Teaching material and energy topics in Grade 5 science curriculum based on STEM education

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Abstract. STEM-oriented education is one of the inevitable trends of world education in order to improve the quality of human resources in the 4.0 industrial era. In this orientation, learners have many opportunities to apply their knowledge into practice, know how to apply and synthesize knowledge of science, technology, technology and mathematics to create products on demand within their ability. Currently, STEM education in Vietnam has gradually been applied to a number of subjects at all educational levels. Science curriculum in elementary schools has very suitable content in STEM orientation. In this study, we conduct a research on theoretical basis and design teaching process for some contents under the topic "Material and energy" in the science program of grade 5 oriented to STEM education which contributes to the improvement of teaching science subjects at elementary schools.

1. Introduction
1.1. Nowadays, within the development of the Industrial Revolution 4.0 all over the world, it affects almost every aspect of life in our society, it creates drastically changes in production methods based on scientific foundation and modern technology. This clearly is a chance but also a challenge for nations in developing their countries. Educating high quality human resources for industrialization and modernization era is top priority of many countries today. One of the practical methods of education that many countries are applying for their students is STEM-oriented education (including: Science, Technology, Engineering and Mathematics). In this orientation, learners know how to apply multi-aspect theories into reality, by doing practical experiments, learners are able to develop essential skills and enhance practical adaptation ability [10], [11].

1.2. In the trend of globalization, having approached to the quintessence of education in the world, Vietnamese education is taking major steps in enhancing the quality of human resources. Resolution No 29-NQ/TW on 04/11/2013, the 8th Plenum of the 11th Party Central Committee has clarified the standpoint for education: “Developing education and training is developing people’s knowledge, human resources, cultivating talents. Transforming education from knowledge-based method into developing full potential of skills and quality. Learning must go along with practicing, theories must connect with reality; combining education at school, at home and in society” [6]. After that, on 04/05/2017, The Prime Minister established Directive No. 16/CTT-TTg about enhancing the power to approach the Industrial Revolution 4.0 [3], distributing mission for each ministry, department on focusing on carrying out proposed solutions. Ministry of Education and Training must soon implement education of science, technology, engineering and mathematics (STEM) in general education; deploying pilot projects in a number of public schools in 2017 – 2018 school year. Conducting the Resolution from Communist Party of Vietnam, National Assembly and Decision of the Prime Minister, the new general education curriculum is built based on the
orientation of developing quality and skills of students. The general education curriculum is established with Circular No. 32/2018-TT-BGDĐT on 26/12/2018, the content of this orientation clarifies: i) With Technology Education “Along with subjects like Mathematics, Science, Natural Science, Physics, Chemistry, Biology and Information Technology, Technology plays a vital part in applying STEM”; ii) With Information Technology Education “along with Mathematics, Science, Natural Science, Physics, Chemistry, Biology, Technology takes part in implementing STEM”. As a result, STEM education has become an official method for educating science, technology, engineering and mathematics in the new curriculum which validates from 02/2019, this will gradually replace the current curriculum with the procedure of changing curriculum and schoolbooks [12], [13].

1.3. According to elementary education curriculum, Science is a compulsory subject from 4 to 5 grade. Derive and develop from Nature and Society (in 1, 2, 3 grade), the content of Science (in 4, 5 grade) include knowledge about Physics, Chemistry, Biology, built up from elementary and basic knowledge of Natural Science and aspects of researching about health education, environment education. With such characteristics, Science in grade 4 and grade 5 has high potential to apply STEM. Nowadays, there is yet any insight research about STEM education in elementary education, mostly the current researches are about extra activities. Consequently, we decided to choose “Teaching material and energy topics in grade-5 Science curriculum basing on STEM education” to conduct the research.

In this research, we give a fundamental knowledge about STEM education and the process of teaching certain content of “Material and energy” topics in grade-5 Science curriculum basing on STEM education.

