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DEVELOPING CREATIVE AND PROBLEM-SOLVING CAPABILITIES FOR STUDENTS THROUGH USING STEM EDUCATION MODEL IN TEACHING HYDROCARBON DERIVATIVES AT HIGH SCHOOL

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ABSTRACT
Problem solving and creativity capacity is one of the important general competencies that need to develop for students in general, high school students in particular. STEM education is an interdisciplinary teaching perspective to equip students with necessary knowledge and skills related to the fields of Science, Technology, Engineering and Mathematics. These knowledge and skills must be taught integrally to help learners apply those knowledge in specific contexts.This article presents the principles, structure and organizational process of teaching STEM education to develop problem solving and creativity capacity for students through teaching hydrocarbon derivative chemistry in high school.

Key Words: Problem solving, student, competency, creativity, STEM.

1. INTRODUCTION
STEM stands for Science, Technology, Engineering and Mathematics. STEM education is an interdisciplinary teaching perspective to equip students with necessary knowledge and skills related to the fields of Science, Technology, Engineering and Mathematics. These knowledge and skills must be taught integrally so that learners can apply those knowledge in specific contexts [1]. STEM education has appeared and been interested in Vietnam in the past few years.In particular, the spirit of STEM education has been thoroughly grasped in the implementation of the new general education program for related subjects. However, STEM education in Vietnam has not been studied in depth, the application of this modern educational model in teaching subjects of the current font program only stops at the initial stage.

Chemistry is a subject in the field of Natural Science. The knowledge in the program of Chemistry in general, Hydrocarbon Derivatives - Chemistry 11 in particular has a close relationship with other sciences such as Physics, Mathematics, Biology, Technology. Therefore, the research and application of the STEM education model in the teaching of natural sciences in general and the teaching of Chemistry in particular is completely grounded and consistent with the comprehensive fundamental innovation orientation. Vietnamese education in the direction of developing students' competencies in order to meet the demands of modern society.

On the other hand, according to the general education program, the master program [2], problem solving and creativity capacity is one of the important general competencies that need to

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be developed for high school students in general, high school students in particular. Especially problem solving and creativity capacity is the basis for developing specific competencies of Chemistry subjects such as: chemical awareness; learn about the natural world from the perspective of chemistry; apply knowledge, skills learned. Thus, the capacity for problem solving and creativity plays an important role for students in the process of learning, working and perceiving the natural world. The development of the capacity for problem solving and creativity is an urgent requirement in the current teaching process of natural sciences and Chemistry subjects in high schools.

2. CONTENT

2.1. STEM overview and problem solving & creativity capacity

2.1.1. STEM education

Currently, STEM education is interested in research by many organizations and educators. In this topic, STEM education is used by us as described in the general education program in 2018 as follows: "STEM education is an educational model based on an interdisciplinary approach, helping students to apply knowledge of Science, Technology, Engineering and Mathematics to solve some practical problems in specific contexts "*[3]*.STEM education is often integrated through science club activities, outside classroom activities or taught through the Natural Sciences subjects.According to the author Le Xuan Quang (2017), there are many ways to classify STEM depending on the field, scope of knowledge or teaching purpose[3]: Complete STEM and missing STEM; Basic STEM and extended STEM; STEM teaches new knowledge and applies STEM. STEM education goals are oriented towards the impact on learners, towards applying knowledge of subjects to practical problem solving. Currently, the 5E process and technical design theory approach are very interested, is a suitable process in STEM education for practical problem solving [4]

