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Administration of Teaching at High Schools by Orientations in STEM Education

Thi Tuyet Mai Bui[a*], Quoc Tien Le[b], Thi Lan Phung[c], [a]Department of Education and Training of Kien An District, Haiphong, Vietnam, [b,c]Haiphong Department of Education and Training, Haiphong, Vietnam, Email: [a*]tuyetmainb@gmail.com

Emerging from the requirement for ongoing education, linking teaching activities with real life, science, technology, engineering and mathematics (STEM)-oriented teaching activities are an urgent and essential requirement, raising the minds and skills of teachers in the educational period 4.0, and having a profound impact on the effectiveness of teaching activities. STEM education makes a positive contribution to the preparation for the implementation of a new school education program. STEM education is an educational perspective, in which STEM subjects are logically linked to, and integrated and applied in, specific real-world contexts, expanding schools, connecting with the community and developing learner competencies in STEM fields. Today, the new perspective of STEM education is to develop learners' abilities not only in science but also in social fields. Vietnam's new general education program is similar in orientation to this new view of STEM education. The benefits of the application and implementation of STEM in general education in Vietnam are undisputed because of the very practical benefits; this method also brings a modern educational philosophy to the trend of industrial revolution 4.0. However, the management of teaching activities in secondary schools when applying the STEM method is not always easy. This article examines the current situation regarding managing teaching activities in high schools, thus offering solutions to improve the quality and effectiveness of teaching activities when applying STEM widely to schools.

Key words: *STEM education, high school, administration of teaching, educational period 4.0.*

Introduction

In keeping with Vietnam's goal to become an industrialised, internationally integrated country, the collective pedagogy of schools is focused on implementing Resolution No. 29-NQ/TW on renovating education, to meet the goals of the training strategy and to create dynamic and

creative human resources for society. Educational innovation is a development goal, with teachers and administrators bearing the responsibility of constantly improving the quality of education (Kieu, Singer & Gannon, 2016). The educational process is shifting from mainly working to equip students with knowledge, to comprehensively developing learners' competence and quality in a wide range of fields. All of Vietnamese society is focused on educational innovation (Zan et al., 2018). Innovative teaching methods are renovating general education towards modernisation, promoting a positive, proactive and creative outlook, and applying knowledge; the focus is on teaching students how to learn and think, encouraging self-study, creating a basis for learners to update and renew their knowledge and skills, and developing capacity (Eichhorst et al., 2015).

First and foremost, the new general education program is built according to the capacity-oriented approach, consistent with the trend of program development of advanced countries in order to implement the requirements of the National Assembly's Resolution No. 88/2014/QH13:

> To create fundamental and comprehensive changes in the quality and effectiveness of general education; combining literacy, human and career guidance; contribute to transforming a substantial education on knowledge transfer to a comprehensive development education in both quality and competence, harmony of morality, virtue, physicality, beauty and bringing into full play the potential of each student.

Innovative teaching methods are a key and breakthrough solution for the implementation of this program (Xia et al., 2017).

Thinking, an essential solution to the implementation of the above objectives is the synchronous interaction operation of the elements in active teaching methods (teachers–learners–materials–environment), overcoming the disadvantages of one-way transmission methods; while at the same time harmoniously combining instrumental and methodological knowledge, with a particular emphasis on teaching learning and self-study methods so learners can continue to educate themselves throughout their lives: 'The old notion that education lasted only 12 or 16 years informal education, the type of lecture reading is outdated' (Geddie, 2015). The new concept must help people, not only in their youth but throughout their lives, continue to learn and succeed in the changing world. Through innovative educational methods, new forms of teaching organisation have been implemented in recent years, such as playdough hands, creative experience education and science, technology, engineering and mathematics (STEM) education. The overhaul of teaching methods should be based on differentiating subjects, based on conditions and the types of competencies and qualities to be developed in learners so appropriate forms of teaching organization may be selected. This enables enhancement of creative experiences and the application of information and communication

technology (ICT) in teaching organisations through the use of learning models combining traditional classes with online learning (Committee on STEM Education, 2018).

