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The Effects of Thinking Empowerment by Questioning in Biology Learning on Problem-Solving Ability

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ABSTRACT

The low level of problem-solving ability requires innovation in learning to overcome it. One of them is through the implementation of the Thinking Empowerment by Questioning learning strategy. This study aims to examine the impact of Thinking Empowerment through Questioning techniques on biology learners' capacity for problem-solving—this type of quasi-experimental research with a quantitative approach and design pretest-posttest experimental control group design. The research was conducted at SMAN 1 Bayan, North Lombok Regency. The population used was all grade X with 288 students. Samples were taken by cluster random sampling technique, with class XA as the experimental class, and class XC as the control class. The instrument used is an essay-shaped test on environmental change material totalling 10 questions. Data analysis technique using Analysis of Covariance test with the help of SPSS 26 software. The result of the Analysis of Covariance shows a significance value of 0.000 <0.05. This means the Thinking Empowerment by Questioning strategy has a significant effect on problem-solving ability in biology learning on environmental change material at SMAN 1 Bayan. The significant result can be a reference for teachers to improve problem-solving ability through the application of the TEQ strategy.

Keywords: Thinking Empowerment by Questioning, Problem Solving Ability, biology learners

Introduction

Problem-solving is one of the skills that students are required to learn. In the teaching and learning process, students need to solve problems. In the process, students are instilled with skill values to solve problems properly and correctly (Endang et al., 2021). Solving problems requires thinking skills. Skills in thinking include observing, reporting, describing, analyzing, classifying, interpreting, criticizing, predicting, drawing conclusions, and making generalizations based on the information collected and processed (Arestu et al., 2019). Being skilled in solving problems means being able to overcome the problems at hand (Mardhiyah et al., 2021).

The problems that humanity faces in the 21st century have grown more complicated. Therefore, 21st-century learning does not only rely on knowledge (Mardhiyah et al., 2021) but also on the thinking skills needed to solve problems (Zubaidah, 2018). Students must be equipped with problem-solving skills to make them a superior generation who are ready to face the challenges of the 21st century (Hidayahtika et al., 2020; Purwati, 2022). This is related to the importance of Problem-solving skills in increasing students' understanding and preparing them to face challenges in the future (Rahman, 2019).

Problem-solving ability is defined as a potential or skill possessed by students so that they can solve problems (Ivane & Dewi, 2022). The ability to solve problems has a close relationship with learning biology as a science cluster, including its relationship with everyday life. In its application, biological material not only requires students to understand the concepts and basic laws of biology but also develop skills to implement their knowledge in problem-solving. Astuti & Izzah (2022) explain, that students need to be trained in problem-solving in order to be able to make the right decisions while studying contextual biology about life problems.

In general, students' problem-solving skills in Indonesia are still low. This is based on the results of research that has been conducted in various schools in Indonesia. The condition of problem-solving ability is in the range of 17%-63%. Research conducted by (Hanifa et al., 2018) showed that the condition of students' problem-solving ability was at 17%. While research conducted by (Nurvela, Malalina, et al., 2020) is in the range of 36%. The rate was 63% according to (Nuraini et al., 2016) investigation. In line with the survey results from the Program for International Student Assessment (PISA) that the problem-solving ability of students in Indonesia is still relatively low, and ranked 62nd out of 72 countries with an average score of 403, while the international average score is 493 (Adinia et al., 2022; Amir et al., 2023). Meanwhile, the problem of low problem-solving ability at SMAN 1 Bayan was obtained from the results of observations on biology learning material on environmental changes, which showed that students' problem-solving ability was still low. This can be seen when the teacher invites students to discuss problems related to environmental pollution, and then students are asked to analyze problem-solving solutions to the problems given. However, on average, students are not able to provide appropriate solutions according to the context of the problem, and most of the students are silent rather than proposing ideas to find alternative solutions in an effort to solve the problem. This is reinforced by the statement of the 10th-grade biology teacher regarding students' low ability to solve problems related to biological material. Not only on environmental change materials but also on other biological materials.

