

Enhancing Scientific Problem-Solving of Grade 10 Students through Problem-Based Learning with Ethical Dilemmas

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Abstract

The purposes of this research were 1) to compare the achievement after using problem-based learning with ethical dilemmas on genetic variation and biotechnology with the criteria of 70 percent, 2) to compare the problem solving in science of Grade 10 students after learned with problem-based learning with ethical dilemmas with the criteria of 70 percent, and 3) to study satisfaction with problem-based learning with ethical dilemmas on genetic variation and biotechnology. The sample used in this research were 38 of Grade 10 students in the academic year 2022. Data were analyzed using mean, percentage, standard deviation, and t-test. The results of the research were as follows 1) the achievement of Grade 10 students receiving problem-based learning with ethical dilemmas after learning was not different from the criterion of 70 percent at a statistical significance level of .05, 2) the scientific problem solving ability of Grade 10 students who received a problem-based learning with ethical dilemmas were not different from the criterion of 75 percent at a statistical significance level of .05, and 3) the students were satisfied with the problem-based learning with ethical dilemmas at the highest level.

Keywords: problem-based learning; ethical dilemmas; achievement; scientific problem-solving ability

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INTRODUCTION

The method of teaching science is one that emphasizes student development and the administration of teaching and learning. Students should be encouraged to find information on their own as much as possible (Szymkowiak et al. 2021)rrr. They may both process and gain knowledge from the techniques of observation, exploration, investigation, and experimentation and then systematize the results into principles, concepts, and knowledge (Forcael et al. 2015) This will allow students to both process and gain knowledge from the methods of observation, exploration, examination, and experimentation. The administration of science education consequently has the essential purpose of enabling students to comprehend the fundamental concepts, ideas, and norms of the many scientific fields as well as the limits and limitations of these fields. In addition to having the capacity to use information and understanding gained from science disciplines to build thinking processes and imagination, they also have the capability to solve issues, manage communication skills, and make judgments.

Several of the courses that the science and technology learning group offers cover the study of life in its natural environment. Elements of life, including those of people, animals, and plants, as well as knowledge on genetic variety, biotechnology, and the development of living things. Students are able to obtain knowledge and awareness of these facts about life on earth, as well as the ability to use this information in their day-to-day lives, because these facts are all true (Buheji and Sisk 2020) (Hermino and Arifin 2020). In addition, the importance of science to human life cannot be overstated, regardless of whether its importance is derived directly or indirectly from scientific endeavors. Whether it's nutrition, agriculture, medicine, the environment, natural resources, or even the economy and national development, it seems like there's always something new to learn.

Learning management that focuses on science education serves a vital role and involves teaching and learning about scientific topics. to provide students with opportunities to enhance their thinking abilities in a variety of areas, including critical thinking and the ability to solve problems. For studies to be carried out successfully, it is necessary to analyze the data, consider the evidence, and categorize the data. The management of learning in the present science disciplines, on the other hand, is a form of learning management that primarily encourages pupils to memorize the material (Kwangmuang et al. 2021). It is more important for students to pass the test than to grasp the material being taught. It is not centered on the scientific method and deprives students of the opportunity to acquire a wide range of abilities, which in turn affects academic progress. Students' capacities for critical thinking, creative problem solving, and inventiveness are being evaluated (Samani and Sunwinarti, S., Putra, B. A., Rahmadian, R., & Rohman 2019).

The vast majority of instructors are the ones who impart their expertise to their respective classes. Because of this, there is little stimulus for students to develop an interest in and passion for teaching (Gultom et al. 2020) (Janpleng and Ruangmontri 2021). The end result was that the students only achieved a moderate level of success in their studies. The learning and development of students cannot be promoted in all areas through the use of the lecture format and non-formal of instruction (Prachagool and Nuangchalerm 2021). Particularly in the area of scientific problem-solving abilities. As a consequence of this, pupils do not develop the ability to think scientifically in terms of how to solve problems. The solution of scientific issues, generally considered to be the foundation of thinking that incorporates many aspects of work is an example of problem-solving thinking (Polyiem and Nuangchalerm 2022).

Educating students on how to identify and address the fundamental issues at play, find a solution to the problem and implement it and conduct an analysis of the outcomes of the replies in order to locate the right and proper response. Problem-solving ability is a skill that may help build attitudes, methods of thinking, values, knowledge, and understanding of diverse social circumstances (Nur et al. 2020) (Suryanto et al. 2021). The solution to the problem may be broken down into the following four steps: The first stage is to identify the problem, followed by the analysis phase, then the solution step, and finally the results verification step. Students are able to follow along with the process of problem-solving thanks to the following algorithm ().

