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TEACHING THE TOPIC OF "*METABOLISM IN ORGANISMS*" IN BIOLOGY GRADE 11 THROUGH PRACTICAL PROBLEMS

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Abstract. Using practical problems in teaching in high schools is meaningful in linking theoretical and practical knowledge, creating problematic situations in teaching, and thereby contributing to the development of qualities and competencies for students, especially the competency of applying knowledge and skills learned. In this article, through the literature review, we have systematized the theoretical basis for practical problems and teaching through practical problems; proposed the process of designing practical problems; built and perfected a system of practical problems under the topic of *"Metabolism in organisms"* in Biology grade 11; and used practical problems to design lessons to practice pedagogy at Van Hien High School (Hanoi) to develop students' competency to apply knowledge and skills learned. Experimental results show the effectiveness and feasibility of using practical problems to develop students' competency in applying learned knowledge and skills.

Keywords: Metabolism in organisms, practical problem, applying learned knowledge and skills.

1. Introduction

Using practical problems in teaching has captured the attention of educators. Dewey (2012) emphasized that "connecting learners and learned knowledge with practice is significant in helping to improve educational effectiveness" [1]. In addition, authors such as Crawford (2001), Berns and Erickson (2001), Selvianiresa and Prabawanto (2017), etc., also asserted that applying real-life situations into teaching can stimulate learners' curiosity and help learners connect knowledge and application that knowledge in practice [2-4].

In research on using practical problems in teaching Biology, most authors such as Van Thi Thanh Nhung (2016), Nguyen Thi Thu Hang and Phan Thi Thanh Hoi (2018), Dinh Quang Bao and Phung Thi Mai Hoa (2020), Ha Van Dung and Khuat Huong Lien (2022), etc., all emphasized that building and using exercises associated with the practice, making a crucial contribution to the development of competency in applying learned knowledge and skills (ALKAS), while also promoting the development of other competencies, including problem-solving, communication, and collaboration, etc. thereby improving the quality of subject teaching [5-8]. However, the authors have not mentioned or clearly defined the practical problems that just mentioned covered the concept of practical exercises. The most typical example of using practical problems in teaching Biology is the work of authors Phan Thi Thanh Hoi and Bui Thi Kieu Nhi (2019) when using local practical problems in Tra Vinh province in teaching, and the result has shown that

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the effectiveness of integrating practical problems into the lesson has contributed to the development of student's competency in ALKAS and improved the efficiency of students' knowledge acquisition [9].

The competency in ALKAS is one of the components of specific competencies in all subjects. To be able to form and develop this competency comprehensively, it is crucial to integrate practical problems into the contents of each lesson in educational activities. Biology is a specific subject of Life Sciences, the object of study is the living world that is close to students' daily life, so practical problems about the surrounding life always exist and contain a lot of knowledge for learners to learn and apply in practice. The topic of *"Metabolism in organisms"* in Biology grade 11 contains plenty of knowledge that is very close to the student's life and the research objects can be plants, animals, or even the learner's own body. These are important factors in integrating practical problems into teaching this topic. They help increase interest and curiosity and create conditions for learners to do research, solve problems, and apply them to practice easily.

Despite understanding the role of using practical problems, a majority of teachers are not giving it enough attention, actively looking for, selecting, and making use of practical problems. Due to the limited resources of documents to guide the design and implementation of practical problems in teaching, in this article, we will systematize the theoretical framework of the practical problems, teaching through practical problems, and at the same time, proposing the process of designing as well as using practical problems in teaching the topic of *"Metabolism in organisms"* in Biology grade 11 to help teachers have reference materials to effectively apply in teaching.

2. Content

2.1. Research objects and methods

2.1.1. Research objects

Practical problems related to the topic of *"Metabolism in organisms"* in Biology grade 11; the process of designing and teaching practical problems related to the content of the topic of *"Metabolism in organisms"* in Biology grade 11, competency in ALKAS in teaching Biology using practical problems.

2.1.2. Research methods

- Theoretical research methods: selecting, collecting, researching, and analyzing the documents that concerned the content of knowledge on the topic of *"Metabolism in organisms"* in Biology grade 11; building and using practical problems in teaching; training competency in ALKAS; and laying the foundation for the scientific basis of the research from these.