The low level of problem-solving skills requires the need for innovative learning strategies for solutions. Among the many choices of strategies in learning, the Thinking Empowerment by Questioning (TEQ) strategy is one of the alternatives that can be applied. Yusuf et al., (2019) explained, that teaching and learning strategies are one of the external factors that affect problem-solving ability. Asking questions is linked to problem-solving skills (Jacques et al., 2020). In order to identify the problem at hand more precisely, asking or creating questions is an activity that involves rephrasing the encountered problem in an alternative editorial form. The effectiveness of the solution that is put into practice will depend on how well the problem is identified. As stated differently, an inaccurate definition of a problem will lead to a solution

that might not be effective. As a result, identifying the problem is an essential first step in solving it (Abdulla et al., 2020; Wolcott et al., 2021).

The use of the Thinking Empowerment by Questioning (TEQ) learning strategy makes students trained to think at a high level through questions. It helps students to see material as a whole knowledge that is easy to remember quickly and efficiently. TEQ strategy is question-based to help students understand the material better and achieve their learning goals.. Using this learning pattern, students can form new knowledge by identifying knowledge based on existing questions (Anggraini, 2016).

The TEQ pattern is an empowering pattern of reasoning questions. Based on its stages, this learning strategy pattern is believed to empower students' thinking processes so that it needs to be applied in learning (Sukini et al., 2020). In addition to maximizing students' thinking activities, this TEQ pattern has a positive influence on critical thinking (Anggraini, 2016; Bustami & Corebima, 2017) which is needed for more complex mental activities. The TEQ strategy emphasizes the use of questions that play an important role in developing critical thinking. The questions interwoven in TEQ are designed to stimulate deep and analytical thinking. Critical thinking is seen as a requirement for the growth of problem-solving skills. This is based on the findings of several previous studies that show an increase in students' critical thinking through the application of the Thinking Empowerment by Questioning strategy, namely by (Mone et al., 2021; Nur et al., 2023).

In light of the aforementioned description, the goal of this study is to examine the impact of the Thinking Empowerment by Questioning (TEQ) technique on students' capacity for problem-solving when learning biology.

Methods

This research is a quasi-experiment with a quantitative approach, with a pretest-posttest experimental control group design. The research was conducted at SMAN 1 Bayan, Anyar Village, Bayan District, North Lombok Regency, which took place from March to April 2023. The study population was all class X with a total of 288 students. Samples were taken using the cluster random sampling technique. Class XA was obtained as the experimental class and XC as the control class. The instrument used was a test in the form of essay questions on environmental change material. The data collected shows the improvement of students' ability to answer the ten-question test. The test was given at the first meeting (pretest) before getting the TEQ strategy treatment for the experimental class and the conventional method for the control class. Then at the last meeting, a posttest was given to the experimental and control classes after receiving treatment. The data obtained were then analyzed by the ANCOVA (analysis of covariance) test with the help of SPSS 26 software. The test used has passed the validity and reliability tests. As a result, ten items were declared valid with the r count of all questions; the highest was 0.714 and the lowest was 0.486 > r table 0.374 so it was feasible to use for data collection. The instrument is also reliable with a Cronbach's Alpha value of 0.791 > 0.374 which means it is consistent in collecting research data. Furthermore, the results of the statistical prerequisite test show that the residual data is normally distributed with a significance of 0.200 > 0.05 using the Kolmogorov-Smirnov test. The data variance is homogeneous with a significance of 0.204 > 0.05 using Levene's test.

Results and Discussion

Measurement of problem-solving capabilities before and after the implementation of the TEQ strategy. Data on problem-solving skills in the control and experimental classes are presented in Table 1.

Table 1. Problem-Solving Ability of Control and Experiment Classes

Aspects	Control		Experiment	
	Pretest	Posttest	Pretest	Posttest
Mean	49.68	62.23	45.42	69.42
Standard deviation	13.255	10.478	20.919	13.334
Category	Quite	High	Quite	High
Percentage change of control and experimental classes				12%

From Table 1, it is known that the mean posttest of the experimental class is higher than the posttest of the control class, with the number 69.42> 62.23. Although the mean of both is different, they are included in the same high category. The magnitude of the percentage change in control class posttests and experimental class posttests is 12%.

Additionally, Table 2 displays students' proficiency in each problem-solving indicator.