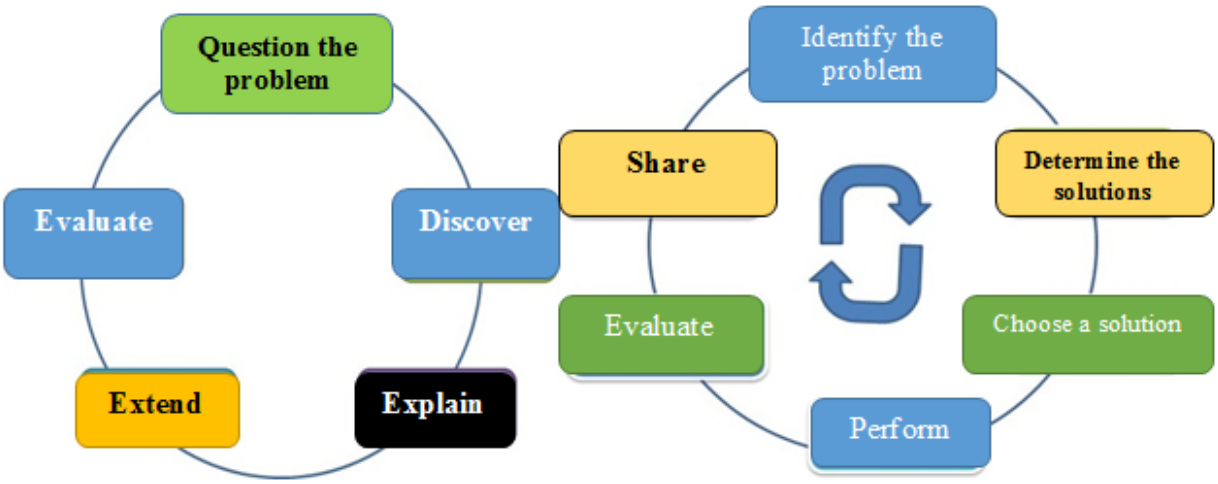

Figure 1. 5E model and approach to technical design theory in STEM education

2.1.2. Problem solving and creativity capacity

According to [2], [5]: Problem solving and creativity capacity is the individual's ability to effectively use cognitive processes, actions and attitudes, motives and emotions to analyze and propose measures, choosing solutions and implementing solutions to learning and practical

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situations, problems where there are no common processes, procedures, and solutions available, and at the same time evaluating the solution problems to adjust and apply flexibly in new circumstances and tasks.

According to the general general education program in 2018, the manifestations of the capacity to solve problems and creativity include 6 component competencies [2]. High school students, the capacities and manifestations of the competencies are shown in table 1 below:

Table 1. The manifestations of problem solving competence and creativity of high school students

The component capacity of problem solving and creativity capacity	**Expression (criteria)**
1. Realize new ideas	- Identify and clarify new and complex information and ideas from different information sources. - Know to analyze independent information sources to see the trend and reliability of new ideas.
2. Detect and clarify the problem	- Analyze situations in study and in life. - Detect and state problematic situations in study and in life.
3. Formulate and implement new ideas	- Giving new ideas in study and in life. Thought not in the same way. - Create new elements based on different ideas. - Forming and connecting ideas. - Research to change solutions to a change of context. - Risk assessment and provision
4. Proposing and choosing the solution	- Know to collect and clarify information related to the problem. - Know to propose and analyze a number of problem solving solutions. - Choose the most suitable solution.
5. Implement and evaluate problem solving & creativity solution	- Know how to implement and evaluate problem solving solutions. - Know how to think about how and conduct problem solving to adjust and apply in new contexts.
6. Independent thinking	- Knowing to ask many valuable questions, not easily accepting one-way information. - Not prejudiced when considering and assessing problems - Be interested in convincing arguments and proofs - Willing to consider, re-evaluate the problem.

2.2. Practical basis

The current situation of high school education shows that students' ability to solve problems and creativity has not been paid much attention.

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Table 2. Results of the extent of teachers' use of competencies in teaching in Bac Giang province

General competencies	***Usage level***				***TB***	***SD***	***P***
	Often	Occasionally	Rarely	Never			
Logical thinking capacity	32	7	1	0	2.78	0.46	<0,001
Cooperation capacity	35	5	0	0	2.88	0.53	<0,001
Creative capacity	14	25	1	0	2.3	0.34	<0,001
Problem solvingcompetence	1	39	0	0	2.0	0.33	<0,001
The criteria are coded as follows: "Often" = 3, "Occasionally" = 2, "Rarely" = 1, "Never" = 0. Data for mean (TB), degree Standard deviation (SD) and T-test (P) test value were processed by SPSS software							

2.3. Structure and organizational process of teaching STEM education

A topic of STEM Education is presented in the following structure [6]:

TOPIC NAME

1. Situation, context
2. The subject's goal
3. Problems to be solved / challenges posed for students
4. Knowledge of background skills
5. Content
6. Methods and forms of organizing topic teaching
7. Examination and evaluation

From the 5E process and approach according to technical design theory, we propose the process of teaching physics of hydrocarbon derivatives according to STEM education orientation, including 5 steps:

