Develop cooperative capacity for students in STEM modelation model

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Abstract: STEM is an educational model which is being concerned by countries around the world and Vietnam. With the goal of developing career capacities and orientations for students, STEM education model helps connect schools, communities, workplaces and global organizations by learning through action. Students experience and apply the integrated knowledge in the areas of Science, Technology, Engineering and Maths to solve practical problems and create products. The nature of STEM education is collaborative teaching. Collaboration in STEM teaching is expressed in the content of the subject, in the learning activities, in the learners and in the cooperative learning results in the education model. STEM is the development of professional-oriented competencies for students.
Keywords: STEM education, integrated, cooperative capacity, career capacity

1. Introduction
STEM is an acronym for Science, Technology, Engineering and Mathematics. According to the National Science Teachers Association – NSTA, established in 1944: “STEM education is an interdisciplinary approach to learning where rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise enabling the development of STEM literacy and with it the ability to compete in the new economy” [8], [14].

Tsupros and partner also defined STEM education is an interdisciplinary approach to learning, where the academic knowledge is closely linked with the practical lessons through students applying the knowledges Science, Technology, Engineering and Mathematics. Into specific contexts creates a connection between schools, communities and businesses that allow learners to develop STEM skills and increase competitiveness in a new economy [7], [15], [16]. According to Le Xuan Quang, interdisciplinarity in STEM education is a combination of twoin Science, Technology, Engineering, and Mathematics fields and above, in which learning content is tied to practiceland teaching methods are implemented from the viewpoint of action-oriented teaching [5].

Many domestic and foreign authors have different definitions of STEM education although the notion is different, the authors all agree that STEM education is an interdisciplinary integrated learning model with each other in various fields and connecting many organizations involved in teaching activities. In STEM education, learning activities prioritize hands-on activities, experience and apply knowledge to
create products or solve real life problems. Learning through action, students will increase their interest, passion for exploring science-technology, creativity in the way they work.

2. Content
2.1. Characteristics of Cooperation learning
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According to Nguyen Thi Thanh: “Cooperation learning is a way of learning in which learners are organized into groups working together to complete learning tasks, among which they have interaction, mutual, Interdependence, from which habits and cooperative skills are formed and developed”[6]. This is a method of participatory learning, direct contribution of many students, working together to achieve common results. In the process of cooperation, students develop their own capacity, have just promoted the capacity to work together among team members, promote positive influence on each other.

2.1.2. Cooperative capacity
According to Le Thi Minh Hoa [1], cooperative capacity is a form of capacity, allow individuals to flexibly and there is an organization between the knowledge needed for cooperative, skills and attitudes, values, personal motivation to effectively meet the requirements of cooperative activities in specific contexts. In which each individual shows a positive, self-conscious, interaction and high responsibility on the basis of knowledge mobilization, own skills to effectively resolve with cooperative activities [1]. Phan Thanh Hoi, Pham Huyen Phuong said that cooperative capacity is the ability to organize and manage groups, perform group activities in a proficient, flexible and creative way to solve common tasks effective [2].

The authors have agreed that cooperative capacity is the capacity associated with cooperative activities, meaning that individuals use knowledge, skills, and attitudes in a certain context to collaborate in groups to solve tasks together.

In our opinion, cooperative capacity is a form of competence that individuals use their knowledge, skills, and attitudes to cooperate in groups to solve assigned tasks in a given context.

2.2. Developing Cooperative capacity in learning through STEM education model
From analysis of the nature of STEM teaching and cooperative learning capacity shows: cooperative in STEM education is not only the integration, interaction between subjects, between students and students, between students and teachers, but also the interaction between students and the environment including all phenomena around students are: family, society, community, learning environment, living environment.

So, the essence of STEM education is cooperative teaching, the cooperative in STEM teaching is manifested in the following factors:

First: Cooperative perform in subjects content.
In essence, STEM education is an interdisciplinary approach between subject the contents, the subjects; therefore, students do not study subjects separately but have integration of the same contents, then apply them to different environments and fields. Due to the interdisciplinary nature, there is Cooperative in the specialize fields through each integrated topic. These are content topics related to two or more subjects, expressed in their application in the same phenomenon, process in nature or society.

