Design and manufacture a number of generator models to organize STEM activities and general physics lessons

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Abstract. In this work, we study and manufacture a number of mini generator models: "thermoelectric machines, hydropower plants and wind power generators" from easy-to-use, environmentally friendly materials. For each model, we provide structure diagrams, operational principles and propose orientations to use generator models in the organization of experience activities, in project teaching, as well as in STEM teaching in high school.

Keywords: Generator model, experience, STEM, STEM teaching

1. Introduction

STEM stands for Science, Technology, Engineering, and Math. STEM education is essentially meant to equip learners with the necessary knowledge and skills in the areas of science, technology, engineering and math. Teaching STEM has helped to "flatten" the global economy in the 21st century. STEM education has evolved into a meta-discipline, an integrated effort that removes traditional barriers between these subjects, and instead focus on innovation and the process of applying design solutions to complex context issues using existing tools and technologies [1][8][10]. STEM education projects and plans have been developed all around the world. However, the key to achieving the success of these methods is to create the interest of learners, help learners to develop self-awareness and take initiative in gaining knowledge. The tool for doing that is experiments, phenomena or practical problems. Therefore, it is very important to develop experimental sets that can serve the teaching of physical knowledge and application, which is one of the prerequisites for the success of the methods active teaching. Therefore, we research and manufacture all kinds of generators used in physics teaching in high school by modern STEM-oriented teaching methods [4][6][9][11][12].

To date in Vietnam, STEM education is not just studied and developed in universities but has been already progressed in high schools [8]. Research on STEM education has been carried out in the Faculty of Physics, Thai Nguyen University of Education. First of all, STEM education is developed to teach students how to apply STEM teaching in high schools [5]. Physics lessons will be interesting, engaging, and help students understand better if teaching is linked to visualizations and active learning. The skills and knowledge in the areas of science, technology, engineering and math (called STEM skills) must be integrated, complemented with each other to help students not only understand the principles but also be able to apply them in practice and create products in daily life. Compared with natural sciences, physics is a subject that is closely related to mathematical, technological, technical and scientific contents, so STEM-oriented education in teaching Physics has a very favorable condition. STEM education is aimed at developing following specific capabilities of each subject for students [3]:

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i. Critical thinking and problem solving skills  
ii. Communication and collaboration skills  
iii. Creativity and discovery skills  
iv. Culture, information and communications technology  
v. Ability to perform project-base tasks  
vi. Presentation capacity

In this work, we study and manufacture models of generators used in physics teaching in high schools using modern STEM-oriented teaching methods.

2. Methodology

2.1. Objectives of the study  
- Manufacturing a number of intuitive and easy-to-use generator models.  
- Proposing some suggestions to build the teaching process according to modern teaching methods: Teaching experience, subject-based teaching, STEM teaching based on the structure and principles of the generator.

2.2. Research Methods  
In this work, we have used the following methods:  
-> Theory research  
- Study the theory of teaching physics  
- Study the theory of STEM teaching  
- Study the theory of construction and operation principles of generators  
-> Practical research  
- We learned about the process of teaching about generators in some high schools in Thai Nguyen province, from which to choose to research, design and manufacture some models of generators: hydropower, thermoelectric machines, wind power generators ... to support this content teaching process.  
- Researching materials in reality when manufacturing electric generator models to meet the requirements: easy to manufacture, easy to make materials, suitable price, good operation, easy to observe ...  
- After successfully manufacturing, we use in some specific activities: Experimental activities for students of Physics Department - Thai Nguyen University of Education, STEM experience activities at Thai Nguyen University of Education showed good teaching effectiveness and received positive feedback from learners and participants.

