ORGANIZING THE TEACHING OF THE TOPIC "ACTIVATION ENERGY OF CHEMICAL REACTIONS" (GRADE 10 CHEMISTRY) USING THE CONTRACT TEACHING METHOD TO DEVELOP STUDENTS' PROBLEM-SOLVING AND CREATIVITY COMPETENCIES

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ABSTRACT

The topic "Activation Energy of Chemical Reactions" in Grade 10 Chemistry aims to expand and deepen students' knowledge of reaction rates. Accordingly, teaching this topic offers numerous opportunities to foster students' chemical thinking, problem-solving and creative competencies. This study proposes a process for applying the contract teaching method to organize instruction that promotes the development of these competencies. Drawing on theoretical research, practical research, and data analysis methods, we developed a five-step teaching process. This process was experimentally implemented with 80 Grade 10 students at Xuan Hoa High School, Xuan Hoa, Phu Tho. The experimental results revealed significant improvements in areas such as information analysis, problem identification, solution selection, implementation planning, problem solving, and evaluation within the experimental group. These findings demonstrate that the application of the contract teaching method effectively supports the development of students' problem-solving and creative competencies, thereby contributing to the innovation of general education aimed at fostering students' qualities and competencies.

TỔ CHỨC DẠY HỌC CHỦ ĐỀ "NĂNG LƯỢNG HOẠT HÓA CỦA PHẢN ỨNG HÓA HỌC" (CHUYÊN ĐỀ HÓA HỌC 10) THEO PHƯƠNG PHÁP DẠY HỌC HỢP ĐỒNG NHẰM PHÁT TRIỂN NĂNG LỰC GIẢI QUYẾT VẤN ĐỀ VÀ SÁNG TẠO CHO HỌC SINH

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TỪ KHÓA

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Năng lượng hoạt hóa

TÓM TẮT

Chủ đề "Năng lượng hoạt hóa của phản ứng hóa học" trong chuyên đề Hóa học 10 có mục tiêu hướng tới mở rộng, nâng cao kiến thức về tốc độ phản ứng hóa học. Do đó, việc tổ chức dạy học chủ đề này có nhiều cơ hội để phát triển tư duy hóa học, năng lực giải quyết vấn đề và sáng tạo cho học sinh. Nghiên cứu này nhằm đề xuất quy trình vận dụng phương pháp dạy học hợp đồng trong tổ chức dạy học để phát triển năng lực giải quyết vấn đề và sáng tạo cho học sinh. Thông qua việc sử dụng các phương pháp nghiên cứu lí thuyết, nghiên cứu thực tiễn, xử lí thông tin, chúng tôi đã đề xuất quy trình dạy học gồm 5 bước. Quy trình này được tiến hành thực nghiệm trên 80 học sinh lớp 10 tại trường Trung học phổ thông Xuân Hòa, Xuân Hòa, Phú Thọ. Kết quả thực nghiệm cho thấy sự phát triển tốt đối với các tiêu chí liên quan đến việc phân tích thông tin, xác định vấn đề cần giải quyết, lựa chọn giải pháp, lập kế hoạch thực hiện, thực hiện giải quyết và đánh giá vấn đề, v.v. ở nhóm thực nghiệm. Điều này chứng tỏ năng lực giải quyết vấn đề và sáng tạo của học sinh đã được phát triển, từ đó góp phần thực hiện đổi mới giáo dục phổ thông theo hướng phát triển phẩm chất, năng lực học sinh.

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1. Introduction

In the context of modern education, developing students' problem-solving and creativity competencies has become an urgent and essential requirement. Vietnam's 2018 General Education Program [1] emphasizes the formation and development of learners' qualities and competencies. Among these, problem-solving and creativity are identified as core competencies that must be cultivated through various subjects; Chemistry, in particular, plays a crucial role in helping students adapt to the rapid advancements in science, technology, and society.

Globally, numerous studies have demonstrated that problem-solving and creative thinking competencies can be effectively developed through active teaching methods such as project-based learning, inquiry-based learning, and contract learning. Knowles [2] highlighted how contract learning can personalize the educational process, foster learner autonomy, and enhance problem-solving competencies. Frank and Scharff [3] emphasized that the use of learning contracts helps learners take a proactive approach to goal-setting and task completion, thereby developing both problem-solving and creative thinking competencies. Other authors, including Thomas [4], Bell [5], and Furtak et al. [6], have also confirmed the effectiveness of teaching methods such as project-based and inquiry-based learning in fostering critical thinking, problem-solving, and teamwork competencies in science education.