Learning how to think critically in order to answer scientific issues is crucial for academic success in science fields. Students identify and address the fundamental issues at play Find a solution to the problem and implement it. and conduct an analysis of the outcomes of the replies in order to locate the right and proper response. It is also vital to the continuation of life. Problem-solving ability is a skill that may help build attitudes, methods of thinking, values, knowledge, and understanding of diverse social circumstances (Di et.al., 2022). The solution to the problem may be broken down into the following four steps: The first stage is to identify the problem, followed by the analysis phase, then the solution step, and finally the results verification step. Students are able to follow along with the process of problem-solving thanks to the following algorithm: until it is possible to draw a conclusion on the results of addressing the problem (Szabo et al. 2020) (Saadati and Felmer 2021).

As a result, the use of proper strategies is essential in order to assist students in developing their problem-solving abilities and to lead to effective problem-solving. In order to foster in

students the ability to think critically and find solutions to scientific issues. It is a challenge or circumstance that involves an ethical conundrum, for which it is difficult to find proper answers (Avery 2019) (Steinberg 2020). It relies on thinking that can solve problems, as well as thinking that can analyze and create new things. Because of this, the principles that make up ethical dilemmas will concentrate on motivating students to set more lofty goals for themselves (Raines and Cox 2021). In addition, the student's awareness of ethical difficulties will be projected if ethical challenges are incorporated into the learning process. This is helpful for motivating students to acquire conceptual change competencies.

Derived from an analysis of research that was conducted on problem-based learning. It was discovered that the methodology of teaching science known as problem-based learning helps students develop their thinking abilities in the context of problem solving. It is possible for students to increase their ability to solve scientific problems, which, in turn, will encourage and build greater learning success among them. According to the evidence and information presented in the previous paragraphs. As a result, the researchers have interest in creating learning management by employing a problem-based learning approach that encourages students in Grade 10 students to think critically and find solutions to scientific challenges. The study as a guideline for the management of their learning experiences. to encourage the development of a greater capacity to successfully answer scientific challenges.

METHODS

This research employed an experimental research by using the one-group posttest-only design.

Participants

The population was Grade 10 students at Phadungnaree School, Mahasarakham province, Thailand. The sample was 38 students in Grade 10 in Science-Mathematics Program, the second semester of the academic year 2022. The samples were obtained by cluster random sampling.

Research tools

Tools used in learning management, namely, problem-based learning with ethical dilemmas, 7 learning plans. The results of the assessment by 3 experts showed that the appropriateness of the learning management plan was of the most appropriate level.

Tools used to collect data are: Achievement test for biological science subjects on genetic variation and biotechnology which was a multiple-choice test, multiple choice type, 4 options, 30 items, the results from the evaluation by 3 experts had an average index of consistency was 0.86, with a difficulty (P) between 0.27-0.78, discriminating power. (B) was between 0.22-0.68 and the reliability (r_{cc}) was 0.79.

A test to measure the ability to think about solving scientific problems by the researcher created according to Weir's (1974) procedure, which was a subjective test consisting of 5 situations, each of which had 4 questions, totaling 20 questions. The results of the evaluation by 3 experts had an average concordance index (IC) of 1.00. The difficulty (P) was between 0.68-0.76, the discriminant power (D) was between 0.24- 0.34, and the confidence value from the Cronbach alpha coefficient was 0.92.

A questionnaire for satisfaction with learning management, which was a 5-level assessment scale of the Likert scale, 20 items. The results from the evaluation by 3 experts had an average appropriateness was 1.00.

Data collection and analysis

Basic statistics include percentage, mean, and standard deviation were used for described its results. Statistics used in hypothesis testing, analyze data to compare achievement after learning management using problem-based learning with ethical dilemmas using one sample t-test. Also, the data to compare the ability to solve scientific problems after learning management. Using the problem as a base together with ethical dilemmas by using one sample t-test. The

satisfaction questionnaire towards learning management was used and described by level of mean scores and level of satisfaction.

RESULTS AND DISCUSSION

Result

Comparison the post-test achievement through problem-based learning with ethical dilemmas on genetic variation and biotechnology with the criteria of 70 percent. The results of post-test achievement with problem-based learning with ethical dilemmas on genetic variation and biotechnology with the 70 percent criteria, the researchers conducted an outcome test. Achievement which was a multiple-choice test, 4 multiple choice, 30 items, to measure achievement after using problem-based learning with ethical dilemmas on genetic variation and biotechnology with criteria 70 percent results are as Table 1.

