Organizing experiences - based learning activities “making bio-products for environmental protection” in STEM Education in high schools

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Abstract. STEM experience-based learning from practical problems will develop students’ skills and arouse their passions for exploring and learning the world. The theoretical research method was used to determine the relationship between experience-based learning and STEM education. Pedagogical experiments on STEM experiential learning activities with the topic "Making bio-products for environmental protection” in high schools are related to students' awareness and skills of practical problem-solving, introduced through the plan to organizing STEM experiential learning activities; The survey method is used to produce results about students' attitudes and behaviors against positive and negative actions with environment. The paper may have implications for developing organizing experience - based learning activities in STEM education.

1. Introduction

Experience-based learning is becoming far more common in schools around the world because the holistic competences of learners are formed through practical experiences. The process of learning through experiences can develop students’ knowledge, skills and attitudes through the analysis of and reflection on their own activities. The purpose of learning process through experience-based learning is to connect students to practical situations to learn in, by and for real-life. Teaching is not just about forming knowledge for students, but more importantly, it is about how to apply knowledge into practice and have decision-making skills to solve the problems [5], [6], [11], [15], [16]. Learners’ experience plays a central role in the learning process. These are events that occur in the learners' lives, the present life, or arising from participating learning activities from a teacher’s guidance [1].

The student’s real-life experiences will give rise to problems which need to be solved. Experience-based learning is based on a set of assumptions learned from experience, in which attention is paid to learners analysing existing experiences and reflecting, evaluating and reproducing in their new experiences. [2], [3], [4], [14]. The analysis, reflection, and assessment of students’ experiences should combine with the learning conditions and fundamental knowledge of STEM so that the students have opportunities to effectively apply STEM knowledge and practice into complex problems in their lifetime [9].

Experience-based learning has long been emphasized because students gain a lot of experience from their own study [8], [14]. Through personal experience through these forms, students accumulate their knowledge, skills, and attitudes and apply them to create real-life problems in a creative way.
STEM education is considered an educational model that integrates science, technology, engineering and math based on real-world applications [13], and consistent with the educational level, related to career orientation. Teachers participating in STEM education feel an improvement in their efforts in collaborating with peers, the quality of the curriculum, existing experience, and professional development [7], [17], [18]. At the same time, they are acting as a catalyst in the process of developing student talents [10]. Participating in STEM education, students are interested in learning, experiencing life-related phenomena and creating products, developing skills in science subjects, problem-solving, and critical thinking, apologize, cooperate, communicate.

Therefore, STEM education is within the scope of concepts, and frameworks of experiential learning. STEM experiential learning is a new educational orientation with many advantages. The experience-based activities are incorporated in fields of study, subjects, and skills which contribute to developing learner autonomy. For these reasons, experience-based learning is considered as a compulsory education activity in the general education curriculum in Vietnam [12].

Studying the theoretical and practical background of experience-based activities, experience-based learning and STEM education allows us to organize experience-based learning activities in STEM education (hereinafter referred to STEM experience-based learning) with the topic “Making bio-products for environmental protection”.

2. Designing the plan to organize STEM experience-based learning activities "Making bio-products for environmental protection" in high schools

The planning and organization of STEM experience-based learning activities are conducted according to flexible principles and processes. However, when designing lesson plans, teachers need to pay attention to the principles of STEM education such as meeting teaching objectives, ensuring the scientific content knowledge and the program requirements, meeting local teaching practices and being relevant to student characteristics; specifying learning products in the lesson plan; and having a diversity of learning space and time. Based on that principles, the plan to organize STEM experience-based learning activities "Making bio-products for environmental protection" is designed according to the structure in Table 1. When carrying out the operation process, the teachers are interested in 3 stages: before lesson, during lesson and after lesson.

| N° | Content                                      | Note                           |
|----|---------------------------------------------|--------------------------------|
| I  | Reasons                                     | To meet teaching requirements  |
| II | Objectives                                  |                                |
| III| Preparation                                 | To be various, scientific and practical |
|    | Contents of STEM experience-based learning activities |                                |
|    | Methods and organization form               |                                |
|    | Facilities and learning materials           |                                |
|    | Assignments                                 |                                |
Two products of STEM experience-based learning activities are "Making herbal pesticides" and "Making compost" introduced in the STEM experience-based learning activity plan with the topic "Making bio-products for environmental protection" with the integration of science, technology, engineering and mathematics. It is not difficult to implement such activities in high schools and encourage students to participate in and create products that can be used in real-life situations in families, residential areas, and schools (table 2).

