THAI NGUYEN UNIVERSITY
UNIVERSITY OF EDUCATION

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ORGANIZATION OF TEACHING THERMOLOGY - GRADE-12 PHYSICS TO DEVELOP STUDENTS' PROBLEM-SOLVING CAPACITY

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LIST OF PUBLISHED SCIENTIFIC WORKS RELATED TO THE THESIS

[1] Nguyen Thi Thu Thuy (2020), "Actual situation of using active teaching methods and techniques in teaching physics at high schools in Hung Yen Province", *Journal of Education*, Issue No. 484 (2nd Term - August 2020), pp. 55-60.

[2] Nguyen Thi Thu Thuy (2021), "Some theoretical issues on teaching to develop problem-solving capacity in teaching physics under general education program 2018", *Journal of Education*, Special issue in July 2021, pp. 11-17.

[3] Nguyen Thi Thu Thuy (2021), "Actual situation of assessment based on teacher competency approach in some Northern Delta provinces", *Education Journal*, Special issue in September 2021, pp. 155-160.

[4] Nguyen Thi Thu Thuy (2021), "Developing a plan to use experiments in teaching "*The gas laws*", physics program in high school", *Vietnam Journal of Educational Sciences*, Issue No. 47 in November 2021, pp. 35-40.

[5] Nguyen Thi Thu Thuy (2021), "Designing rubrics used in teaching "*The gas laws*", physics program in high school", *Journal of Education*, Special Issue in December 2021, pp. 55-61.

[6] Nguyen Thi Thu Thuy (2022), "Designing a teaching process to develop problem-solving capacity in teaching physics at high schools", *Journal of Education*, Special Issue in July 2022.

INTRODUCTION

1. Reason for writing

In the context of Vietnam, the educational goal has shifted from "*comprehensive people training*" (Education Law 2005) to "*comprehensive people development*" (Education Law 2019). Facing rapid development of science and technology, knowledge has become an index to measure of human wealth. Education is focused with top priority in order to help people improve themselves, foster talents, and train high-quality human resources for the country.

Resolution No. 29 of the 8th Plenum of the 11th Session on fundamental and comprehensive reform of education and training also clearly states: "*Basically renovating the form and method of testing, examination and assessment of education and training results, ensuring honesty and objectivity. Testing, examination and assessment of education and training results need to step by step follow advanced criteria that are trusted and recognized by the world educational society and community. Coordinating the use of assessment results in learning process with end-of-term and end-of-academic-year assessment results; teacher's assessment with learner's self- assessment.*

Teaching in the direction of developing students' capacity is an educational approach in line with general trend of general education program in many countries around the world. For Vietnam, this is an urgent and breakthrough requirement for the fundamental and comprehensive educational innovation under Resolution No. 29 (2013) of the Party and Resolution No. 88 (2014) of the National Assembly.

Stemming from the above issues, we once again affirm the necessity of teaching to develop students' capacity. In studies on teaching in Vietnam, we found that there has been no research on development of problem-solving capacity in teaching grade-12 Physics, Thermology section, general education program 2018 Therefore, we have chosen the topic: "**Organization of teaching Thermology - grade-12 Physics to develop students' problem-solving capacity**" for research in this thesis.

2. Aims of the study

- Designing a teaching process to develop students' problem-solving capacity when teaching various types of Physics knowledge in high schools.
- Demonstration of the teaching process and teaching organization with some knowledge of Thermology in grade-12 Physics, general education program 2018.

3. Research subject and scope

3.1. Research subject

- Knowledge about Ideal Gas - Thermology session, grade-12 Physics, general education program 2018.
- Problem-solving capacity of high school students
- Teaching process that develops problem-solving capacity

3.2. Research scope

- Knowledge: Focusing on two topics: Structure of substances and the Gas laws, including the following contents:

- The kinetic molecular theory of matter
- The kinetic molecular theory of gases
- Boyle's Law
- Charles' Law
- Equation of state of ideal gases.
- Gay-Lussac's Law.

- Problem-solving capacity: focusing on understanding the capacity structure, ways to develop this capacity in teaching, especially in teaching physics, and capacity assessment tools when teaching at high schools.

- Teaching process: paying attention to factors affecting capacity development in teaching, thereby designing a teaching process to develop problem-solving capacity for 5 types of specific knowledge in physics and applying illustrations in teaching about Ideal Gas.

- Investigation of actual situation and pedagogical experiment: conducted in Hung Yen Province.

4. Research object

The research was experimented with students at schools: My Hao High School, Van Giang High School, and Duong Quang Ham High School in Hung Yen Province.

5. Scientific hypothesis

If the organization of teaching some knowledge of Thermology - grade-12 Physics, General Education Program 2018, follows the problem-solving process based on the built problem-solving capacity structure, it will develop students' problem-solving capacity.

6. Research mission

- Researching theoretical basis for development of learners' capacity in general and focusing on development of students' problem-solving capacity in teaching physics.

- Researching practical basis of developing students' problem-solving capacity when teaching physics at high schools.

- Researching process of building a problem-solving capacity structure and a problem-solving capacity assessment tool.

- Researching measures to develop problem-solving capacity when teaching physics at high schools.

- Researching teaching process to develop problem-solving capacity and designing teaching process to develop problem-solving capacity applied to 5 types of knowledge in physics.

- Analyzing knowledge and finding out requirements of Ministry of Education when teaching about Ideal Gas, Thermology, grade-12 Physics,

General Education Program 2018.

