Implement of STEM education in Vietnamese high school: unit of acid-base reagent from purple cabbage

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Abstract. This study aimed to clarify implement of STEM education in Vietnamese high school in the unit of acid-base reagent from purple cabbage. Methodology regarded experimental design. The samples included 84 students of experimental class grade 11 of 4 high schools: 02 schools in Hanoi are Hai Ba Trung high school and Van Lang high school; 02 schools in Thai Nguyen are Thai Nguyen high school and Gang Thep high school, in the term of 2017-2018. The intervention of STEM topic of acid-base reagent from purple cabbage was organized for the samples. Students’ problem solving capacity in learning about the STEM topic of acid-base reagent from purple cabbage will be evaluated through their performance on conducted activities. Students’ problem solving capacity score was compared between before and after impacts. The findings showed that the students’ performances on conducted activities revealed their problem-solving capacity. The findings will clarify 1) summary of students’ problem-solving capacity comparing between before and after intervention, and 2) the development level of students’ problem-solving capacity. It found that average score of problem solving capacity of experimental class before impacts = 2.47. And, average score of problem solving capacity of experimental class after impacts = 3.13. The scores of the criteria for assessing the environmental impact of the experimental class after impact are always greater than before the impact, the value of p < 0.05, the level of ES effect is 0.78. The value of ES indicates that the experimental results have a moderate effect.

Keywords: STEM education, acid-base reagents, purple cabbage

1. Introduction

A boarded view of perceptions, beliefs and actions on STEM, Yuenyong [7] suggested consensus five characteristics distinguish integrated STEM instruction from other teacher pedagogy: (a) the content and practices of one or more anchor science and mathematics disciplines define some of the primary learning goals; (b) the integrator is the engineering practices and engineering design of technologies as the context; (c) the engineering design or engineering practices related to relevant technologies requires the use of scientific and mathematical concepts through design justification; (d) the development of 21st century skills is emphasized; and (e) the context of instruction requires solving a real-world problem or task through teamwork. This conceptualization of STEM is grounded in learning research [7].

Vietnam is moving to the industrialization and modernization to become a country which has the modern economy and get on well with international economy. Before the fourth industrial revolution, education has a vital role in the development of society. According to the direction 16/TC – TTg of the
Prime Minister on May 4th 2017, the solutions of education were presented: “...Strongly change the policy, program, method of education and training in order to create the qualified resources to deal with new technology, furthermore, we need to focus on pushing the training in Science, Technology, Engineering, Mathematics (STEM), foreign language and informatics in general education system. The tasks were also presented: Conducting education focusing on Science, Technology, Engineering, Mathematics (STEM) in general education system, organize to experiment at a few high schools from the term 2017-2018...” [4]

STEM education appeared in Vietnam a few years ago. It has just been the stage of media announcement and experimental. It has not been an official education activity in high school. However, STEM education with the tasks of providing crucial knowledge and skills for students in 21st Century will become a widespread education model in the future [1]. Therefore, STEM education is highly needed the concern and awareness of the whole society.

Nowadays, in Vietnam, STEM and STEM education have not been researched deeply. Those articles and materials of STEM education in Vietnam are just information, comments and applications in teaching through integrated topics [6]. Especially, STEM education topics in Chemistry are limited.

In the process of teaching Chemistry and determining soil environment of farmers, using reagents causes some problems: the lack of reagent paper because of the poor facilities; expired and broken reagents, unclear identification signals because of the poor quality, the size of reagent paper makes observing difficult. In this case, making reagent solution is a practical method. Today, some ingredients are easy to find in life to use as a reagent such as: hibiscus petals, gompherna globose, purple cabbage, hydrangeas flowers, turmeric, geranium petals, blueberries [5].

The method of making these solutions from available ingredients provides fate, excitement and students’ learning efficiency. It also provides the purposes of innovating teaching method and improving education quality. Besides, this method makes students, farmers determine the soil environment to cultivate, using familiar products: vinegar, lemon, laundry soap without using harmful chemicals that makes Chemistry become closer to students and farmers lives, putting knowledge in reality.

2. Methodology
Methodology regarded experimental design. Students’ products on the Intervention of the STEM topic of “acid-base reagent from purple cabbage” will be evaluated between before and after impacts in order to clarify students’ problem-solving capacity.

2.1 Sample
The sample is randomly selected, including 84 students of grade 11, which is divided to 4 classes in 4 different schools (2 of them are in the city and the others are from the countryside of the Northern mountainous of Vietnam. Nowadays, the pressure of examinations and marks at high school is very high. The parents of students always want their children to have a good learning achievement but they do not care about other factors such as: problem solving capacity, creative capacity... of their children. Among with the number of students at the same time, we also feel difficult to observe and evaluate the development of those capacities of each and every student. Instead of that, we examine and evaluate each capacity using the observing form and take the average score for each capacity in the experimental class before and after the impact. We have worked with each group for about 1-2 months, 1-2 times a week with the education activities according to STEM orientation. We worked with the total of 6 periods.