2. Background and problems of the research

The trend of studying STEM first occurred in the beginning of the 90s of XX century, the term “STEM” first appeared in United States of America, besides, there are several other terms for that like STEM aspect, STEM education, STEM integration,… In which, STEM is understood as a method of approaching multiple aspects in the process of learning of students, the content of each subject appears in each other and completes each other [7]. In STEM education, students are organized and instructed to link related knowledge as science, technology, engineering and mathematics to solve real problems or follow the tasks given by the educator. By solving real problems in STEM education’s method, the process of study becomes more appealing, stimulates and encourages students’ passion for scientific research. Moreover, linking school with community as well as other organizations by solving local problems or national and international problems such as climate change, environment pollution, disasters,… With such characteristics, STEM-oriented education, is the connection, linking knowledge of multiple fields and through practical experiences, learners are able to apply related knowledge to solve the problem.

Until now, STEM education is being studied more and more and it’s also being applied in many countries such as England, France, United States of America, Russia, China, Japan, Korea, Australia, Singapore, Israel, Poland, Brazil, … [5]

In Vietnam, STEM education first appeared in 2010 through the cooperation of domestic education firms with foreign organizations, they worked independently mostly, STEM education was not in the curriculum of general education. To follow the slogan “Study goes as a pair with practice”, “theories goes as a pair with reality”, since 2012, Ministry of Education and Training has organized many events such as “Applying multi-subject knowledge to solve practical problems for high school students” contest and “Teaching integrational topics for high school teachers” contest, “Science and Engineering Fair” for high school students [5], International Exhibition for Young Inventors, “ROBOCON”. Even though all of the events above do not fully accommodate STEM education, but fundamentally, it is a form of STEM education.

In 2016 – 2017 school year, British Council cooperated with Vietnamese Ministry of Education and Training to conduct the pilot project “Applying UK STEM Approach in Vietnam context” in 15 secondary and high schools in provinces such as Hanoi, Hai Duong, Hai Phong, Quang Ninh and Nam Dinh [4], this was an important prerequisite to develop STEM on a scale of nationwide. In elementary education, there are a number of subjects that STEM can be used in as Science, Technology (Grade 4 and 5). However, STEM education is still fairly strange to elementary school teachers and elementary school students because it has not been implemented and trained officially like in secondary schools and high schools. In which the condition is favorable, a number of organizations which have been implementing STEM
activities are Endeavor Learning Institute and S3 Creative Academy, … these activities stand independently from the content of learning curriculum, this is a form of business and community broadcasting.

In this research, we proposed the process of teaching certain content of “Material and energy” topics in grade-5 Science curriculum basing on STEM education. With elementary education, our approach followed Sanders’ opinion about STEM education: “STEM education includes approaches that explore teaching and learning between/among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects” [9], from this opinion, STEM education is understood as the connection of more than 2 different fields of Science, Technology, Engineering and Mathematics. Because the content of the Science subject is about science so STEM education in Science subject of grade 5 can be comprehended as the connection of more than 2 fields of Technology, Engineering and Mathematics.

Material and energy

Characteristics and usages of common material

1. Bamboo, rattan, calamus
2. Iron, cast iron, steel
3. Copper and copper alloys
4. Aluminum
5. Limestone
6. Construction ceramics: brick, tile
7. Cement
8. Glass
9. Rubber
10. Plastic
11. Floss

The transformation of substances

1. The transformation of substances
2. Mixture
3. Solution
4. Chemical changes

Energy consumption

1. Energy
2. Solar energy
3. Using fuel energy
4. Using wind energy and running water energy
5. Using electrical power
6. Safety and avoid wasting when using electricity

Figure 1. The content of “Material and energy” topic of Science in grade 5

Figure 1 shows the content of “Material and energy” topic of Science in grade 5 is very close to real life and can be fully built following STEM-oriented lesson based on STEM spirit.