For example the oxygen topic is an interdisciplinary combination of chemistry, geography, biology subjects. Chemistry helps students learn about the structure and properties of oxygen, the application of oxygen in industry, and learn how to prepare oxygen; Biology helps students to recognize the role of oxygen in the life of organisms; Geography explores the atmosphere the distribution of air temperature on Earth. Students will study each major topic, wide-ranging applications in fields that will be updated and applied practically. So it helps students not to repeat the same content many times in different subjects, just overloaded, boring, there is no general understanding as well as the applicability of general knowledge to practice.
**Second: Cooperative together in problem solving**

STEM education utilizes a learning method that is primarily based on practical and experiential activities. To solve learning problems, students not only work independently but also cooperative with each other, each student applies their different levels of competency to study together. Cooperative is also expressed through the interaction between students and the community such as exchanging with experts in the fields in which knowledge is learning, interacting with the community, local people or organizations, enterprise. Through cooperative experience, students acquire different knowledge and competencies.

In STEM teaching, students must apply knowledge of scientific fields to solve problems in practice. Therefore, students must search and study the knowledge of subject-related issues through textbooks, instructional materials, laboratory equipment, technological equipment and use them to solve problems. These knowledge and skills must be integrated and complementary to help students not only understand the principles but also be able to practice and create products in everyday life.

**Third: Cooperative together in methods to perform academic tasks**

In each STEM-themed lesson, students are placed in a situation with practical problems to be solved related to scientific knowledge. STEM education utilizes a learning method that is primarily based on practical and experiential activities. Cooperative together in methods to perform academic tasks is expressed through the cooperative together in methods to perform academic tasks of students with learning activities such as interaction with utensils, materials, and game activities through various forms of experience such as project work, learning, role-playing, extracurricular activities, sightseeing, experiments. Through which students are working together, exchanging, giving ideas, helping each other to solve learning tasks. Since then, forming and forge the skills and competencies lacking for students.

2.3. Design teaching topics based on STEM Education model in high schools in the direction of developing cooperative capacity

According to Van Thị Thanh Nhung [4], teaching with STEM model in the current general education curriculum can be implemented in two contexts:

- Learning through the topic is built on the connection of knowledge of many different subjects. Teachers take the topic as the starting point of the cognitive process, students learn, research and self-direct the research of relevant knowledge.
- Learning through scientific research activities and applying knowledge into practice. On the basis of synthesizing theoretical knowledge of STEM subjects, students apply creative knowledge to create practical applications product.

With the above approaches, students must work together to carry out learning tasks.

In order to gradually introduce STEM Education into high schools as a premise, the basis for implementing a new high school education program, in our opinion, it is necessary to build according to each subject STEM. STEM topics need to be very flexible and can be implemented in many forms. In order to build a STEM topic that helps students to develop the cooperation capacity, we recommend a design process that includes the following steps:

**Step 1. Building the topic**

Building topics is an important content in designing integrated lesson in general, teaching STEM model in particular. Therefore, choosing a topic should select subjects with relevant knowledge to solve the problems in the given topic. The presence of subject knowledge is also a way to inspire as it stimulates students' interest and curiosity. Select challenging topics and encourage learners to engage in the discovery process, Thinking and problem solving are essential in teaching in an interdisciplinary approach.

**1. Basis for choosing topics**
To select a topic, teachers must have a deep understanding of the subject curriculum, especially the programs of subjects that are related to each other to compare, to respect characteristics that guide students to achieve a defined teaching goal. For the selection of topics in teaching according to STEM model, there are approaches to select topics as follows.

+ Approach based on objects of the natural world but having close and close relationship with human life ...
+ Approach based on the principle of sustainable exploitation and use of natural resources.

For example: garbage and garbage disposal are always a global pressing issue. Currently, in the world in general and in Vietnam in particular, the garbage treatment is being concerned and needs the cooperation of many objects, including students.

In high school, garbage-related knowledge is covered in many lessons of Chemistry, Technology, Biology, Geography makes knowledge search disjointed, not seamless. Some of the repetitive knowledge make it difficult for students to acquire knowledge and apply to solve problems raised in life.

2. Name the subject

From the above information, the teacher identifies and names the topic / lesson. The title of the lesson or topic needs to fully reflect the topic / lesson content and must attract students in learning. Teachers raise practical problems in many forms such as: a story, a real situation, practical exercises, learning projects that solve practical problems, creative experience activities, research activities scientific research… make students appear need for practical problem solving.

For example: Teacher names the topic: SUPER HERO TEAM - Microbiology. The topic of superhero - microorganism contains both knowledge about microorganisms and helps students know the role of microorganisms in life, thereby applying them in practice to help people solve many problems in life.

Step 2: Determine the goal of the topic

It is necessary to identify the goals of knowledge, skills and attitudes that need to be achieved after implementing the STEM topic for students. The goals need to be clear, feasible and relevant to student competencies and local conditions.

