DESIGNING AND ORGANIZING STEM EDUCATION: "DRY HAND SANITIZER" TOPIC BY MODEL 5E IN GRADE 11 ORGANIC CHEMISTRY

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Abstract

STEM education has been a vital educational trend in the world. Over the past few years, in Vietnam this approach has been practiced widely in the K-12 education to facilitate school students participation in experiential activities and apply knowledge to create products or solve practical problems. In this article, we briefly introduce STEM education and the 5E model to design and organize the topic of "dry hand sanitizing" in grade-11 Organic Chemistry. We performed the pedagogical experiment by organizing the extracurricular activities at Thien Ho Duong High School, Dong Thap province, and observing their worksheets and learning outputs. The obtained results initially show the efficiency of the proposed method.

Keywords: *5E model, attar, disinfectant solution, STEM, STEM education.*

THIẾT KẾ VÀ TỔ CHỨC DẠY HỌC CHỦ ĐỀ GIÁO DỤC STEM "NƯỚC RỬA TAY KHÔ" THEO MÔ HÌNH 5E TRONG CHƯƠNG TRÌNH HÓA HỌC HỮU CƠ LỚP 11

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Tóm tắt

Giáo dục STEM đang trở thành một xu hướng giáo dục mang tính tất yếu trên thế giới. Tại Việt Nam giáo dục STEM đang được triển khai rộng rãi ở các trường phổ thông giúp học sinh hướng tới các hoạt động trải nghiệm và vận dụng kiến thức để tạo ra sản phẩm hoặc giải quyết các vấn đề thực tiễn trong cuộc sống. Trong phạm vi bài báo, chúng tôi giới thiệu sơ lược về giáo dục STEM, vận dụng mô hình 5E thiết kế và tổ chức dạy học chủ đề "nước rửa tay khô" trong chương trình Hóa học hữu cơ lớp 11. Chúng tôi đã tiến hành thực nghiệm sư phạm qua tổ chức hoạt động ngoại khóa tại trường Trung học phổ thông Thiên Hộ Dương. Đánh giá sự tiến bộ của học sinh thông qua sản phẩm hoạt động, phiếu quan sát. Kết quả thực nghiệm sư phạm bước đầu cho thấy hiệu quả và tính khả thi của phương pháp đề xuất.

Từ khóa: *Dung dịch sát khuẩn, giáo dục STEM, mô hình 5E, tinh dầu.*

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1. Introduction

Originated in the USA, STEM education has been of interest and researched in all countries in the world for many years (Tytler, 2007). In Vietnam, STEM education is deeply concerned, Directive No.16/CT-TTg of the Prime Minister dated May 4, 2017, proposed the solutions in education: "Major changes in policies, contents, methods for educating and training to have highly qualified human resources being able to take up the modern process of producing, especially, promoting scientific, technological, engineering and mathematic subjects, foreign languages, technology information training in general education curriculum" (Prime Minister, 2017, p.3). STEM education is known as the new approach for educating and training future human resource. It plays emphasis on the connectivity of four fields, namely Science, Technology, Engineering and Mathematics. STEM-based topics are deemed to facilitate students connect school knowledge with the real world to solve practical problems, increase learning interest, formulate, and develop qualities and competencies.

The 5E model was developed in the 1980s as a model of science teaching by the "learner-centered" approach built on the theory of constructivist teaching. This 5-phase model is supposed to help students acquire knowledge systematically and effectively. In the Covid-19 epidemic context, being disinfected is indispensable for every family. Hand sanitizer can kill bacteria, viruses, and pathogens that are harmful to health. Hand sanitizer combined with natural attar has a gentle scent, which protects hands and skin, and increases antiseptic properties. In this article, we designed and organized teaching activities in the STEM topic "dry hand sanitizer" in grade 11 Organic Chemistry.

2. Research contents

2.1. Overview STEM education

STEM stands for Science, Technology, Engineering and Mathematics, which are used to discuss the policies for the development of Science, Technology, Engineering, and Mathematics in the US. It was first used by the National Science Foundation (NSF) (US) in 2001.

According to Tsupros et al. (2009), STEM education is an interdisciplinary approach to learning where academic knowledge is closely combined with real-world lessons through which students are taught how to apply science, technology, engineering, and mathematics knowledge in specific contexts. Thus, it can connect schools, communities, and businesses, allow learners to improve STEM skills and boost their competitive abilities in the technology ages.