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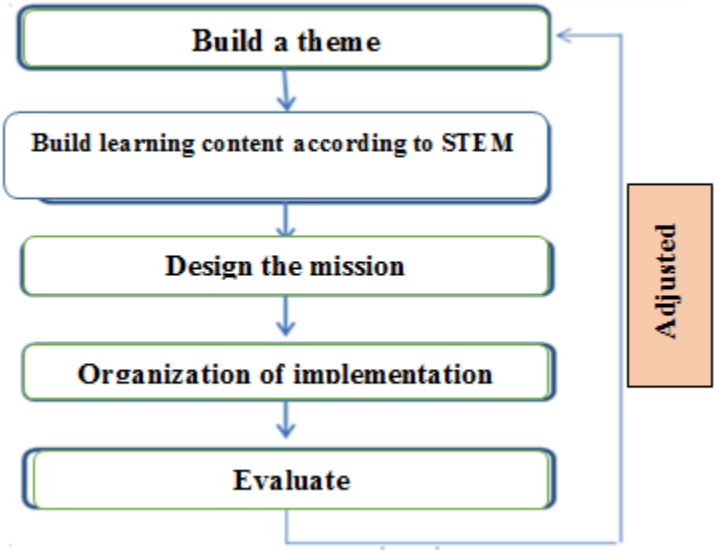
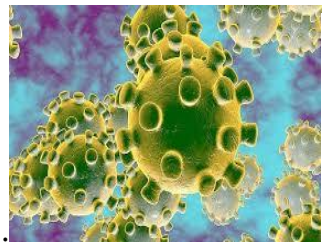


Figure 2. The process of teaching chemistry in the direction of STEM education

2.4. STEM educational topic "Dry hand sanitizer preparation"

I. Situation, context

Bacteria (harmful) / viruses / parasites have many harmful effects on human health: Decreasing the immune system; Weakening of functional organs; Dangerous to life, ... One of the most visible harms of bacteria is colic, food poisoning (when eating and drinking unhygienic food or contaminated limbs, ...). In addition, there are many pandemics caused by viruses such as: SAR, H5N1, H1N1… and now we are facing a very dangerous Covid - 19 epidemic caused by a new strain of the Corona virus



It can be seen that bacteria (harmful) / viruses / parasites pose a great risk to humans. To minimize the harmful effects of bacteria (harmful) / viruses / parasites, one of the most effective measures is to prevent the body from being infected with bacteria (harmful) / viruses. / this parasite. To prevent the penetration of bacteria / viruses / parasites to the body. Wash hands frequently and properly with soap and clean water; or alcohol-based hand sanitizers. Eating and drinking hygienic, ensuring food safety and hygiene. Use a mask correctly. Avoid close contact with sick people. When epidemic outbreaks, there may be a shortage of goods such as soap and hand sanitizer, so how can a solution of hand sanitizer be prepared to protect health.

Therefore, we choose the STEM topic "Mixing dry hand sanitizer" with the aim of reinforcing knowledge of the Ancolho lesson, using the easy-to-find ingredients, in addition to helping

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students experience with the hand-sanitizer project. Dry: From raw material collection, production process design, to packaging design, product promotion planning; ... With diversified activities, students can develop their ability to solve problems and creating and applying knowledge of many STEM fields.

II. The subject's goal

1. Knowledge

- Students mentioned the harmful effects of bacteria (harmful) / viruses / parasites on human health and how to prevent them.
- Students presented the effect and antiseptic ability of alcohol at different concentrations.
- Students have given the concept of alcohol level, how to dilute alcohol solution
- Students state the required ingredients of dry hand sanitizer.
- Students can apply interdisciplinary knowledge (Chemistry, Biology, Mathematics, Technology, Engineering ...) to analyze the process of preparing dry hand sanitizer, assess the chemical composition of the product.

2. Skills

- Technical design of tools, preparation process for dry hand sanitizer to ensure safety
- Proceed to prepare dry hand sanitizer
- Using the internet to gather information; software for creating videos, presentations ...
- Calculate and determine the amount of ingredients to be prepared

3. Attitude

- Having a positive and cooperative attitude in teamwork;
- Enjoying, passionate about scientific research;
- Consciously protect their health and everyone else's health.

4. Capacity development

- Capacity to solve problems and be creative when doing the process of creating dry hand sanitizer;
- Self-control and self-study capacity: Students self-review knowledge and apply knowledge to build a process of creating dry hand sanitizer.