Based on the content of the curriculum, we proposed the process of teaching certain content of “Material and energy” topics in grade-5 Science curriculum basing on STEM education as following:

Step 1. Choosing the content of the lesson
In current curriculum, not every lesson can be designed based on STEM-oriented education, so we need to choose suitable content with STEM orientation which can connect more than 2 aspects of Engineering, Technology, Mathematics to design.

Step 2. Specify the aims of the lesson
Based on the content to specify the aims of the lesson, the aims must ensure knowledge, skills and attitude still follow the original curriculum, in which focus skills of STEM orientation like collaborative skills, problem-solving skills, communication skills, practical skills, …

Step 3. Specify the related fields
Base on the content of the lesson, level of students, the condition of the facilities, estimated time for activities. From those conditions, specify the related fields as following:
Example:

Table 1. Specify related fields

| Activity                  | Aim of activity                                                  | Related fields       | Tool, material                      |
|---------------------------|------------------------------------------------------------------|----------------------|-------------------------------------|
| Create multifunctional hanger | Linking knowledge of Technology, Mathematics to make the aluminum multifunctional hanger | Engineering, Technology, Mathematics | Pliers, aluminum wire, super glue, iron glue |
|                           | The design of the hanger                                          |                      |                                     |
|                           | Describe by words or draw the aluminum multifunctional hanger     |                      |                                     |
|                           | Calculate the length of aluminum needed to make a 5cm aluminum hanger |                      |                                     |
| Create bamboo fence       | Linking knowledge of Engineering, Technology, Mathematics to make the bamboo fence | Students design the fence | 10 bamboo sticks 15cm long and 1 cm wide (diameter). |
|                           | Barriers made of bamboo sticks are arranged in parallel, evenly spaced. The bamboo sticks are held tightly by 2 bamboo bars arranged perpendicularly to the parallel, evenly spaced bamboo bars. Use glue to stick the bamboo sticks together |                      | 2 bamboo bars 20 cm long and 1 cm wide (diameter). |
|                           | - Measure the correct size of the bamboo sticks                  |                      | - Super glue, iron glue.            |
|                           | - Place the parallel bamboo sticks 1.5 cm apart                   |                      | - 30cm plastic ruler.               |
|                           | - Glue spreaders                                                  |                      | - Glue spreaders                    |

**Step 4. Design the lesson**

The design of the lesson can be presented in many different ways. We introduce the following suggested template:

**Lesson title/ Name of the lesson**

**Aims of the lesson:**
- Knowledge
- Skills
- Attitude

**Preparation**
- Teacher
- Student

**Teaching-learning activities**

**Consolidation**

While designing the lesson, it is necessary to balance the time for students to learn new theoretical knowledge with the time for students to practice, ensuring there is enough time for practicing making products.

In teaching-learning activities, it is necessary to apply positive teaching methods to encourage the participation of students to practice collaborative skills, practical skills, problem-solving skills, …

**Step 5. Organize teaching activities**

Follow the design of teaching process in step 4.
In the process of organizing teaching activities, it is necessary to arrange and sort out suitable practice places, safe practice activities and creating a comfortable psychological environment, encouraging creativity and cooperation.

While students are performing given tasks, teacher needs to cover the groups for timely support and guidance. At the same time, observe and evaluate students throughout the process of performing given tasks, not just the final product.

**Step 6. Evaluation**

Teacher re-evaluates the suitability of the lesson content with the related fields, feasibility compared to the current conditions of the school, practicality, fit, ... on the basis of which there are adjustments and improve accordingly.

**3. Results and discussion**

Within the scope of this study, we illustrate the design of lesson about: Bamboo, rattan, calamus

**Name of the lesson:** **BAMBOO, RATTAN, CALAMUS**

**I. Aims of the lesson**

After the lesson, student must comprehend:

- **Knowledge:** Understand characteristics and usages of bamboo, rattan, calamus.
- **Skills:** Applying lesson knowledge and knowledge related to techniques and mathematics to make fences from bamboo. Gain collaborative skills, problem-solving skills, communication skills, practical skills.
- **Attitude:** Educate students scientific disciplines, seriousness in practicing, grow students’ passion for research.

