Status and solutions of STEM integrated teaching competence of the natural science teaching staffs at secondary schools in central coast and central highlands regions of Vietnam

Vo Van Duyen Em
Faculty of Education, Quy Nhon University, Vietnam

the corresponding author’s e-mail: vovanduyenem@qnu.edu.vn

Abstract. Integrated teaching is one of the main orientations in changing the general education curriculum at secondary schools in Vietnam. STEM education which is responsible for providing skills for the 21st century students, is also abilities to meet the demand of the modern society. Add, STEM education is tasked with early detection, stimulating interest and educating the younger generation in competencies in the fields of mathematics, sciences, engineering, technology and informatics in order to prepare human resources to meet the requirements of socio-economic development. However, in the reality, STEM integrated teaching competence of the natural science teaching staffs at secondary school are a worrying problem. The writing mentions to the status of STEM integrated teaching competence of natural science teachers in secondary schools at Central Coast and Central Highlands regions of Vietnam and solution of their teaching competence improvement.

1. Introduction
The Vietnam general education program is developed and implemented from the 2020-2021 school year in the direction of integration at the elementary and junior high levels, with deep differentiation at the upper secondary level. At the same time, Vietnamese educators are studying the application of STEM education to the new general education curriculum [1], [9], [12], [13]. STEM in English stands for Science, Technology, Engineering and Mathematics. Although the concept of STEM in English does not include informatics, it is necessary to understand the specialized fields in STEM including informatics or information technology [5], [10], [11]. Promoting STEM education aims to develop human resources to meet the increasing needs of professions related to mathematics, natural sciences, engineering, technology and informatics. Especially, the human resource has the capacity to create and innovate technology, improve the competitiveness of the economy in the context of globalization and revolution 4.0.

High school STEM education equips students with basic competencies in the areas of mathematics, natural science, engineering, technology and informatics. Knowledge of these areas needs to be integrated, linked with each other so that students can apply them to solve practical problems. STEM is not a subject or a training profession but includes many subjects as well as many different professions. STEM subjects are called STEM subjects, and STEM training occupations are called STEM professions.
One of the solutions enhance STEM education and orientation capability is bringing the courses integrated into the program of general education in primary and junior high school, which subjects them to natural science subject in middle school [2]. However, when applying this new solution, the school had to respond to new issues that need to be discussed, including the training and retraining of teachers, conditions of facilities, especially the staff STEM integrated teaching competence teachers. To study the issues raised above, we conduct a survey and evaluate the current situation of STEM’s integrated teaching capacity of natural science teachers at junior secondary schools in the Central Coast and Central Highlands regions of Vietnam, propose some solutions to enhance STEM education to improve teaching capacity for teachers.

2. Research content

2.1 STEM application situation of science teachers at secondary schools in the Central Coast and Central Highlands region of Vietnam

2.1.1 Research methods

To understand the status applied teaching integrated STEM teachers of science subjects in the provinces of Central Coast and Central Highlands Vietnam, we have been conducting surveys of teachers are directly teaching of subjects in secondary schools.

Survey area: 8 provinces including Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Gia Lai, Kon Tum and Dak Lak.

Target audience: 336 teachers who are teaching Math, Physics, Chemistry, Biology, Technology and Informatics subjects at secondary schools (6 subject teachers / school x 7 schools / province x 8 provinces).

Survey method: Investigation by questionnaire, discussion and exchange.

Basis for building a set of survey questions: Circular 20/2018/TT-BGDDT “Regulations on vocational training for teachers of general education institutions” [3]; Integrated teaching and teaching of STEM [6, 8]; Expert comments.

Survey content: Basic capacity of the secondary school teachers; Knowledge, ability to apply integrated teaching and STEM education in teaching of natural science teachers; The situation of teachers using teaching methods; The degree of effectiveness when teachers apply information technology in teaching; Implement a coherent learning model; Needs for fostering basic competency groups of teachers.

Time to observe and process results: From July 2018 to July 2019.

