Section 4. Education system

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CRITERIA FOR TEACHING INTEGRAL STEM TOPICS (iSTEM) IN VIETNAM HIGH SCHOOL

Abstract. STEM education is a suitable model for innovating Vietnam's education, focusing on developing students' abilities and qualities. STEM-integrated teaching is essential in high schools to develop students' thinking and creativity, communication and cooperation abilities to meet the needs of the country's development. Building an integrated STEM topic (referred to as iSTEM topic) for single-subject teaching is an issue that many teachers are interested in, especially in the 2018 General Education Program. What criteria to build a topic integrating STEM in single-subject teaching of current general education curricula? This is the research question in this paper. Based on the survey, analysis and evaluation of the existing iSTEM topic criteria, we propose a set of criteria for implementing iSTEM topic design in teaching Physics at high schools in Vietnam.

Keywords: STEM-integrated topic, STEM integrated topic criteria, iSTEM topic.

1. Approach

The current general education program of Vietnam (2001) implements integrated education at the primary level (natural and social subjects, science subjects); single-subject education in secondary schools and high schools, the connection and integration between subjects are expressed quite separated in the curriculum.

Overcoming that situation, since 2012 the Ministry of Education and Training has organized a contest "Teaching by integrated topics" for high school teachers, and a contest "Applying interdisciplinary knowledge to solve practical problems" for high school students. The contest is spontaneous, unpublished research about this entire activity, drawing theoretical conclusions about the design of STEM-integrated topics so that teachers can apply it widely.

In the 2018 general education program [1], STEM education is more oriented; Specifically: increasing integration in the lower grades (Natural Science subjects in secondary school), having a full range of S, T, E, M subjects in high school: Math (compulsory subject group), Physics, Chemistry, Biology, Technology, Informatics (elective subjects group); 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-design and organize teaching of STEM-integrated topics in their subjects, for local educational content, elective topics, and experiential activities [1]. Official Dispatch 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 – GDTrH dated October 8, 2014 (applicable to all lessons).

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

2. Research content and research results

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.

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 and mathematics to solve practical problems in specific contexts" [1]. Forms of STEM organization identified under [2] are:

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

2) Organize a STEM experiential activity (club or practical experience activities).

3) Organizing scientific and technical research activities (scientific research contests 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 in international language as iSTEM lesson/topic.

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.

2.1. Define iSTEM topic concept

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

From the research on STEM integrated education, we determine the concept of the iSTEM topic as follows

The integrated STEM topic 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:

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

2.2. Criteria of an iSTEM topic

2.2.1. Analysis and evaluation of published research results on the topic criteria iSTEM

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

Not many research results on this issue. Analyzing the published research results on the criteria of an iSTEM topic, we get Table 1 below.

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 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.	1/ Solve practical problems; 2/ Knowledge in the STEM field; 3/ Activity – practice orientation; 4/ Teamwork.	1/ Solve practical problems; 2/ Applying knowledge in STEM subjects; 3/ Practice orientation 4/ Encourage teamwork.	1/ Fascinating and motivating context 2/ Engineering design challenge; 3/ An opportunity to learn from failure through redesign; 4/ Math and (or) science content; 5/ Student centered method; 6/ Teamwork and communication.	1/ Fascinating and motivating context; 2/ Engineering design challenge; 3/ Integrating scientific content; 4/ Math content integration; 5/ Teaching strategies; 6/ Teamwork; 7/ Communication; 8/ Evaluation; 9/ Organization.	1/ Problem-centered learning; 2/ Question-based learning and design; 3/ Integrate STEM learning content; 4/ Collaborative learning; 5/ Research-based learning.

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 psycho-physiological characteristics and abilities 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 interest, needs and beliefs to solve practical problems.

– Technical product or process (even simple) must be a 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 product criteria, but it is not clear what engineering design challenge was required to create this product; Works [4; 5] lack this criterion; works [6; 7] raise technical design challenges, but do not explicitly specify product criteria, work [8] do not explicitly state this criterion.

– Students' products need to have various versions, not excluding the faulty version, which is realizing the technical design process in creative activities, works [4; 5; 7; 8] does not have this criterion while works [3; 6] have it (criteria 6 [3], criterion 3 of [6]).

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

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

2.2.2. Proposing a set of criteria to identify and evaluate iSTEM topics

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

Logic of building a set of criteria: elements of the teaching process. Any teaching process includes 5 elements: Objectives, Contents, Methods, Organizational Forms, Testing and Evaluation. This is the basis for arranging the criteria of STEM topics.

Objective Criteria (Criterion M): The topic must be rooted in an interesting real-world problem that 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.

3. Conclusion

This set of iSTEM topic criteria is a theoretical framework for building iSTEM topics in single-subject teaching in high schools. We polled teachers about this set of criteria to assess the feasibility of applying; 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 assessment criteria of iSTEM topic is necessary, transparent, easy to control; is a handbook for teachers to build iSTEM topics.

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

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