- Expert consultation methods: consulting with experts in the field of education about the designing process practical problems, and the teaching process using practical problems.

- Pedagogical experiment methods: conducting pedagogical experiments on 11^{th}-grade students to verify the effectiveness of the designed process.

2.2. Results and discussion

2.2.1. Practical problems in teaching

Practical problems in teaching are defined by the authors in various ways, specifically:

- According to Nguyen Thanh Nga et al. (2019), "Practical problems in teaching are open problems, appearing in real life and close to students. Those are real problems or simulated real problems, built by teachers for students to solve to achieve certain teaching goals" [10].

- Tran Thai Toan (2020) stated "Practical problems in teaching are natural or social phenomena occurring in life containing things that need to be explained, demonstrated, and solved through learning tasks built and organized by the teacher for students to do" [11].

- Phan Thi Thanh Hoi and Nguyen Tan Phat (2022) defined in more detail "practical problems are the situations, things, phenomena associated with all the material activities of humans without prior understanding of the results, it is necessary to consider, research and find solutions to improve nature and society to serve human purposes" [12].

Based on the above-mentioned definitions, it can be assumed that: Practical problems in teaching are the problems that associate teaching content with real life and contain contradictions that students need to think about, consider, and research to prove or solve them to understand more about practice, and simultaneously develop the qualities and competencies of learners, especially the competency in ALKAS.

2.2.2. Teaching through practical problems

According to the definition of "practical problems", it can be seen that putting situations, things, and phenomena associated with life into teaching activities will create contradictions in students' perceptions, thereby stimulating students' awareness and simultaneously contributing to the development of qualities and competencies for learners. Therefore, we can conclude that *"Teaching through practical problems is a teaching approach, in which teachers must design exercises, and learning tasks derived from practical situations and material activities in life associated with the learning contents and organization for students to solve those tasks to promote the positivity, proactivity, and creativity in students, contributing to the development of students' qualities and competencies".*

2.2.3. The competency in applying learned knowledge and skills

**** Definition of the competency in ALKAS***

The competency in ALKAS has been researched and defined by many authors in many different aspects as "the subjects' ability to identify practical problems, apply relevant knowledge or explore and discover knowledge to implement effectively solving practical problems" [6] or "the student's ability to apply their learned knowledge and skills to explain and evaluate common phenomena in nature and life; have the right attitude" [13]. According to these definitions, it can be generalized that the competency in ALKAS is the learners' ability to apply known knowledge or exploration and discovery to apply it in real life, helping to solve problems that exist in the world around them effectively.

**** Structure of the competency in ALKAS***

Many authors have studied the competency in ALKAS and given the structure of its components. Based on the research results of Nguyen Thi Thu Hang, Phan Thi Thanh Hoi [6], Dinh Quang Bao and Phung Thi Mai Hoa [7], we agree and assume that the competency in ALKAS can be expressed through the criteria: (1) Identify practical problems; (2) Determine the knowledge related to practical problems; (3) Propose measures to solve practical problems and explain it; (4) Perform practical problems solving and discuss, report the results of the solutions.

2.2.4. Design practical problems in teaching the topic of "*Metabolism in* organisms" in Biology grade 11

When designing practical problems in teaching, it is necessary to base them on several principles such as practical problems must be associated with the objectives of the topic/lesson; practical problems must be "hot" problems that urgently need to be resolved globally, in Vietnam, and locally; practical problems must contain cognitive contradictions for students, to stimulating thinking, activeness, and creativity of learners [12].

According to several previous studies, and the above principles, the process of constructing practical problems in a topic is determined in four steps: (1) Identify the central scope of knowledge of the topic; (2) Identify the objectives of each central scope of knowledge; (3) Identify practical problems related to the central scope of knowledge based on the objectives; (4) Consult experts and update, and supplement practical problems.

Based on the above process and the topic of "*Metabolism in organisms*" in Biology grade 11 content prescribed in The 2018 General Education Curriculum in Biology, we have designed practical problems as shown in Table 1.

