncover more innovative solutions.

Stage 4: Prototype - Planning and Implementation.

This is the activity of manufacturing products, creating model ideas and solutions, showing the solution’s authenticity and practicality.

Stage 5: Test - Presenting and perfecting the product.

This is the stage where the groups of students try to present and give feedback and comments in the group. From the test results, the team will fine-tune and perfect the product.

An example of applying Design Thinking in Physics teaching through STEM activities with the topic "Design your power bank"

- Topic: Design your power bank
- Subject: Physics 11
- Student: Grade 11
- STEM knowledge:
 - + Science: Apply knowledge of electrical circuits to assemble the charger's circuit.
 - + Technology: Present and learn about the properties of materials such as laptop batteries, Boost Modules and Battery Charger Modules, switches to install circuits, etc.
 - + Engineering: Draw the circuit diagram of the power bank.
 - + Mathematics: Calculate the capacity and amperage of the charger, ..., and collect and process data during design and testing.
 - Objective:
 - + Knowledge: Students know electricity sources, electric capacity, and energy-saving use.
 - + Ability:
 - Ability to perceive and use Physics: List commonly used electronic components. Know their parameters, principles, and functions; Describe the concept of electrical power; Write the formula to calculate the electrical power; Draw the circuit diagram of the power bank; Calculate the amperage, electrical capacity to use the number of batteries by the needs; Collect and process data.
 - Communicative and collaborative skills: Teamwork, cooperation among members to complete tasks; Practice critical thinking, listening skills, exchanging ideas to come to conclusions; Practice planning and presentation skills.
 - + Qualities: Excited, love the subject; Enthusiastic, participates in activities, actively seeks knowledge, and takes responsibility in group activities; Meticulous, careful and follow safety rules during class time.
 - Preparation of teachers and students:
 - + Teacher: Prepare 10 to 15 kits, each set includes: Laptop battery, power cord, switch, Boost module, battery charger module, soldering machine, glue candle, glue gun, scissors; Manual document; Projector, laptop, speaker; Student activity sheet.
 - + Students: Learn electrical and battery storage capacity knowledge.
 - Teaching activities:

Activity 1:- Research and find out the problem.

Target	Survey to find out students' interest in electric energy	
Content	The teacher poses a problem, and the students discuss and answer the questions.	
Learning products	Students' answers	
Activities	Teacher activities: <ul style="list-style-type: none"> - Divide into groups: the teacher divides into groups of 3-5 students/group - Problem setting: Teacher can introduce the topic with a short video about the importance of electric energy; or create a scenario (turn off all power in the classroom). Teacher then asked questions to stimulate students' brainstorming: <ul style="list-style-type: none"> Question 1: What are the uses of electricity in modern life? Why is electricity important? Question 2: What would happen if we don't have electricity? Question 3: What do you do when your phone runs out of battery? Question 4: How can we save electricity 	Student activities: <ul style="list-style-type: none"> - Group activities, discussion to answer the questions

	activity? - The teacher summarizes the students' answers	
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Activity 2:- Find out related knowledge and identify the problem.

Target	Students identify the problem and the tasks.	
Content	- Teachers ask questions, students discuss and answer questions - Students receive the task of designing and manufacturing a power bank	
Learning products	Students' answers	
Activities	<p>Teacher activities:</p> <ul style="list-style-type: none"> - The teacher introduces the topic and the practical context of the case: Due to the increasing demand for mobile devices such as smartphones and tablets, while battery technology has not been developed at the corresponding level, the portable charger has become an essential tool for many users. However, good quality power banks always come with a high price tag. As an inventor, please make a power bank that suits your needs and has the lowest price possible. - Ask a question about the topic's core: "How is a power bank made and how does it work?" - Guide students to identify the Physics knowledge contained in the topic - Specify the tasks of the topic: <ul style="list-style-type: none"> + Learn about related Physics knowledge +Product design and manufacture: A backup phone charger - Organize from 3 to 4 groups of students to report and ask the remaining groups to comment and discuss the problem to be solved; Evaluate group opinions. - Orientation of the students' subsequent activities. 	<p>Student activities:</p> <ul style="list-style-type: none"> - Teams define the work to be done; Division of duties; Each member of the group comes up with their idea first, then shares it with others and the whole group to hear; Speak up individually in a group - Report, comment, and discuss with the groups what they have learned - Identify knowledge related to the problem. - Identify the problem to be solved - Plan the following activities

Activity 3:- Come up with ideas for implementation.

Target	Students come up with ideas for designing and manufacturing products	
Content	Report, discuss, give feedback, and evaluate product ideas	
Learning products	Orientation questions; Criteria of the product; Complete the Student Activity Sheet	
Activities	<p>Teacher activities:</p> <ul style="list-style-type: none"> - The teacher asks the group of students to ask guiding questions; Assist students in identifying guiding questions. - Support students in identifying product criteria - Guide and support students to discuss in groups and complete study sheets - Provide documents and videos related to the charger. - Guide students to learn. - Organize for any 1 to 2 groups of students to report on the main contents of the knowledge contained in the topic; Ask the 	<p>Student activities:</p> <ul style="list-style-type: none"> - Asking guiding questions (What is the electrical capacity? What is the function of the battery in the power bank? How to install the circuit correctly? What are the precautions when installing the electrical circuit?) - Define product criteria - Study materials and discuss them in groups(students can learn more at home); Complete the questions on the worksheet. - Learn about the portable charge(students can learn at home) - The groups discuss together in the

	remaining groups to make comments and supplements if they are lacking; Teacher comments and evaluates student's report; Summary of knowledge to remember - Clarify the problem to be solved	group and with other groups about the solutions related to the group's project; report, make comments, and discuss with the groups what they have learned; Take notes of what you need to remember. - Plan to solve the problem.
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Activity 4:- Choosing options to design and manufacture products.

