

# Analysis of Biological Problem Solving Ability in Environmental Change Materials

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**Abstract:** To solve problems accurately and focused, students must have problem solving skills. The purpose of this study was to evaluate class X students of SMA N 4 Yogyakarta in the even semester of the academic year. This study uses a descriptive quantitative research method. As a sample used simple random sampling. According to Polya, there are four indicators of problem-solving ability: Understanding the problem, preparing, implementing plans, and re-checking are steps that must be taken. On the topic of environmental change, the test instrument revealed that students' problem-solving abilities were in the high range. But if we look at each indicator separately, we can see that all four of them belong to a group. This is because students do not double-check their written answers and continue to doubt these answers. The non-test instrument study, on the other hand, the non-test instrument study found that students' problem solving abilities were very good. Based on these findings, it can be concluded that the students' overall problem solving abilities are of a high standard. Because research findings cannot be used with all materials, problem solving skills must be tested with different materials.

**Keywords:** Biological; Problem-solving skill; Science Learning

## Introduction

The challenge of improvement in science and technology requires students to possess the skills in the 21st century that will be used to compete against the era of globalization and accelerate the rapidly evolving information flow. High-level thinking skills are a very important skill in the 21st century. High-level thinking skill is defined as the highest level of thinking skill that requires students to include analysis, evaluation and creating synthetics (Turiman et al., 2012). High-level thinking skills are grouped into 4 domains consisting of the digital age, inventive thinking, communication and productive. The 21st century is regarded as a century of transformation in various fields, especially education that requires various skills, one of which is problem-solving skills (Epstein et al., 2002).

Problem solving skill is actually needed in the learning process of science, since science learning cannot be separated from the combination of thinking skills and creativity skill to create a new product. Problem solving

skill is a kind of expert thinking that has a strong desire to solve problems in life. Each student has different problem solving skills and it is influenced by several factors (Selcuk et al., 2008). According to Mourtos et al. (2004), there are six aspects that can be used to measure the extent to which the student problem solving skills, namely 1) define the problem; defining problem encountered, describing problems encountered, determining the information that must be known to define problem, and justify the basis of the criteria to determine the final product, 2) explore the problem, determining the problem-related object, examining the problem related to the assumptions and stating the hypothesis related to the problem, 3) planning the solution in which the student develops a plan to solve the problems, mapping out sub-material related to the problem, select the theory of principles and approaches appropriate to the problem, and determining information to find the solution, 4) implement the plan, at this stage students apply the plan that has been set, 5) solution; evaluating the solution used to solve the

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problem; and step 6) evaluate; in this step, the solution is checked, assumptions related to the solution is made, estimating the results obtained when implementing solutions and communicate solutions that have been made (Mourtos et al., 2004).

Biology as one of the sciences in learning, focuses on a process skills approach that the teacher hopes can encourage students to have the ability to solve problems through the scientific method, and imitate the way scientists work in discovering new facts (Nugraha et al., 2019). Therefore, in learning biology a scientific approach must be applied that emphasizes the process of discovery and giving direct experience using learning methods, for the educational process through problem-solving skills. The learning outcomes of each student are expected to be more meaningful, and the results of the learning process can be beneficial for students. Agustina (2012), state that learning to solve problems is basically learning to use scientific methods or to think systematically, logically, regularly, and thoroughly.

Research suggests that problem-based learning approaches that use ill-defined problems facilitate learning and conceptual change and the ability to transfer that learning to other domains (Kitchener et al., 1981). In a problem-based learning environment, instructors function as "metacognitive coaches" (Barrows, 1988) rather than simply information presenters or discussion leaders. In their well-known report, *Science for All Americans*, Rutherford and Ahlgren (1990) discuss the potentials of ill-defined problem solving for enhancing not only subject matter learning, but also the metacognitive skills that are integral to scientific literacy: "Students should be given problems-at levels appropriate to their maturity-that require them to decide what evidence is relevant and to offer their own interpretations of what the evidence means. This puts a premium, just as science does, on careful observations and thoughtful analysis. Students need guidance, encouragement, and practice in collecting, sorting and analyzing evidence, and in building arguments based on it." Instructional approaches that utilize ill-structured problem solving not only result in increased learning (Gallagher et al., 1995) and information retention (Boud et al., 1991), but also encourage epistemological understanding of the discipline (Wilkinson et al., 1991) and enhance motivation (Carter, 1988). In this paper we discuss an instructional approach that makes use of collaborative problem-based learning to accrue these benefits and encourage conceptual change.