2.1.2 Survey results

| Group 1 | Ability to reach the object |
|---------|-----------------------------|
| 1.1     | Student access skills       |
|         | Good | Rather | Medium | Weak  |
|         | 55.4 | 29.6   | 13.5   | 1.5   |
| 1.2     | Skills to solve educational and teaching situations |
|         | 59.5 | 25.9   | 13.4   | 1.2   |
| 1.3     | Mobilization skills of other educational components |
|         | 35.4 | 36.9   | 22.1   | 5.6   |
| 1.4     | Comment skills, student assessment |
|         | 65.6 | 18.5   | 15.9   | 0.0   |
| Group 2 | Teaching ability in class   |
| 2.1     | Design teaching plans based on a new theoretical model |
|         | 36.6 | 30.0   | 21.4   | 12.0  |
Table 1 (Cont’)

| The capacity                                           | Level achieved (%) |
|--------------------------------------------------------|--------------------|
|                                                        | Good   | Rather | Medium | Weak   |
| 2.2 Organize teaching according to positive models     | 30.4   | 25.5   | 31.0   | 13.1   |
| 2.3 Establish teaching activities to support the teaching plan | 50.2   | 30.6   | 15.7   | 3.5    |
| 2.4 Application of information technology and teaching facilities | 53.4   | 28.2   | 12.8   | 5.6    |
| Group 3 Capacity to organize educational activities    |        |        |        |        |
| 3.1 Operational planning skills are feasible           | 37.8   | 29.4   | 26.4   | 6.4    |
| 3.2 Skills to mobilize other participants              | 35.4   | 29.2   | 28.6   | 6.8    |
| 3.3 Skills to evaluate the effectiveness of educational activities | 37.8   | 30.8   | 27.0   | 4.4    |
| Group 4 Evaluation capacity in teaching                |        |        |        |        |
| 4.1 Use tests in student assessment                    | 59.5   | 20.2   | 16.1   | 4.2    |
| 4.2 Use other evaluation methods                       | 38.1   | 34.8   | 21.9   | 5.2    |
| 4.3 Use specialized software                           | 40.4   | 30.8   | 20.8   | 8.0    |
| Category 5 Capacity to make teaching reports and recommendations |        |        |        |        |
| 5.1 Write a teaching report                            | 46.0   | 24.2   | 21.4   | 8.4    |
| 5.2 Mobilize other components to participate in teaching them and education | 29.2   | 35.2   | 26.6   | 9.0    |
| 5.3 Recommendations to the leadership levels are effective | 45.8   | 27.8   | 16.4   | 10.0   |

Analysis of survey results on teachers’ basic competency groups: Most teachers have achieved basic competencies. However, there are still some inadequate competencies such as skills of mobilizing other educational components, designing teaching plans based on new theoretical models, organizing teaching according to positive and careful models. Ability to evaluate the effectiveness of educational activities, to use other evaluation methods, to mobilize other components to participate in teaching and education.

Table 2. Capacity understanding of teachers about teaching integrated

| Capacity                                          | Knowledge level (%) |
|---------------------------------------------------|---------------------|
|                                                   | Very knowledgeable | Knowledge | Little understanding | Lack of understanding |
| Understand the nature of integrated teaching      | 18.8                | 67.0       | 10.2                 | 4.0                  |
| Know how to build integrated topics and content   | 13.4                | 31.5       | 19.6                 | 35.5                 |
| Design the teaching plan in the direction of integration (objectives, methods, content, pedagogical activities, etc.) | 15.2                | 25.6       | 28.4                 | 30.8                 |
### Table 2 (Cont’)

| Capacity                                              | Knowledge level (%) |
|-------------------------------------------------------|---------------------|
|                                                       | Very knowledgeable | Knowledge  | Little understanding | Lack of understanding |
| Know how to use integrated teaching methods and techniques | 10.2               | 15.8       | 22.4                 | 51.6                  |
| Implement well integrated teaching process in the classroom and outside the classroom | 10.0               | 28.2       | 11.8                 | 50.0                  |

Analysis of survey results on teachers’ understanding of integrated teaching: Most teachers research and learn about integrated teaching, many teachers know how to build topics and implement them. Integrated content, designed teaching plans in the direction of integration. However, the capacity to use integrated teaching methods and techniques for some teachers is limited, and the approach to integrated teaching processes in the classroom and outside the classroom is moderate.