- Designing teaching process to develop problem-solving capacity and problem-solving capacity assessment tool when teaching 6 parts of knowledge about Ideal Gas, Thermology, grade-12 Physics, General Education Program 2018.

- Carrying out pedagogical experiment, collecting and processing data of the experimental process to evaluate the effectiveness and feasibility of the designed process in developing students' problem-solving capacity.

7. Research methods

7.1. Theoretical research method

7.2. Practical research method

7.3. Expert method

7.4. Pedagogical experiment

7.5. Mathematical statistical method

8. New contributions of the thesis

8.1. In terms of theory

- Developing concept, structure and tool to assess problem-solving capacity.

- Building a teaching process to develop problem-solving capacity in teaching 5 types of physics knowledge including: physical phenomena, physical laws, physical theories, physical quantities, and applications of physics in life.

8.2. In terms of practice

- Investigating actual situation of teaching physics at high schools with over 3000 questionnaires for students and teachers.

- Designing a teaching process to develop problem-solving capacity and building a problem-solving capacity assessment tool when teaching 6 parts of knowledge about Ideal Gas, Thermology, grade-12 Physics, General Education Program 2018.

- Results of pedagogical experiment with valuable information about:

- Assessment of development of each component of students' problem-solving capacity when teaching physics at high schools.
- Limitations in developing components of problem-solving capacity when teaching according to the designed process.
- Measures to remedy and ways to improve learning process and to design learning records so as to best develop each component of problem-solving capacity when studying physics at high schools.

9. Thesis structure

In addition to the introduction, the conclusion, the list of abbreviations, the list of tables, figures, graphs, references, and appendices; The thesis consists of 4 chapters:

Chapter 1. Research problem overview.

Chapter 2. Theoretical and practical basis for teaching in the direction of

problem-solving capacity development in physics at high schools.

Chapter 3. Designing teaching process to develop problem-solving capacity when teaching about Ideal Gas, Thermology, grade-12 Physics, General Education Program 2018.

Chapter 4. Pedagogical experiment.

Chapter 1. RESEARCH PROBLEM OVERVIEW.

1.1. History of teaching in the direction of capacity development
1.2. Studies on teaching in the direction of capacity development
1.3. Studies on teaching in the direction of problem-solving capacity development
1.3.1. In the world
1.3.2. In Vietnam
1.4. Studies on teaching in the direction of problem-solving capacity development in Physics
1.4.1. In the world
1.4.2. In Vietnam
1.5. The problem raised by the topic

Chapter 2
THEORETICAL AND PRACTICAL BASIS FOR TEACHING IN THE DIRECTION OF PROBLEM-SOLVING CAPACITY DEVELOPMENT IN PHYSICS AT HIGH SCHOOLS.

2.1. Learning about capacity and problem-solving capacity
2.1.1. Concept of capacity

Within the research scope, we agree on the point of view that*: "Each person's capacity is an attribute formed and developed by combination of factors such as skills, knowledge, experience, emotions, motives, etc., which is available or has been acquired through training, and is synthesized to solve a specific task or situation".*

2.1.2. Concept of problem and problem-solving

(1) Concept of "problem"

In education, the concept of "*problem*" is understood as *a learning situation containing cognitive contradictions*, and solving this problem will help students acquire knowledge, form skills and positive attitudes. Problem is often stated in the form of a question, and, when students answer that question, they will achieve the teaching goal through the process of inquiry, research, exchange, discussion, inference, analysis, doing experiments... by individuals or groups of students.

(2) Concept of problem-solving

To explain the phrase "*problem-solving*", some researchers introduce the following concept:

D'Zurilla and Nezu (2001) argue that problem-solving is *a process of self-awareness and action*, in which individuals try to identify problems and come up with solutions that are appropriate to each specific problem in daily life.

Martínez (2005) put forward the view that problem-solving is *the process of reaching a goal where it is not clear how to proceed*.

2.1.3. Concept of problem-solving capacity

Within the research scope, we use the concept: *"Problem-solving capacity is an individual's ability to effectively solve a posed problem (in life as well as in learning) by mobilizing knowledge, skills, life experience with a positive attitude when the solution is not known in advance"*.

2.1.4. Building a problem-solving capacity structure

2.1.4.1. Process of building capacity structure

2.1.4.2. Some problem-solving capacity structures

2.1.4.3. Applying problem-solving capacity structure building in teaching physics at high schools

2.2. Teaching in the direction of capacity development

2.2.1. Concept of teaching and teaching in the direction of capacity development

2.2.1.1. Concept of teaching and the teaching process

Teaching is the process by which teachers organize learning activities for students in schools, in order to give students scientific knowledge, practice skills and foster positive and correct attitudes of students while students are inside and outside school. Thereby, their capacities and qualities are fostered according to national educational goals. In other words, teaching is an educational method with the goal of forming and perfecting students' personality, training human resources in accordance with social requirements.

2.2.1.2. Concept of teaching in the direction of capacity development

It can be understood that: *"Teaching in the direction of capacity development does not refer to a specific teaching method or technique, but a concept that covers many different teaching methods, forms and techniques, which are used flexibly and coordinated smoothly by teachers in the teaching process in order to optimally develop students' capacity system built in national educational goals"*.