Along with organising learners to perform learning tasks in the classroom, it is important to attach importance to assigning tasks and guiding learning at home and elsewhere outside schools. Promoting scientific research activities involves strengthening practice-based learning models, building and using classroom bookcases and developing a reading culture associated with the activities of science clubs in the school. It is also important to enhance exchange and cooperation activities to promote an interest in learning, improve life skills and increase understanding of the traditional cultural values of the nation and the essence of world culture. Teachers organise and guide activities, create a friendly learning environment and set up problematic situations to encourage learners to participate actively in learning tasks, self-affirm their competence and their aspirations, develop training habits and the ability to self-study, promote their potentials and effectively apply their accumulated knowledge and skills to 'develop the comprehensive people in Industry 4.0' (Hoang & Pham, 2018).

In order to transform learning, it is necessary to renew teaching methods. Teaching directs learning, but students' study habits also affect teaching. For example, there are cases where students require active teaching, but the teachers have been unable to provide it, and there are cases where teachers enthusiastically apply positive teaching methods but fail because students are not yet adaptive, because they are still familiar with passive learning (Nguyen, 2019). Therefore, teachers must be persistent in gradually building students' skills and capacities with an active and moderate learning method, from the bottom up. When using innovative teaching methods, there must be cooperation from both teachers and students; the smooth coordination of teaching activities with learning activities needs to occur. Thus, the use of the active teaching and learning can be distinguished from passive teaching and learning (Galushkin et al., 2019).

Managing teaching activities involves managing the process of activities of teachers to bring high efficiency to the quality of teaching. In teaching activities, teaching methods are an essential factor that directly affects the quality of teaching. Innovative teaching methods will contribute significantly to improving the quality of teaching and the overall educational quality of the school. Therefore, management of teaching activities cannot ignore the management of innovative methods. In doing this, principals have an impact on everyone in the school, as well as its organization and physical conditions, to ensure that the innovation of teaching methods reaches the set goals (Quang et al., 2015).

Following on from the requirement of educational innovation, the requirement of associating teaching activities with real life, STEM education-oriented teaching activities in the general education program is the focus of research and investment by many managers and educators. Therefore, teaching management at STEM-oriented high schools is an imperative for

improving the mentality and reach of teachers in the 4.0 education period. It has a profound impact on the effectiveness of teaching activities, making a positive contribution to preparing to implement a new school education program.

Literature and Methodology

Overview of STEM

STEM is an English abbreviation of the words science, technology, engineering and mathematics: 'STEM education is an integrated education method (Science–Technology–Engineering–Mathematics) rather than a subject in which the lessons are built under the STEM theme to integrate Science and Maths knowledge with problems in Technology and Engineering in the real world' (Kim et al., 2015). STEM education is a teaching model that closely connects theory and practice, creating practical applied products. STEM educational content is designed according to the principle of integration, and follows positive teaching methods in order to promote initiative and creativity, enhance self-study skills and practical skills, apply interdisciplinary knowledge to solve problems in real life, and form and develop students' problem-solving capacity. The foundation of STEM education is science education, so the topics in STEM teaching content are diverse, ranging from teaching robotics activities to biology, physics, mathematics, technology and engineering. The actual implementation of STEM teaching topics has demonstrated that 'STEM education better supports students in social and humanities subjects' (US Department of Education, 2016). The new draft of the general education program clearly shows the STEM education ideology: 'The direction of innovating the educational methodology outlined in the general education curriculum is in line with STEM education at an active level of interdisciplinary teaching, to apply interdisciplinary knowledge to solve practical problems' (Dika & D'Amico, 2016).

A prestigious US organisation in the field of science education, the National Science Teachers Association (NSTA), established in 1944, proposed the STEM education concept with the original definition as follows:

> STEM education is an interdisciplinary approach in the learning process, in which the conceptual academic principles are integrated with real-world lessons, where students apply knowledge in science, technology, engineering and math into specific contexts that help connect schools, communities, workplaces, and global organizations. (Chen, Tabssum & Nguyen, 2019)

Since then, developing capabilities in the STEM field have enabled it to compete in the new economy. The STEM Education Research Institute of the University of Missouri has published an article outlining three important characteristics when talking about STEM education:

1 *An 'interdisciplinary' approach that differs from a 'multidisciplinary' approach.* Although there are also many industries and fields, 'interdisciplinary' shows the connection and mutual support in each industry. Therefore, if a curriculum in a school has many subjects, and teachers teach different disciplines without connecting and complementing each other, it is not called STEM education (Ong, Smith, & Ko, 2018).
2 *The integration with lessons in the real world, demonstrating the practicality and application of knowledge in solving practical problems*. Here there is no barrier to learning theoretical knowledge through application. STEM education programs must necessarily focus on practical activities and apply knowledge to create products or solve real-life problems.
3 *The connection from schools to communities to global organizations.* It is the era of a flat world – industrial revolution 4.0 – where automation and remote control operate via mobile electronics through the internet. The STEM education process is not only geared to local specific issues but must be placed in a global economic context and understand global trends, climate change and renewable energy among other issues.