Table 1. Practical problems in the topic of "Metabolism in organisms" in Biology grade 11

Content		**Practical problems**
The exchange of water and minerals in plants	- The role of water. - The absorption of water and minerals in the root. - The transport of substances in plants. - The transpiration in leaves. - The role of mineral elements. - Nitrogen nutrition. - Factors affecting water exchange and mineral nutrition in plants and their application.	- The saline intrusion in lowlands. - Planting fruit trees with organic fertilizer. - Growing hydroponic vegetables on an industrial scale. - Growing strawberries in the clean agriculture direction in Da Lat. - Crops flooded during rainy seasons. - Using bio-fertilizers in farming. - Proper watering time for plants. - Improving the alkaline and acidic soils for planting. - Testing for micronutrient residues in agricultural products for export.
Photosynthesis in plants	- Overview of photosynthesis. - Stages of photosynthesis. - Factors affecting photosynthesis. - Photosynthesis and crop yield.	- Durian achieves high yield when grown in Southern Vietnam. - Lighting lamps for dragon fruit fields in Binh Thuan Province. - Planting flowers and fruit trees out of season. - Growing vegetables with LED lighting. - Intercropping, crop rotation.
Respiration in plants	- Definition. - The role of respiration. - Stages of respiration in plants. - Factors affecting respiration in plants. - Application. - Relationship between photosynthesis and respiration.	- Preservation of agricultural products when exporting agricultural products to other areas in the country or abroad. - Mass crop deaths in the rainy and flood seasons. - Measures to stimulate the germination of tubers, seeds, and stems. - Planting ornamental plants in closed rooms.
Nutrition and digestion in animals	- Nutrition. - Gastrointestinal forms in animals. - Application.	- Peptic ulcer disease. - Breakfast-skipping Habit. - The rate of malnutrition between urban and rural areas. - Nutrition by age group and profession. - Food hygiene and safety. - Abuse of accelerated weight loss pills. - Detox weight loss.

Respiration and gas exchange in animals	- The roles of respiration. - Types of respiration. - Application.	- Air pollution and fine dust in Hanoi. - The habit of not wearing a mask out on the street. - Current situation of tobacco and e-cigarette use among students. - Respiratory diseases such as asthma, pneumonia, flu, etc. - Fitness and exercise program. - Aquaculture methods in coastal lagoons.
Transportation of substances in the animal's body	- Overview of the transport system. - Types of circulatory systems. - Structure and functioning of the heart and vascular system. - Intravascular transport of blood. - Regulation of cardiac activity. - Application.	- Current situation of stimulant use among young people. - The rate of stroke in young people. - Cardiovascular diseases (heart failure, stroke, etc.). - Fitness and exercise program. - Harmful effects of alcohol abuse. - Salty eating habits, eating a lot of sweets. - Use of fat when preparing food.
Immunity in animals	- Causes of disease. - Definition of immunity. - Immune system. - Specific and Nonspecific immunity. - Application.	- Allergies to pollen, animal hair, food, and cosmetics. - The role of vaccines in the prevention of the COVID-19 epidemic. - Anaphylaxis in children. - Antibiotic allergy testing. - Diseases of the immune system (HIV, cancer, autoimmune diseases, etc.).
Secretion and homeostasis	- Excretory and excretory mechanisms. - The role of the kidneys in excretion. - The concept of homeostasis and dynamic equilibrium. - Homeostasis. - Application.	- Testing of biochemical indicators. - Effects of alcohol on the kidneys. - Kidney diseases (renal failure, kidney stones, etc.). - Salty eating habits, eating a lot of sweets. - Students' drinking habits. - Abuse of drugs and antibiotics when suffering from the disease. - Milk tea drinking habits in young people.

2.2.5. Teaching the topic of *"Metabolism in organisms"* in Biology grade 11 using practical problems to develop students' competency in applying learned knowledge and skills

To develop competency in ALKAS, it is necessary to organize lessons using practical problems with steps corresponding to the structural elements of this competency. Depending on pedagogical purposes, practical problems can be used to open lessons, create situations to solve and form new knowledge, or do exercises to put into practice. Through the literature review, we found that practical problems will be highly effective in improving teaching quality if used such as:

- Situations for Problems-based learning or Role-play method.

- Problems that need experimentation, research, analysis, and discovery in Inquiry-based learning, Project-based learning, STEM education, or Research-based learning.

- Situations, exercises in the 5E cycle (Engage or Elaborate phase) or Experiential learning cycle (Concrete Experience or Active Experimentation phase)'s one phase.