In the sense of cross-subject integration, Sanders defines "STEM Education as the approach method and discovery in teaching and learning between two or more STEM subjects or between one STEM topic and one or more subjects in schools" (2009, p.20).

STEM education is often associated with the integrated curriculum (Johnson et al., 2016), and project or problem-based learning (Crippen & Archambault, 2012). STEM is the way to increase the effectiveness of education, essential in teaching for interpreting phenomena happening in the natural world which requires various fields of knowledge (Moomaw, 2013; Talley, 2016; Vasquez et al., 2013).

From the above approaches, it is possible to understand the nature of STEM education that equips learners with necessary knowledge and skills related to the fields of Science, Technology, Engineering and Mathematics. They should be integrated, supporting one another. Students not only understand the principles but also can practice and create products in daily life. STEM education will bridge the gap between theory and practice, creating capable people to work in a highly creative environment in the 21st century. For high school students, studying STEM subjects can orient their future career pursuits. STEM education applies mainly practice-based learning methods and creative experiential activities, the most progressive and flexible educational methods such as: Learning through projects - topics, learning through games and especially, the method of learning by doing thoroughly applied to STEM-integrated subjects.

2.2. The 5E model in STEM education

Rodger and his coworkers firstly proposed the 5E model in 1987. After a building and testing period, this model was publicly recognized in 2006, with the topic "The BSCS (Biological Sciences Curriculum Study) 5E Instructional Model: Origins and Effectiveness" at the National Institutes of Health

(NIH) (Rodger, 2015). As a discovery-constructivist approach, this teaching model is deemed to facilitate students construct new knowledge based on the already-acquired one. This model plays an important role in curriculum development, and especially for science classes. Today, some authors are interested in the 5E process and consider it a suitable process for STEM education.

The 5E model is abbreviated by 5 words Engage, Explore, Explain, Elaborate and Evaluate. These are equilibrium with 5 steps of the teaching process (Rodger, 2015).

Figure 1. The model expresses the teaching process of 5E

Based on this model, we propose a 5-step teaching process of STEM as follows:

Step 1: Engage

The first step is important. The teacher can help students increasing interest and excitement about the lesson's content. Depending on the lesson's content, the teacher can give many ways to arouse students' interest. In this step, the teacher will assess and review to identify students' interest and excitement about the learning content to modify the next steps of the 5E model.

Step 2: Explore

In this step, students can directly participate in learning situations. They begin to do their experiments. They build their knowledge of the topic for themselves by searching and exploring data. The teacher only plays the role of coordinating, supervising, helping, and providing materials. Students make their assumptions, self – test, and report results.

Step 3: Explain

The teacher gives students chances to explain the experimental results and phenomena and find answers for their judgments. Then, the teacher analyzes and makes conclusions. In this step, teachers can explain and standardize the terms and concepts. Then, the teacher guides the process again.

Step 4: Elaborate

If the selected topic is expandable or connected with similar themes, then the teacher can ask students to present solutions or predictions to prepare for the next lesson. This step provides an opportunity for students to apply knowledge, to practice skills to apply in specific situations. Students can have more knowledge and a deeper understanding to use practically.

Step 5: Evaluate

In the last step, students self-assess all contents that they learned. They compare their obtained knowledge with the previous learning. Teachers evaluate to record results and adjust methods to suit students. The evaluation is not necessarily the final step of the process because the teacher can assess during the learning process or activity of students. The assessment tools are very diverse, including descriptive notes, illustration figures, presentations, or products of the activities process. Teachers need to be flexible in using different assessment methods in the learning process.

2.3. Designing and organizing activities for teaching the topic of STEM education "dry hand sanitizer" using 5E model

2.3.1. The reason for choosing the topic

Experiencing the Covid-19 pandemic, hand sanitizer is no longer strange to everyone because now everywhere people can use it to disinfect and prevent disease. What are the ingredients of hand sanitizer? How to get a hand sanitizer that not only kills bacteria but also makes the skin soft and has a gentle natural scent? The topic of making hand sanitizer at home is

a suitable choice. This topic aimed to help students have experiences with real conditions, apply the knowledge they have from terpenes, and alcohols in organic chemistry in the grade 11 program, to create some products to serve the needs of life.

2.3.2. The STEM knowledge in the topic

Science(S): Properties and applications of alcohol, lemongrass attar; The basic ingredients of dry hand sanitizer.

Technology (T): Using ingredients easy to find and safe: Alcohol, hydrogen peroxide, glycerol, and lemongrass.