According to Indriyanti et al. (2019), the ability to solve problems is one of the focuses that the teacher wants to achieve, because through problem solving skills students can actualize what they get from learning

to then apply it in their lives. The process of solving a problem certainly requires steps to find a solution. According to Polya in Anwar (2013) there are four indicators that must be carried out to arrive at solving the problem, namely: 1) Understanding the problem, 2) Developing a plan, 3) Implementing the plan, and 4) Checking again. In the first stage, students must understand what problems will be solved by knowing in advance what scientific phenomena are happening and what are the obstacles or obstacles that occur and the causes of these scientific phenomena. Then, from the obstacles or constraints and causes, students can think of solutions by developing what kind of plans to overcome the obstacles. Next, students begin to carry out plans that have been prepared beforehand carefully. After students carry out their plans, students must check again whether the plans carried out are appropriate and what kind of results are supported by strong arguments. Judging from the learning activities of teachers and students in solving a problem, the teacher has implemented problem solving indicators but students still need to be assisted by the teacher so that they have directed and systematic thinking according to the indicators.

One of the materials in science subjects that requires problem solving skills is Environmental Change. Sumampouw et al. (2018) revealed that based on several studies, currently around our environment both water, air and soil have undergone many changes in composition so that the environmental balance is disturbed. This is due to environmental pollution. Therefore, it is very important for students to understand and know the causes and ongoing impacts so that students can solve this problem and find the right solution. In line with the research results of Astuti et al. (2020) it shows that students' ability to solve problems is in the low category. Students are only able to achieve two indicators in problem solving, namely understanding the problem and making plans. The research objective was to analyze students' abilities in solving problems related to environmental change issues so that the results can be a reference for subsequent research in developing students' problem solving abilities. the purpose of the study was to determine the problem-solving abilities that exist in schools, and to analyze the problem-solving abilities of students.

## Method

Quantitative descriptive is used in the research method. The research was conducted at SMA Negeri 4 in Yogyakarta. The instruments used were questions (tests) and questionnaires (non-tests). The population used in the study was 280 students of class X. The

sampling technique used was simple random sampling. Samples were taken as many as 28 students using the formula according to Gay and Diehl (1992), namely: Sample = 10% x population.

### Result and Discussion

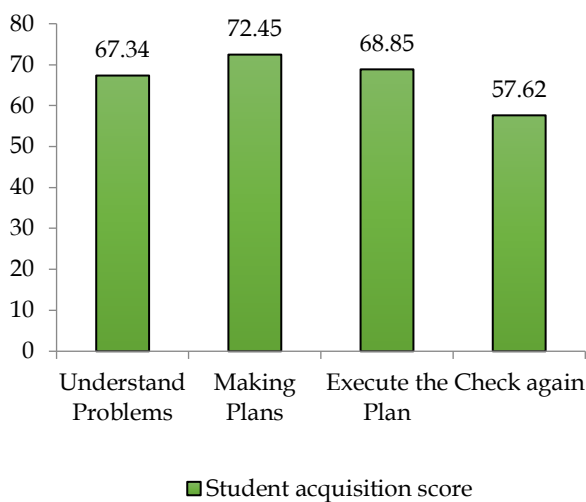
#### Problem Solving Ability Based on the Test Instrument

Analysis of problem solving abilities with test instruments is obtained by using questions with a score range of 0-3. The data on the results of the frequency distribution of students are presented in the table below:

**Table 1.** Results of Student Test Frequency Distribution

No	Value Intervals	Criteria	Frequency	Alternative Frequency
1	81 - 100	Very high	6	15.36
2	61 - 80	High	20	51.32
3	41 - 60	Enough	13	33.31
4	21 - 40	Low	0	0
5	≤ 20	That's low	0	0
Amount			39	100
Average			65.64	
Criteria			High	

Table 1 shows that there were 6 students who got very high criteria with a percentage of 15.36%, 20 students who got high criteria with a percentage of 51.32%, and 13 students who got sufficient criteria with a percentage of 33.33 %. In this test instrument, the average value of the accumulated results of all students' scores was 65.64 and could be categorized into the High criteria. The results in the table above can be translated back based on the four indicators of problem solving ability so that the results in the following diagram are obtained:



