



# A Preliminary Study on Grade X Students' Problem-Solving Skills as the 21st Century Skills in Biology Course

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**Abstract.** Problem-solving skills are essential skills to face the demands of the 21st century. Problem-solving skills help students to think reflectively in conceptualizing and understanding problems, designing to find the solutions, implementing solutions as well as evaluating the effectiveness of solutions used to solve problems. This study aimed to investigate the problem-solving skills of grade X students at SMA Negeri 1 Majene West Sulawesi on biodiversity and virus topic. A survey was conducted on 123 participants for one month. The data were collected through a problem-solving skills test which adapted from indicator of Greenstein (2012), consisting of 16 questions and then analyzed descriptively. The results showed that the percentage of average score on each problem-solving indicator, which sorted from the lowest category to the highest category; a very low category in the indicator of the applies problem-solving steps (49.09), implement solutions to the real-world applications (49.09) and evaluating solutions (49.70). A low category in the indicator of deductive reasoning (51.12), defending solutions (52.44), identifying the problem (52.85), inductive reasoning (53.56), identifying solutions (55.89). When they are counted as an overall score, the average value of students' problem-solving skills (51.71) was in the low category. Our results indicated that the learning activities might not be problem-solving oriented, which further could not make students act as active learners. Therefore, more efforts are needed to improve students' problem-solving skills, one of which is through the application of certain learning strategies or models that can improve students' problem-solving skills.

**Keywords:** Problem-Solving Skills, 21st Century Learning, Biology Course.

## 1 Introduction

The dynamic expansion of the times requires a way of implementing an education system that focuses on developing 21st-century skills so that students can adapt to the global era [1]. The 21st-century learning requires a wide variety of skills that must be grasped by students in order to solve complex problems in life [2]. Problems are defined as difficulties that stimulate cognitive, affective, psychomotor, emotional, and behavioral abilities to find solutions in a synergal manner [3]. Teachers need to equip students with problem-solving in classroom learning. Problem-solving make it easy for students to understand the concepts in depth and to achieve better learning

achievement [4]. Problem solving is a way of thinking that leads people to identify problems, stimulate initial knowledge related to problems, define problems, explore alternative solutions, execute solutions, enhance data, and evaluate applied solutions. They are all more commonly called as problem-solving skills [5].

Problem-solving skills are multidimensional and comprehensive [6]. Problem-solving skills involve cognitive activities to solve problems using specific discovery steps and to enforce solutions through careful organization of information [7], [8]. Problem-solving skills help students to overcome a problem by collaboration, creativity, thinking abilities, and learning motivation [9]. Problem-solving skills facilitate students' reflective thinking to connect concepts with problems in everyday life [10]. Students with high problem-solving skills will easily understand issues, identify practical solutions, choose the best solution, and make the right decisions [11]. Problem-solving skills consist of eight indicators, namely identifying problems, applying problem-solving steps, identifying solutions, evaluating solutions, defending solutions, implementing in real-world application, demonstrating inductive and deductive reasoning [12]. In the world of real work, problem-solving skills are closely related to individual success in creating solutions.

Some previous research has shown that students' problem-solving skills are still low in other science learning [13], [14], because the learning in class is still not oriented towards problem solving activities, and thus also not placing students as active learners [15]. The other research found that most students have difficulties in understanding issues so that they cannot develop problem solving strategies and fail to create solutions [16]. Furthermore, students were also not fully contributing in formulating solutions and developing arguments to defend solutions in group discussions [17].

Learning at school is needed to improve students' awareness of problem solving. Teachers need to empower students' problem-solving so that they can construct their thinking patterns to carry out problem-solving-based tasks systematically [18]. Problem-solving skills have been confirmed to be the strongest predictor of cognitive ability, self-efficacy, and student learning achievement [19]. So, seeing the potential for problem solving skills that still need to be in line with the reality in the field means that problem solving skills must continue to be utilized optimally. Moreover, problem-solving is an applicable skill in biology learning, which demands complex skills [20]. Constructivist learning theory supports the application of biological concepts in problem-solving activities that position students as the centre of learning that seeks to understand and define their knowledge through problem-solving activities [8].

Biology is concerned with understanding nature systematically. As part of science, Biology requires students to grasp and gather knowledge through discovery and reflect this knowledge on natural phenomena [21]. The broad scope of biology including biodiversity [22] and viruses [23] courses, makes it difficult for students to learn it. These courses examine issues that are considered crucial because they relate to the existence and preservation of living things and pandemics caused by viral infections. Thus, the Merdeka Curriculum expects students to be able to create solutions to problems based on local, national, or global issues related to biodiversity and viruses [24]. Therefore, students' problem-solving skills regarding biodiversity and viruses are essential to improving learning achievement. This research aimed to

assess the problem-solving skills of student grade X in SMA Negeri 1 Majene, Sulawesi Barat, as our effort to enhance the quality of learning and student problem-solving skills by applying innovative learning models.