2.2. Methods of Inquiry
The crucial method is impact research. Basing on the purpose of developing problem-solving capacity for students, the research group has presented some initial assessments: STEM activities are able to develop problem-solving capacity of students. Therefore, the research group builds practical inquiring forms in order to find out the difficulties and the needs of students about STEM education
activities and problem-solving capacity. Using the result, the research group proposes the process of teaching Science using STEM education orientation to develop problem-solving capacity of students and design a full detail of one STEM activity with the topic: “Invent acid-base reagent from purple cabbage”. The result of the impact will be evaluated and measured by problem-solving capacity criteria while students are solving these problems from the topic. Analyzing the result will help the research answer the questions: How STEM education activities affect on problem-solving capacity of students? How will these capacities be developed before and after conducting the STEM topic of “acid-base reagent from purple cabbage”.

2.3 Intervention of the STEM topic of “acid-base reagent from purple cabbage”

The STEM education intervention was developed regarding on the general process of teaching Science in STEM education orientation including 5 steps [3] as the figure 1.

![Figure 1. STEM Process of teaching Science in STEM education orientation](image)

The learning activities in STEM topic of “acid-base reagent from purple cabbage” will be clarified through the following aspects: reason of choosing the topic, STEM knowledge in the topic, aims of the topic, and conducting of activities.

2.3.1 Reason of choosing the topic

Purple cabbage is a popular ingredient and easy to find in life. The main pigment extracted by purple cabbage is cyanidin 3,5-diglucoside of the anthocyanin color (purple) and it changes clearly based on the pH of the environment [2]. In acid environment, it has strong red color, in base environment, it changes to blue and maintains for a long time. Using purple cabbage solution to recognize acid and base and soil environment with simple methods, to choose fertilizer and plants which are suitable. Besides, making litmus paper helps students know about the environment of matters, helps farmers know about soil environment without purple cabbage.

2.3.2 STEM knowledge in the topic

- Science (S): How to determine the environment of matter, soil, the pH of the solutions
- Technology (T): Use safe and available ingredients: purple cabbage, lemon, baking soda, vinegar, soap, bleach, and so on.
- Engineering (E): The process of making reagent solution form purple cabbage
- Mathematics (M): Determine the pH of the solution
2.3.3 Aims of the topic

- Knowledge:
  + Students know how to use Science knowledge to solve problems.
  + Students are able to distinguish the environment of familiar substances in life using acid-base reagent.
  + Students analyze the acid-base soil environment, use it to give the solution to improve the soil and choose the suitable plants for the soil.
  + Students apply knowledge to make litmus paper from purple cabbage.
- Skills:
  + Students know the soil environment using acid-base reagent.
  + Students make litmus paper for farmers and high school laboratory
- Attitude
  + Improve the excitement to explore science, develop and create new things
- Capacities:
  + General capacities: Problem-solving capacity, cooperation capacity
  + Particular capacities: Chemistry experimental capacity, problem-solving capacity through Chemistry, capacity of applying Chemistry knowledge in life.

2.3.4 Conducting of activities

The STEM topic of “acid-base reagent from purple cabbage” provided seven learning activities. These included a) activity 1: Building process of extracting purple cabbage solution, b) activity 2: Practice making an acid-base indicator extracted from purple cabbage, c) activity 3: Applying test set of indicators to identify environmental substances, d) Activity 4: Making indicator paper from purple cabbage solution, e) Activity 5: Test the indicator paper with substances need indentifying environment, f) Activity 6: Quantify pH of substances, and g) Activity 7: Complete the content of evaluation form of the whole process

a) Activity 1: Building process of extracting purple cabbage solution
   - Aim: Students know how to extract purple cabbage solution
   - Conduct: Students could be able to present the processes of extracting purple cabbage solution in the following 3 steps.
     • Step 1 included 1) Finely chopped purple cabbage, 2) put into a puree machine, and pressed, filtered for water.
     • Step 2 included 1) Finely chopped purple cabbage, 2) Soak in hot water for about 20 minutes, and 3) take the purple water.
     • Step 3 included 1) Separate layers of purple cabbage, 2) boil for 5 minutes. After heating at different times, the color of the solution is extracted from the purple leaf that is gradually darkened by purple pigmentation. Anthocyanin in the leaf is separated from the cell into a solution, and 3) filter the purple water.

b) Activity 2: Practice making an acid-base indicator extracted from purple cabbage
   - Aim: Students know how to do some progress of extracting purple cabbage indicator for reagent.
   - Conduct: Students can choose one in three processes to complete the task with the condition of the class

c) Activity 3: Applying test set of indicators to identify environmental substances.
   - Aim: Students know who to determine environment using purple cabbage reagent.
   - Conduct:
     • Take samples of the solution into the named cup. Squeeze in the cups of purple
cabbage solution that each group has prepared in advance.