Table 1. Comparison of results of post- test achievement with problem-based learning with ethical dilemmas on genetic variation and biotechnology with the criteria of 70 percent

Test	N	Full score (30)		Percentage	\bar{x}	SD	t	Sig
		highest point	lowest score					
Post-test	38	27	15	68.60	20.58	8.582	-1.008	.16

* $p < 0.05$

Table 1, it was found that the achievement after learning by using problem-based learning with ethical dilemmas. Students earn points by taking an achievement test. The mean was 20.58, with the highest score being 27 and the lowest score being 15, representing 68.60 percent with a standard deviation of 8.582. One sample t-test was shown that there were significantly differences .05 level of statistics. It can be concluded that the achievement of Grade 10 students who received problem-based learning with ethical dilemmas after learning was not different from the 70 percent criterion.

The comparison of the ability to think about solving scientific problems after the problem-based learning with ethical dilemmas to pass the criteria of 75 percent. A comparative study of the ability to think about scientific problem solving after a problem-based learning with ethical dilemmas to pass the criteria of 75 percent, the researcher has prepared a test to measure the ability to think about solving scientific problems. This is a subjective test consisting of 5 situations, each of which consists of 4 questions, totaling 20 items, to measure the ability to think about solving scientific problems after the problem-based learning with ethical dilemmas to pass the criteria of 75 percent, the results are as Table 2.

Table 2 Results of developing the ability to think and solve scientific problems after using problem-based learning with ethical dilemmas. to pass the criteria of 75 percent

test	Full score (80)				\bar{x}	SD	t	Sig
	problem identification (20)	problem analysis (20)	problem formulation (20)	checking results (20)				
Post-test	16.29	15.21	15.34	15.03	61.87	9.29	1.240	.11

* $p < 0.05$

Table 2, it was found that the ability to think about solving scientific problems after using problem-based learning with ethical dilemmas. Students scored points for taking a test measuring their ability to think about solving scientific problems. The average was 61.87, representing 77.34 percent, with a standard deviation of 9.29. One sample t-test was shown that there were significantly differences .05 level of statistics. In thinking about solving scientific problems of

Grade 10 students who received problem-based learning with ethical dilemmas after learning did not differ from the 75 percent criterion.

The results of the study of satisfaction with problem-based learning with ethical dilemmas on genetic variation and biotechnology. To study satisfaction with problem-based learning with ethical dilemmas. The researcher prepared a satisfaction questionnaire for learning management, which was a 5-level assessment scale of the Likert scale, 20 items, to measure satisfaction with learning management after learning management, the results are as Table 3.

Table 3 Table of results of the study of satisfaction with problem-based learning with ethical dilemmas on genetic variation and biotechnology

Items	\bar{x}	SD	Satisfaction level
Terms of teaching			
1. I like that teaching and learning encourages students to have the ability to solve scientific problems systematically	4.74	0.59	Very Satisfied
2. I like that teaching and learning encourages students to be assertive and dare to answer questions	4.92	0.27	Very Satisfied
3. I like that teaching and learning encourages students to understand the content	4.92	0.35	Very Satisfied
4. I am satisfied that the learning management encourages students to have knowledge outside of the classroom	4.97	0.16	Very Satisfied
5. I am satisfied that the time spent on teaching and learning is appropriate	4.89	0.31	Very Satisfied
Promotion of learning			
6. I am satisfied with teaching and learning activities that promote research and knowledge pursuits	4.89	0.38	Very Satisfied
7. I am satisfied that students are encouraged to use their passion to solve problems	4.82	0.51	Very Satisfied
8. I enjoy training students to work in groups	4.89	0.31	Very Satisfied
9. I am satisfied with the availability of appropriate and sufficient textbooks, knowledge sheets, and teaching materials for research	4.97	0.16	Very Satisfied
10. I am satisfied with having a classroom. Learning media and facilities are appropriate and adequate	4.95	0.22	Very Satisfied
Measurement and evaluation			
11. I like having proper measurement and evaluation	4.92	0.35	Very Satisfied
12. I am satisfied that measurements and evaluations are clear and fair	4.92	0.27	Very Satisfied
13. I am satisfied that measurement and evaluation are consistent with learning activities	4.92	0.27	Very Satisfied
14. I am satisfied that the student's grades are disclosed	4.87	0.41	Very Satisfied
15. I am satisfied that there is a guideline for finding answers and giving answers so that learners know their results	4.84	0.43	Very Satisfied
Instructor			
16. I appreciate that teachers give students the opportunity to ask questions	4.87	0.34	Very Satisfied
17. I like that teachers explain the content clearly and easily understand	4.89	0.31	Very Satisfied
18. I appreciate that teachers give students the opportunity to participate in summarizing the materials	4.84	0.43	Very Satisfied
19. I appreciate the help and advice from teachers so that students can solve problems and seek knowledge	4.92	0.27	Very Satisfied
20. I am satisfied that the teaching materials used by the teachers are consistent with the content and appropriate	4.97	0.16	Very Satisfied
Average	4.90	0.33	Very Satisfied