Goals of STEM Education

Depending on the context, STEM education goals vary from one country to another. In the United Kingdom, the goal of STEM education is to create high-quality scientific research in human resources. In the United States, three primary goals for STEM education are: equipping all citizens with STEM skills; expanding the STEM workforce, and including women and ethnic minorities in STEM education; and harnessing the country's human potential, by increasing the number of students who will pursue and research in-depth STEM fields. In Australia, the goal of STEM education is to build the nation's foundational knowledge in order to meet the emerging challenges of developing an economy for the twenty-first century (Means et al., 2016). STEM education goals are, however, all directed towards the impact on learners, aiming to apply the knowledge of subjects to solve practical problems to meet the country's socioeconomic development goals.

The application of STEM education has the following basic objectives: (1) to contribute to the educational objectives stated in the general education program; (2) to develop the skills needed to apply knowledge to practice for general students through STEM applications, aiming to build specific competencies in subjects of physics, chemistry, biology, technology, informatics and mathematics; and (3) to know how to apply the knowledge of STEM subjects to solve practical problems. It is possible to propose new practical problems and solutions to solve these problems in practice (Al Salami, Makela & de Miranda, 2017).

Methods of Developing STEM Education Topics in High Schools

In order to gradually introduce STEM education into high schools, there needs to be a basis for implementing a new general education program. We think we need to build on subject-specific topics or interdisciplinary integration in STEM subjects. STEM topics need to be very flexible and can be implemented in many forms. In order to develop a STEM-oriented topic for capacity development for students, the following steps should be followed:

Step 1. Identify the Subject, Time, Form of STEM Theme Organisation

Subject
There is a need to identify subjects that are appropriate to the theme. based on content that is closely linked to the general curriculum of the Ministry of Education and Training. Students should follow this from Grade 1 to Grade 12.

Time
There is a need to determine the appropriate time required, including preparation time and implementation time. Each topic should build class time from 60 to 90 minutes.

Form of organization
Classes can be held during regular school hours in STEM rooms of the school or production facilities, STEM rooms of enterprises or at vocational training schools.

Step 2. State Practical Issues

Teachers raise practical problems in many ways, such as a story, a real situation, practical exercises, learning projects that solve practical problems, creative experience activities or scientific research activities, to make students appear to need to solve practical problems.

Step 3. Ask Oriented Questions, Form Ideas of Topics, STEM Knowledge System in the Topic

The questions need to focus on the content: What is the topic for? What is the main task of the topic? What does the topic mean in practice? Which STEM subject knowledge is involved? Topic ideas are about practical issues that are relevant to solving practical problems, building a knowledge system in the field of STEM in the topic. Knowledge of related STEM subjects needs to identify the focus, and to ensure it is directly related to the topic, so when developing a STEM topic, cooperation between teachers is essential.

Step 4. Define the Goal of the Topic

It is necessary to identify the knowledge, skills and attitudes to be achieved after implementing STEM topics for students. Objectives need to be clear and feasible, and appropriate to the student's capacity and local conditions.

Step 5. Prepare Samples, Chemicals, Tools, Locations to Implement STEM Topics

Based on the content and the topic objectives, teachers prepare or guide students to adequately prepare the facilities and tools necessary to organise the implementation of the topic.

Step 6. Identify Practical Problem-solving Processes (or Activities) Using STEM and Implement Practical Problem-solving Activities

Teachers build organisational processes and implement STEM topics according to the activities in a clear, transparent and easy way. At a higher level, the teacher only sets the topic objectives and requirements to be achieved, then provides the necessary facilities to require students to develop the steps and implement the topic themselves. One of the core objectives of the STEM theme program is to inspire individuals to be creative, helping to develop the characteristics of creative individuals: fluency, flexibility, originality and meticulousness (Phuong, 2019).