3. Manufacturing some generator models

3.1. Wind power generator model  
a. Structure  
Experimental equipment includes the following components: (Figure 1)  
- Fan insulation (1)  
- Body: Electric casing and tubers (2)  
- Automatic wind direction adjustment system of generator (3)  
- Led display system (4)  
- Stand and rack (5)  
- Wind supply system (electric fan)  
b. How to install and operate  
+ How to install:  
- Install electric generator on the body  
- Attach the body to the base to make sure the machine  
- Install a fan on the shaft of the generator  
- Install automatic direction adjustment system on the camera body.  
- Connect lighting system to generator.  
+ Operation: Plug the electric fan plug into the power source and blow the wind directly into the generator's impeller, the rotor rotates and we will observe the operation lighting system, proving that there is electricity in the external circuit, the machine operates qualified.
c. Principle of operation: Wind-powered generators operate on the principle of converting mechanical energy (wind energy) into electricity. Wind energy will rotate the rotor of the generator, dragging the rotor of the bulb to rotate in the magnetic field, the induction current will appear (explained based on the principle of electromagnetic induction) taking out the external circuit to use.

3.2. Model of thermoelectric machine
a. Structure (Figure 2)

- Heat supply unit (gas + flammable copper pipe) (1)
- Closed water containers (closed bottles with 2 locks) (2)
- Stand (3)
- Impeller (4)
- Generators (5)
- External circuit lighting system (led) (6)
b. How to install and operate
   + How to install
   - Install heat supply system on the base, fixed by screw.
   - Install 4 vit to create water tank rack
   - Fix the pitcher on the shelf
- Install the impeller on the generator shaft
- Connect electric generator with lighting system to form closed circuit
+ How to operate
Turn on the fuel combustion system (gas) and provide water to the water, after a while the water will transform into a vapor and then spin the propeller along the rotor of the rotating tuber, generating electricity based on the principle of Electromagnetic induction.
c. Principle of operation: Steam-powered generators operate on the principle of turning thermal energy into steam, steam having the mechanical energy converted into electricity. The thermal energy will heat up and evaporate, the steam will turn the generator's rotor, pull the rotor of the bulb to rotate in the magnetic field, the induction current will appear (explained based on the current principle. electromagnetic sensor) removed external circuit to use.

3.3. Hydroelectric model
a. Structure (Figure 3)
Structure of hydroelectric model is provided as the figure as figure 3. It consists of water turbines (1), generators (2), stand (3), two flywheels and curves (4), 3v light bulbs (5), styrofoam containers for water (6) and water pump (7).

b. How to install and operate
+ How to install
- Installation of water turbines and large coaxial wheels, fixed on racks (drawings)
- Install small flywheel on the shaft of generator
- Install electric generator on the rack, fixed again.
- Use belt to connect 2 flywheels
- Install pressure divider valve on the water supply hose, the other end of the water hose fixed to the faucet.
+ How to operate
Open the pressure divider valve for water spraying on the water turbine, the water turbine rotates along the rotor of the rotating tuber, the bulb is bright, the machine works well.
c. Principle of operation: Water-powered generators operate according to the principle of converting the mechanical energy (energy of water flow) into electricity. The energy of the water flow will rotate the propeller of the generator, pulling the rotor of the bulb to rotate in the magnetic field, the induction current will appear (explained based on the principle of electromagnetic induction) taking out the external circuit to use.

4. Orientation of organizing teaching activities
4.1. Organization of experience activities
The use of built-in generator models in the organization of teaching some common knowledge contents under the innovation-oriented general education program can be conducted in the form of creating experiments situations or use as an application device together with structural principles as well as operational principles will create excitement, stimulate and create favorable conditions for students to explore new knowledge.
Below is the structure diagram, operation principles of generator models and some pictures of the experience sessions on hydroelectric models.

4.2. Used in project teaching organization
Teaching about the application of physical technology not only gives learners knowledge of devices and applications of devices in life but also provides knowledge about the process of device development and impact of that development process to social life, to the economy, to the development of science and technology. In the process of teaching physics at high school Teachers can organize teaching projects:

* Project 1: The process of converting energy into electricity in life;
* Project 2: Electricity production and the role of electricity in life with the final product is a model of generators: electricity, hydropower, wind power generators. The organization of these projects teachers will create a favorable environment for students to be active, creative, develop skills and capabilities to meet the innovation trend of general education today.