Table 2. Information about STEM experience-based learning activities "Making bio-products for environmental protection"

| Operating characteristics | Making herbal pesticides                                                      | Making compost                                                                 |
|----------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| Research questions         | - How can we make a simple and economical production which is influential in eliminating pests and limiting environmental disadvantages when using chemical pesticides? | How can we make a simple and economical production which is influential in limiting the discharge of waste into the environment and producing environmental-friendly fertilizer products? |
| Aims: Knowledge            | To explain scientific basis of making herbal pesticides.                     | To explain the scientific basis of making compost.                            |
|                            | To train practical skills in experimenting and making a number of plant and pest control products. | To train practical skills in manufacturing organic fertilizer products from domestic waste. |
| Skills                     | To be conscious of making and using biological products to protect the environment and human health. | To be conscious of reusing products from domestic waste to minimize environmental pollution. |
| Attitude                   | To improve knowledge understanding, problem solving skill, innovative abilities, and responsibility. | To improve knowledge understanding, problem solving skill, innovative abilities, and responsibility. |
| Competences                |                                                                               |                                                                               |
### Table 2. (Cont’)

| Operating characteristics | Making herbal pesticides | Making compost |
|----------------------------|--------------------------|----------------|
| Integrated content: Science | Sources of pests and diseases of plants; physical and chemical factors affecting pests and diseases: control measures; effects of herbal pesticides. | Waste classification and meaning; role of microorganisms in waste treatment; effects of bio-organic fertilizer (compost) |
| Technology Engineering | Biotechnology | Microbiological technology |
| Mathematics | Process of making cheap and easy herbal pesticides. | Process of making bio-organic fertilizer from domestic waste. |
| Core activities: Preparation | Calculation of formula, cost of the product. | Calculation of mixing rate, incubation time, and using rate. |
| Making products | Information on herbs and pesticides; raw materials, practical learning facilities. | Collection and classification of organic waste, inorganic waste, recycled waste; practical tools for making compost. |
| Introducing products | Students work in groups in class or at home; introduce the objectives, materials, and how to make products. | Students work in groups at a household, local or school garden; introduce the objectives, materials, and composting process. |
| Testing products | Student groups introduce the herbal pesticide products directly; and how to use them. | Student groups present the compost products through video photos; and how to use them for plant. |
| Assignment | Herbal pesticides are sprayed on suitable plants at home and school gardens. Students regularly check and record the experimental results; propagandize the use of biological pesticides. | Composts are used on different types of soil, suitable plants at home gardens and school gardens. Students check and record the experimental results; propagandize the classification and reuse of organic waste. |
| - Competence to apply knowledge and skills (by making products and product introduction presentation) | - Competence of self-learning and problem-solving (by reports on scientific bases, product testing results and propaganda) |
| - Attitude towards environmental protection activities (by the survey using a 3-level Likert scale.) | |

### 3. Participants

Experimenting STEM experience-based learning activities with the topic "Making bio-products for environmental protection" was conducted in the school year of 2018 - 2019, at 3 high schools in Thai Nguyen province: Gang Thep, Thai Nguyen, and Yen Ninh, with 194 students participated.

### 4. Finding and Discussion

During the STEM experience-based learning, it can be realized that students are active and enthusiastic in participating in activities; actively proposing plans for organizing activities such as cutting organic waste, composting with plastic composting holes to replace containers; coordinating herbs with the new formula; being creative in making a report and performance of their activities. These results are recorded with the images below (Picture 1).
Picture 1. STEM experience-based learning activities of "Making bio-products for environmental protection"
The attitude and behavior of students participating in the STEM experience-based learning activities was surveyed by a 3-level Likert scale questionnaire (about attitude: Agree, Unsure, Disagree; about behavior: Often, Sometimes, and Never) with 10 activities related to environmental protection, which has shown a divergence of students' attitudes and behaviors against positive and negative actions (Table 3).