Engineering (E): Procedure plot of distillation lemongrass attar and procedure plot of creating hand sanitizer.

Mathematics (M): The mathematics is applied to calculate the ratio of ingredients to distil lemongrass essential oil and make hand sanitizer.

2.3.3. Time to do this topic: 2 periods (extra-curricular) and 1 week to prepare at home.

2.3.4. Lesson plan of "dry hand sanitizer" as 5E model

a. Objectives

By the end of the lesson, students are supposed to formulate and develop qualities and competencies:

The chemical competence

- Ability to be aware of the chemistry

+ Say about the properties and applications of alcohols and lemongrass attar.

+ Determine the ingredient of dry hand sanitizer from WHO standards.

+ Present the basic process and operations to extract lemongrass attar and make dry hand sanitizer from the World Health Organization (WHO) standard.

+ Explain the process to extract lemongrass attar and make dry hand sanitizer from WHO standards.

- Ability to learn about nature from a chemical perspective:

+ Design the procedure of extracting lemongrass attar, and the procedure of preparing dry hand sanitizer by the actual conditions.

+ Experiment to extract lemongrass attar and prepare dry hand sanitizer.

- Ability to apply knowledge and skills learned

+ Apply knowledge of steam distillation to the extraction process of lemongrass attar.

+ Apply knowledge of alcohol properties to prepare hand sanitizer safely and effectively.

The general competence

- ***Ability to solve the problem creativity:*** Plan and conduct experiment to prepare a natural scent of dry hand sanitizer from WHO standards.

- ***Ability to communicate and cooperate:*** Discuss ideas between group members about the procedure and product.

The main quality

- Be honest: Honestly report the experiment and results.

- Be responsible: Ensure safety during the experiment, preserve and use the chemical and materials reasonably. Propagate and mobilize people to use dry hand sanitizer to prevent disease and protect the health of themselves and the community.

b. Materials and tools

- Ingredients: Lemongrass, alcohol 960, hydrogen peroxide, glycerol, water.

- Tools: Stove, distillation pot, glass cup, measuring tube, spray bottle.

c. Learning activities

Activity 1: Engage

The teacher prepares some types of dry hand sanitizer for groups of students to observe and use, then asking questions:

(1) Please give comments about the used product.

(2) Do you know what the ingredients of dry hand sanitizers are?

The teacher leads in: All types of dry hand sanitizers have a bactericidal effect, but each has a different scent and bactericidal effect, depending on the ingredient and ratio of the preparation. From there, the teacher introduces the task of the topic, which is to prepare dry hand sanitizer. By knowledge learned or from real life, students have to find out the procedure to prepare natural lemongrass scented dry hand sanitizer successfully.

The teacher gives detailed tasks and product evaluation criteria.

Student receive tasks; discuss product evaluation criteria, and the teacher answers questions.

Learning products expected:

- Answers to questions (1) and (2).
- Products evaluation criteria sheet.
- A plan to perform group tasks.

Activity 2: Explore

Students study the background knowledge about terpenes and alcohols, searching for the chemical composition and extraction of lemongrass essential oil, ingredients and how to prepare an antiseptic solution through online documents with teacher's support tickets. Then, they propose the procedure of extracting lemongrass essential oil, and preparing dry hand sanitizer from WHO standards.

SUPPORT SHEET

Extracting the lemongrass attar	**Preparing the dry hand sanitizer**
Prepare materials and tools: Lemongrass of about 10-12 months old has been prepared by washing and chopping; water; ice; large pot, rack, glass bowl, dark bottles small. Procedure: Water is added about 1/3 of a large pot containing 500 g of lemongrass, then a rack with a glass bowl is placed in the center of this pot. Begin heat slowly to release the essential oil. Turn on the lid upside down and add ice. It is necessary to add the ice continuously in process. Most essential oil will be collected about 30 - 45 minutes. The essential oil mixed with water in the bowl. Place the mixture of essential oil and water into a dark bottle for storage.	The ingredient of the disinfectant solution includes Ethanol (alcohol), hydrogen peroxide, glycerol and distilled water or cooled boiled water. In WHO, the ingredient of dry hand sanitizer is the volume ratio of 80% ethanol, 1.45% glycerol, and 0.125% hydrogen peroxide. To have 1000 mL of dry hand sanitizer solution, we can perform as follows: Add 14.5 mL of glycerol $C_3H_5(OH)3$ 98% to 833.3 mL of medical alcohol 96^o and stir up, add, and stir 41.7 mL H_2O_2 3% hydrogen peroxide (wound antiseptic peroxide), continue to add slowly and stir 110.5 mL mixture of lemongrass attar and water until a homogeneous mixture is obtained. Then, divide the solutions into 20 ml, 50 mL, and 100 mL containers and spray bottles, shake well to dissolve, and let these vials stand for 72 hours before use.

