American Journal of Sciences and Engineering Research

E-ISSN -2348 – 703X, Volume 6, Issue 2, 2023

Process of Designing Integrated Stem Topic Teaching (iSTEM) Apply in Vietnam High School

Le Thinh - Pham Thi Phu

Vinh University, Vietnam

ABSTRACT:

In Vietnam, STEM integrated education is focused on implementing in the 2018 Education Reform Program. Teaching integrated STEM topic (referred to as iSTEM topics) for science subjects is a problem that many teachers care and support. On the basis of analysis and evaluation of existing processes and criteria, we propose a process to develop iSTEM topics for teaching Physics in high schools in Vietnam.

KEY WORD: STEM integrated topic, process of building iSTEM topic, iSTEM topic

I. Approach

In our country, integrated education in general and STEM integrated education in particular have been interested in recent years. In order to actualize integrated education and integrated STEM education in our country's high schools to a certain extent, since 2012 the Ministry of Education and Training has organized the contest "Teaching with integrated topic" for high school teachers, and the contest "Applying interdisciplinary knowledge to solve real-life situations" for high school students. There has been no published research on this whole activity, drawing theoretical conclusions about the design of STEM-integrated topics so that teachers can widely apply it.

In the General Education Program 2018 [1], STEM education is more oriented; Specifically: increasing integration in the lower grades (Natural Sciences subject in junior high school), having all subjects S, T, E, M in high school: Mathematics (compulsory subject group), Physics , Chemistry, Biology, Technology, Informatics (under the group of elective subjects); in which the time spent on Technology and Informatics subjects is significantly increased compared to the current program. However, regarding the integration of STEM subjects, the 2018 program remains open. Teachers have to self-help design and organize teaching of STEM-integrated topics in their subjects, for local educational content, elective topics, and experiential activities [1]. Official Letter 3089/BGDĐT – GDTrH dated August 14, 2020 on the implementation of STEM education in high schools [2] has more detailed instructions, but there are still some unresolved issues as the criteria for STEM lessons/topics are still according to Official Letter 5555/BGDĐT – GDTH dated October 8, 2014 (applicable to all lessons).

This is a new task that causes many difficulties for teachers: How to design and teach STEM-integrated subject in single-subject teaching (physics) in high schools is a research question that we deal in this article.

II. Research content

STEM is an abbreviation for English, S - Science (including Natural Sciences such as Physics, Chemistry, Biology, Earth Science), T - Technology, E - Engineering and M - Mathematics.

 Received-23-02-2023, Accepted- 04-03-2023

STEM education is a term with two meanings. The first meaning is the education of Science, Technology, Engineering and Mathematics subjects. The second meaning, is education that integrates the above subjects (Integrated STEM Education, abbreviated iSTEM education), this is an interdisciplinary approach towards developing learners' competencies, preparing human resources for the future careers in STEM fields such as Natural Science (S), Technology (T), Engineering (E), Mathematics (M).

In Vietnam, STEM education is mostly understood in the second sense. In the 2018 General Education Program, the Ministry of Education and Training stated that "STEM education is an educational model based on an interdisciplinary approach, helping students apply scientific, technological, engineering knowledge and mathematics to solve some practical problems in specific contexts" [1]. The forms of STEM educational institutions identified under [2] are:

(1) Teaching science subjects according to iSTEM lessons (called in international languages);

(2) Organize STEM experiential activities (clubs or hands-on activities).

(3) Organizing scientific and technical research activities (scientific research competitions at all levels, STEM festivals).

In which form (1) is the main form, mass implementation for all students, STEM lessons/topics follow an integrated or interdisciplinary approach, the content closely follows the general education curriculum, called "iSTEM lesson/topic" in international language.

We focus on researching and building a theoretical framework for this concept - the topic of integrated STEM teaching (abbreviation of iSTEM topic), hoping to be able to serve as a guide for implementing the main form of STEM teaching in Vietnamese high school. This theoretical framework includes: iSTEM topic identification criteria and iSTEM topic development process, which should be disclosed explicitly.

2.1. Determining the conceptual content of a STEM topic and the criteria of an iSTEM topic

2.1.1. iSTEM topic concept

The iSTEM topic is the term used when it comes to teaching interdisciplinary topics, integrating knowledge and skills in Physics, Chemistry, Biology, Technology, Informatics and Mathematics.