III. Problems to be solved / challenges posed for students

Students of groups need to prepare dry hand sanitizer from alcohol, glyceron, water, essential oils, ... to meet the following requirements: Ability to kill bacteria, not to dry hands, have attractive smell.

IV. Knowledge, background skills used in the topic

- Chemistry subject: Chemistry 11, chapter 9, lesson 40: Alcohol
- Biology: Biology 10, chapter 3: Viruses and infectious diseases
- Technology subject: Technology 11, chapter 2, lesson 8: Design and technical drawings
- Mathematics: Math 10, chapter 5: Total, average

V. Content

1. Tools and chemicals

- Tools: Spray bottle; Glass bottle (plastic bottle) capacity 500 ml (Lavie bottle), small funnel.
- Alcohol Alcohol 96^0: 415 ml; Hydrogen peroxide: 20 ml; Glyxerin: 7.5 ml; Essential oils: 2.5 ml; Distilled water: 55 ml

2. Procedure

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- Step 1: Pour 415 ml alcohol 96^0 into the big bottle.
- Step 2: Use a syringe to take 20 ml of hydrogen peroxide, then pour it into an alcohol container.
- Step 3: Continue adding 7.5 ml of glycerol. Since glycerol is very viscous, it will stick to the measuring cylinder. It is therefore necessary to rinse the cylinders with cool distilled or boiled water and then pour into the flask.
- Step 4: Add about 2-3ml of essential oils to reduce the alcohol smell and the solution has a pleasant aroma. Immediately close the lid of the flask after preparing the solution so as not to evaporate.
- Step 5: Shake or gently stir the solution with a chopstick.
- Step 6: Pour the solution through a small bottle for convenient carrying and use.

3. Requirements for the product

Table 3. Evaluation of dry hand sanitizer products

Criteria	***Points maximum***	***Points achieved***
Dry hand sanitizer scent (attractive)	3	
Transparent solution, homogeneous solution	4	
Creative, compact, beautiful, and affordable hand sanitizer bottle	3	
Total score	**10**	

Table 4. Evaluation of report and product design

Criteria	**Points maximum**	**Points achieved**
Record all steps clearly and briefly	3	
Explain the process of creating dry hand sanitizer, the role of each ingredient in the product	4	
Presentation clearly, logically and vividly.	3	
Total score	**10**	

VI. Methods and forms of organizing topic teaching

1. Define STEM knowledge in the topic

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Table 5. STEM knowledge in topic

Product	*Science (S)*	*Technology (T)*	*Engineering (E)*	*Mathematics (M)*
Hand sanitizer is dry Product Packaging Template, Poster; slideshow or video presentation about the product	Chemical composition dry hand sanitizer; Harm of bacteria (harmful) / viruses / parasites on human health and how to prevent them; The role of dry hand sanitizer	The equipment; tools used to prepare dry hand sanitizer	A PowerPoint drawing or design depicting a recipe for dry hand sanitizer; Computer software to design product packaging samples.	Determine the amount of ingredients needed to prepare 500ml of dry hand sanitizer; Calculate the cost and effectiveness of dispensing dry hand sanitizer.

2. Preparation:

- Teacher:

+ Observation checklist;

+ Project evaluation form of teachers and students;

Content knowledge key after the project is completed;

+ Necessary teaching equipment to implement the project, necessary materials for practical experiment;

+ The documents related to dry hand sanitizer; Prepare a dry hand sanitizer

- The student

+ Knowledge related to bacteria (harmful) / viruses / parasites that can cause great harm to humans

+ Knowledge related to dry hand sanitizer

+ Diary book and phone (with video recording function)

3. Expected products:

- Students 'products: Answer teachers' orientation questions; design diagram / drawing of dry hand sanitizer preparation process; video recording of the team's performance; dry handwashing liquid; product packaging samples; posters to introduce the product as well as its uses; presentations to introduce and promote the product.

V. Implementation plan:

Activity 1: Warm up (15 - 20 minutes)
- Teacher divides student class into 04 groups, elects group leader and group secretary. - Teacher: Ask students to state the harmful effects of bacteria (harmful) / viruses / parasites on human health. - HS: Some common harmful effects of bacteria (harmful) / viruses / parasites to human health: + Decreases the immune system; + Weakening the functional organs; + Dangerous to life ...