Table 2. Score Based on Problem-Solving Indicator

Indicator	Class			
	Control	Category	Experiment	Category
Problem identification	94.03	Very high	91.94	Very high
Formulate the problem	86.71	Very high	86.48	Very high
Look for problem-solving strategies	63.06	High	67.81	High
Act on problem-solving strategies	41.16	Quite	55.84	Quite
Look back and evaluate the effects of problem-solving activities	26.29	Low	44.97	Low

Based on Table 2, it is stated that the problem identification indication is the highest indicator in the control and experimental classes. The mean score of the control class is 94.03. While the experimental class is 91.94. The second indicator, namely, formulating the problem, showed that the mean score of the control group was higher (86.71) than the experimental class (86.48). Although the mean scores are different, they are both categorized as very high. Furthermore, the lowest indicator in both classes is reviewing and evaluating the effects of problem-solving activities. The control class mean score is 26.29 which is categorized as low. While the experimental class is 44.97 which is a sufficient category.

A comparison of the mean problem-solving ability based on problem-solving indicators is shown in Figure 1.

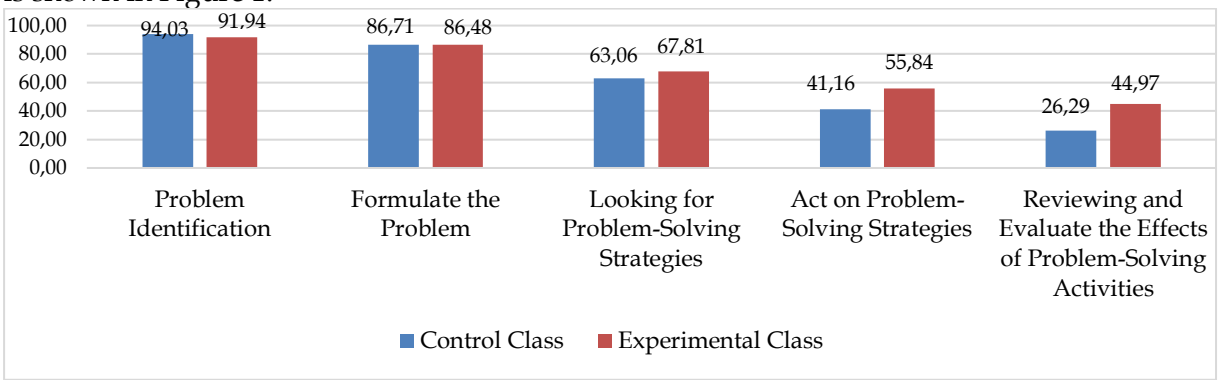

Figure 1. Comparison of problem-solving skills based on indicators in control and experimental classes.

The categorization of problem-solving ability is presented in Table 3.

Table 3. Category of Problem-Solving Ability

No.	Value Interval	Category
1.	81-100	Very high
2.	61-80	High
3.	41-60	Quite
4.	21-40	Low
5.	≤20	Very Low

(Elvianasti et al., 2022)

The range of problem-solving abilities is known to span from a very low category with a value interval of ≤ 20 to a very high category with a value interval of 81-100, based on Table 3.

Data from ANCOVA (Analysis of Covariance) analysis are presented in Table 4.

Table 4. ANCOVA Analysis Results

Dependent Variable: Posttest

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	7427.652[a]	2	3713.826	109.481	.000
Intercept	10002.407	1	10002.407	294.865	.000
Pretest	6625.572	1	6625.572	195.318	.000
Strategi	1450.945	1	1450.945	42.773	.000
Error	2001.396	59	33.922		
Total	278051.000	62			
Corrected Total	9429.048	61			

In accordance with Table 4. The significance value of the strategy is found to be 0.000 < 0.05. Ha is therefore accepted while H0 is rejected. Consequently, the Thinking Empowerment by Questioning method has a significant effect on problem-solving skills.

It is understood from the ANCOVA test findings that there is a considerable impact of the Thinking Empowerment by Questioning strategy on problem-solving skills, indicated by the smaller significance value of the strategy, which is 0.000 < 0.05. This is because, in the experimental class taught with the TEQ strategy, students are trained to solve the problems listed in the student worksheet to be able to build their better understanding of the. In student worksheets, questions are presented that are arranged to be interrelated and logically intertwined, a characteristic of TEQ worksheets. Such questions can help students think about how to solve problems. In its context with problem-solving, the TEQ strategy can help individuals explore relevant information, propose alternative solutions, and analyze various aspects related to problem-solving. Jacques et al., (2020) assert that one of the most crucial aspects of the classroom learning process is the act of asking questions. Students can expand their knowledge by responding to the questions posed, and the teacher will then assess their responses (Hathcock et al., 2014). In this sense, questions can help students learn how to solve problems they encounter, particularly if the questions are based on the students' actual problems The results of this analysis are reinforced by the acquisition of a higher mean experimental class problem-solving ability, with the number 69.42. While the control class is 62.23. Although the problem-solving ability category of both classes is equally high.