Step 7. Report Results, State New Recommendations and Proposals

After completing the topic, the results of the STEM application process to solve practical problems are reported, in order to propose some new issues and new ideas related to the topic. The teacher concludes the problem and summarises it.

The Actual Situation of STEM Teaching Activities in High Schools

The form of STEM education introduced into Vietnam did not originate from educational scientific research or macroeconomic policies on human resources, but rather the Robot Contest for high school students implemented by technology companies in Vietnam with foreign organisations. For example, the DTics Robotics contest of DTT Eduspec was held from 2015 (Quang et al., 2015). Official seminars were also organised by DTT Eduspec with STEM education orientation focusing on new subjects such as robotics and data science. Since then, STEM education has begun to spread, taking many different forms, and experiencing different means of implementation, as well as spawning various support organisations. In recent school years, in the spirit of the whole education sector implementing a fundamental and comprehensive transformation of education, high schools have oriented STEM education at the unit. Although there were many efforts in the initial pilot implementation, generally the

awareness of STEM education among teachers and parents remains limited, with STEM education framed as teaching robot programming with modern equipment. Specifically, when discussing the orientation of STEM education implementation, it was suggested that rural schools would find it difficult to implement this educational model due to limited facilities: 'We do not have enough classrooms, space is very precious and we do not have classrooms with equipment that are integrated. The equipment for STEM teaching is even more unavailable'; and 'City schools are easy to socialise, the school invests 600–700 thousand to buy a robot for students to study, and in rural areas it is complicated. Buying money is not allowed because it is not in the list of equipment that has been specified by the Ministry' (Ellermeijer & Tran, 2019).

The STEM education-oriented teaching activities in some high schools are mainly implemented on the model of creative science clubs, as part of extracurricular educational activities, which are not visible in the definition of the interdisciplinary, integrated teaching curriculum of teachers. In the 2017–18 school year in Ho Chi Minh City, many communication activities on STEM education were held, including the Festival of the Creative High School and High School Team Club, which generated exciting creative products and high applicability, showing potential STEM scientific models of team clubs, notably intelligent pumps, reconnaissance aircraft robots, multi-purpose cleaning robots, automatic watering systems and landscape robots, alarms for children and many more (Jeevan, 2018)

Many parents and teachers are concerned that the implementation of STEM education will adversely affect students' test results. The cause comes from the test method; the current examination method is the essay or multiple choice theory test that tests knowledge and skills to solve exercises. Meanwhile, STEM products are created by students investing in research and application of interdisciplinary, practical and experimental knowledge. This is an obstacle for high schools on the path of implementing a STEM education program, as part of preparing to implement a new high school program. The system of private education companies in Vietnam has rapidly introduced STEM education, mainly robot activities to teach at high schools in some big cities such as Hanoi, Ho Chi Minh and Da Nang through socialisation. However, rural areas currently cannot access robot-related activities because the cost of buying foreign robots is prohibitive. Therefore, in rural areas, other solutions are being proposed by the Union of STEM Education Companies in Hanoi, such as S3 Creative Academy, Kidscode STEM. Thus STEM education in Vietnam today is mostly implemented by private companies in big cities with some movement activities in many localities.

The STEM Festival is an initiative of the STEM Alliance organised by the S3 Innovation Institute, Pomath Math Center, STEM Academy under the auspices of the Ministry of Science and Technology. The first STEM festival was held at Hanoi University of Technology in 2015. So far, the STEM Festival has been held every year on 18 May, Vietnam Science and Technology Day.

An essential meaning of the STEM Festival for STEM education is the community communication, social connection, STEM education ecosystem connection in Vietnam.