**Table 3. Attitudes and behavior of students toward environmental protection activities**

| Activities                                                                 | Attitude (%) | Behavior (%) |
|----------------------------------------------------------------------------|--------------|--------------|
|                                                                            | Agree | Unsure | Disagree | Often | Sometimes | Never |
| Using herbs and organic waste to make environmental protection products     | 54.12 | 25.77 | 20.10    | 4.12  | 62.37      | 33.51 |
| Collecting and classifying waste in their families and schools              | 67.01 | 27.32 | 5.67     | 42.78 | 48.97      | 8.25  |
| Cleaning and reusing plastic bags                                          | 50.52 | 38.66 | 10.82    | 39.18 | 50.52      | 10.31 |
| Making compost from organic waste                                          | 59.28 | 31.96 | 8.76     | 7.22  | 57.73      | 35.05 |
| Using biological pesticides                                                | 54.12 | 29.38 | 16.49    | 4.12  | 60.82      | 35.05 |
| Using chemical pesticides                                                  | 23.71 | 32.99 | 43.30    | 0.00  | 15.46      | 84.54 |
| Trapping snakes, frogs, and birds for food or trade                        | 17.01 | 37.63 | 45.36    | 6.70  | 17.01      | 76.29 |
| Discharging garbage and wastewater directly into water sources or bury it on the ground | 6.70 | 36.08 | 57.22    | 23.20 | 44.85      | 31.96 |
| Throwing bottles and containers of plant protection products at their place of use | 4.12 | 42.27 | 53.61    | 9.28  | 24.23      | 66.49 |
| Participating in the environmental cleanup campaign launched by agencies and organizations | 68.04 | 19.07 | 12.89    | 35.05 | 60.82      | 4.12  |

Regarding students’ awareness and attitudes: The percentage of positive activities to protect the environment such as using herbs and organic waste to make environmental protection products; collecting and classifying waste in their families and schools; cleaning and reusing plastic bags; making compost from organic waste; using biological pesticides; participating in the environmental cleanup campaign launched by agencies and organizations was over 50%, and only under 15% of student showed their disagreement. This rate was in contrast to actions that negatively affect the environment such as spraying chemical pesticides; trapping snakes, frogs, and birds to eat or sell; discharging garbage or wastewater directly into water sources or hiding it in the ground; throwing bottles and packages containing plant protection products right at the place of use (less than 25% agree, and more than 40% disagree). Thus, when participating in the STEM experience-based learning activities of “Making bio-products for environmental protection”, students raise their awareness about environmental protection by studying the scientific basis of the processes and technology, and practicing manufacturing environmental protection products. However, for each activity, a significant proportion of students (19% to 38%) expressed their unsure attitude, which means that there is a need to organize more STEM experience-based learning activities toward environmental protection.

Regarding the student's behaviors: Due to the lack of activities to learn about STEM experiences in environmental protection, the percentage of students determined the frequency of positive and
negative activities toward the environment are low, but also some activities such as collecting and classifying waste in their families and schools; cleaning and reusing plastic bags; participating in the environmental cleanup campaign launched by agencies and organizations have a significant proportion of students choosing “Often” from 35% to 43%. These are students’ daily activities because they happen regularly in their families and local communities. Therefore, STEM experience-based learning activities need a close combination with educational organizations to organize a range of types of experience-based learning activities in different areas. The proportion of activities that effect on the environment positively was from 48% to 63%, but the act of discharging garbage, wastewater directly into the water source or hiding it in the ground accounted for 44,85% of the activities, and every activity has never taken by some students. Thus, the important role of environmental practices and experiences in education has been determined to contribute to change the students' activities and behaviors.

5. Conclusion
Theories and practices of experience-based learning and general education have proved that STEM education is related to the scope of concepts, connotations and frameworks of experience-based activities. STEM experience-based learning is a new educational orientation, stemming from practical issues, through experience, students will be aroused their passions to explore and learn the world around them.

Starting from the feasibility of implementing the STEM experience-based learning activities "Making bio-products for environmental protection" in high schools, the activity plan is designed and organized, initially bringing certain results. However, it is necessary to expand the model in many localities, with diverse forms, rich content and follow-up studies to evaluate the testing of student-made products.

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