In Vietnam, various researchers have focused on developing students' problem-solving and creativity competencies through innovative teaching approaches. Notable contributions include [7] - [12]. These studies have explored the characteristics, structures, and expressions of problem-solving and creativity competencies, proposing several strategies to enhance these competencies such as project-based learning, problem-based learning, and integrated teaching.

Contract teaching is among the active learning approaches that support the personalization of learning, enabling students to construct knowledge actively and independently. This method has proven effective in enhancing self-study, problem-solving, and creative thinking competencies in learners [13]. Therefore, studying the application of this teaching method to organize instruction on learning topics aimed at developing general competencies, particularly problem-solving and creativity is an important and urgent requirement to support teachers in effectively implementing the 2018 General Education Program. This article proposes a process for applying the contract teaching method to organize instruction on the topic "Activation Energy of Chemical Reactions" (Grade 10 Chemistry), with the aim of developing students' problem-solving and creativity competencies.

2. Methodology

This study employed a combination of the following research methods:

Theoretical research methods were used to review existing literature on competency-based education, the development of problem-solving and creativity competencies, contract teaching, and active teaching methods in Chemistry instruction. Based on this theoretical foundation, the study proposes a process for applying the contract teaching method in organizing instruction on the topic "Activation Energy of Chemical Reactions", aiming to foster students' problem-solving and creative thinking competencies.

Practical research methods involved conducting a pedagogical experiment to evaluate the appropriateness and effectiveness of the proposed teaching process. The experiment was carried out with 40 students from class 10A1 (experimental group) and 40 students from class 10A2 (control group) at Xuan Hoa High School, Xuan Hoa, Phu Tho during the 2023-2024 academic year. In the experimental class, the proposed contract teaching process was implemented, while the control class was taught using traditional methods such as lectures and guided discussions. Data collection tools included: (1) a rubric-based assessment form to evaluate students' development in problem-solving and creativity competencies at two points-before and after the intervention in the experimental group; and (2) a 15-minute test administered simultaneously to both groups to compare academic performance and assess the effectiveness of the teaching intervention.

Data analysis methods: we used SPSS software to statistically process the results of the pedagogical experiment. The assessment of the development of the criteria of problem-solving and creativity of students in the experimental class (from grade 1 to 10) was carried out through a Paired-Samples T-Test in the pre-impact and post-impact stages. For the test, we used the Paired-Samples T-Test to compare the results achieved by the experimental class and the control class.

The results were confirmed through statistical parameters, including standard deviation and the p-value (Sig.) of the T-test. Based on these findings, the feasibility and effectiveness of applying the contract teaching method to organize instruction on the topic "Activation Energy of Chemical Reactions" were demonstrated.

3. Findings and discussion

3.1. Problem-solving and creative competencies

Problem-solving and creative competencies refers to an individual's competencies to effectively utilize cognitive processes, actions, attitudes, motivations, and emotions to analyze problems, propose and select appropriate solutions, and implement them to address learning and real-life situations where there are no pre-defined procedures or common solutions. This competencies also includes evaluating the effectiveness of solutions, making adjustments, and flexibly applying them in new contexts and tasks [14].

The structure of problem-solving and creative competencies includes the following components: Recognizing new ideas; Identifying and clarifying problems; Generating and implementing new ideas; Proposing and selecting solutions; Designing and organizing activities; and Thinking independently [1].

3.2. Concept of contract teaching

Contract teaching is a method of organizing the learning environment in which each student is assigned to complete a learning contract consisting of various tasks and exercises within a set period. Students are empowered to make independent decisions regarding task selection (self-selection), the time allocated for each task, and the sequence in which the tasks are carried out-all within the agreed timeframe [15].

3.3. The process of applying the contract teaching method in Chemistry to develop students' problem-solving and creativity

The following is a proposed process for applying the contract teaching method in high school Chemistry to foster students' problem-solving and creative competencies:

Step 1. Define teaching objectives: In this step, teachers need to base their decisions on the program requirements, the characteristics of the teaching content of each topic, and the students themselves in order to determine appropriate teaching objectives.

Step 2. Identify the core problem and learning content for the contract: Based on the objectives, teachers determine the key problems students are expected to solve. These may be introduced through guiding questions.

Step 3. Develop the learning contract:

Contract Tasks: These should include both mandatory tasks (ensuring all students meet the curriculum requirements) and optional tasks (allowing students to apply, extend knowledge).