Expected products:

- The procedure sheet for distilling lemongrass attar and the procedure sheet for preparing dry hand sanitizer.
- Products: Lemongrass attar after distillation and dry hand sanitizer after preparation.

Activity 3: Explain

After completing the tasks, students answer teacher questions:

Question 1: *Why must the preparation equipment be cleaned and coated alcohol before proceeding?*

Question 2: *How much alcohol concentration must be within the allowable range for the dry hand sanitizer solution to be safe and effective for users?*

Question 3: *How does alcohol concentration below and above the allowable limit affect the effectiveness of use?*

Question 4: *What effect does Glycerol have in the preparation of dry hand sanitizer? Can it be replaced with other substances?*

Question 5: *What is the effect of lemongrass attar in the preparation of dry hand sanitizer? Can you suggest extracting and using other natural essential oils locally available?*

Question 6: *Today, most used scents are synthetic scents. How does this problem affect health and the living environment?*

Question 7: *Describe some characteristics of the prepared product dry hand sanitizer? (state, smell, moisture). How do you feel after using this product?*

Expected products: Students' responses

Activity 4: Extend

- To deepen and expand the knowledge of students, the teacher asks them to apply the dry hand sanitizer with the lemongrass flavor process to conduct experiments with different materials locally found.

Expected products:

- Different types of natural essential oils: lemongrass essential oil, citrus peel essential oil, melaleuca essential oil, cinnamon essential oil, and the like.

- Dry hand sanitizer with different ingredients and mixing ratios.

Activity 5: Evaluate

The teacher assigns a representative student of each group to report the work and showcase their products; then, answering questions. Other groups participate in discussing the results of the reporting group.

The teacher evaluates the products based on the evaluation criteria in activity 1 and the student's performance in the process of performing the task.

Expected products:

- The dry hand sanitizer product of the group has been prepared.

- The presentation of groups.

2.4. Results of the experiment

Experimental method: pre-and post-impacts are examined for assessment. Evaluation tools are tests, questionnaires, and rubrics.

- The teacher gives the test to students to evaluate their competence in applying the learned knowledge and skill before the experiment (pre-impact).

- The teacher conducts the test for students to evaluate their competence in applying the learned knowledge and skill after the experiment (post-impact).

This study was conducted at Thien Ho Duong High School. The participants were 86 students in two classes in grade 11. We designed the teaching plan and performed the activities in the form of extra-curricular activities. The obtained data were analysed by SPSS 22.0 software.

Table 1. Pre- and post-experiment scores

Experimental class	Total number of students	Students' score rate frequencies									
		1 – 10 score rate									
		1	2	3	4	5	6	7	8	9	10
Pre-experiment	86	0	0	0	6	12	28	19	14	6	1
Post-experiment	86	0	0	0	0	7	16	22	26	11	4

Table 2. Characteristic parameters

Characteristic parameters	Pre-experiment	Post-experiment
Mean	6.52	7.38
Standard deviation	1.361	1.285
The difference of mean	0.867	
P (Sig.)	0.000	
Level of Influence (ES)	0.61	

The results in Table 1 and Table 2 showed that:

- The average test score of the class in the post-experiment was higher than that in the pre-one. The difference in mean score value is 0.867, which indicates that students are engaged in experiences with STEM educational activities. Their competence in applying the knowledge and skill is improved.

- The t-Test results are less than 0.05 ($p < 0.05$), which proves that the mean score of the test of the experimental class is significant with 95% confidence. Because the level of influence (ES) is 0.61, the effectiveness is medium. The above

values of the t-Test and ES indicate the pedagogical experiment has a medium level, and the investigation can be expanded.