Thus, the TEQ strategy can improve students' ability in problem-solving. The thinking skills of students in the experimental class taught with the TEQ strategy are more trained because the learning process cannot be separated from questions so the ability to solve problems is more skillful. The questions are a problem that must be solved by answering them. This process of finding answers trains the ability to think. Repetition of questions will help students gain a better understanding of the material. In line with the drill theory, doing the same activity repeatedly aims to form automatic patterns or habits in students so that they have higher skills and dexterity than what is learned (Wolcott et al., 2021). Exercises that are given repeatedly and planned help students to think analytically.

Through a series of questions given on the TEQ sheet, students try to answer them to solve the problem. Answering these questions can trigger students' thinking skills and help them solve problems. Ramdiah & Corebima, (2014) stated, that through TEQ learning students will try to answer the questions so that it triggers them to think and find answers to existing questions. Thus, the way of thinking will develop thinking skills so that it can solve problems. According to Kusuma et al., (2021), as part of the learning process for finishing the TEQ worksheet, students look for information, pick up knowledge, and record their thoughts and observations in writing. Students can develop their metacognitive abilities through this exercise. This is so that students can see various approaches to problem-solving by examining his thought process as it was expressed in his writing.

The thinking process involves students learning through repetitive activities, memorizing, understanding, and reflecting to achieve effective learning outcomes and thus improve skills in problem-solving (Rodzalan & Saat, 2015). Empowering the thinking process can be done through the questioning method. The thinking process will be stimulated by activating questions. Through questions, students can form new learning (Anggraini, 2016). New learning is the initial information obtained which is then processed and stored in Short Term Memory (STM). STM plays an important role in the thinking process, which is used as partial storage of problems in problem-solving activities while accessing information from Long Term Memory (LTM) that is relevant to a problem so that it can become complete information in solving problems.

In the experimental class taught with the TEQ strategy, students are more encouraged to think so that they will train their high-order thinking skills. Critical thinking and metacognition are part of higher-order thinking. Some research results show that the TEQ strategy contributes to the improvement of critical thinking and metacognition. These two cognitive aspects are known to have a close correlation to problem-solving ability. Nur et al., (2023) revealed that the TEQ strategy is an effective active learning to encourage students' critical thinking in science learning. Sulianto et al., (2018) reported that the two skills—critical thinking and problem-solving have a strong association. In the absence of a unidirectional relationship between critical thinking and issue-solving, problem-solving abilities will decline. The TEQ strategy triggers students to think so that if applied continuously it is believed that students will be skilled at thinking and students can regulate their thinking processes. The regulation of this thinking process can then be referred to as metacognitive skills (Bahri & Idris, 2017). Regarding the relationship between metacognition and problem-solving, it can be seen from research conducted by Bahiyah et al., (2019) and Lestari et al., (2017) which found that there is a significant relationship between students' metacognitive knowledge and problem-solving ability. Furthermore, Güner & Erbay, (2021), explained that students with high metacognitive skills tend to solve problems correctly by using the right strategy. Meanwhile, those with low metacognitive skills are less able and have difficulty understanding the problem, choosing the right strategy, as well as finding the correct answer.

Based on several studies that reveal that the TEQ strategy can improve the cognitive aspects of critical thinking and metacognition, it can be a trigger that supports the application of the TEQ strategy in improving students' problem-solving abilities. Because critical thinking and metacognition correlate with students' ability to problem-solve. Conversely, there is a

claim that inquiry-based questions play a significant part in enhancing students' capacity for metacognition and self-reflection. When someone is faced with a situation to solve a problem, the process definitely involves a series of questions and evaluations (Can & Inel Ekici, 2021). Inquiry-based learning and problem-based learning are two scenarios of learning models that are inseparably linked to questioning in the classroom setting. Strong questioning strategies, according to Kim & Kim (2016), are an essential part of the learning process because they help students think more deeply about the real-world and contextual issues they encounter.