2.2.2. Components involved in teaching process

2.3. Teaching in the direction of capacity development in Physics at high school

2.3.1. Basic features of Physics

2.3.2. Measures to develop problem-solving capacity in teaching Physics at high schools

2.4. Designing a teaching process to develop problem-solving capacity in Physics at high schools

With the characteristic of being an experimental science, experiments in teaching physics contribute to visualization of phenomena and making learning students' attitudes and activities active. Therefore, it is necessary to increase the use of experiments in each teaching stage for all content of physics knowledge.

With that point of view, we refer to contents of training program for high school teachers and apply the proposed general process to design teaching process with the goal of developing problem-solving capacity for each specific types of knowledge in physics, which is shown in following flowcharts:

1	Approaching the situation with problem	------	Approaching the phenomenon to be studied through recreating experiences, experiments, videos, pictures...
2	Stating the problem to be solved	------	Asking questions representing problem that need to be studied: - "When does the phenomenon happen" - "Why does the phenomenon happen?"
3	Proposing hypothesis	------	Building hypothesis
4	Solution selection and planning	------	Proposing an experimental plan to test the hypothesis
5	Problem solving	------	Conducting experiment to test the hypothesis, reporting results and giving conclusions
6	Assessment (Theory assessment and solution assessment)	------	- Stating the concept of the phenomenon - Assessing the effectiveness of the solution
7	Application in new situations	------	Recognizing manifestations of learned phenomena in nature or in new situations

Figure 2.4. Flowchart of teaching process to develop problem-solving capacity

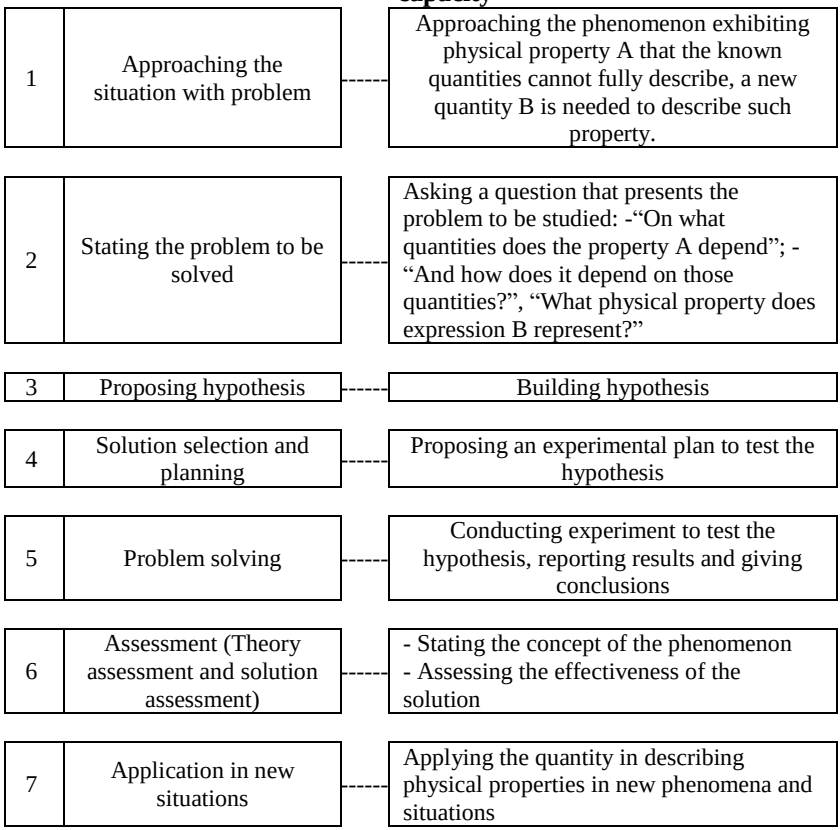
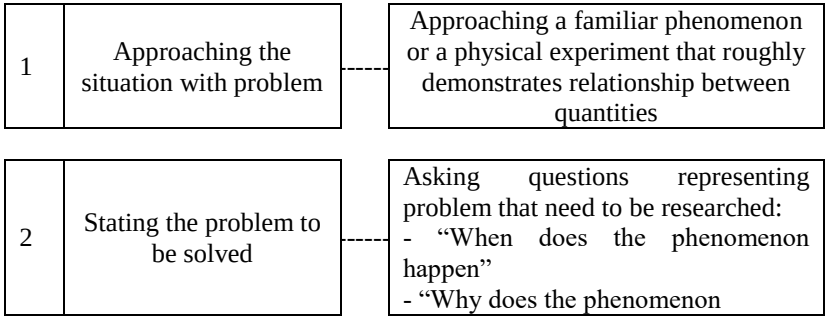


Figure 2.5. Flowchart of teaching process to develop problem-solving capacity in teaching physical quantities



		happen?”
3	Proposing hypothesis	Building hypothesis
4	Solution selection and planning	(1) Proposing an experimental plan to test the hypothesis (2) Choosing theoretical basis for logical reasoning to ….
5	Problem solving	(1) Conducting experiment to test the hypothesis, reporting results and giving conclusions (2) Conducting logical reasoning based on theoretical grounds
6	Assessment (Theory assessment and solution assessment)	Stating unit of quantity - Stating the law and its scope of application - Assessing the effectiveness of the solution;
7	Application in new situations	Applying the law in other physical phenomena

Figure 2.6. Flowchart of teaching process to develop problem-solving capacity in teaching physics laws