After students learned STEM education topics, we distributed questionnaires to find out about students' attitudes and interests through the tools of the topic. The results are displayed as follows:

Table 3. Students' attitudes and interests in learning after the experiment

Criteria	Level			
	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)
1. Teaching with the topic of STEM education is a new teaching method.	0,00	4.65	62.79	32.56
2. Knowledge of many fields are integrated to solve the STEM education topic.	0,00	1.16	69.77	29.07
3. Build the procedure and create the specific product.	1.16	6.98	72.09	19.77
4. Develop teamwork, cooperation and exchange skills with peers and teachers.	0,00	2.32	53.49	44.19
5. Develop presentation and product presentation skills.	0,00	1.16	54.65	44.19
6. Be participated in the assessment process, self-evaluating yourself and others.	0,00	5.82	67.44	26.74
7. Have an interest in learning, exploring, and scientific researching.	2.33	9.30	69.77	18.60
8. Love for Chemistry and apply subject knowledge to solve real life problems.	0,00	1.16	51.17	47.67

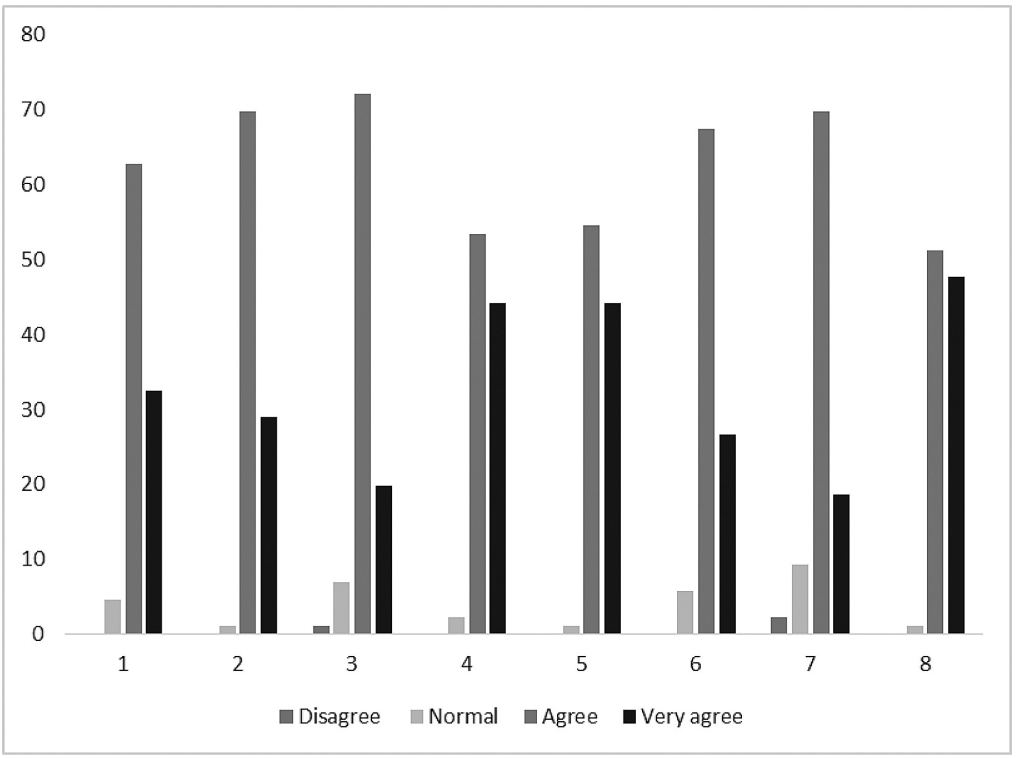

Figure 2. Students' attitudes and interests in learning after the experiment

The survey results indicate that most of the students agree and strongly agree with a very high ratio. After studying a STEM topic, students can work in groups, exchange, and cooperate with 97.68% of the agreement and strongly agree. Through STEM activities, students can use knowledge of many fields to solve practical problems. They have an interest in learning and love the subject. All criteria are agreed upon and strongly agreed with the above ratio of 90%.

In addition, we also noticed the difficulties they encountered building the procedure and the experiment of creating products in implementing the STEM topic. The comments focused on the following issues:

- The equipment for distilling lemongrass essential oil is still rudimentary so the essential oil is mixed with a lot of water, and the distillation efficiency is low.

- It is also passive in finding aerosol cans with the suitable capacity to store, preserve and use the product.

- Time to study other subjects in class is still a lot.

- Despite above difficulties, students were interested participating in STEM educational activities. It is not only in Chemistry but also in other subjects.

3. Conclusion

STEM education is a necessary educational orientation in the current educational context of Vietnam. Through STEM activities, students can form and develop qualities and competencies oriented by the new general education program. Through producing dry hand sanitizer, students not only develop the ability to apply the learned knowledge and skills in life but also have a sense of health protection and responsible for themselves and the community.

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