From research on STEM integrated education, we define the iSTEM topic concept as follows:

The topic of integrated STEM teaching (referred to as iSTEM topic for short) includes the content and method of organizing learning activities based on the technical design process so that students can:

- Self-reliance to acquire knowledge, skills, and goals in the educational program of Physics, Chemistry, Biology, Technology, Informatics, Mathematics.
- Use that knowledge as a scientific basis to create meaningful practical problem-solving products.

2.1.2. Criteria of an iSTEM topic

The criterion of an iSTEM topic is a set of signs to identify and evaluate whether a teaching topic is an iSTEM topic or not, the English term is Conceptual frameworks for the evaluation of integrated STEM unit.

There are not many research results on this issue. Analyzing typical published research results on the criteria of an iSTEM topic, we are presented with Table 1:

Table 1: Published results on iSTEM topic criteria

Ministry of Education and Training (2018) [3].	Nguyen Thanh Nga and associates (2019) [4].	Le Xuan Quang (2017) [5].	Moore and associates (2014) [6].	Guzey and associates (2016) [7].	Meester and associates (2021) [8].
1/ Solve practical problems; 2/ Structure that combines the scientific process and the engineering	1/ Solve practical problems; 2/ Knowledge in the STEM field;	1/ Solve practical problems; 2/ Applying knowledge in STEM	1/ Fascinating and motivating context 2/ Engineering design challenge; 3/ An opportunity to learn from	1/ Fascinating and motivating context; 2/ Engineering design challenge; 3/ Integrating scientific content;	1/ Problem-centered learning; 2/ Question-based learning and design; 3/ Integrate STEM

design process; 3/ Exploring Activities, creating products; 4/ Constructive group activities; 5/ The content is mainly from the science and math subjects in the program; 6/ The teaching process has many correct answers, considering failure is necessary in learning.	3/ Activity – practice orientation; 4/ Teamwork.	subjects; 3/ Practice orientation 4/ Encourage teamwork.	failure through redesign; 4/ Math and (or) science content; 5/ Student centered method; 6/ Teamwork and communication.	4/ Math content integration; 5/ Teaching strategies; 6/ Teamwork; 7/ Communication; 8/ Evaluation; 9/ Organization.	learning content; 4/ Collaborative learning; 5/ Research-based learning.

Analysis and evaluation: The above-mentioned sets of criteria have shown the most basic characteristics of an iSTEM topic such as: Integration of STEM learning contents, collaborative learning, design-based learning; However, there are still some limitations:

Not arranged according to a unified logic (in all 6 works) so it is difficult to control.

Criteria "Practical problems" of [3], [4], [5], [8] are general, not specific; there are many practical problems that are not suitable with the psychophysiological characteristics and capacity of high school students; need to be more clearly defined. The works [6], [7] have overcome that limitation: The context is attractive and motivating, making learners have interests, needs and beliefs to solve practical problems.

Technical product or process (even simple) must be a difficulty and challenge for learners to overcome, thereby connecting knowledge of subjects S, T, E, M, bringing practical meaning of that knowledge. Work [3] states only the criteria of product, but it is not clear what engineering design challenge was required to create this product; Work [4], [5] lack this criterion; works [6], [7] raise technical design challenges, but do not explicitly specify product criteria, works [8] do not explicitly state this criterion.

Students' products need to have many versions, not excluding faulty versions is actualizing the technical design process in creative activities, works [4], [5], [7], [8] does not have this criterion; Works [3], [6] have been overcome (criteria 6 [3], criterion 3 of [6]).

The set of 9 criteria of [7] is too much and not specific to the criteria 5,7,8,9. Any teaching process has these elements, but there are no specific signs for teaching STEM topics about these factors.

In addition, the criterion 2 [4] "gathering knowledge in the STEM field" is too broad, possibly beyond the general education curriculum, causing overload for students.

To overcome the above limitations, selectively refer to the research results of domestic and foreign authors, we propose the following set of criteria for identifying and evaluating iSTEM teaching topics:

Choosing logic to build a set of criteria: elements of the teaching process. Any teaching process includes 5 elements: Objectives, Contents, Methods, Organizational form, Testing and Evaluation. This is the basis for arranging the criteria of STEM topics.