Although practical problems can be implemented in many different ways, the organization of teaching through practical problems still follows a certain process. Therefore, based on the research results of Phan Thi Thanh Hoi and Bui Thi Kieu Nhi [9], we propose a process of organizing teaching using practical problems including five steps as follows:

Step 1: Organize to identify practical problems

The teacher introduces topics/lessons and gives practical problems directly (leads students straight to the problem) or indirectly (in the form of learning games, exercises, and questions from which students have to find the problem). Students identify practical problems and ask research questions (if any).

Step 2: Instruct to make an inquiry practical problems plan

The teacher assigns learning tasks and instructs students to inquire about the practical problems plan including the tasks needed to be solved; solving duration; learning aids/methods; expected product; and persons assigned to perform (for group tasks). In addition, the teacher needs to introduce and guide students to self-assess the inquiry and solve practical problems based on the sample evaluation criteria form provided by the teacher.

Step 3: Organize to implement an inquiry practical problems plan

Based on a designed plan, students can self-study (or collaborate) to implement assigned tasks. Students can inquire about practical problems through observation, investigation, information collection, experimentation, and surveys. In these activities, students should take the initiative and be proactive in finding information, making scientific inquiries, giving comparisons, analyzing data, and processing to look for the solutions to practical problems assigned by the teacher.

Step 4: Organize reports and discuss the inquiry, solve practical problems results

Students will report learning products (exercises, reports, journals, wall newspapers, models, infographics,...) under the guidance of teachers. Simultaneously, students will also discuss and ask relevant questions about the results of solving practical problems as well as propose new ideas about that problem or related practical problems. Teachers act as "the judge" to give conclusions and draw out the content of the topic/lesson.

Step 5: Organize the assessment of students' achievement of lesson objectives

The teacher instructs students to self-assess and cross-evaluate the results of learning and solving practical problems (through individual activities or group activities) based on the evaluation criteria form provided by the teacher or teacher and students' form, to determine the competency in ALKAS of learners. Besides, the teachers conduct students to assess, synthesize, and analyze assessment results to make general remarks, requiring learners to state advantages, and drawbacks to overcome. At the same time, the teacher also needs to listen to opinions, suggestions, and limitations in organizing the teaching process to adjust accordingly.

Example: Teaching the lesson/content *of "Respiration and gas exchange in animals",* and select the objectives that can be related to and applied in practice including*:* "Apply the knowledge of gas exchange and respiration to prevent respiratory diseases"; "Explain the hazardous effects of smoking on health"; Explain the role of physical education and sports; "Explain the hazardous effects of air pollution on respiration"; "Inquiry respiratory diseases"; "Present your standpoints on penalizing smokers in public places and banning children under the age of 16 from smoking". Based on these objectives, we can determine practical problems related to such as Respiratory diseases; The hazardous effects of smoking on respiration; The hazardous effects of air pollution on respiration; The role of physical education and sports on respiration; etc.

According to determined practical problems, instruct students to do scientific research on the topic of "Influences of living habits and environmental factors on the local incidence of respiratory diseases".

Step 1: Organize to identify practical problems

The teacher poses the topic of "Influences of living habits and environmental factors on the local incidence of respiratory diseases", and requires students to work in pairs to ask for research questions on the topic. For example:

- What is respiratory disease? Name some respiratory diseases.

- How can living habits affect the incidence of respiratory diseases? What routines increase/decrease the chance of respiratory disease?

- How do living habits affect the incidence of respiratory disease?

- How do environmental factors affect the incidence of respiratory diseases? Which factors influence the incidence of respiratory disease?

- Current situation of living habits and some local environmental indicators.

- Current situation of local respiratory disease incidence.

- What measures can be taken to encourage/limit living habits that help reduce/increase the incidence of respiratory diseases?

- What measures can be taken to maintain local environmental factors at an indicator suitable for respiratory health?

The teacher requires students to work in groups and make scientific hypotheses based on research questions.

Step 2: Instruct to make an inquiry practical problems plan

The teacher divides the class into four groups (from six to eight students per group) with contents as follows:

- Group 1 and Group 3: Inquiry about the influences of living habits on local respiratory diseases and their prevention.

- Group 2 and Group 4: Inquiry about the influences of environmental factors (physical, chemical. Biology) on local respiratory diseases and their prevention.

The teacher requires the groups to make an inquiry practical problems plan and build contents according to the form in Table 2. Each group needs to inquire and investigate the information, which depends on the task contents that the teacher assigned.