Implementation Format: Teachers can flexibly assign contract tasks for students to complete individually or in groups, either at home or in class.

Support Materials: These cards offer varying levels of guidance but do not provide direct answers. They are designed in advance by teachers based on anticipated difficulties.

Step 4. Develop a lesson organization process: We propose a teaching organization process aligned with the contract-based teaching method to foster students' problem-solving and creative competencies, as presented in Table 1.

Table 1. *The process of organizing instruction using the contract teaching method to develop students' problem-solving and creative competencies*

No.	Activity name	Student activities during contract implementation	Forms
1	Study the contract and identify the problem to be solved	- Study the contract tasks, including both mandatory and optional components. - Identify the issues to be addressed in relation to the contract tasks.	Online
2	Enter into a learning contract	- Select optional tasks based on individual competencies and interests and Sign a performance contract with the teacher.	Online
	Problem-Solving Plan	Students develop a plan to carry out the contract tasks, specifying the following main components: Form of implementation (individual or group); Time allocation for each task; Location of implementation (at home or in class).	Online
3	Implement the plan	- Students implement the contract tasks according to the established plan.	Online/ Offline
4	Report and evaluate contract performance results	- Students present the results of their contract task implementation. - Students evaluate their own performance and reflect on the effectiveness of the completed tasks.	Online/ Offline
5	Contract liquidation	- Students complete the contract conclusion process. - Students summarize and consolidate the key knowledge acquired from the lesson.	Offline

3.4. Organizing the teaching of the topic: "Activation Energy of Chemical Reactions"

Based on the proposed application process, the teaching of the topic "Activation Energy of Chemical Reactions" was conducted over 90 minutes in class, as outlined below:

LESSON TITLE: ACTIVATION ENERGY OF CHEMICAL REACTIONS

I. Objectives

1. Competencies: (1) Present the concept of activation energy; ***(2)*** Explain the influence of activation energy and temperature on reaction rate through the Arrhenius $k = A.e^{(-E_a/RT)}$.; ***(3)*** Explain the role of catalysts in chemical reactions; ***(4)*** Problem solving and creativity.

2. Qualities: Foster diligence and responsibility through the completion of contract tasks.

II. Teaching Aids and Learning Materials: Learning contract, support cards, A0 paper.

III. Teaching Process

Activity 1: Studying the contract and identifying the problem to be solved *(At home)*

a) Objectives: Present the contract tasks and the problems to be solved

b) Implementing organization:

- The teacher assigns each student a contract (distributed in the previous lesson). Students are asked to review the assigned contract, analyze the tasks (both required and optional), and identify the problems that need to be solved in relation to those tasks.

1. The contract

HIGH SCHOOL: … **STUDY CONTRACT**

SCHOOL YEAR: … – … **TOPIC: ACTIVATION ENERGY CHEMICAL REACTIONS**

FULL NAME OF STUDENT: …

Mission	Content	Select	Form	◷	Location			✓	
1	Present the concept, symbol, and characteristics of activation energy	✪	🧍						☺😐☹
2	Describe the effects of activation energy and temperature on reaction rate	✪	🧍🧍🧍	15’					☺😐☹
3	State the definition of a catalyst	✪	🧍						☺😐☹
	Describe the main characteristics of catalysts	✪	🧍🧍🧍	15’					☺😐☹
4	Describe the role of catalysts	✪	🧍🧍	15’					☺😐☹
5	Exercise 1	✪	🧍🧍	15’					☺😐☹
6	Exercise 2		🧍						☺😐☹
	Learning games		🧍						☺😐☹

✓ Completed 👍: Good progress 👎: Having trouble 🧍: Personal activities 🧍🧍: Pair work 🧍🧍🧍: Work in groups ☺ Very comfortable 😐 Normal ☹ Not satisfied ✪: Mandatory Tasks ◷: Maximum time : Optional Quests : Teacher-assisted activities : Practice in class : Do it at home

STUDENT TEACHER

2. Obligations of students signing a learning contract

Fulfill the tasks as committed in the contract; Adhere to the rules and regulations of the class.

3. Specific Tasks:

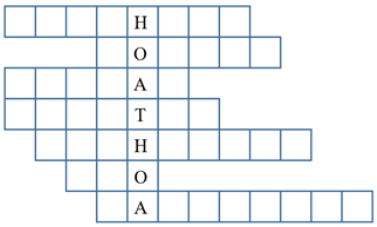
Task 1-4: Students carry out the tasks specified in the contract.