1. Knowledge:
   - Students state the structure and characteristics of microorganisms, the role of microorganisms in life.
   - Presenting the concept of environmental pollution, the causes of environmental pollution, especially domestic waste, stating measures to limit pollution of the living environment.
   - Understand the growth of microorganisms in continuous or discontinuous culture media.
   - Explain the role of microorganisms in domestic waste.
   - Know the reactions that occur during composting

2. Skills
   - Train students with experimental observation skills, draw comments
   - Forming for students the skills of teamwork, information presentation, critical, practical skills
   - Develop curiosity, creativity and passion for research.
   - Equip students with global skills in the twenty-first century: critical and creative thinking, oral and presentation skills, interpersonal and collaborative skills.

3. Attitude
   - Forming for students a sense of personal and community responsibility to protect the environment.
   - Through self-research the students formulate themselves experiences and ways to handle situations in life.
   - See the important role of STEM knowledge and skills in solving practical issues, product design and manufacturing.
   - Recognizing the need for interdisciplinary and integrated insights in life and the power of STEM fields in the economy and society today.
   - Help students with career orientation.

4. Capacity orientation
Table 1: Capacity orientations

| General capacity                                      | Own capacity                                      |
|-------------------------------------------------------|---------------------------------------------------|
| Self-learning Capacity                                | Awareness capacity of scientific knowledge        |
| Capacity to solve problems and be creative            | The capacity to explore and explore               |
| Communication and cooperation Capacity                 | Capacity to apply scientific knowledge into practice|
| ICT capacity                                          |                                                   |

**Step 3. Build thematic content**

After getting the topic, building the content of the topic is an important job, it is also a difficult job for teachers. In teaching according to STEM model, to approach the problems of natural sciences, technology, math, engineering, when build content, it should clarify the following issues:

1. **Identify the problem that needs to be addressed in a topic**

The essence of this step is to provide pedagogical ideas to identify problems and to apply STEM subjects' knowledge to solve problems. To develop the capacity to apply knowledge to solve problems in teaching in high school, this is considered the most important step. From real life practice, teachers can suggestions to raise issues that contain cognitive contradictions. To solve these contradictory, students not only apply the knowledge they have learned from different subjects to solve, but they can also take practical actions to create products. With the ingenuity and fluency in using pedagogical methods, teachers raise practical problems in many forms such as: a story, a practical situation, practical exercises, and solving learning projects. Solve practical issues, creative experience activities, scientific research activities…make students appear need for practical problem solving.

The problems are often questions, situations through the topic learning process that students can answer. An integrated topic following the STEM model, there may be many issues to be addressed. Depending on students' ability, level and physiological development to develop the content of the issues accordingly.

With the above example, the question is: How to thoroughly handle domestic garbage without affecting environmental pollution through the following practical exercise of the pollution of garbage domestic waste. According to the latest survey, one day in a big city like Hanoi, Ho Chi Minh City discharged about 0.7 kg of waste / person / day, in the city just released about 0.5 kg / person / daily, in small cities, towns and rural areas discharged about 0.3 kg / person / day. So one day in our country with over 90 million people has discharged. How much garbage into the environment? The problem here is that while garbage is always discharged into the environment in such a large amount, there has not been a thorough solution to deal with pollution of the landscape and living environment. So, how will we reduce the environmental pollution caused by domestic garbage?

2. **Identify relevant knowledge circuit**

From researching program of subjects to identifying topics, teachers can identify the logic and knowledge circuits related to the subjects developed and applied to solve thematic problems and duration for students to research and complete the thematic content. In the above example, the relevant knowledge circuit is:
Table 2: Knowledge related to the topic

| Subjects     | Knowledge related to the topic                                                                                                                                                                                                 |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Math         | Statistics of household garbage composition (15-20 households), find out the ratio of ingredients in the yeast process, yeast and garbage mixing ratio.                                                                                  |
| Chemistry    | Understanding the components of organic garbage, possible reactions during treatment, The rate of garbage decomposition depends on the composition and properties of organic substances, paying attention to the relevant conditions like pH. |
| Physical     | Understand the temperature conditions during the composting process, the temperature conditions during the fermentation process.                                                                                           |
| biology      | Conducting a survey and classification of household waste of households. Learn probiotics, microorganisms in probiotics.                                                                                                    |
| Technology   | How to make probiotics. Composting methods to create compost. Proceed to make probiotics, composting from organic household waste of their households. Get compost to grow vegetables.                                              |