Table 2. The sample group plan of inquiry practical problems and create contents

**** Topic:*** *Influences of living habits and environmental factors on the local incidence of respiratory diseases* School:..... Class: ..... Group: ..... *Group 1. Inquiry about the influence of living habits on local respiratory diseases and their prevention* **** Research contents*** - The concept of respiratory diseases. Some common respiratory diseases. - The relationship of lifestyle habits with the incidence of respiratory diseases. - Mechanisms affecting the incidence of respiratory diseases of living habits. - Current situation of living habits and incidence of respiratory diseases of local people. - Current state of local people's understanding of measures that contribute to limiting/increasing the risk of respiratory diseases. **** Research questions*** - What is respiratory disease? Name some respiratory diseases. - How do living habits affect the incidence of respiratory diseases? What routines increase/decrease the chance of respiratory disease? - How do living habits affect the incidence of respiratory disease? - How do environmental factors affect the incidence of respiratory diseases? Which factors influence the incidence of respiratory disease? - What is the mechanism of living habits' affection on respiratory disease incidence?

- What are the current situation of living habits and the incidence of respiratory diseases among local people?
- What is the current state of understanding about measures that contribute to limiting/increasing the risk of respiratory diseases of local people?

**** Implementation Plan (Implementation duration: 3 weeks)***

No.	Mission	Time	Location/ Method/ Support subject	Expected product	Assigned person
1	Collect information needed for the inquiry based on the contents and research questions	6 days	- Internet, books, scientific journals, etc. - School Library - Laptops, tablets	- Information stored in physical formats: articles, theses, journals, etc. - Information stored in digital formats: images, videos, audio, files, etc.	
2	Investigate the current situation of living habits, the incidence of respiratory diseases in the locality, and people's understanding of measures that contribute to limiting/ increasing the risk of respiratory disease -Location: -Time: - Transportation: - Respondents: - Survey method(s): using questionnaires, interviews, and recordings.	4 days	- Video and audio equipment (phone, camera, etc.) - Investigate forms - Note-taking tools: notebook, paper, pen.	- Documentable information. - Information from the questionnaire. - Videos, photos - Audio files	
3	Group discussion, product design framing	1 day	- Products collected from the two previous missions - Laptops, tablets - Notebook, paper, pen, etc.	Product design framework: videos, audio, files, report out-line (Infographic, Word file, PowerPoint).	
4	Product designing	4 days	- Laptops, tablets - Notebook, paper, pen, etc.	- Finished products: Word file, infographics, results summary diagram, finished videos, etc.	

	5	Product reporting	20 mins	- Laptop - Reporting products - Notebook, paper, pen, etc.			

Step 3: Organize to implement an inquiry practical problems plan

According to the designed plan, the teacher organizes students to perform tasks at home. The tasks include:

- Collecting information related to research contents and questions, figures, images, videos, etc.
- Designing survey forms and actual investigation in the locality.
- Processing collected raw information and data.
- Group discussion to agree on results. Thereby, designing and perfecting the product for reporting.

During the period when students implement plans at home, The teacher urges, reminds, and supports students to complete tasks when necessary. Each group also needs to contact and regularly update the completion progress for the teacher to guide and help in time.

Step 4: Organize reports and discuss the inquiry, solve practical problems results

The teacher organizes students to report the inquiry and solve problems results directly in class. Each group took turns presenting and sharing about the products that the group made. Other groups of students listened, commented, and asked questions. Finally, the teacher comments and asks questions for the presenting team to answer, and conclude the lesson contents.

Step 5: Organize the assessment of students' achievement of lesson objectives

The teacher requires each group to self-assess and cross-evaluate the results of the learning products according to the evaluation form provided by the teacher. Each group self-assesses and evaluates each other. The teacher evaluates learning activity results and requires students to draw advantages, difficulties, and limitations in the solving problems tasks process. Students share and the teacher listens, from there, teachers draw experiences to improve in the next time teaching.

2.2.5. Pedagogical experiment

To test the effectiveness of using practical problems to develop students' competency in ALKAS, we conducted the pedagogical experiment at Van Hien High School, Dong Da District, Hanoi during the 2022 - 2023 school year with two 11th grades (grade 11A7 and grade 11A9) with the total of 93 students. During the experiment, we organized and taught three lessons "Respiration in plants"; "Respiration and gas exchange in animals"; and "Excretion and homeostasis".