### Table 3. Teacher awareness about STEM

| Awareness                        | Awareness level (%) |
|----------------------------------|---------------------|
|                                  | Very good | Good | Normal | Not found out |
| STEM                             | 4.2    | 6.0  | 5.7    | 84.1          |
| STEM lesson plan                 | 2.8    | 5.2  | 5.5    | 86.5          |
| STEM education                   | 6.4    | 6.0  | 8.2    | 79.4          |
| STEM Festival                    | 0.0    | 2.1  | 1.0    | 96.9          |
| Robotics competition             | 1.2    | 4.8  | 3.9    | 90.1          |

Analysis of survey results on teacher awareness about STEM: Most of the teachers have few opportunities and opportunities to learn, approach about STEM, research and experience on STEM projects, STEM education, STEM assembly or Robotics contest.

### Table 4. Teachers use the teaching methods

| Teaching methods used in teaching and learning | Usage level (%) |
|-----------------------------------------------|-----------------|
|                                               | Very often | Regularly | Sometimes | Never |
| Presentation                                  | 21.0      | 62.8     | 16.2      | 0.0   |
| Conversation                                  | 39.5      | 53.5     | 7.0       | 0.0   |
| Identify and resolve the problem              | 8.2       | 25.6     | 52.4      | 13.8  |
| Discover                                     | 9.1       | 20.4     | 15.6      | 54.9  |
| Cooperative group                            | 9.5       | 23.5     | 46.8      | 20.2  |
| Project                                      | 5.0       | 10.5     | 20.6      | 63.9  |
| According to the corner, contract             | 0.0       | 6.2      | 12.4      | 81.4  |

Analysis of survey results on teachers using teaching methods: Most teachers still use many traditional teaching methods such as presentation methods, conversation methods. Positive teaching methods such as problem-solving and problem-solving methods, exploratory teaching methods, group collaborative teaching methods, project methods, angle-based teaching methods and contracts are still underused, used or not used in the teaching process.
Table 5. The degree of effectiveness when teachers apply information technology in teaching

| Application of information technology in teaching | Efficiency level (%) |
|--------------------------------------------------|-----------------------|
|                                                  | Very good | Good | Normal | Not good |
| Mind mapping                                     | 52.2      | 30.0 | 11.0   | 6.8      |
| Insert images, videos                            | 53.2      | 28.6 | 10.0   | 8.2      |
| Simulation                                       | 50.0      | 35.2 | 9.4    | 5.4      |
| Practice, practice                               | 42.3      | 49.7 | 8.0    | 0.0      |
| Slideshow                                        | 37.2      | 30.2 | 22.4   | 10.2     |
| Webquest                                         | 20.4      | 53.0 | 18.8   | 7.8      |

Analysis of survey results on the effectiveness level when teachers apply information technology in teaching: Most teachers are well aware of the position, role and effect of information technology application in teaching. Teachers have used information technology to assist in teaching for many different purposes.

Table 6. Integrated learning model

| Learning model                                      | Level of implementation (%) |
|----------------------------------------------------|-----------------------------|
|                                                    | Very often | Regularly | Sometimes | Never |
| Have students do exercise exercises                 | 34.6       | 65.4      | 0.0       | 0.0   |
| Students are allowed to experiment                  | 5.5        | 20.5      | 30.0      | 44.0  |
| Students can apply their knowledge into practice    | 8.6        | 25.2      | 35.8      | 30.4  |
| Students use their knowledge to create products     | 0.0        | 4.7       | 9.5       | 85.8  |
| Students are placed before problematic situations in practice need to be resolved, with regard to the scientific knowledge | 1.8 | 7.6 | 12.8 | 77.8 |
| Put students in the role of inventors               | 0.0        | 0.0       | 5.4       | 94.6  |

Analysis of survey results on the coherent learning model: Most teachers focus on the goal of teaching knowledge is mainly, little or no access for students to experience, participate activities to develop capacity or adapt to real-life situations.

Table 7. Needs of fostering basic competency groups of teachers

| The capacity                                | Demand for training (%) |
|---------------------------------------------|-------------------------|
|                                             | Very necessary | Necessary | Not necessary yet | Unnecessary |
| Group 1 Ability to reach the object         |              |           |                   |             |
| 1.1 Student access skills                   | 23.8         | 30.0      | 35.6              | 10.6        |
| 1.2 Skills to solve educational and teaching situations | 25.4 | 29.2 | 36.0 | 9.4 |
| 1.3 Mobilization skills of other educational components | 22.2 | 26.6 | 46.6 | 4.6 |
| 1.4 Comment skills, student assessment      | 28.6         | 31.6      | 28.8              | 11.0        |
| Group 2 Teaching ability in class           |              |           |                   |             |
| 2.1 Design teaching plans based on a new theoretical model | 35.6 | 28.2 | 26.6 | 9.6 |
Table 7. (Cont’)