2. Building thematic content
Based on the general idea and solving problems raised by the topic, teachers determine the knowledge to be included in the subject. The knowledge of integrated thematic interdisciplinary often involve two or more subjects. So, it is necessary to base on the initial objectives to determine the core content to be included in the thematic. To make this step well, teachers can coordinate with subject teachers related to the subject matter to develop content to ensure the accuracy of the content and the richness of expression. In the example above, the thematic content includes:

1. The concept of domestic garbage, domestic garbage classification
2. Definition, characteristics and composition of organic garbage
3. Methods of treating organic garbage without causing environmental pollution
4. Application of microbiological technology in handling organic garbage
   - The concept of microbiological technology
   - Microbiological products in garbage treatment technology
   - Practicing processing of probiotics to treat organic garbage on a household scale

Step 4. Design learning activities
In designing lesson plans based on STEM model, designing learning activities is an important step, it is necessary to enhance activities to promote the active and proactive of each individual learner, at the same time, develop capacity to cooperate, work together to build a problem-solving plan. Because issues in interdisciplinary teaching topics are often associated with practical contexts or situations involving students, priority should be given to experiential activities that bring students into real life to occupy domains knowledge, problem solving. From specific activities, teachers can choose methods and forms of organizing lessons to suit the activities of students.

One of the core values of the STEM theme program is to inspire individual creativity, helping to develop the characteristics of individuals: fluency, flexibility, originality, meticulousness.

In the above example, the teacher divides the class into small groups, each group has a leader, a secretary and 7-8 members. Tasks of groups were carried out the following activities:
Table 3: Tasks of groups

| Activity 1: Understanding garbage, garbage classification, nature, characteristics and composition of organic garbage; The methods of treating organic garbage do not pollute the environment. |
|---|
| The work to be perform: |
| - Dividing the tasks of the members of the group based on the capacity of each individual |
| - Learn the theoretical basis of household garbage, household garbage classification and characteristics |
| - Learn the methods of handling domestic garbage |
| - Investigate the situation of domestic garbage treatment and the pollution caused by domestic garbage |

| Activity 2: Understanding the application of microbiological technology in organic garbage treatment |
|---|
| The work to be perform: |
| - Dividing the tasks of the members of the group based on the capacity of each individual |
| - Learn microbiological technology in domestic garbage treatment |
| - Manufacturing microbiological products for processing environmental protection garbage |
| - Experiments proving the effectiveness of probiotics on daily-life garbage treatment |
| + Experiment 1: Organic garbage left in the natural environment after 7 days |
| + Experiment 2: Burying organic garbage for 7 days. |
| Experiment 3: Anaerobic mixture of garbage and microorganisms produced for 7 days. Observe the rate of decomposition of garbage and odors |
| Record products with photos and videos. |

Step 5. Design teaching plan

Based on the proposed activities, teachers can plan lesson plans. The plan should specify the time to complete the topic, the expected learning activities, expected groups and activities of each group; expected student's required product. Describe clearly the products that students must complete in terms of content and form of presentation (newspaper articles, presentations, photo albums, videos, models, real objects, experiment tools, software ...); specify the name and requirements of the product along with product evaluation criteria, etc.

STEM thematic teaching plan must show the following contents:

1. Identify the subject and duration of STEM thematic organization
   * Object: need to identify subjects that are appropriate to the theme on the basis of content closely linked to the general curriculum of the Ministry of Education and Training. According to the general education program, students who can take STEM courses are students from grades 1 to 12. Therefore, when designing thematic subjects, it is necessary to determine exactly used for each specific object.
   * Time: need to determine the appropriate time including preparation time, implementation time. Each topic should build classroom time from 60 to 90 minutes.

With the above topic,
- Target audience: Grade 10 high school students
- Duration: 1 week
- Form of organization: formal and extracurricular
2. **Identify the medium, specimens, tool for perform STEM topic**

Based on the content, objectives, teachers prepare or guide students to fully prepare the facilities, tools ... necessary to organize the implementation of the topic.

For the above example, the material to be prepared is:

- Plastic bottles / trash
- Raw materials for producing probiotics: Cu Rieng, rice, bran powder, yogurt
- Experimental place and some other equipment.

![Figure 1: Galangal stems and roots (Alpinia officinarum)](image)

3. **Form of organization**

STEM teaching subjects can be held during regular classes at STEM rooms of the school or production facilities, STEM rooms of enterprises, vocational training schools, etc., when designing, it is necessary to clearly identify the venue, essential equipment, etc. So, when designing thematic, it is necessary to specify where the subject matter can be implemented.

For the above topic, students can perform in the main curriculum in classrooms, laboratories, and extra-curricular activities in local practical conditions.