1	Approaching the situation with problem	Approaching experiments, phenomena, experiences, ideal models... is the basis for building contents of the theory.
2	Stating the problem to be solved	Asking questions that represent the problem to be studied: -"On what basis are the root causes of phenomena A, B, C... explained?; - “On what basis is the relationship between the quantities A, B, C... in the law X, the principle Y explained?
3	Proposing hypothesis	Building hypothesis, conjecture about the inner nature of phenomena, about relationship between physical

		quantities
4	Solution selection and planning	Proposing an experimental plan to test the hypothesis
5	Problem solving	Conducting experiment to test the hypothesis
6	Assessment (Theory assessment and solution assessment)	- Stating content of the theory - Assessing effectiveness of the solution
7	Application in new situations	Applying content of the theory to explain the phenomena on the basis of the theory and predict the evolution of new phenomena

Figure 2.7. Flowchart of teaching process to develop problem-solving capacity in teaching physics theories

1	Approaching the situation with problem	White box problem: Observing original device Black box problem: Giving needs and tasks to be performed that known technical equipment has not been able to meet or has met ineffectively
2	Stating the problem to be solved	White box problem: Function, operating principle of the device? Black box problem: How is the device's structure and model drawn?
3	Proposing hypothesis	White box problem: Constructing a hypothesis about the operating principle and structure of the device Black box problem: Constructing a hypothesis about a functional matter model that matches the device's requirements
4	Solution selection and planning	White box problem: Proposing the solution which is to approach and observe the device Black box problem: Proposing a drawing

		model, functional matter model
5	Problem solving	White box problem: Opening the device and observing the structure, building a drawing model showing the structure and operating principle of the device Black box problem: Conducting an experiment to see if the functional matter model can fulfill the requirements.
6	Assessment (Theory assessment and solution assessment)	- Stating conclusion about the structure, operating principle of the device - Assessing effectiveness of the solution
7	Application in new situations	- Comparing the built device with devices having the same function in life in order to supplement and improve for operational efficiency improvement

Figure 2.8. Flowchart of teaching process to develop problem-solving capacity in teaching technological applications of physics

2.5. Assessment of problem-solving capacity in teaching physics

2.5.1. Learn about assessment

2.5.1.1. Concept of assessment and assessment in education

We consider the perspective of assessment in education according to orientation of National Education Program 2018*: "Assessment of subject learning outcomes is to assess the capacity of problem perception and problem-solving".*

2.5.1.2. Assessment objectives

2.5.1.3 Assessment form

2.5.1.4. Assessment methods and tools

2.5.1.5. Modern trends in capacity assessment in teaching at high schools

2.5.2. Developing a process for capacity assessment

2.6. Actual situation of teaching Physics and teaching section of Thermology at high schools

2.6.1. Survey objective

2.6.2. Survey results on actual application of teachers' active teaching methods and techniques in teaching physics

2.6.2.1. Teachers' perception of active teaching methods and techniques

Through investigation, it can be seen that teachers have not provided problem-solving strategies in teaching process, have not diversified and concretized learning situations through natural phenomena, phenomena in life and physical experiments. Teachers also have not fully promoted the role of experiments in all stages of teaching process. Therefore, the goal of developing students' problem-solving capacity when teaching physics at high schools in practice in Hung Yen Province has not been met.

Chapter 3
DESIGNING TEACHING PROCESS TO DEVELOP PROBLEM-SOLVING CAPACITY WHEN TEACHING ABOUT IDEAL GAS, THERMOLOGY, GRADE-12 PHYSICS, GENERAL EDUCATION PROGRAM 2018.

Chapter 4. PEDAGOGICAL EXPERIMENT.

4.2.1. Purpose of pedagogical experiment round 1

4.2.2. Process of pedagogical experiment round 1

4.2.3. Result of pedagogical experiment round 1

4.2.3.1. Assessing feasibility of specific teaching process for 6 parts of physics knowledge

- Results of student questionnaires after the pedagogical experiment:
  - ✓ Over 80% of students are interested and very interested in the program
  - ✓ Students assess that the lesson structure is logical and clear
  - ✓ 100% of students assess that the learning method is easy to understand
  - ✓ 75% of students want to continue learning according to the established method and process.
- Level of students' cooperation, initiative and activity increases gradually in the learning process. In the first session, students have little interaction with teacher and less interaction with each other. This gradually improves in subsequent sessions.
- In addition, students also actively interact with teachers not only during class time, but also outside of class time.
- The groups actively submit their papers on time, correcting papers after reporting according to suggestions of teachers and other groups.
- The speed of students' response to teacher's questions increases gradually.
- Based on the results of the questionnaires:

→ Thus, the teaching process ensures feasibility.

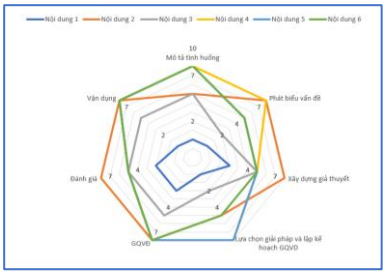
4.2.3.2. Evaluating effectiveness of specific teaching process for 6 parts of physics knowledge

- The results of assessing development of each problem-solving capacity's component for 8 experimental students after 6 parts of knowledge are shown in following charts.