| The capacity                                                                 | Demand for training (%) |
|------------------------------------------------------------------------------|-------------------------|
|                                                                              | Very necessary | Necessary | Not necessary yet | Unnecessary |
| 2.2 Organize teaching according to positive models                            | 40.2           | 28.6      | 31.2              | 0.0         |
| 2.3 Establish teaching activities to support the teaching plan                 | 30.4           | 24.6      | 42.4              | 2.6         |
| 2.4 Application of information technology and teaching facilities              | 42.6           | 24.8      | 30.2              | 2.4         |
| Group 3 Capacity to organize educational activities                           |               |           |                   |             |
| 3.1 Operational planning skills are feasible                                  | 23.5           | 20.5      | 48.2              | 7.8         |
| 3.2 Skills to mobilize other participants                                     | 33.6           | 11.4      | 47.4              | 7.6         |
| 3.3 Skills to evaluate the effectiveness of educational activities           | 39.8           | 20.0      | 30.6              | 9.6         |
| Group 4 Evaluation capacity in teaching                                       |               |           |                   |             |
| 4.1 Use tests in student assessment                                           | 38.5           | 20.1      | 31.8              | 9.6         |
| 4.2 Use other evaluation methods                                              | 30.2           | 18.8      | 46.2              | 4.8         |
| 4.3 Use specialized software                                                  | 48.3           | 20.9      | 26.6              | 4.2         |
| Category 5 Capacity to make teaching reports and recommendations              |               |           |                   |             |
| 5.1 Write a teaching report                                                   | 24.4           | 19.4      | 50.8              | 5.4         |
| 5.2 Mobilizing other components to participate in teaching and education      | 20.2           | 21.8      | 53.4              | 4.6         |
| 5.3 Recommendations to the leadership levels are effective                    | 39.2           | 19.8      | 30.2              | 10.8        |

Analyzing the results of the survey on the need to foster the basic competencies of teachers: The need to foster tubers a teacher’ natural science in the high school facility on the general capacity and both the specific competencies of STEM teaching are immense and necessary.

2.1.3 Discuss the survey results

The sample of surveys and surveys was carried out on a fairly large scale, the comments of the subject teachers at secondary schools with regard to geographical location and economic and cultural conditions, society of localities in the Central Coast provinces and the Central Highlands of Vietnam. The results of the STEM integrated teaching capacity survey show that: natural subject teachers in secondary schools have certain professional competencies, which are the prescribed competencies,
regulations in the professional standards for teachers of general education institutions have been issued. However, the number of teachers do not have or have had, but not good for the professional capacity also occupies relatively large number (over 50%).

In addition to general career competencies, teachers need to have other important competencies, such as: deep professional competence and scientific knowledge to integrate STEM into the teaching process, broad interdisciplinary, STEM knowledge of integrated teaching and education, curriculum analysis competence, integrated discovery capacity, problem-solving, knowledge selection, ability to use methods active teaching, the ability to use modern teaching facilities, etc. For these competencies, most of the surveyed teachers do not have or have but have not been really good to implement STEM teaching.

On the other hand, most of the surveyed teachers have never learned or accessed about STEM and is related to STEM education. Teachers have not innovated much in subject-teaching methods, positive teaching methods to be student-centered have not been used much, so students still mainly approach the content of academic knowledge, but have not yet developed the capacity to apply knowledge into practice and have not participated in many creative experience activities. Teacher is teaching science subjects in secondary schools has aspirations and the huge demand for work training, professional training on the general capacity and the capacity characteristics of teaching STEM.

From the survey results, it is shown that researching and proposing synchronous solutions to foster and develop the necessary capacities for teachers of natural sciences at secondary schools in the context of innovation. General education is a topical, practical issue and needs great attention of educators.