4.3. Used in STEM teaching
4.3.1. Stages in STEM teaching [2]
STEM-oriented instruction is implemented in the following stages:

*Stage 1: Select STEM topics*
STEM topics in teaching are issues associated with the designing and manufacturing of products related to high school physics knowledge. STEM topics should have a close relationship with reality, solving practical problems, serving the daily life or entertainment of learners.

*Stage 2: Define STEM tasks*
Based on the STEM topics, students are asked to identify STEM tasks that need to be addressed

*Stage 3: Study STEM documents and materials*
After receiving STEM assignments, students study STEM documents so that they can clearly identify the ideas and methods of generate outcomes as well as learn about the contents of relevant physics knowledge in from the STEM topics.

![Figure 8. Procedure of the teaching process under STEM education.](image)

*Stage 4: Generate STEM outcomes*
- Divide classes into groups
- Groups actively assign specific tasks to each member of the group according to their capacity
- Investigate the tools and materials distributed

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Figure 8. Procedure of the teaching process under STEM education.
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- Generate STEM outcomes

This is a difficult step so teachers need to keep track of the activities of each group and give timely help and guidance if necessary. On the other hand, product manufacturing also requires students to meet safety rules so teachers should prepare safety rules and disseminate them to learners. Some complex details may need processing, and then teacher can help learners in this process.

Stage 5: Test the outcomes

During this phase, there are two possibilities for the groups that test the outcomes to access the relevant knowledge of the topic: (1) If the product has defects in its manufacturing process or not consistent with the given knowledge, those groups should review the STEM documents to further refine the product; (2) If the product meets the requirements, those groups will use it to collect the results, make conclusion on the knowledge of magnetic field.

Stage 6: Report experimental results

Groups report the results obtained in stage 5 in form of tables, graphs or qualitative conclusions.

Stage 7: Comments and discussion

Groups review and evaluate products of other groups in the form of peer review. Then, teacher evaluates and gives comments and discussion. Students are encouraged to review the teacher's assessments.

Stage 8: Conclusion

Teacher makes conclusions about the tasks achieved, the knowledge students have acquired, the positive and limited aspects in the teaching process. In addition, teacher gives rewards to members, groups with good sense of learning, good learning results, reminding and giving advises to individuals and groups who do not have good results.

4.3.2. Operation of STEM to manufacture hydroelectric models

Stage 1: Practical issues

Students observe video about generators with water power of people in Giac 2 village, Mo Vang, Van Yen and Yen Bai communes (Source: https://vtv.vn/san-pham/su-dung-suc-nuoc-tao-dien-o-mien-nui-20150201021533036.htm)

The question arises: With the availability of water and electricity generation, how did people do to generate electricity? According to the way people have done it, do you design and build a generator model with water power?

Stage 2: Proposing solutions to solve problems

![Figure 9: Video about using electricity to generate electricity in the highlands](image-url)
Stage 3: Conducting product manufacturing

Figure 10: Students are discussing proposed solutions

Figure 11: Students are building hydroelectric models

Stage 4: Presenting and operating products

Figure 12: Students present products
5. Conclusion

In this project, we have built 03 models of generators: water power generators (hydroelectricity), wind power generators, and thermoelectric generators. Each model comes with structural diagrams, operational principles to ensure accuracy, visualization, aesthetics, economics and propose plans to use models in teaching physics at school. With easy-to-use materials, environmentally friendly, we have built generator models that meet the needs of vehicle use in teaching the innovation of general education. It can be said that the use of cheap and easy-to-use materials to create experiments, the means to support the teaching process is feasible and necessary in the conditions of high schools in Vietnam today. Experimental activities, project-based teaching activities, STEM activities not only stimulate learning interest, promote students’ positive and creative but also create conditions for students to develop their abilities. STEM specific.

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