- Observe and comment on the color change of indicator solution
- Make the following conclusions about the environment: acidic solutions are vinegar, lemon, chloroacetic acid, orange juice, yogurt; Basic solutions are backing soda, calcium hydroxide, ammonia solution, potassium permanganate, Vim water, Javen water. These could be seen as the figure 2.

Figure 2: Photos of students identifying environmental substances using purple cabbage solution

d) Activity 4: Making indicator paper from purple cabbage solution

- Aim: Students succeed in making indicator paper from purple cabbage solution
- Conduct:
  - Propose the problems: How long can purple cabbage solution be? How to preserve purple cabbage solution? If you have not kept long or no purple cabbage for a long time, how do you get the indicator?
  - Solve the problem: Depending on the temperature conditions to preserve the purple cabbage solution, usually at normal temperatures, purple cabbage solution can be kept for 3 days if not tightly closed, for longer will be damaged. To preserve the purple cabbage solution longer, it is possible to add alcohol 90%, or as a color indicator for long term use, in the absence of purple cabbage.
  - Making indicator paper from purple cabbage as following steps. Step 1: Prepare purple cabbage solution (process similar to the above, can use alcohol 90%). Step 2: Soak the filter paper in about 60 minutes (Figure 3). Step 3: Dry, filter paper (Figure 4). Step 4: Cut the 1 × 5 indicator (Figure 5. Step 5: Store in a clean zip lock or glass jar.
e) Activity 5: Test the indicator paper with substances need indentifying environment
- Aim: Students identify environmental substances using indicator paper
- Conduct: Test paper produced with the substances that need to determine the environment as above. It was found that the paper had the character of purple litmus paper, so it is possible to use this method to make lintels for the identification papers in the laboratory at school or to test the soil environment in the season without cabbage. purple (Figure 6).

f) Activity 6: Quantify pH of substances
- Aim: Students quantify pH of substances.
- Conduct: Identify pH of substances
  - Based on the pH determination formula of the solutions: 0.1M hydrochloric acid, 0.1M ammonia solution, 0.1M NaOH solution, 0.01M Ca(OH)2 solution.
  - Based on the pH-determining scale of the lemon, vinegar, nabica salt, Vim water, Javen water, orange juice, yogurt.

g) Activity 7: Complete the content of evaluation form of the whole process
- Aim: Students complete evaluation form of products
- Conduct:
  - Teachers design self-evaluation form, question form for students’ excitement after conducting this topic. This is a meaningful and necessary activity to finish STEM topic
  - Products score of each group will be counted by average score of student self-evaluation and teachers’ evaluation
3. Findings

The 84 students of experimental class grade 11 of 4 high schools: 02 schools in Hanoi are Hai Ba Trung high school and Van Lang high school; 02 schools in Thai Nguyen are Thai Nguyen high school and Gang Thep high school, in the term of 2017-2018; designed lesson plans and conducted activities, evaluated products of students. The students’ performances on conducted activities revealed their problem-solving capacity. The findings will clarify 1) summary of students’ problem-solving capacity comparing between before and after intervention, and 2) the development level of students’ problem-solving capacity.

3.1 summary of students’ problem-solving capacity comparing between before and after intervention

All of groups have their own products with good quality. The result is calculated by the average score of students’ self-evaluation and teacher’s assessment. We used the observing form for teacher as a tool to evaluate problem-solving capacity of students in experimental class before and after impacts. The result was handled by mathematical statistics, we have synthesized the results as follows:

Table 1: Summary table of parameters evaluating problem-solving capacity of students before and after intervention.