To develop students' competency in ALKAS, based on the structure of this competency, we gave scores under specific criteria, each criterion with three levels, equivalent to 2 points (0: not yet done; 1: done; 2: Well done): (1) Identify practical problems and make questions related to practical problems; (2) Determine the knowledge related to practical problems; (3) Propose measures to solve practical problems and explain it; (4) Perform practical problems solving; (5) Discuss and report the results of solving problems. Based on the regulations on student assessment according to the 2018 General Education Program [13], we divided the total score of the competency in ALKAS into four levels: 4th Level - overall score greater than or equal to 8; 3rd Level - overall score from 6.5 to below 8; 2nd Level - overall score from 5 to less than 6.5; and 1st level - overall score below 5.

Before starting the experiment, we used a test of students' competency in ALKAS, and then, at the end of each topic, we scored a test and the obtained results are shown in Figure 1.

The chart above shows the changes in the competency in ALKAS level of students through each survey. Specifically, before starting the experiment (the 1st test), the proportion of students

at the 1st level and 2nd level was very high (83.3 %), while the proportion of students who achieved the 3rd level was very small (10.8 %) and the percentage of students reaching 4th level was only half of the rate of 3rd level (5.4 %). This result is consistent with previous research findings because most students were only exposed to problem detection, asking questions related to practical problems, identifying relevant knowledge, and/or proposing practical problem-solving measures. Therefore, at the beginning of the experiment, the proportion of students at the 1st level and 2nd level of the competency in ALKAS accounted for a majority proportion.

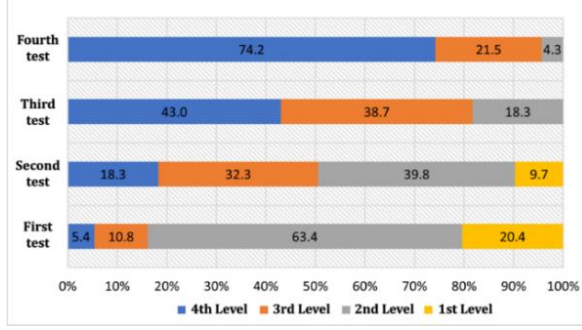

Figure 1. The competency in ALKAS level of students before and after the experiment

However, upon using practical problems in teaching, through 3 surveys (2nd, 3rd, and 4th), the percentage of students achieving 1st level decreased significantly through each test (from 20.4 % to 9.7 % and equal to 0 % after the second test). The proportion of students achieving 3rd and 4th levels increased significantly after three surveys, nearly six times higher than those reaching 3rd and 4th levels in the period before the start of the experiment (95.7% compared to 16.2%). This result is likewise consistent and quite similar to the research results of authors Phan Thi Thanh Hoi, Bui Thi Kieu Nhi (2019), and Tran Thai Toan (2020). It can be explained that learners already have a background in detecting, asking questions, and identifying knowledge related to practical problems. Therefore, when using practical problems to train learners in planning operations, implementing practical problem-solving according to the designed plan, and reporting, explaining as well as proposing new measures or new practical problems, it will significantly contribute to the change in the proportion of students reaching 3rd and 4th levels in terms of their competency in ALKAS. This result has shown that integrating practical issues into teaching helps develop competency in ALKAS for students and also contributes to improving the quality of subject teaching.

3. Conclusions

Through an overview of previous studies, the article has systematized the theoretical basis of practical problems and teaching through practical problems. At the same time, we propose the process of designing practical problems in teaching the topic of "*Metabolism in organisms*" in Biology grade 11, building 50 practical problems on this topic. From the identified practical problems, we propose using the practical problems process in teaching to develop competency in ALKAS. The experimental results of three lessons under the topic of *"Metabolism in organisms*" in Biology grade 11 in two grades 11 at Van Lang High School, Dong Da district, Hanoi show that the use of practical problems in teaching organizations has brought significant effects in training and developing students' competency in ALKAS (no student achieved 1st level in terms of the competency in ALKAS since the 2nd test), simultaneously, learners also feel that the knowledge becomes closer and more practical, thereby stimulating curiosity, excitement, and positivity in the learning process.

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