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- Teacher: One of the most visible harms of bacteria is stomach pain, food poisoning (when eating and drinking unhygienic food or contaminated limbs, ...)
- GV: In addition, there are many pandemics caused by viruses such as: SAR, H5N1, H1N1 ... and emphasizing that we are currently facing a very dangerous Covid - 19 epidemic caused by a new strain of the Corona virus. .
- GV: It can be seen that bacteria (harmful) / viruses / parasites have a great risk of harming humans. To minimize the harmful effects of bacteria (harmful) / viruses / parasites, one of the most effective measures is to prevent the body from being infected with bacteria (harmful) / viruses. / this parasite.
- Teacher: Ask students to state measures to limit the ability of bacteria / viruses / parasites to enter the body:
- HS: Some measures to prevent the invasion of bacteria / viruses / parasites
+ Wash hands frequently and properly with soap and clean water; or alcohol-based hand sanitizers;
+ Eating and drinking hygienic, ensuring food safety and hygiene;
Use a mask properly;
Avoid close contact with infected people.
- Teacher: Based on students' answers to summarize some main measures and emphasize the need to wash hands frequently with soap and clean water; or other hand sanitizers.
- Teacher raises the problem: When an epidemic occurs, it can cause a shortage of goods such as soap, hand sanitizer ... (cannot buy these goods), so how can I mix Preparing hand sanitizer to protect health.
- Students: Can prepare hand sanitizer by themselves.
- Teacher: Comment and agree with students to learn and prepare dry hand sanitizer solution.

Activity 2: Learn how to make a dry hand sanitizer (20 minutes)

- Teacher assigns the task "Learn the process of preparing dry hand sanitizer" to groups of students.
- Students: Group discussion, research, learn information from the internet and choose the process of preparing dry hand sanitizer (ingredients, steps and advantages of preparation method).
- Students complete tasks and present the results of discussion on A4 paper in the following form:

1. The main ingredient of dry hand sanitizer
2. Tools to be used
3. Materials needed
4. Steps to prepare
5. The advantages of dispensing method.

- Teacher asks groups to stick products on the board and organize groups to report and discuss group products.
- Students appoint a group representative and report on group activities.
- Teachers agree on the method of preparing a dry hand sanitizer between groups according to WHO guidelines.

Activity 3: Prepare a dry hand sanitizer (40 minutes)

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Task: The groups proceed to prepare dry hand sanitizer. - Teacher: Organize groups to prepare dry hand sanitizer according to the agreed formula and state the evaluation criteria: - Criteria for product evaluation: Scent of dry hand sanitizer; Transparent, homogeneous solution; Hand sanitizer vial has full information about uses, ingredients, usage, ... - Students: Prepare to prepare dry hand sanitizer in groups. - Teacher: Observe and support groups in the process of completing tasks.
Activity 4: Product reporting (30 minutes)
- Teacher: Organize groups to report products after finishing, focusing on the following main contents: Uses; Ingredient; Using; The outstanding advantages of the product. - Students: Groups appoint representatives to report products according to the instructions of teachers.
Activity 5: Evaluation of results, review (10 minutes)
Use the evaluation tools outlined in the sectionVII

VII. CHECK

Table 6. Evaluation form of the capacity criteria for problem solving and creativity through observations of teachers

Full name of observed student: …… ... Group …… ..... Class …… ...
Name of lesson / topic: …… ..... …… ....
Full name of supervising teacher: …… .....

TT	Criteria	*Level*		
		Not good	***achieve the goal***	***Good***
1	Identifying information in STEM teaching topics			
2	Detect and state problematic situations in the topic of STEM teaching.			
3	Proposing and analyzing problem solving solutions in implementing STEM topic			
4	Select the most suitable solution to implement STEM teaching topic			
5	Planning to implement the STEM theme			
6	Adjust your plan as needed to suit your situation and be effective			
7	Evaluate and analyze solutions that have implemented problem solving in the topic STEM			
8	Ask lots of valuable questions, don't accept one-way information.			
9	Not prejudiced when considering and evaluating problems in implementing STEM topics.			
10	Willingness to consider, re-evaluate issues in implementing STEM topic.			
Each criterion is evaluated according to the following 3 levels: Not yet achieved: 1.0 point; Pass:				

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2.0 points; Good: 3.0 points.