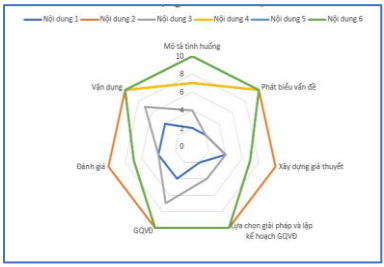
  To be visual in observing the chart, we convention the levels corresponding to points when plotting as:

Level 0 - 2 points; Level 1 - 4 points; Level 2 – 7 points; Level 3 – 10 points

Student 01 – VG Student 02 - VG



Student 03 – VG



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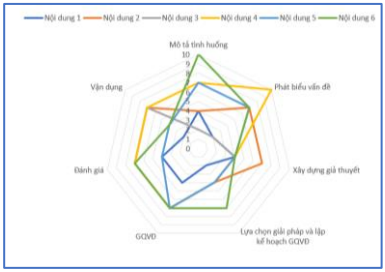
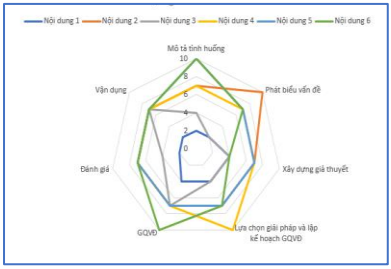
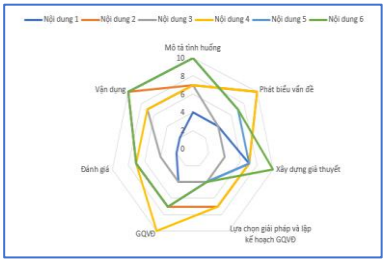


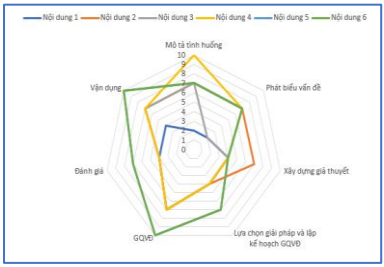
Student 05 – VG



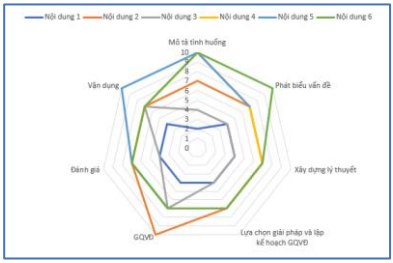
Student 06 -VG

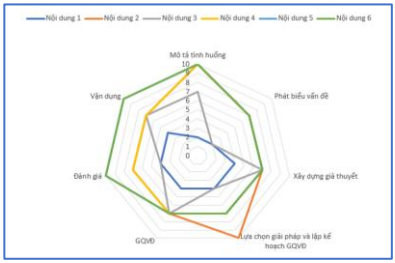


Student 07 – VG



Student 08 – VG





- Through analysis of experimental teaching videos, we also find that students gradually increase their interaction with teachers, their response speed to questions and quality of their answers also increase over time.

Thus, the process that has been built ensures feasibility and effectiveness in developing problem-solving capacity when teaching with a small group of students. We will conduct mass teaching with large-size class to test the hypothesis again.

4.2.2.3. Improving teaching process and capacity structure to increase efficiency in developing students' problem-solving capacity

After experiment round 1, we discover some limitations in the teaching process and problem-solving capacity structure, so we have adjusted as follows:

- The statement that requires students to describe the situation needs to be more specific, so that it is easier to orient students' thinking about the area of physical knowledge to be studied.
- After the activity "Approaching the situation", it is advisable to clearly agree on the learning task for the whole lesson (Teachers need to be the one to orient and institutionalize in this stage). This is a premise for students to more easily state the problem to be solved.
- The component "assessment" of problem-solving capacity should have two behavioral indicators: hypothesis assessment and solution assessment. This is easier than assessing the level of capacity development through two separate activities.
- Hint questions, supporting questions should be used by teachers in a timely manner, avoiding the situation where students are confused when the time to think about the answer is too long.
- Designing answers for the activity "Application" should follow the problem-solving process provided to students.
- Problem-solving activities should be conducted in class with attentive support from teachers. In the process of performing problem-solving tasks outside of class time, for initial content, students take a lot of time and effort to complete with low quality. Therefore, in round 2, we design the problem-solving activity to be fully conducted in classroom. This helps teachers easily detect students' difficulties and provide timely and appropriate support in the learning process. Moreover, it helps teachers observe each student's level and capacity of cooperation in the group and find members who are "difficult to integrate" so as to supplement their own pedagogical impact content.

Therefore, we decide to change the experimental procedure as shown below.

Students report round 1

4.3. Organization of pedagogical experiment round 2

4.3.1. Analysis of developments when teaching the content "Kinetic molecular theory of matter"

Teacher introduces general learning process including 7 activities and names learning content in session 1. Then the teacher and students participate in the activities of the first lesson.