**Figure 1.** Diagram of indicators of problem solving ability in problems

The table above is four indicators of problem solving abilities with each average score of the level of understanding of students. The indicator of understanding the problem obtains a score of 67.34% with high criteria. In this indicator students are considered able to understand the problem if students can determine the main problem and mention the causes and effects of the problem correctly. The indicator for preparing a plan obtains a score of 72.45% with high criteria. In this indicator students are considered capable of making plans if students can find the right way or solution. The indicator of carrying out the plan obtains a score of 68.85% with high criteria. In this indicator students are considered capable of carrying out the plan if they can carry out the previous indicators. The last indicator is to check again which gets a score of 57.62% with sufficient criteria. Students are said to be capable if students check back against previous indicators.

Problem solving ability is the ability of students to solve problems in a gradual way. Problem-solving ability has four indicators that can be used to analyze the problem-solving abilities of SMAN 4 Yogyakarta students, namely understanding problems, making plans, implementing plans and checking again. The results that have been obtained indicate that the average value of students' problem solving abilities is included in the high criteria. Overall, students are able to develop their thinking so they are able to solve the problems listed in the questions. However, if analyzed for each indicator, it can be seen that the rechecking indicator has the lowest percentage and is included in the sufficient criteria.

This is not in line with the results on the questionnaire sheet. Overall, the results of obtaining student questionnaire sheets show that students are able to understand the questions. This can be seen in the acquisition of an average value which indicates that the questionnaire instrument is included in the high criteria. There are four indicators of problem solving ability and three of them are included in the high category, namely the indicators of checking again, making plans, and implementing plans. These indicators can help students in completing challenges. Problem solving skills are useful when solving complex and multidimensional challenges that can be developed in active learning that engages students (Mahanal et al., 2022).

The results obtained show that all indicators are in the High criteria with not much different percentages. The lowest result on the accumulation of this questionnaire lies in the indicator of understanding the problem with a percentage of 74.26%. While the highest results in the accumulation of student questionnaires lie in the indicators of planning and re-checking. Both have the same percentage of 80.12%. In addition, the indicator

of carrying out the plan is in the third highest position with a percentage of 81.21%. The average on the questionnaire sheet shows a value of 70.54 so that all students are in the High category.

This condition can occur because students feel that when answering questions it is in accordance with the statements on the questionnaire sheet which contains steps to work on the questions. However, in reality when working on the questions students did not really do it according to the statements on the questionnaire sheet. According to Fan et al. (2021) if students find it difficult to understand the task, it is more difficult for them to comment in describing clearly and completely the steps they are doing.

This is what makes the percentage of the question instrument lower than the questionnaire sheet instrument. The opposite condition occurs in the other three indicators, namely understanding the problem, making plans, and carrying out the plan, students give answers correctly, and students carry out the steps for working on the questions in accordance with the statements on the questionnaire sheet. The indicator of understanding the problem gets high results because in understanding the problem students already understand the situation. This is in line with the opinion Gilad et al. (1983) that the ability to understand problems is the first step for students in solving problems, to recognize problems students must have "knowledge" about the situation.

In solving problems with Polya, students are able to understand the problem but use language that resembles the problem (Marwazi et al., 2019). According to Astuti et al. (2020) students can understand a problem if students can analyze and describe the meaning of the problem. This ability is the first step for students in working on problem solving questions. If students experience mistakes in analyzing questions, students will have difficulty solving problems. The results shown on this indicator in the questions are in line with the results in the questionnaire. The results of students' problem-solving abilities on the questions are included in the high criteria and on the questionnaire sheets are included in the high criteria. This means that the question instrument and the questionnaire instrument are interrelated. Students when working on questions according to the statements on the questionnaire sheet. In the indicator of preparing students' plans is also categorized as high because this step is the next stage after students are able to analyze problems. This is because students can find and plan solutions and problem issues are also related to students' daily problems so that students have obtained an overview in finding solutions. Agree with Anwar (2013) students can find and plan solutions or ways to solve problems in

questions if students are directed to see a problem in questions and with real conditions and do not rely on memory. Polya's problem-solving abilities can guide students so that they not only memorize and remember but also can solve problems in questions by associating them with real conditions and situations (Supiyati et al., 2019).