Table 7. Self-assessment of problem solving and creative capacity development

Full name of student: …… ..… .. Group ……Class …… ..... Name of lesson / topic: …… .. ……				
TT	**Criteria**	***Level***		
		Not good	***achieve the goal***	***Not good***
1	Identifying information in STEM teaching topics			
2	Detect and state problematic situations in the topic of STEM teaching.			
3	Proposing and analyzing problem solving solutions in implementing STEM topic			
4	Select the most suitable solution to implement STEM teaching topic			
5	Planning to implement the STEM theme			
6	Adjust your plan as needed to suit your situation and be effective			
7	Evaluate and analyze solutions that have implemented problem solving in the topic STEM			
8	Ask lots of valuable questions, don't accept one-way information.			
9	Not prejudiced when considering and evaluating problems in implementing STEM topics.			
10	Willingness to consider, re-evaluate issues in implementing STEM topic.			
Each criterion is evaluated according to the following 3 levels: Not yet achieved: 1.0 point; Pass: 2.0 points; Good: 3.0 points.				

2.5. Research results

Table 8. Results of observing experimental classes on the development of students' ability to solve problems and creativity

Evaluation criteria	Experimental pedagogy (Before impact)				Experimental pedagogy (After impact)				Y1-X1
	Number of students scoring			(X1)	Number of students scoring			(Y1)	
	3.0	2.0	1.0		3.0	2.0	1.0		
1	15	26	37	1.72	20	43	15	2.06	0.34
2	8	33	37	1.63	16	44	18	1.97	0.34
3	11	34	33	1.72	18	48	12	2.08	0.36
4	11	29	38	1.65	20	42	16	2.05	0.4

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5	10	25	43	1.58	18	40	20	1.97	0.39
6	15	25	38	1.71	23	44	11	2.15	0.44
7	7	35	36	1.63	13	53	12	2.02	0.39
8	7	25	46	1.5	12	46	20	1.9	0.40
9	13	26	39	1.67	21	43	14	2.09	0.42
10	15	28	35	1.74	25	40	13	2.15	0.41
Total score				16.46	Total score			20.44	

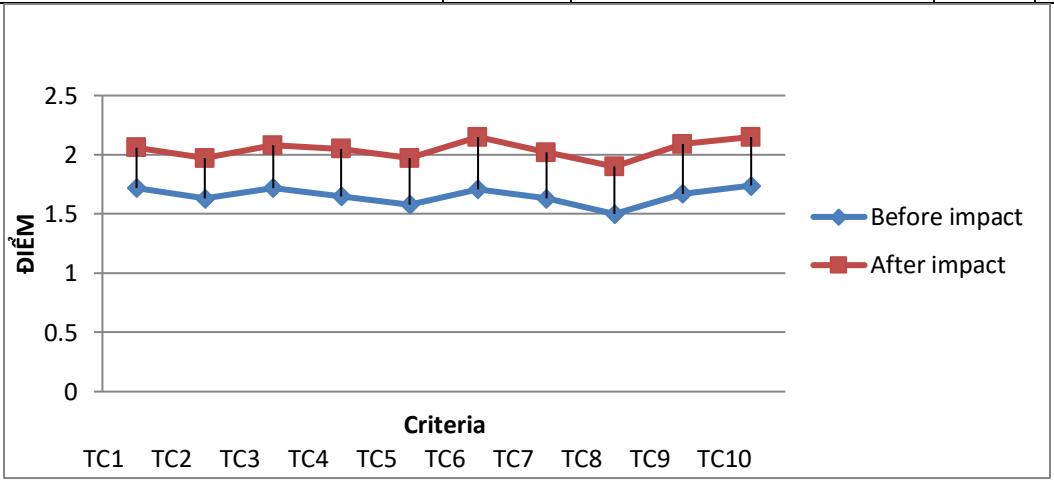

Figure 2. Chart of evaluation criteria for problem solving and creativity of experimental group students

Based on the observation checklist of Yen Dung 2 High School Teacher, we can see that the results achieved in each criterion of the experimental group students after the impact are higher than before the impact. Criteria 4, 6, 8. From the results obtained in each lesson hour, we find that with the application of the STEM education model, we have created excitement and promoted the positivity and initiative in awareness of Students and meet the objectives of the topic.

3. CONCLUSION

Through the principles, structure and organizational process of teaching STEM education to develop problem solving and creativity capacity for students through teaching hydrocarbon derivative chemistry in high schools. We have applied and tested to use in teaching at Yen Dung 2 High School, giving results reliable, effective in promoting students to develop problem solving and creativity capacity of students; at the same time make students believe and interested in Chemistry in particular and natural sciences in general.

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