**II. Preparation**

- **Teacher preparation:** Handouts, a number of bamboo and rattan and calamus bars; illustrating images; super glue, iron glue; Bamboo barrier pattern.
- **Student preparation:** Each group carries 15 bamboo sticks of 15cm length; 2 bamboo sticks of 20 cm length (can use disposable bamboo chopsticks sold at supermarkets); ruler, pencil, 4 bottles of super glue, 1 bottle of small 502 iron glue.

**III. Teaching-learning activities**

1) **Activity 1:** Learn about the characteristics and uses of bamboo, rattan and calamus

   - **Aims:** Students create a table to compare characteristics of bamboo, rattan and calamus.
- Activity: Students discuss in groups of 4 to complete the handout. Students observe the images in textbook, discuss in groups and fill out the handout; Representatives of all groups present their results.

**Handout**

Complete the following table:

| Characteristic | Bamboo | Rattan |
|----------------|--------|--------|
| Usage          |        |        |

2) Activity 2: Observe the instructions for making bamboo fences

- Teacher instructs students on how to make bamboo fences. Following the orders below:
  + The fences are made of 15 cm long bamboo sticks arranged in parallel, evenly spaced at 1.5 cm.

**Figure 3. Parallel and evenly spaced bamboo sticks**

+ The bamboo sticks are held by 2 bamboo bars arranged perpendicularly to the parallel and evenly spaced bamboo sticks, use super glue to stabilize the bamboo sticks, do as the following instruction:
  
  Apply super glue on one side of two horizontal bars, wait 1 minute for the glue to dry. Use a ruler to press on the parallel sticks so that they are not skew, mark the measured distance and spread super glue on upper side of the parallel sticks, wait 1 minute for the glue to dry.

**Figure 4. Stabilizing the parallel bamboo sticks, marking and spreading glue**

+ Use a ruler to press on the parallel sticks to stabilize, place 2 horizontal bars on the parallel sticks (on the side that glue was spread), hold and press for a couple of seconds. Fix the position of the sticks, and then apply iron glue on the contact points of vertical sticks and horizontal bars.

**Figure 5. Applying iron glue on the contact points of vertical sticks and horizontal bars**

Wait 10 seconds for the glue to dry, take the ruler out, we have a bamboo fence.
3) Activity 3
- Students draw the design of the fence, arrange materials in accordance with specifications about lengths, widths, needed tools, …
- Performing the tasks according to the teacher’s instructions.
- While students are practicing, teachers need to observe and remind students to follow the correct set of actions, assign tasks that include teamwork, maintain labor safety.

4) Activity 4
- Students present the products of their groups. Group representatives report the process of making the product.
- Teacher ask the groups to comment on each other’s products, and then teacher gives comment on the preparation of needed tools, material; morale, attitude when students take part in the group activities; skills in the process of making and the group’s product.

III. Consolidation
- Students repeat the characteristics, usages of bamboo, rattan and calamus; the valuable lesson from the process of making bamboo fences.
- Teacher gives comment on the lesson and give directions for the next lesson.

Similar to other content in the “Material and energy” topics in grade-5 Science curriculum basing on STEM-oriented education, such as: Aluminum, cement, construction ceramics, rubber, … all of the tools and materials that students can make use of, old household objects that are no longer used, easy to find, suitable with every area of the country.

4. Conclusion
The content of “Material and energy” topics in Science grade 5 is very suitable for designing STEM-oriented lessons. The practical and experiential activities in STEM lesson of “Material and energy” topics are compliant with the orientation of developing skills and quality of learners. To ensure the effects of STEM-oriented lesson, we need to follow the 6-step process. In the process of designing the activities, we need to prioritize in using available local materials. In conclusion, implementing STEM education in elementary education is completely suitable and practical, even in remote areas.

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