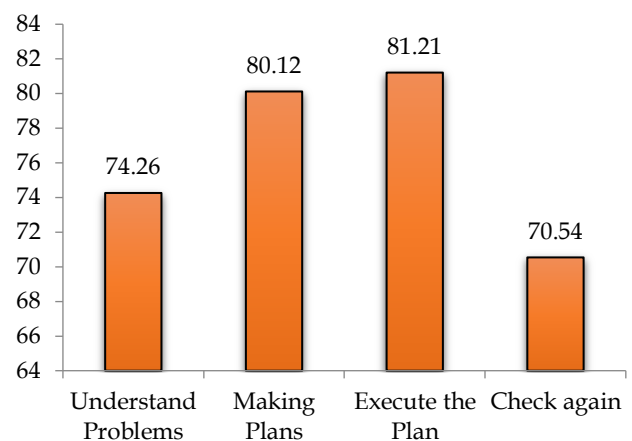
*Problem Solving Ability Based on Non-Test Instruments*

The results of the analysis of students' problem-solving abilities with a non-test instrument in the form of a questionnaire consisting of 20 statements with four possible answers, namely strongly disagree (STS), disagree (TS), agree (S), strongly agree (SS). The frequency distribution data of the questionnaire sheet can be presented as table 2.

**Table 2.** The Frequency Distribution Data of the Questionnaire Sheet

No	Value Intervals	Criteria	Frequency	Alternative Frequency
1	81 - 100	Very high	6	15.36
2	61 - 80	High	20	51.32
3	41 - 60	Enough	13	33.31
4	21 - 40	Low	0	0
5	≤ 20	That's low	0	0
Amount			39	100
Average			65.64	
Criteria			High	

Based on table 2, it can be said that all students can understand each indicator of problem solving and can be translated back based on the four indicators of problem solving ability so that the results are obtained in Figure 2.



**Figure 2.** Diagram of problem solving ability indicators on the questionnaire sheet

The results of the analysis on the indicators for planning are also supported by a questionnaire that has been filled in by students. The results on this indicator

are the highest percentage and this is in line with the results on the question instrument. This means that students are very sure of the answer, understand the intent of the question and can provide the right solution. The indicator of carrying out the plan is the third stage of the problem-solving ability indicator. Students are said to be able to carry out plans if students can choose the right solution and carry out the solution.

The results of the analysis on this indicator show that students are able to carry out the plan well. The indicator of implementing the plan is included in the High criteria. This means that students are able to determine the right solution and involve their experiences in everyday life in order to solve problems. In addition, students are also able to develop their minds and have a systematic mindset. This is in line with Anwar's statement (2013) that at this stage students' systematic mindset in solving problems and accompanied by their experience in solving problems can help students in carrying out indicators of carrying out plans smoothly. The results of the analysis on the questions are also supported by the results of the analysis on the student questionnaire sheet which shows that on this indicator the students really understand the questions and feel confident that the answers they set forth are in accordance with the steps of problem solving abilities. The checking back indicator is the last indicator on problem solving ability. Students can be said to be able to pass this indicator if students double-check the answers to the previous indicators.

In this indicator students are asked to re-check their answers by providing strong arguments to ensure that the answers to the previous questions are correct. This indicator looks easy because they are only asked to re-check and most of the students are lazy to provide arguments so that the answers given cannot support the previous answers. Based on the students' answers, most of them only wrote makeshift arguments and were not strong enough to ensure that the solutions given by students were correct and appropriate. Students assume that the answers given in the previous questions are correct. But there may be mistakes that are not realized by students. This agrees with research conducted by Fitriyana et al. (2022) where the average student error is because they do not re-check the answers that have been written and feel very confident about the answers. This is also in line with the statement of Nugraha et al. (2019) that in this indicator students have not been able to provide evidence that the solutions given are correct.

## Conclusion

Based on the results of the research, it can be concluded that the ability to solve scientific problems in

class X students as a whole is included in the high category. However, of the four indicators of problem solving ability, there is one indicator that is included in the sufficient category, namely the re-examining indicator. This is because students do not double-check their answers and do not provide sufficiently strong arguments for their answers.

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## Author Contributions

The Main author, Sugma Rizki Tri Utami Yustisiana, contributed to designing research, conducting research, and writing research articles. The Second author, Tien Aminatun, played a role in guiding the research to writing articles. The third author, Dina Ayu Kiswandini, played a role in assisting in the implementation of the research and preparing the research instruments used in data collection.

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## Conflicts of Interest

The authors declare no conflict of interest.

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