4. **Expected finished products and display products**

STEM model learning is a form of learning through action, so the results of learning activities need product. Therefore, after doing the topic, students report the results of STEM apply process to solve practical problems, Product presentation works. Teachers should anticipate the type of product they complete, the form of display, expansion and development so that students propose a number of newly arising issues and new ideas related to the topic.

In the above example, the student must present the process of producing probiotics; The experimental results are observed and comments drawn from the experiment.

Here are some illustrations:

![Figure 2: Rice flour and galangal flour](image)
Figure 3: Probiotics

Step 6: Evaluation
Teachers ask students to self-evaluate and assessment between students about the operation process and products based on the evaluation sheets. Teachers evaluate and systematize knowledge before students save results to individual learning records.

Figure 4: Results of experiments over days

3. Conclusion
Through applying STEM teaching into practice we realize that students are working in learning groups, cooperating with each other, research together, work together to create products. Through the handshaking action, students will gain a deep understanding of the theory and the nature of phenomenal. Students are to work in groups, discuss and explore by themselves, apply knowledge into practical activities. When working in groups, students will be placed in an environment that promotes the needs of communicating and sharing ideas and exploring solutions together. Develop cooperative skills, communication ...From there, students develop special cognitive and social skills and develop specialized, career-specific competencies for students that society needs today.

References
[1]. Lê Thị Minh Hoa (2014), Developing collaborative capacity for middle school students, Educational Journal - Issue 343, October. (Vietnamese)
[2]. Phan Thị Thanh Hồi, Phan Huyền Phương (2015), Strengthen students' cooperation capacity in teaching the chapter of physical transformation and energy - biology 11 high school, Science magazine, Hanoi National University of Education, 60 (1): 88-97 (Vietnamese)
[3]. Phan Thị Thanh Hồi, Pham Huyền Phương (2015), Assessment of collaborative capacity in teaching the chapter of material and energy-biological metabolism, 11 high school, Scientific Journal, Hanoi National University of Education, 60 (2): 102-113 (Vietnamese)
[4]. Văn Thị Thanh Nhúng (2018), Designing some teaching topics according to STEM educational model, Final report of key scientific research topics at school level, Hue University of Education. (Vietnamese)
[5]. Lê Xuân Quang (2017), Teaching General Technology subject to STEM education, Education Science Doctoral Thesis, Hanoi National University of Education. (Vietnamese)

[6]. Nguyễn Thị Thanh (2013), teaching in the direction of developing cooperative learning skills for pedagogical university students, educational science doctoral thesis, Thai Nguyen University of Education (Vietnamese)

[7]. Tsupros N., Kohler R., and Hallinen J. (2009), STEM education: A project to identify the missing components, Intermediate Unit 1: Center for STEM Education and Leonard Gelfand Center for Service Learning and Outreach, Carnegie Mellon University, Pennsylvania.

[8]. Kar-Tin Lee1, Rod Nason (2009), Reforming the Preparation of Future STEM Teachers, 2nd International STEM in Education Conference, Queensland University of Technology, Brisbane k5.lee@qut.edu.au, p.33-39.

[9]. Brown J. (2012), "The current status of STEM education research", Journal of STEM Education: Innovations and Research, 13(5), pp. 7-11.

[10]. Ejiwale, J. (2013). Barriers to successful implementation of STEM education. Journal of Education and Learning. Vol.7 (2) pp. 63-74.

[11]. Kar-Tin Lee1, Rod Nason (2009), Reforming the Preparation of Future STEM Teachers, 2nd International STEM in Education Conference, Queensland University of Technology, Brisbane k5.lee@qut.edu.au, p.33-39

[12]. Sanders M. (2009), "STEM, STEM Education, STEM mania", Technology Teacher, 68(4), pp. 20-26.

[13]. Nguyễn Thị Thụy Trang (2019), "High school students in Vietnam apply scientific method to solve problem used in stem education", International Conference - Hanoi, Vietnam

[14]. Sutaphan, S. and Yuenyong, C. (2019). STEM Education Teaching approach: Inquiry from the Context Based. Journal of Physics: Conference Series, 1340 (1), 012003

[15]. Linh NQ, Duc NM, & Yuenyong C 2019 Developing critical thinking of students through STEM educational orientation program in Vietnam. Journal of Physics: Conference Series, 1340 (1), 012025

[16]. Duc NM, Linh NQ, & Yuenyong C 2019 Implement of STEM education in Vietnamese high school: unit of acid-base reagent from purple cabbage. Journal of Physics: Conference Series, 1340 (1), 012029