Task 5: Exercise 1: A chemical reaction has an activation energy of Ea = 35 kJ/mol. When the temperature increases from 200 K to 400 K, how will the reaction rate change?

Task 6: Exercise 2: Ozone depletion and the ozone hole have raised concerns about increased risks of skin cancer, sunburn, blindness, cataracts, and more. The ozone layer plays a crucial role in blocking most harmful wavelengths of ultraviolet (UV) radiation from reaching the Earth's surface. Ozone molecules can be destroyed in two stages: $Cl + O_3 \longrightarrow ClO + O_2$; $ClO + O_3 \longrightarrow Cl + O_2$

What is the catalyst in these processes?

Crossword Game: Answer the questions or find the missing words to fill in the blanks.



Q1. The first row has 8 letters: Ea is the energy...that the reactants need for the chemical reaction to occur.

Q2. Horizontal row 2 has 6 letters: The science that studies matter and its changes.

Q3. Horizontal row number 3 has 6 letters: A substance that increases the reaction rate but remains unchanged in both quality and quantity after the reaction.

Q4. Horizontal row number 4 has 6 letters: A factor that affects the reaction rate.

Q5. Horizontal row number 5 has 9 letters: The scientist who discovered the relationship between temperature, activation energy, and the rate constant.

Q6. Horizontal row number 6 has 3 letters: When activation energy (Ea) increases, the rate constant (k) becomes...

Q7. Horizontal row number 7 has 9 letters: A catalyst reduces the ... of the reaction.

Keyword: The minimum energy that a reactant must have for a chemical reaction to occur.

4. Regulations on support voucher levels: Individual support voucher; Group support vouchers.

- Students analyze the tasks outlined in the contract and identify the key issues that need to be addressed in accordance with the teacher's guidance.
- Students exchange and discuss unclear things.
- The teacher summarizes the issues to be addressed and prepares students to sign the contract.

Activity 2: Signing the contract and developing a problem-solving plan *(At home)*

a) Objectives: Students are able to select optional tasks based on their individual competencies and sign a learning contract with the teacher; Students develop a problem-solving plan.

b) Implementing organization:

- The teacher instructs students to select optional tasks that align with their individual competencies and sign a learning contract. Then, the teacher guides students in developing a plan to solve the assigned tasks/problems using the following table:

No.	Task/problem to be solved	Individual/ Group	Time	Location (at home/in class)	Reference resources	Teacher Support
...						

- Students follow the teacher's instructions and discuss the contents of the contract.
- The teacher summarizes and emphasizes the key contents and timelines for completing the tasks outlined in the signed contract.

Activity 3: Implementing the contract *(60 minutes)*

a) Objectives: (1); (2); (3) and (4).

b) Implementing organization:

- Teachers organize students to carry out the tasks outlined in the signed contract according to the established plan, and to present their products on A4 or A0 paper.
- Students carry out the learning tasks stated in the signed contract according to plan.

- Teachers organize students into discussion groups to complete learning tasks.
- Teachers monitor, provide feedback and support students in completing individual and group tasks; provide help sheets when students encounter difficulties.

Activity 4: Reporting and evaluating the results of contract implementation *(25 minutes)*

a) Objectives: Present and evaluate the results of the contract implementation.

Table 2. *Criteria and levels for assessing students' problem-solving and creativity competencies*

No.	Criteria for Problem-Solving and Creativity	Level 1 (1.0)	Level 2 (2.0)	Level 3 (3.0)
1	Analyze and clarify information in the assigned contracts			
2	Identify issues to be resolved in the assigned contract			
3	Present new ideas in learning			
4	Propose solutions to improve or replace those that are no longer suitable			
5	Propose and analyze several solutions to address the problem			
6	Select the most appropriate solution and develop a plan to solve the problem			
7	Implement the problem-solving solution according to the plan			
8	Evaluate problem solving solutions and make adjustments			
9	Ask many valuable, objective questions when assessing the problem			
10	Evaluate issues based on convincing arguments and evidence			

b) Implementing organization:

- Teachers ask students to report on and evaluate the results of their contract implementation.
- Report, discussion: Tasks 1, 2, 3, 4, 5: A student representative presents the results of the individual/group task; Task 6: Volunteers are invited to solve Exercises 2 and participate in the learning game.
- The teacher provides feedback and summarizes the key learning of the lesson.