The success of the STEM Day series so far lies not in how many students attend each year, but rather in how many companies and schools participate. The success of the national STEM Festival is locatd in the spread of the STEM education spirit to schools across the country. So far, there have been hundreds of STEM Day events held at the schools and higher education levels. The spirit of the STEM Festival is supported by the tireless advocacy and support of the members of the STEM Alliance. The STEM education movement has spread to regions from mountainous and border areas such as Ha Giang and Nghe An to coastal plains such as Hai Phong and Ha Long. Among the pioneers in the movement of activities and STEM Festivals, Thanh Chuong–Nghe An district is mentioned; it has 88 STEM clubs at all levels, with 100 per cent of the teachers in charge of STEM clubs trained in robotics and STEM integration thematically. This is different from the club model in big cities, where STEM education companies' teachers operate and maintain STEM clubs. In rural areas, the activities of STEM clubs are organised and operated by teachers of the school with training and transfer of the S3 Creative Academy program. Thanh Chuong was also the first place in the country to host the Swimming Robot Competition for elementary and junior high school students at the local STEM Festival 2018. Other districts, such as Nam Truc–Nam Dinh and Thai Thuy–Thai Binh also have active STEM clubs outside of school hours, serving as a basis for schools and the Education Department to organise STEM activities with 100 per cent participating schools.

There are currently two types of STEM clubs that are maintained in high schools. One is a socialised club organised by companies in association with the school. This form of schooling mainly takes place in city schools, where parents are willing to pay extra for outside-school educational activities. The content of these clubs is focused mainly on areas such as robots and computer programming. Another type of club that is maintained mainly in rural areas is extracurricular clubs. Typical localities that maintain ongoing STEM club activities include Thai Thuy–Thai Binh, Nam Truc–Nam Dinh, Thanh Chuong–Nghe An and Bac Tu Liem–Hanoi. In order to acquire the fundamental skills to run STEM clubs, the teachers have gone through a training process and become acquainted with the topics of STEM integration by social organisations and individuals, who have contributed funds to support teachers and schools to purchase necessary equipment. Part of the equipment funding comes from the schools themselves.

Let’s look at one example in Nam Truc district, Nam Dinh province. By the end of the 2017–18 school year, on 2 June 2018, Nam Truc district organised its first STEM Festival with the name ‘Awakening the 4.0 village wisdom’. All 55 schools in the district participated, following the three pillars of STEM education. A district robot programming contest was held, with the participation of 16 village schools. What surprised the guests most was not only that Nam Truc

district had STEM clubs at all elementary and junior high schools, but the whole district had about 80 teachers who could guide students in programming robots. Such success seems impossible at the village level in the absence of professional guidance from the Ministry of Education and Training and with no budget. On 20 November 2018, VTV1 Vietnam Television reported that 22 village schools in Nam Truc district participated in the second robot programming contest organised by the Department of Education and Training. This is a big step, and provides valuable professional experience in promoting STEM in the countryside.

In recent years, Vietnamese students have attended other STEM education activities currently maintained at some schools and localities, such as the Robot Contest of Vietnamese and Foreign Organizations, Competition for Creative Science and Technology (Visef), and science and technology competitions for elementary and junior high school students from countries such as Korea and Thailand. STEM activities are now quite abundant in schools. However, these activities in large cities are mostly socialised activities, and can be far too expensive for disadvantaged students. Meanwhile, the model in the rural area schools is club activities run by the school teachers themselves, based on the school's resources as well as the community's support for low-cost solutions tailored to local conditions.

Solutions to Improve STEM-oriented Teaching Management in High Schools

In order for the STEM education program to be implemented in high schools to achieve the desired goals, the principal needs to invest heavily in self-fostering and fostering of teachers at the grassroots level, by developing training content at the unit, derived from the teaching requirements of teachers in the new period and summarised from STEM educational pilot practice, in the direction of improving the science and meeting the needs of teachers in terms of giving them the ability and skills to implement STEM educational programs.

Purpose of the Measure

To create positive changes in the awareness of teachers, students and parents of STEM teaching activities, it is important to not only adapt, but also adequately prepare the spirit and capacity of teachers to actively implement STEM educational programs, contributing to the implementation of educational innovation in the period of international integration.

Content of the Measure

To raise awareness of the importance of teacher training at the unit, measures are required to manage STEM-oriented teaching activities in order to achieve the desired results when each manager and teacher is made fully and adequately aware of the importance of self-training and fostering teachers in the unit. The plan for directing the training at the unit should therefore

focus on making each manager and teacher aware that the active self-training and ethical participation in the training at the unit will benefit teachers, since then, it has contributed to the modernisation of education: 'the modernization of education is first of all the modernization of the people, the modernization of the management institution and the modernization of the school operation mechanism' (Siew, Amir & Chong, 2015).