Objective Criteria (Criterion M): The topic must be rooted in a real-world problem that appeals to and motivates learners to overcome (a) moderate engineering design challenge, creating a product to solve the problem..

Content Criteria (Criteria N): The topic must cover the knowledge and skills of the educational program in S, T, E, M (Physics, Chemistry, Biology, Mathematics, Technology, Informatics).

Criteria for the relationship between objectives and content (Criteria M&N): The scientific basis of the product (objective) is the knowledge of S, T, E, M subjects of the educational program (content). This relationship should be visualized with a concept diagram (Conceptual Flow Graphic abbreviated CFG) [9].

Methodological Criteria (Criterion P): Learning activities must be organized according to the engineering design process.

Criteria on organizational form (criteria T): Students work in groups inside and outside the classroom to solve problems.

Evaluation criteria (Criterion D): The student's subject learning outcomes must be the physical product of several different versions that do not exclude the faulty version. Evaluation of student learning outcomes and the development of students' abilities are based on the results of this product assessment and the process of creating that product.

2.2. Proposing process of building iSTEM topic

Building (or designing) an iSTEM topic is to create a teaching plan that meets the iSTEM topic criteria mentioned in section 2.1. That plan must include objectives, contents, methods of organizing learning activities and evaluating learning results according to the identified objectives. The process ò building iSTEM topic is the steps teachers take to create that plan.

2.2.1. Analyze and evaluate the existing processes of building iSTEM topic

We have gathered research results on this issue by national and international authors. The following is a summary of typical results (Table 2):

Table 2: Research results on iSTEM topic building process

Process of building STEM topic	According to the Ministry of Education and Training [2] (2020) &[3] (2019)	According to Nguyen Thanh Nga and associates [4] (2018)	According to Le Xuan Quang [5] (2017)	According to Mcfadden and associates (2017) [10]	According to Meester and associates (2021) [8]
Steps	4	5	5	5	15
Step 1	Topic selection	Practical problems	Select specific content in the subject	Choose an event as the centered topic	1/ Identify target groups and analyze the context 2/ Forming a group of multidisciplinary teachers and dividing topics *3/ Brainstorm on topic content*
Step 2	Identify the problem to be solved	iSTEM topic ideas	Connecting products and items applied in reality	Forming an engineering design challenge	*4/ Identify and connect learning content* *5/ Defining the challenge* 6/ Forming subgroups and

					dividing content *7/ Study the feasibility of the challenge*
Step 3	Formulate product criteria/problem solving solutions	Identify the STEM knowledge that needs to be addressed	Analyze the application	Discuss to simplifies the challenge	*8/ Break down challenges into subproblems*
Step 4	Designing the process of organizing teaching activities.	Define iSTEM topic goals	Indicate relevant knowledge in STEM subjects	Split into modules	9/ Design learning activities associate with STEM 10/ Testing and manufacturing prototypes and resources
Step 5		Building iSTEM topic-oriented questionnaires	Forming the topic: topic name, goal, connection of program, capacity.	Gather a series of activities related to the central topic	11/ Report and exchange feedback 12/ Modify the topic plan 13/ Write a script 14/Finish the program 15/ Document and modify packages
Comment	Unable to show: - Teaching goals - Plan to evaluate learning outcomes by objectives	Unable to show: - Methods of teaching by topics - Plan to evaluate learning outcomes	Unable to show: - Methods of teaching by topics - Plan to evaluate learning outcomes by objectives	Unable to show - Teaching goals - Teaching content	Important steps are italicized; Too many steps for a community of teachers

2.2.2. Proposing process of building iSTEM topic

From the analysis of the above processes, based on the proposed set of criteria for iSTEM topic, we provide a process to build an iSTEM topic, in teaching a single subject (Physics) including 7 steps (see Table 3).