Activity 5: Contract Termination *(5 minutes)*

a) Objectives: Students summarize and consolidate the essential knowledge from the lesson.

b) Implementing organization:

- The teacher asks students to draw their own conclusions from the implementation of the contract and summarize the main knowledge in their notebooks.
- Students summarize the main knowledge, write it down in their personal notebooks and discuss any unclear issues.
- The teacher summarizes the main knowledge of the lesson, guides and assigns learning tasks for the next lesson.

3.5. Assessing the development of students' problem-solving and creative competencies through the organization of teaching on the topic "Activation Energy of Chemical Reactions" using the contract teaching method

We use assessment tools including: (1) Assessment form according to teacher criteria; (2) Test. The assessment form according to teacher criteria includes 10 criteria and 03 assessment levels (details at https://bit.ly/3Sx9pj9) presented in Table 2.

3.5.1. Evaluation results based on criteria

Table 3 presents the results achieved by students in the experimental class based on the criteria-based assessment form. From the results presented in Table 3, it can be observed that for each criterion (from 1 to 10), the values of $Y - X > 0$ and $p < 0.05$. Additionally, the standard deviation of the experimental group after the intervention is smaller than before the intervention. This indicates that the students in the experimental group performed better in each criterion after the application of the intervention. The most significant improvements were observed in criteria 1, 2, 6, and 10. This is because, during the learning process, students are frequently engaged in activities such as analyzing and clarifying information, identifying problems that need to be solved, selecting appropriate solutions and planning problem-solving strategies, and evaluating problems based on well-reasoned

arguments and evidence. When conducting research on the topic "Activation Energy of Chemical Reactions", these activities help foster the development of the corresponding criteria in students.

Table 3. *Summary table of evaluation results based on the criteria for students in the experimental group*

Criteria	Before Intervention					After Intervention					*Y - X*	T-test (p)
	Number of students passing			Average score	SD	Number of students passing			Average score	SD		
	1.0	2.0	3.0	(*X*)		1.0	2.0	3.0	(*Y*)			
1	15	16	9	1.85	0.77	6	23	11	2.13	0.65	0.28	0.001
2	10	20	10	2.00	0.72	4	23	13	2.23	0.62	0.23	0.002
3	16	18	6	1.75	0.71	9	23	8	1.97	0.66	0.22	0.002
4	17	17	6	1.73	0.72	11	22	7	1.90	0.67	0.17	0.006
5	14	16	10	1.90	0.78	9	21	10	2.03	0.69	0.13	0.023
6	12	18	10	1.95	0.75	6	19	15	2.23	0.69	0.28	0.001
7	12	19	9	1.93	0.73	9	20	11	2.05	0.71	0.12	0.023
8	14	18	8	1.85	0.75	7	25	8	2.03	0.62	0.18	0.006
9	20	14	6	1.65	0.74	13	20	7	1.85	0.69	0.2	0.003
10	19	14	7	1.70	0.68	10	22	8	1.95	0.67	0.25	0.001

3.5.2. Test results

The results of the 15-minute test are presented in Table 4.

Table 4. *Statistical parameters of students' test results*

	Statistical parameters					
	Medium	Median	Mode	Standard deviation	Average Treatment Effect	p (Sig.)
Experimental Group (10A1)	6.85	7	7	1.28	0.90	0.003
Control Group (10A2)	5.95	6	6	1.39		

Based on the test results of the experimental and control classes presented in Table 4, it can be observed that the average difference in scores (Experimental - Control) > 0, $p < 0.05$, indicating that the difference in average scores is statistically significant. Moreover, the standard deviation of the experimental class's test results is smaller than that of the control class, suggesting that the scores in the experimental class are more consistent. These findings demonstrate that the test results of the experimental class are higher than those of the control class, indicating that the intervention was effective.

4. Conclusion

The results of the pedagogical experiment, after statistical analysis, showed that students' problem-solving and creativity competencies were effectively developed through the application of the contract teaching method in teaching the topic "Activation Energy of Chemical Reactions" following the proposed process. During the contract-based learning process, students took initiative in identifying problems, proposing and planning solutions, searching for information, and making efficient use of their study time both at home and in class to complete assigned tasks. The proposed teaching process can be flexibly applied to organize instruction on other topics within the Chemistry curriculum, thereby enhancing learning outcomes and contributing to the innovation of teaching and learning methods in high school Chemistry education.

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