Target	- Students design and manufacture a power bank. - Teamwork, adequate division of work in the working process.	
Content	Students work in groups to design and manufacture products.	
Learning products	- A power bank design drawing - A list of materials. - A work breakdown table. - A power bank	
Activities	Teacher activities: - Present the product criteria mentioned in activity 1, guiding the students to propose solutions. - Observe, guide, and remind students when testing products. - Teacher quickly checks the reports of the groups in turn - Teacher gives comments and evaluations	Student activities: - Based on the set criteria, students discuss in groups and develop solutions and hypotheses to solve the problem. - Prepare a table of raw materials and determine the cost of each material. - Design structural drawings. - Build products and run tests.

Activity 5:- Presenting and perfecting the product.

Target	Students confidently introduce products to the class. - Product introduction script - Students introduce the product in front of the class	
Content	Students present their group's work.	
Learning products	- Product introduction script - Students introduce the product to the	
Activities	Teacher activities: - Teacher gives comments and evaluations.	Student activities: - Analysis of test results; Conclude. - The groups present their design products to the teacher and other groups in the class about the model's effectiveness and make suggestions and comments among the groups. - Record the results; Continue to edit and perfect the product.

- **Student activity sheet:** Teachers can use study sheets with the following orientation contents:

STUDENT ACTIVITY SHEET

1. Find out what needs to be researched: What is the research problem of the power bank? Criteria of the product?

2. Learn knowledge

Use textbooks and other resources to complete the following questions:

- What is electrical power?
- State the law of Joule–Lenz?
- What is the work of the power supply? What is the formula for calculating the capacity of a power source?
- What relationship does the work of the power source have to the power consumed in a closed circuit?
- Calculate the power consumed and electrical power when a current of 1A is flowing through the conductor for 1 hour, knowing the potential difference between these two conductors is 6V.
- On the mobile phone battery label, it says 3300 mAh. State the meaning of that parameter.

- A power source with an electromotive force of 12V, connected to this power source with a light bulb to form a closed circuit, provides a current with a magnitude of 0.8 A. Calculate the work this power source produces in 15 minutes and calculate the power of the power source then.

3. Hypothesize a solution to solve the problem

4. Product design and manufacture:

- Draw product design drawings
- Materials used (Material name, cost, quantity)
- Description of product manufacturing steps:
- Describe the operation of product testing

5. Test run and evaluate the product

- Record the necessary data and changes in the tests (specify reasons)
- Make a table of product evaluation criteria and self-assess the product
- Compare products between groups and develop improvements to your team's creations.

Conclusion:-

Combining Design Thinking in general teaching and teaching Physics with the orientation of STEM education is a new approach to applying learner-centered teaching methods. Its value is not in the amount of scientific knowledge that equips students more or less, but most importantly, in forming students' skills to use knowledge in the fields of Science, Technology, Engineering, and Mathematics to solve problems of modern life. On that basis, forming learners the way of thinking, the practice of seeing the problem, the method of solving the problem of the era of everything connected, digitalization, and artificial intelligence. The article has synthesized the overview of STEM education and researched the initial proposal on implementing the steps in Design Thinking applied to teaching Physics through STEM activities for high school teachers. With the hope that, in teaching and learning Physics through implementing activities, the STEM project that arouses students' interest will always go hand in hand with the effectiveness of learning while developing the required competencies for students.

Reference:-

1. Vietnam Ministry of Education and Training. (2018). Circular 32/2018/TT-BGDĐT on the issuance of the 2018 General Education Curriculum.
2. Vietnam Ministry of Education and Training. (2018).Circular 32/2018/TT-BGDĐT on the issuance of the 2018 Physics Curriculum.
3. Vietnam Ministry of Education and Training. (2019).Training materials for developing and implementing STEM education topics in high schools.
4. Nadelson, L. S., Seifert, A. L. (2017). Integrated STEM defined: Contexts, challenges, and the future.The Journal of Educational Research, 110(3), 221-223, <https://doi.org/10.1080/00220671.2017.1289775>.
5. Williams, P. J., & Williams, P. J. (2019). The principles of teaching and learning in STEM education The Principlesof Teaching and Learning in STEM Education. 020001(March). <https://doi.org/10.1063/1.5093996>.
6. Diefenthaler, A., et al. (2017). Thinking and ActingLike a Designer: How design thinking supports innovation in K-12 Education. WISE & IDEO.
7. Carroll, M., et al. (2010). Destination, imaginationand the fires within: Design Thinking in a middle schoolclassroom, International Journal of Art & DesignEducation, 29(1): p.37-53.
8. RikkeFriis Dam. (2021). The 5 Stages in the Design Thinking Process. In Interaction Design Foundation. Retrieved from <https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process>.
9. Uebornickel, F. and W. Brenner. (2020). Design Thinking: The Handbook, World Scientific.