Activity 1: Approaching the situation

Activity 2: Stating the problem to be solved

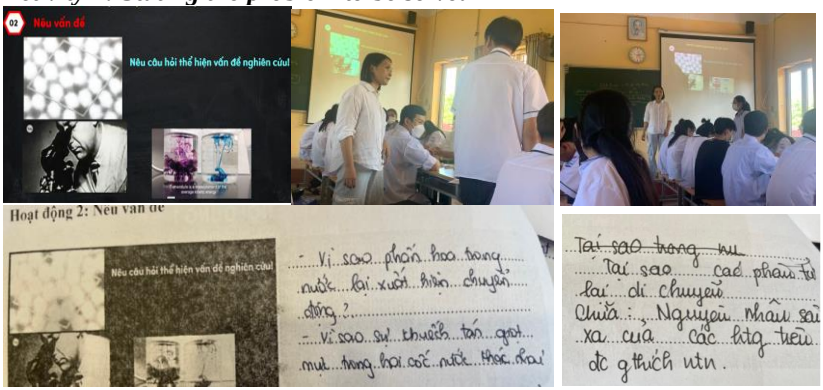


Figure 4.1. Some experimental images in activity 2

Activity 3: Proposing hypothesis

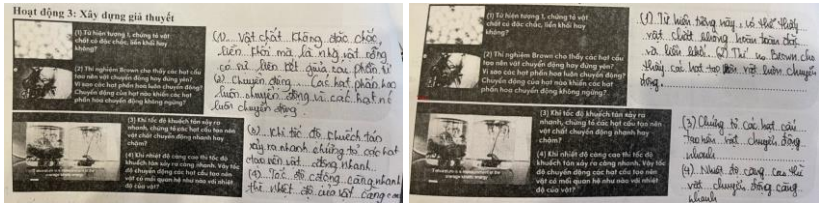


Figure 4.2. Students build hypotheses about kinetic molecular theory of matter

Activity 4: Choosing solution

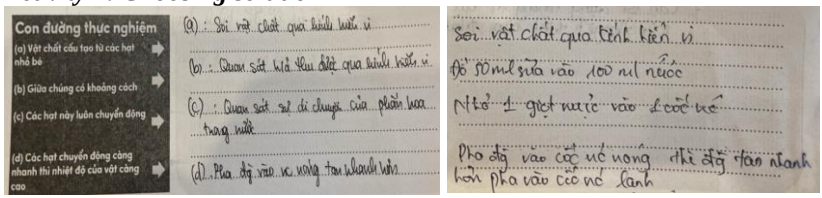


Figure 4.3. Students come up with solutions to the problem they need to learn

Activity 5: Solving the problem

Figure 4.4. Groups discuss and report

Activity 6: Assessment

- Teacher institutionalizes knowledge, comments on advantages and limitations, makes suggestions to make each group's products better, and draws experiences for the next report.
- Based on that, students draw conclusions about new knowledge (hypothesis assessment), assess the products of their group and other groups in the learning record.
- The students' level of achievement when participating in activities

Activity 7: Application

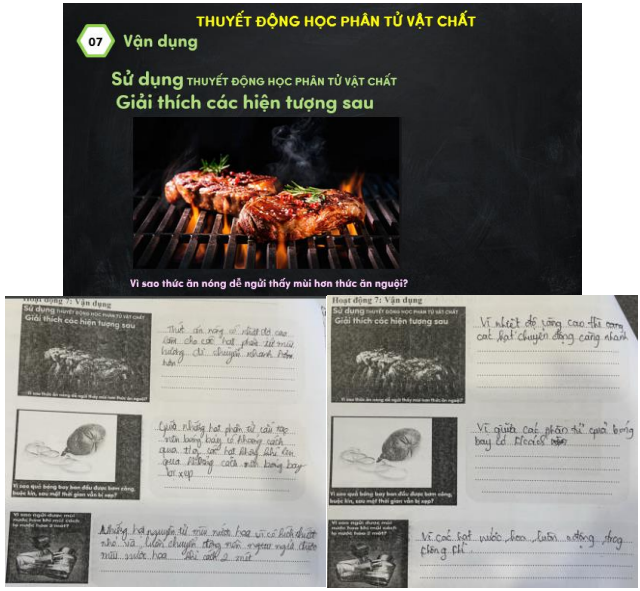


Figure 4.5. Some answers of students in the activity "Application"

GENERAL COMMENT

- *Classroom atmosphere*

The first session goes pretty well. At first, students are somewhat timid at the beginning of the session, because they are not familiar with the study method. When the teacher calls some students to share their answers, some of them do not have the answer. However, in subsequent activities, students are more confident, comfortable, and natural when interacting with the teacher. In group activities, the majority of students actively and dynamically participate in. The atmosphere in the class also gradually becomes happier at the end of the class.

- *Results of assessment of problem-solving capacity*

In most activities, when assessing each component of problem solving-capacity, students mainly reach level 1; in some activities, they reach level 0. Besides, time factor is not guaranteed. Teaching time lasts 35 minutes longer than expected due to very slow reaction and operation speed.

In general, in all 7 activities, only a few students reach level 2 in one or two activities. Thus, students mainly achieve below the required level (level 1).

4.3.2. Analysis of developments when teaching the content of kinetic molecular theory of gases

GENERAL COMMENT

- *Classroom atmosphere:*

The classroom atmosphere in the second session is more friendly and

natural. Students have access to a variety of physical phenomena so students are more attracted and excited.

Students are confident in all activities of the lesson because they are familiar with the way of operation and the two contents are about the same physical theory with many similarities. No student refuses to share the answer as in content 1.

- *Results of assessment of problem-solving capacity:*

The session ensures the scheduled time. Most of the results of assessment of components of most students reach level 2 and level 3, proving that students quickly catch up with the new way of learning, they begin to be able to mobilize experience and background knowledge in new learning content. Moreover, the characteristic when teaching theory is that the system of related phenomena should ensure richness and familiarity with life, so it is easier for students in all activities of the lesson. We believe that, if we have the opportunity to continue to teach another theory of physics according to the established process, the experimental results will further confirm the effectiveness of this process.