2.2 Some of the measures to improve STEM education for teachers of sciences at secondary schools

2.2.1 Training

a) Continuing to renew teacher training in the direction of developing professional capacity

The objective of teacher training is to build in learners the capacity to carry out basic activities in vocational practice rather than specific, specific knowledge, skills and attitudes. They are the capacities for them to mobilize in an integrated and flexible manner the knowledge, skills and attitudes that have been equipped to deal with real situations in specific contexts. Therefore, in the model of teacher training in the direction of developing professional competencies, the requirements of vocational competence for students will be determined from the practice of professional activities for teacher training. Creation must combine theoretical learning with practice, experience, link between theoretical knowledge and practical knowledge, linking scientific knowledge with experiential knowledge and action knowledge.

b) Develop a new training program for pedagogy in teaching sciences based on a CDIO approach

In order to innovate the training of teachers in the direction of developing professional capacity, it is necessary to design a new program of pedagogical science training in the direction of streamlining, modern and integrated to suit in accordance with the overall program and curriculum of sciences. The training program should pay attention to reducing the number of hours of academic theory, the need to enhance practice, apply knowledge to practice, especially to develop capacity development and vocational skills for pedagogical students.

The teaching method of teachers needs to be innovative in a positive way for students, in which attention is paid to improving the lesson, using positive teaching methods to help students train their competencies and skills. Necessary competencies such as teaching competence, ability to reach students, the ability to organize educational activities, assessment competence in teaching, program analysis, discovery and aggregating capacity problems, capacity to choose knowledge, research capacity, etc.

c) Fully equipped with facilities, teaching equipment and creative design of teaching aids
Secondary schools should be equipped with subject classrooms, teaching equipment, chemicals and laboratory equipment for science subjects. Teachers and students have access to equipment and learning tools to perform the pedagogical processes required by STEM teaching.

Teachers need to have creative capacity in designing and manufacturing teaching aids [7], to research, learn, use equipment, tools and chemicals available in life. At the same time, teachers can take advantage of discarded products and discarded materials to design vivid, intuitive and creative STEM teaching topics [4].

2.2.2 Retraining work
For the training of teachers to be effective and put into practice, the following solutions need to be implemented:

a) It is necessary to conduct a survey and reevaluation of the current capacity of teachers based on objective, scientific and accurate criteria so that they can be compared with the standards and requirements of the general education curriculum and curriculum of natural sciences to identify the content that needs to be fostered accordingly.

b) The Ministry of Education, and main Pedagogical Universities should develop programs and design training contents for teachers to teach the integration of science subjects. In particular, it is necessary to pay attention to the design of training materials with specific content, logic, ease of use, avoiding academic theory, so there is a plan for illustrative teaching and a reasonable pedagogic process in practice.

c) Innovating methods of fostering teachers in training sessions, creating a fundamental change from passive listening to lectures of teachers in focused training sessions to self-study and group discussion with colleagues under the guidance of educational experts, actively interacting with training materials, learning online with the support of audio-visual equipment, etc.

d) Facilitate teachers to contribute their own experiences, develop program content close to the need to improve the quality of teaching and education at general education institutions.

2.2.3 Business planning and recruitment

a) It is necessary to review and formulate a master plan for the contingent of science teachers in the area of the region, proceeding in sufficient quantity, ensuring the quality of teaching and learning, and synchronizing in structure, type. In every secondary school, there is a good, friendly and responsible pedagogical environment for teachers to strive to continuously improve the professional and professional quality, in which the development core is the key teachers of the subject as the core. Therefore, there must be a number of teachers who are trained to exceed the standard in every secondary school.

b) In recruitment, attention should be paid to both prequalification and examination. When teachers take entrance exams, it is necessary to pay more attention in evaluating professional competencies in order to recruit teachers with good professional and professional qualifications, meeting the requirements of renovating general education.

2.2.4 Cooperation outside the school

a) It is necessary to have mechanisms to link and exchange with STEM laboratories or research centers at universities or research facilities with the ability to provide specialized experiments for grade levels learning.

b) Establish a support network between facilities and programs that provide STEM education outside of school, cooperation between junior high schools and non-school facilities.

c) The ideas of developing networking are important issue for build up the learning environment for STEM education.
3. Conclusion

It could be mentioned that curriculum, teacher education and school administration should be reformed for Vietnam STEM education. Curriculum needs to be reformed for providing the standard of practicing knowledge of science and mathematics in context of technology and engineering. In training and fostering teachers of natural sciences at secondary schools, it is necessary to orient the teaching profession’s competence, teachers must be equipped with educational sciences, natural sciences competence and specialized teaching theory. The implementation of natural science integration subjects at lower secondary schools in general education programs requires appropriate and cautious teacher training and retraining.

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