Table 3: Process of building iSTEM topic

Steps	Content	Criteria
Step 1. Identify the problem	- Look for real-life scenarios to create a problem situation; - Proposing the problem	**Criteria M** - Fascinating, motivating context

		- Technical design challenge
Step 2. Identify the product / technology solution that can solve the problem	- Naming technology products/solutions - Find out similar products/technology solutions already on the market, evaluate advantages and disadvantages - Developing a system of standards and criteria for products/technology solutions - Design evaluation sheets of technology products/solutions	**Criteria D** - Product review plan
Step 3. Identify background knowledge	- Gather knowledge of science and math subjects as a basis for designing, manufacturing and operating technology products/solutions (drawing diagrams of the relationship between background knowledge and products (CFG); - Identify the place of each knowledge in relevant science subjects (Physics, Chemistry, Biology), Technology, Informatics and Mathematics in the educational curriculum.	**Criteria M&N** Draw diagrams linking products or technology solutions and knowledge in subjects S, T, E, M (CFG)
Step 4. Determine the teaching objectives of the topic	- Determine the target of knowledge and skills according to the curriculum of the subjects mentioned in step 3. - Identify other competency goals.	**Criteria M**
Step 5. Build a set of product-oriented questions	Build a set of product-oriented questions based on the learning process organized according to the technical design process.	**Criteria P**
Step 6 Design the process of organizing learning activities	Design activities of groups of students according to the technical design process: (1) Identify the problem - (2) Find out the background knowledge - (3) Propose designs - (4) Discuss and choose the design - (5) Manufacturing the product – (6) Product presentation, evaluation – (7) Design adjustment, product adjustment.	**Criteria P, Criteria T**
Step 7 Design a plan to evaluate learning outcomes according to the objectives in Step 4	- Design tools to evaluate subject capacity goals (Awareness, Understanding Science, Application); - Design a tool to evaluate common competency goals - Develop a plan to use evaluation tools	**Criteria D**

III. Conclusion

This set of criteria and process of building iSTEM topic is a theoretical framework for building iSTEM topics in single-subject teaching in high schools. We polled teachers about this set of criteria and process to assess its feasibility; Due to the limitation of the article size, we cannot publish the specific results of the teacher survey, but the overall result is that more than 90% of the teachers surveyed believe that the set of identification and evaluation criteria for iSTEM topic is necessary, transparent, easy to control; The process of building iSTEM topics is clear, complete, and is a manual for teachers to be ready to apply the development of iSTEM topics, although there are still some difficult steps that need to be trained (step 3 drawing CFG, step 5, step 6).

We have also applied to build iSTEM topic for internal subject level (Physic), part and full iSTEM levels. The results mentioned above will be published in other papers.

IV. References

1. Ministry of Education and Training, (2018), General Education Program 2018 (Master Program).
2. Ministry of Education and Training, (2020), Official Letter No. 3089/BGDĐT-GDTrH Implementing STEM education in secondary education.
3. Ministry of Education and Training, (2019), Training of administrators and teachers on building STEM topics in secondary education, Training documents, Secondary Education Development Program phase 2.
4. Nguyen Thanh Nga - Phung Viet Hai - Nguyen Quang Linh - Hoang Phuoc Muoi, (2018), Designing and organizing teaching STEM topics for junior and high school students, Ho Chi Minh City Pedagogical University Publishing.
5. Le Xuan Quang, (2017), Teaching Technology in junior high schools with the orientation of STEM education, Doctoral thesis in educational science, Hanoi National University of Education.
6. Moore T. J., Stohlman M.S., Wang H. H., Tank K. M., & Roehrig G. H, (2014), *Implementation and Intergration of Engineering in K-12 STEM education*, In J.Strobel, S. Pruzer & M. Cardela (Eds), Engineering in pre-college setting: Research into practice. Rotterdam: Sense Publishers.
7. Guzey S. S., Moore T. J. - Harwell M., (2016), *Building Up STEM: An Analysis of Teacher – Developed Engineering Design – Based STEM Intergration Curricular Matetials*, Journal of Pre-College Engineering Education Research (J-PEER), Vol 6, https://docs.lib.purdue.edu/jpeer/vol6/iss1/2, p.11-15.
8. De Meester, J., De Cock, M., Langie, G. and Dehaene, W, (2021), *The Process of Designing Integrated STEM Learning Materials: Case Study towards an Evidence-based Model*, European Journal of STEM Education, 6(1), 10, https://doi.org/10.20897/ejsteme/11341, Published: November 11, 2021.
9. Gillian H. Roehrig, Emily A. Dare, Elizabeth Ring-Whalen and Jeanna R. Wieselmann, (2021), *Understanding coherence and integration in integrated STEM curriculum*, International Journal of STEM Education, https://doi.org/10.1186/s40594-020-00259-8.