4.3.3. Analysis of developments when teaching the content of Isothermal process - Boyle's law

GENERAL COMMENT

- *Classroom atmosphere:*

For the first time, students have access to "absurd" phenomena, which contradict their thinking, so students are very curious and excited to discover new knowledge.

During class time, there are activities of conducting experiments, measuring, collecting and processing data, so the groups are very excited because they have direct contact with equipment, which rarely happens when studying physics at school.

Most students are active and cooperative during class time.

- *Results of assessment of problem-solving capacity:*

The class time is longer than expected by more than 30 minutes because students are not familiar with experimental operations and manners to collect and process data. All activities need teacher's orientation and support. Due to the activeness of students, the assessment results in subsequent activities gradually increase, mainly at levels 2 and 3.

There is also positive change in groupwork and presentation skills, reflected in the fact that the tasks are more difficult but the working time does not change compared to the first session and those who used to be afraid to speak confidently step up to present group's report.

The activity that causes the most difficulties for students is "Stating the problem to be studied". In the 2nd session, almost the whole class reach level 3

in this activity, but in the 3rd session, they are mainly at level 1, a few are at level 2. This proves the importance of mastering the process for each type of students' knowledge. Being exposed only once to the process of one type of knowledge, then, in the next session with the same type of knowledge, the performance assessment results of students will increase significantly. We will test this together in the 4th session, the knowledge learned in this session is the same as that of the 3rd session, about the laws of physics.

4.3.4. Analysis of developments when teaching the content of Isochoric process - Charles's law

GENERAL COMMENT

- *Classroom atmosphere:*

Familiarity with the teaching process and the type of knowledge taught makes students happy, confident and excited to participate in the session. The relaxed, friendly atmosphere lasts throughout the session due to the students' confidence in learning new knowledge. Especially, for the task of making the experimental set, students urgently do it in class in 30 minutes, even though they could take it home. This shows the enthusiasm and eagerness of the students to create the experiment set and conduct experiments, one of the group tasks of problem-solving activities.

- *Results of assessment of problem-solving capacity:*

As we have analyzed and predicted the results from the 3rd session, the results of the 4th session demonstrate the effectiveness of the designed teaching process. Students mainly reach level 2 and 3 in all activities. A few students reach level 1 in some activities. Through video analysis, we find that students who reach this level lack enthusiasm in learning, lack concentration and desire to learn during their participation in activities.

The lowest results are shown in the activity "Assessing solutions", mainly at level 2. This can be explained by the fact that students have just created their own experiments for the first time, and their experience in conducting experiments is not much, so it is difficult to provide a complete and accurate comment on the advantages and disadvantages of the experimental set, the more difficult it is to come up with a plan to improve the experiment set.

In general, after 4 sessions, the results of all activities have changed in a positive direction. The speed of operation and the quality of operation are both improved.

4.3.5. Analysis of developments when teaching the content of Equation of state of ideal gases

GENERAL COMMENT

- *Classroom atmosphere:*

The class still maintains a stable, cheerful, friendly atmosphere.

Students are increasingly confident, so the working speed is faster and the results of assessment of learning activities are higher. Some students in group 3 and group 4 have changed their attitudes, from indifferent to active in group activities; especially, students in the group volunteer to give presentations.

- *Results of assessment of problem-solving capacity:*

For students, when learning content 5, the most difficult task to complete is to propose a hypothesis. The reason is that the relationship of the three state parameters when they all change is difficult to judge the rule, not as easy and simple as when learning the relationship of two parameters in iso-process. It is difficult for students to visualize and predict the relationships, although it is easy to raise issues that need to be studied. The teacher has supported and oriented with many questions and hints, but the difficulty shows on the faces and attitudes of the students very clearly. The results achieved in this task are mainly level 2 and some are at level 1.

After overcoming this biggest difficulty, students continue to show their agility and vivacity in subsequent activities. Results in subsequent activities are stable compared to previous sessions.

4.3.6. Analysis of developments when teaching the content of Isobaric process - Gay-Lussac's law

GENERAL COMMENT

- *Classroom atmosphere:*

Students are informed that this is the last session, so some students are psychologically affected, and they are more distracted at the end of the session than they were at the beginning. However, the whole class still actively cooperates with the teacher most of the time.

- *Results of assessment of problem-solving capacity:*

In all activities, the majority of students show excellent performance, mainly at level 3, a few at level 2.

This result partly confirms the output quality of students in the experimental class, confirms the effectiveness and feasibility of the proposed teaching process.

4.4. Results of pedagogical experiment

4.4.1. Quantitative assessment results on the level of similarity of students in the experimental class and the control class at the input

Table 4.10. The results of analysis of average mark in Physics of the control class and the experimental class

Class	Average mark	Median	Standard deviation
Experimental class - 10A1	8.401	8.4	1.481
Control class - 10A2	8.387	8.35	1.758

Thus, the average mark and median of the two groups are approximately

equal, the spectra of mark have little deviation, so level equivalence of control class and experimental class is guaranteed.

4.4.2. Quantitative assessment results on the output test marks of the experimental class and the control class when using objective multiple-choice questions

Table 4.11. Results of analysis of output test marks (objective tests) of the control class and the experimental class

Class	Average mark	Median	Standard deviation
Experimental class -10A1	6.717	7.000	0.843
Control class - 10A2	6.217	6.500	1.038

The results show that the average mark and median are close to each other, so the distribution data is considered correct.