Table 3, it was found that students were satisfied with problem-based learning with ethical dilemmas. The average satisfaction with learning management was 4.90, in the range of 4.50-5.00, which was the highest level of satisfaction. and the mean standard deviation was 0.33. The level of satisfaction could be verified that students liked to deal with the learning management and ready to participate classroom activities.

Discussions

From this research, the development of problem-based learning with ethical dilemmas promotes the ability to think and solve scientific problems, the results can be discussed. Comparing the achievement of Grade 10 students who received problem-based learning with ethical dilemmas with the 70 percent threshold. It was found that the achievement of students after receiving problem-based learning with ethical dilemmas was not statistically significant difference from the 70 percent threshold at the level of .05, which was inconsistent with the hypothesis. The results of the research showed that after using problem-based learning with ethical dilemmas. Students improved their achievement from before learning management with an increase in post-school grade point average compared to before. The average post-test achievement score was 20.58 points out of 30, while the pre-test average was 13.37 points out of 30 or 44.56 percent, which is less than 45 percent when the post-test achievement score of problem-based learning with ethical dilemmas was compared to the 70 percent threshold. Encourage learners to learn and lead to new knowledge.

It is stated that problem-based learning management is a learning management that allows students to solve problems through investigating the root cause of problems and practicing problem solving on their own. This enables students to understand the problem and be able to build knowledge (Siagan et al. 2019). This resulted in higher student achievement in which from the post-learning records. The early stages of learning management, students were unable to explain the occurrence of mutation and the induction of mutation. Therefore, the researchers solved the problem by adjusting the learning plan to give students a better understanding of the material. Students are able to participate in activities on their own and exchange knowledge within the group, allowing students to create new knowledge on their own (Chamdani et al. 2022).

Students have increased their assessment of knowledge with an average score, problem-based learning management by gaining students' knowledge and understanding the lesson. Students' achievement is higher that students did not improve their achievement as well as they should. In addition, problem-based learning with ethical dilemmas is an activity that emphasizes on students to develop their ability to think and solve scientific problems. The emphasis on measuring and evaluating cognition, memory and comprehension may be another reason why students achievement has not improved as much as it should.

The results of the comparison of the scientific problem-solving abilities of Grade 10 students after using problem-based learning with ethical dilemmas with the 75 percent threshold. It showed that the ability to solve scientific problems of students who received problem-based learning with ethical dilemmas was not statistically significant difference from the 70 percent threshold at the level of .05, it also was inconsistent with the hypothesis. There were 27 students with an average score of more than 75 percent out of 38 students or 71.05 percent, and 11 students with an average score of less than 75 percent out of 38 students or 28.95 percent. It demonstrates that each problem-based learning with ethical dilemmas encourages students to create new knowledge.

From bringing problem situations related to ethical dilemmas as an important context of learning activities. There are steps to solve problems using the scientific method by problem identification, students are able to clarify the problem. Then, diagnose the problem or find out if the problem is the real problem. Problem analysis, students are able to tell the root cause or possible cause of the problem from the situation. Determining the solution, students find a solution to match the cause of the problem. Checking results, students can discuss the results of problem solving. These steps mentioned above encourage students to have rational problem-

solving skills. Students have a higher ability to think and solve scientific problems (Ali 2019) (Salido and Dasari 2019) (Sarkar et al. 2020) (Tambunan 2019). This leads to a way in which students can solve problems that match the root cause of the problem and can use the information obtained to explain the consequences after solving the problem.

This is because problem-based learning stimulates the development of reason-solving skills by emphasizing self-determination and knowing how to work together within the group. Problem-based learning emphasizes on finding the root cause of problems and finding ways to study and research to solve them. Each step in the learning management process can help students to think and solve scientific problems. It was found that students' ability to develop scientific problem-solving abilities did not increase as much as they should. 1) Students are unable to identify real problems or problems that may arise from the problem situation determined by the researcher. 2) Students are unable to analyze the problem, which is a continuous step from identifying the problem so that the student can accurately and clearly describe the real problem of the problem situation, which is the result of the student not understanding the given problem situation. This prevents students from taking the next stage of their activities. 3) Students are unable to determine how to solve problems. 4) Students are unable to verify the results of the solution they have chosen because the process of verifying the results is very difficult. It requires an understanding of all the above scientific problem solving steps. To be able to draw conclusions and explain from the activities that the consequences of solving the selected problem are 5) In the content of genetic variation and biotechnology, where students are organized to learn using problems as a basis in conjunction with ethical dilemmas, there is no relation to their ability to think scientifically and problem-solving and 6) The problem situations that the researcher has prepared are problem situations that students can encounter in real life or have previous experiences.