In problem-solving indicators, there are differences in the mean acquisition of each indicator in the experimental and control classes. The problem-solving indicators in this study are 1) problem identification; 2) formulating the problem; 3) looking for problem-solving strategies; 4) acting on problem-solving strategies; and 5) looking back and evaluating the effects of problem-solving activities (Suhirman & Yusuf, 2019).

The highest indicator acquisition in the experimental and control classes was the first indicator, which is problem identification. The mean score of the experimental class was 91.94, while that of the control class was 94.03. Although the mean score of the experimental class is lower than the control class, the categories in both classes are very high. The second indicator (problem formulation) displayed the same findings, with the control class's mean score being higher than the experimental class's. Then, the lowest indicator in the experimental and control classes was the indicator of reviewing and evaluating the effects of problem-solving activities. The experimental class mean score was 44.97 with a sufficient category. Meanwhile, the mean score of the control class was 26.29, which is a low category. In general, the indicator with the highest gain in the experimental class is the one that refers to problem-solving. While the control class is problem identification.

Differences in results were obtained in the first and second indicators, where the mean score of the control class was higher than the experimental class may be related to the limited time available, so learning did not run optimally. Another equally significant factor is the condition of students who are more proficient in providing answers to questions than in identifying issues and then posing them as questions. This situation is in opposition to the TEQ strategy's standard features, which employ questions as a tool or instrument to strengthen students' critical thinking skills. In this case, more instruction is needed to help students identify and find specific problems that can be applied in their daily lives and problems that require solutions. In contrast, the higher indicators of problem-solving in the experimental class are those that refer to problem-solving because students are more accustomed to solving or answering questions in the TEQ sheet so they are better able at finding problem-solving steps. Bahri & Idris (2017) said students are used to answering questions on the TEQ sheet so that it can stimulate their critical thinking. The TEQ strategy helps students think analytically and creatively. Asking questions on TEQ sheets is a form of learning activity that can develop skills in problem-solving (Utami & Dewi, 2020). Critical thinking will be increasingly focused on the TEQ syntax of the “Think” and “Evaluation” stages because it contains conclusions from the learning material. This phase raises more analytical questions and requires high-level thinking skills that are problem-solving-oriented. According to Yasir et al., (2020) which states, questions at the reflection stage usually re-emerged in the thinking and evaluation part, but with a higher level of difficulty. While the "Contemplate" phase only contains concepts and sub-concepts included it is an extension of concepts. The general structure of the TEQ sheet is: prepare, conduct, contemplate, think, evaluate, and command (Kusuma & Baskara, 2022). The preparation stage is setting up the TEQ worksheet, conduct is answering the questions in the TEQ sheet which is directly directed at the contemplation stage, and command is the stage of seeking information from uncleared material.. Then, the category equation obtained by the experimental and control classes refers to the interval of assessment of students' problem-solving skills that have been determined to

be in the same categorization range. However, in terms of mean scores, the experimental class is significantly different from the control class.

Furthermore, the acquisition of the fifth problem-solving indicator, reviewing and evaluating the effects of problem-solving activities, is the lowest because students already feel confident in their respective answers, so they feel no need to see or cross-check the answers. Purnamasari & Setiawan (2019) also explained that students' difficulties when reviewing or on the indicator of re-examining answers, that is, when students do not know how to cross-check correctly and students could not manage the timing of the work properly. In an effort to overcome the weakness of these indicators, the need to encourage students to think reflectively is the ability of students to associate new knowledge with previous knowledge so that they can draw conclusions about how to solve new problems. Reflective thinking makes a person, whether certain or not, about how to solve a problem, so it encourages them to do research repeatedly until they find a solution. Improvement of reflective thinking can be done through habituation and practice. The question-based TEQ strategy can stimulate students' reflective thinking through thinking exercises with repeated questions (Fedinafaliza et al., 2021; Sukini et al., 2020). Questions that are interrelated with each other from the TEQ syntax will encourage students to recall what was previously learned. This triggers the acquisition of a higher mean of the indicator of reviewing in the experimental class.

Conclusion

The data analysis and hypothesis testing results indicate that the Thinking Empowerment by Questioning (TEQ) technique substantially impacts students in biology learning class X SMAN 1 Bayan's ability to solve problems. Teachers could, therefore, use this TEQ technique when teaching biology to help students become more adept at addressing problems, particularly when it comes to content on environmental change.

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