The average mark and median of the control class are lower than those of the experimental class, proving the effectiveness of the designed teaching process.

4.4.3. Quantitative assessment results on the output test marks of the experimental class and the control class when using questions following structure of steps in the problem-solving process

Table 4.12. Results of analysis of output test marks (capacity test) of the control class and the experimental class

Class	Average mark	Median	Standard deviation
Experimental class -10A1	7.617	7.000	1.481
Control class - 10A2	5.100	4.500	1.758

The average mark is relatively close to the median, so the data is considered correct.

The average mark and median of the control class are lower than those of the experimental class, proving the effectiveness of the designed teaching process.

4.4.4. Results of assessing development of students' problem-solving capacity during the experimental process

4.4.4.1. Results on achieved level of each component of problem-solving capacity in the experimental process for 9 students

Through teaching 6 parts of knowledge, we find that development of components of problem-solving capacity is relatively stable. There are periods when certain component's progress is stopped because of students' confusion when approaching the content of which research method is completely different from the previous content. If there are many opportunities to experience learning with this process and students master the learning process with all five types of physics knowledge, we believe that the development of each component will reach the highest and stable level when students study physics in high school.

4.4.5. Results of qualitative assessment of effectiveness and feasibility of the experimental program

4.4.5.1. Purpose

4.4.5.2. Content of the questionnaires

4.4.5.3. Results

4.4.5.4. Conclusion

Through the investigation results, we can confirm the feasibility and effectiveness of the designed teaching process:

- ✓ Students are excited about learning activities. They actively participate in group activities as well as solving individual tasks
- ✓ Students see for themselves the benefits that the experimental program brings
- ✓ The task of designing, manufacturing and conducting experiments does not make students feel overwhelmed. On the contrary, it is very interesting and meets requirements of the learning task.
- ✓ At the beginning of the experimental program, students face many difficulties because they are not familiar with the way of learning and thinking about physics, however, after 6 parts, the majority of students want to continue learning in this way.

CONCLUSION

1. CONCLUSIONS

From studying theoretical and practical bases, designing and experimenting with the teaching process to develop problem-solving capacity in teaching physics at high schools, we have the following conclusions about the thesis' achievements:

- ✓ Identifying research gaps and research missions.
- ✓ Identifying and constructing the structure of problem-solving capacity with detailed description of the levels of each behavioral indicator.
- ✓ Proposing specific measures to develop students' problem-solving capacity when teaching Physics at high schools.
- ✓ Building a teaching process to develop problem-solving capacity for five types of physics knowledge with application of proposed measures.
- ✓ Designing process flowchart and specific teaching process in the direction of developing students' problem-solving capacity when teaching about Ideal Gas, Thermology, grade-12 Physics, General education program 2018
- ✓ Building a tool to assess problem-solving capacity (rubric, academic record, test) with 3 levels of each behavioral indicator.
- ✓ Conducting experimental teaching of 6 parts of knowledge according to the process of developing problem-solving capacity in two types of

knowledge, namely physical theories and physical laws. The experimental process takes place in two rounds in 4 classes, for small groups and large classes. Students have designed, self-manufactured and conducted experiments to investigate the gas laws, the obtained results deviate from the expressions of the laws very little (less than 5%).

- ✓ Collecting and processing experimental data for the purpose of upgrading and improving the teaching process and academic records so as to improve efficiency in developing students' problem-solving capacity.

The results of pedagogical experiment show that the use of designed teaching process (with application of specific measures) in 6 parts of knowledge has helped students form and develop problem-solving capacity. This confirms the correctness of the hypothesis that the scientific topic has given.

2. PROPOSALS

We offer proposals for the next research direction of the topic:

- ✓ Continuing to improve the teaching process so as to improve efficiency and ensure appropriateness when teaching about content of Thermology, grade-12 Physics in developing students' problem-solving capacity.
- ✓ Continuing to research and design the teaching process to develop problem-solving capacity in other contents and other types of knowledge of physics.
- ✓ Enhancing inclusion of experiment-related activities such as: designing, manufacturing, conducting, collecting and processing experimental results... into different cognitive stages in the process of teaching physics.
- ✓ Building a system of learning materials, questions, exercises, and tests for students in the direction of developing problem-solving capacity.
- ✓ Designing a tool system to assess students' problem-solving capacity during physics learning at high schools.

3. RECOMMENDATIONS

(1) To Ministry of Education and Training

- ✓ Disseminating the teaching process to develop students' problem-solving capacity in teaching Physics at high schools for each type of Physics knowledge.
- ✓ Informing research results of the topic to teachers nationwide by putting the research results in the educational database.

(2) To high school teachers

- ✓ Studying the teaching process to develop problem-solving capacity and problem-solving capacity assessment tool so that it can be applied in practice in teaching physics at high schools.

- ✓ Applying research results of the thesis flexibly and smoothly into teaching practice at each high school.
- ✓ Applying the general process designed in the thesis to design teaching process in the direction of developing problem-solving capacity for other teaching contents.
- ✓ Applying, improving, and flexibly changing the tool to assess students' problem-solving capacity and the structure and content of academic records in the teaching process, ensuring suitability of the teaching content, students and existing facilities and means of the school.
- ✓ Researching to contribute to perfecting the theoretical basis and practical basis of education so as to develop capacity of students in high schools.