Based on the conclusions that the researchers identified the reasons why students' ability to develop scientific problem-solving abilities did not increase as much as they should. Students' inability to develop their scientific problem-solving thinking skills is not as high as it should be. Students are unable to identify problems from problem situations, students are unable to develop their ability to think and solve scientific problems as well as they should.

Satisfaction with problem-based learning with ethical dilemmas on genetic variation and biotechnology, it was found that students were satisfied with problem-based learning with ethical dilemmas. It is equal to 4.90 in the range of 4.50-5.00, which is the most satisfactory level. As a result, students are interested in learning and teaching activities. This allows students to visualize and understand the problem from the problem situation clearly.

As a result, students are more satisfied with the management of biological sciences, resulting in more students being interested in learning biological sciences. Problem-based learning management allows students to learn and build knowledge on their own. Know how to take responsibility for assigned tasks. Students are very satisfied with their studies. It helps to create an atmosphere conducive to learning, which will have a positive impact on better academic achievement and satisfaction with problem-based learning management is high. As a result of this, students' learning behavior has changed for the better. Students learn to analyze and solve problems on their own under group collaboration (Mora et.al., 2020). Based on the findings, satisfaction with problem-based learning can be discussed with different aspects of students' ethical dilemmas. The areas with the highest satisfaction among students were learning promotion, which had an average score of 4.90, followed by teaching and learning.

Measurement and evaluation and teaching, it has an average score of 4.89, which is the highest level of satisfaction with overall learning management. The researchers presented each aspect as follows: 1) Learning promotion found that students had the highest level of satisfaction because problem-based learning with ethical dilemmas is a learning management that promotes research and knowledge pursuit. Encouraging students to apply their knowledge to problem solving are required, stimulate students to work in groups. In addition, facilities such as textbooks, knowledge sheets and teaching materials for study are provided appropriately and adequately to meet the needs of students. Problem-based learning is the use of problems in organizing activities

that use problem situations to stimulate and attract students' curiosity (Yulianti et al. 2019) (Yulianti et.al., 2019). Encourage students to have the ability to think and solve problems. 2) In terms of teaching and learning, it was found that students had the highest level of satisfaction because problem-based learning with ethical dilemmas is a learning arrangement that allocates appropriate teaching time. Students understand the content, have assertiveness, are willing to answer questions and encourage students to study their knowledge outside the classroom (Nieswandt et al. 2020).

Problem-based learning management is an interesting learning activity. Students participate in learning and problem solving through collaborative exchange of students within the group and give students the freedom to study. In terms of assessment and evaluation, it was found that students had the highest level of satisfaction because problem-based learning with ethical dilemmas is a learning management that has appropriate measurement and evaluation, clarity, fairness and consistency with learning activities. Problem-based learning management is a learning management that is measured and evaluated through a variety of methods. Students can propose measurement and evaluation guidelines in line with learning activities, and 4) Instructors found that students had the highest level of satisfaction because in managing problem-based learning with ethical dilemmas, teachers explained the content clearly. Teachers provide support, guidance, so that students can solve problems and seek knowledge. Problem-based learning management is a learning management in which teachers are responsible for guiding. Therefore, problem-based learning with ethical dilemmas are one way to help students achieve satisfaction with learning management. As a result, students' learning habits have changed for the better. Students learn to analyze and solve problems on their own under team collaboration. Information from a variety of sources and synthesize findings into what has been learned. Present to your classmates to learn and discuss together. Students have the highest level of satisfaction with problem-based learning with ethical dilemmas.

However, learning activities using problem-based learning with ethical dilemmas to apply in teaching and learning. Teachers should understand every step of the learning management approach thoroughly and clearly. Teachers also should not overburden students because it may cause students to feel pressured and stressed with the workload. It was found that the achievement and the ability to think about scientific problem solving of the students who received the problem-based learning with ethical dilemmas. on genetic variation and biotechnology lower than the threshold of 70 percent. This may be the result of the content that the researcher has chosen to use in the research may not be suitable for the learning management method. Subsequent research should include a content analysis and also select the content that is consistent with the methodology of problem-based learning with ethical dilemmas

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