Fostering awareness of STEM education, renovating teaching activities.

The renovation of general education must start with renovating the way of thinking and teaching in each teacher and renewing the mindset and innovating the management of teaching activities among managerial staff. In order to transform and raise awareness about STEM education programs, the fostering of innovation of teaching activities is an important step. This content must come from mastering the goals of the STEM educational program, mastering integrated and interdisciplinary teaching techniques, focusing on positive teaching methods and developing the skills to introduce innovate testing and evaluation methods in the teaching process. In the professional group activities, school administrators direct the professional groups to focus on clarifying new points in the STEM education program, study the integrated approach of STEM education in the new general education curriculum, and study interdisciplinary content and teaching skills for exploitation and practice.

Teachers and administrators are fostering skills to implement modern teaching methods, skills to test and evaluate students in the direction of innovation and skills to use and preserve teaching equipment. STEM education-oriented teaching is associated with innovating teaching methods developed over the years. Teachers are still somewhat confused about the implementation of modern teaching methods and new forms of teaching organization according to STEM educational characteristics. Therefore, school administrators need to continue fostering selective skills in teachers, and to encourage them to use positive teaching methods and appropriate forms of teaching in the new period, fostering integrated teaching, interdisciplinary teaching skills, experiential activities and extra-curricular lessons. At the same time, it is important foster skills in using and preserving modern teaching equipment. In the process of fostering such skills, it is necessary to guide teachers in how to test and evaluate students in the direction of innovation, and how to evaluate students during research and problem solving, not just to assess the final results.

Fostering skills in building and implementing STEM topics

STEM education promotes teaching on integrating science subjects, project-based teaching, practising knowledge, and creating products to serve productive labour and life. Therefore, teachers need to be fostered and strengthened in the skills required to build and implement STEM topics that are appropriate with the level and psychology of students' age, by the

curriculum of the grade levels. The skills needed to guide students in scientific research must also be properly promoted by teachers in STEM education. When students have an open learning environment, they have more conditions to express their potential and promote their creativity, thus developing the capacity to solve problems in learning and life.

Organising the Implementation of Measures

Planning the training of teachers in STEM education awareness and teaching skills involves developing training content derived from teaching requirements under a STEM education orientation. Experimental organisation of the topics and learning content from expert reports on STEM education-oriented teaching is also important, as is building a team of leading teachers as the core of STEM-oriented teaching activities at the school, sharing integrated teaching experience and interdisciplinary teaching. It is vital to promote the active role of professional groups in self-fostering and fostering teachers at schools.

School administrators can enhance the inspection and evaluation of results of self-fostering and fostering teachers; they need to be deeply concerned about the change in teachers' awareness and the development of teachers' competence and skills of application. The success of implementing such a program is expressed in the results of expanding the vision, recognising the mission of individuals and collectives, improving the ability to participate in the management of STEM-oriented teaching activities, renovating teaching activities and improving teaching. Periodically reviewing, evaluating, and drawing experience from STEM educational activities at the unit can create a basis for effectively planning the professional development of the school in the next stage.

Conclusion

Managing STEM-oriented teaching activities is an important way to implement fundamental change and impact the quality of teaching, creating momentum for the smooth implementation of a new school education program.

Implementing STEM-oriented teaching activities enables students to discover many exciting things in the world of scientific knowledge, and to assert themselves and the benefits of learning through products that will serve them throughout life. Such a program will enable students to develop thinking, creative, critical, communication and collaboration, and project work skills. The content and structure of the overall program mean that STEM education will require considerable space and time for deployment. The educational nature of the new general education curriculum will demand an interdisciplinary approach in teaching STEM subjects to provide opportunities for students to connect their learning with real-life problems. Students will be able to come up with creative solutions when they have opportunities to apply the

knowledge they have learned, helping them to think broadly about specific situations and problems.

To successfully manage STEM education teaching activities at the high school level during this period of international integration, it is necessary to transform management thinking, particularly that of the principal. Innovative management thinking does not mean that managers must do everything differently from before, but the core focus should be on awareness and acting in accordance with the practical conditions of each school, creating a new standard of quality and a new level of effective education, to address the concerns and meet the challenges of a rapidly changing society.

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