| Criteria | Experimental class after impacts | Experimental class before impacts |
|----------|---------------------------------|----------------------------------|
|          | Number of students | Average score of each criteria | Number of students | Average score of each criteria |
| 1        | 1.0 | 2.0 | 3.0 | 4.0 | 1.0 | 2.0 | 3.0 | 4.0 |
| 2        | 4   | 8   | 31  | 41  | 19  | 19  | 18  | 28  |
| 3        | 5   | 7   | 34  | 38  | 18  | 23  | 28  | 15  |
| 4        | 9   | 13  | 32  | 30  | 20  | 23  | 31  | 10  |
| 5        | 6   | 11  | 32  | 35  | 18  | 19  | 17  | 30  |
| 6        | 6   | 14  | 30  | 34  | 19  | 23  | 30  | 12  |
| 7        | 9   | 12  | 30  | 33  | 19  | 23  | 30  | 12  |
| 8        | 4   | 7   | 37  | 36  | 18  | 24  | 17  | 25  |
| 9        | 8   | 14  | 32  | 30  | 20  | 22  | 30  | 12  |
| 10       | 4   | 17  | 31  | 32  | 24  | 20  | 31  | 9   |

Average score of problem solving capacity of experimental class after impacts = 3.13
Average score of problem solving capacity of experimental class before impacts = 2.47

Average score difference = 0.66
Standard deviation of experimental class after impacts = 0.88
Standard deviation of experimental class before impacts = 0.85

Independent t-test verification p = 1.71.10^{-4}
Impact Level ES = 0.78

Name the criteria in numerical order: 1) Find and identify problematic situations in chemistry; 2) identify and address problematic situations in chemistry related to practical applications; 3) Analyze problematic situations in chemistry and related practical applications; 4) Planning and solving some simple problems in studying chemistry and in practice; 5) Identify information, collect and clarify information relevant to the issue to be addressed in the STEM topic; 6) Proposing some solutions for resolving problems; 7) Analyze and select the most suitable solution; 8) Successfully implemented the solution according to the selected plan; 9) Evaluate the effectiveness of the chosen solution accurately and briefly; 10) Apply the solution in the same context or situation.
3.2 The development level of students’ problem-solving capacity

The development level of students’ problem-solving capacity could be represented as the figure 7. From the results of the problem-solving capacity criteria in students after the topic evaluated by the teacher, the scores of the criteria for assessing the environmental impact of the experimental class after impact are always greater than before the impact, the value of \( p < 0.05 \), the level of ES effect is 0.78. The value of ES indicates that the experimental results have a moderate effect.

Criteria for the higher grade of the experimental class were criteria 1 (3.30), criteria 3 (3.25) and criteria 5 (3.14), criteria 8 (3.25). This means that the students has realized that after completing the topic, students will be able to analyze the problematic situations in studying chemistry and related to practical application in studying Science, successfully implemented the solution according to the selected plan. The ability to identify information, to collect and clarify information relevant to the problem solved in the STEM topic is very good. However, the criteria for having a lower grade is that of criteria 7 (3.04), criteria 9 (3.0) indicates that students have not shown good performance in analyzing and choosing the right solution. Incorporate problematic situations in the study of Science and related to practical application, have not evaluated the effectiveness of the solution has been selected precisely and briefly. As such, STEM education orientation has created a very natural environment for students to express themselves in situations where they need to apply knowledge to solve practical problems.

4. Conclusion

It is possible to develop problem-solving capacity of students through STEM activities. Teaching in STEM education orientation provides the needs of innovating teaching method in high schools. Not only it completes the aim at teaching, it also make the opportunities for students to self-study, self-research, develop problem-solving capacity of students. Problem-solving capacity of students in experimental class after impacts always better than before impacts which is shown clearly by the observing form of teachers. Research result need to be experiment in wider objects, in longer time so that the conclusion given will be more realiable.

Nowadays, STEM education is an education orientation which is necessary in Vietnam. It encourages training in Science, Technology, Engineering and Mathematics, improve creativity, desire to explore science. With the solution of making indicator from available ingredients, it creates belief, excitement and efficiency in learning for students. This makes Chemistry become closer to students’ life, connect the knowledge to real life, apply the development of science. This is a practical activity that helps students build experimental capacity, the ability to apply knowledge in reality, to solve
problems and give more motivation in learning Chemistry.

The exploitation and application of the strengths of STEM education is extremely beneficial and necessary for general education in Vietnam. STEM education creates people who can meet the needs of the 21st century, responding to the nation's economic and social development and can positively impact the changing economies. Knowledge in the context of globalization. But in the real situation of the country in terms of qualification and capacity of the managerial staff of teachers; material facilities of the school; Socio-economic conditions of localities, the application of STEM to schools should have the attention of the Ministry of Education and Training, managers and leaders of schools to STEM education. On the other hand, STEM education guidelines should be developed in schools, and testing, evaluation and testing activities should be consistent with STEM's basic ideas.

Acknowledgement
This article is published from the research results of the topic CS-2019-05" in the " Implement of STEM education in Vietnamese high school: unit of acid-base reagent from purple cabbage " article, this article by author Nguyen Mau Duc, Nguyen Quang Linh, Chokchai Yuenyong.

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