## 2 Methodology

This study used a quantitative descriptive approach to assess students' problem-solving skills based on the characteristics of the variables studied. The investigation was conducted on 123 students from grade X at SMA Negeri 1 Majene, West Sulawesi. Data collection techniques used problem-solving skill instruments in the form of essay tests on biodiversity and virus materials. The instruments used were first validated by experts in content and biology learning and then tested for validity and reliability, using the *Aiken V index* and the *Cronbach alpha* formula. The results of the validity test and reliability test are 0.80 in a valid category and 0.750 in a high category, respectively. The instrument consists of sixteen question items that lead to 8 (eight) problem-solving indicators as shown in Table 1.

**Table 1.** Problem solving skills indicators.

Indicator	Description
Identifies the problem	The ability to describe a problem specifically in line with the situations
Applies problem solving steps	The ability to use various ways and strategies to solve any problems
Identifies solutions	The ability to find and describe the solutions
Evaluates solutions	The ability to evaluate and analyze all possible solutions before choosing the most precise one
Defends solutions	The ability to analyze all the solutions and pick one that shows an individual's understanding of a problem and the outcome of the solution.
Implement solutions to the real-world applications	The ability to demonstrate problem solving skills in reality
Inductive reasoning	The ability to identify and interpret relevant facts and information that helps someone to draw logical solutions
Deductive reasoning	The ability to work with fundamental principles of a topic and to use relevant generalizations to draw logical conclusions

Source: [12]

The data obtained from the results of the problem-solving skills test by students were then analyzed using descriptive analysis by making a percentage (%). The percentage value was calculated using the Equation (1).

$$N = \frac{SC}{SM} \times 100 \tag{1}$$

Note:

*N* = Score

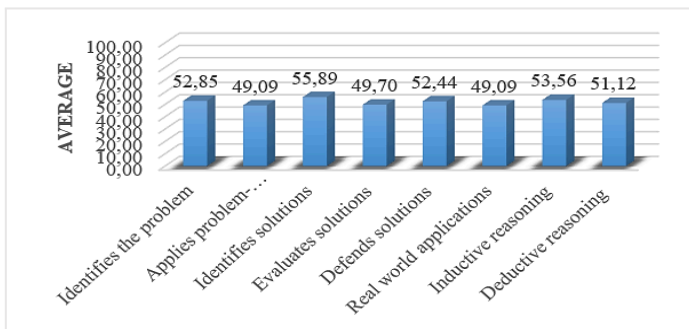
*SC* = Achievement score

*SM* = Maximum score

Each indicator of problem-solving skills had a score that was classified as very high ( $94.25 < XX^b$ ), high ( $79.75 < X \leq 94.25$ ), moderate ( $65.25 < X \leq 79.75$ ), low ( $50.75 < X \leq 65.25$ ), or very low ( $X \leq 50.75$ ).  $X$  means total student scores [14].

### 3 Result and Discussion

The results of the problem-solving skills survey conducted on grade X students of SMA Negeri 1 Majene, West Sulawesi were illustrated in Figure 1. Students' problem-solving skills are described based on eight indicators of problem-solving skills [12]. In addition, the students' problem-solving skills profiles used the average of scores (in %) for each indicator of students' problem-solving skills.



**Fig. 1.** The average score of student's problem-solving skills per indicator

Based on the illustration in Figure 1, identifies solutions are reported as the highest score (55.89), followed by inductive reasoning (53.56), identifies the problem (52.85), defends solutions (52.44), deductive reasoning (51.12), evaluates solutions (49.70), and the same score occur on applying problem solving steps and real-world applications (49.09). Identifies the problem, identifies solutions, defends solutions, inductive reasoning, and deductive reasoning are categorized as low, while the other three indicators, namely apply problem-solving steps, evaluates solutions, and real-world applications, are categorized as very low. When they are counted as an overall score, the average value of students' problem-solving skills (51.71) was in the low category.

The data showed that identifies the problem, or often associated with how to define the problem, is in the low category, meaning that students needed to be more focused on determining the main problem in the discourse. Students were asked to describe the problem in detail. Based on the questions, most students still need to provide an exploratory description of the problem or describe supporting ideas related to the problem. Biology has contextual material, so identifying problems is the most crucial step for students to understand the complexity of problems that lead to knowledge construction [25]. Problem identification facilitates students to spur their intellect in creating innovative solutions and have a meaningful impact [26]. If students can identify qualified problems, then students can quickly analyze and

synthesize unclear problems by collecting data and information packaged into an array of ideas [27]. Research showed that problem identification in biology learning has a positive impact on how students understand the context of the problem systematically, which affects the quantity, quality, inventiveness, and type of solutions produced [28].

Applies problem-solving steps obtained an average score that was in the very low category. The researcher suggested that students needed to be trained in compiling problem-solving steps. Students were instructed to describe the problem-solving steps to be directed in producing solutions. For examining the given answers, most students answered the questions in simple solutions that should be stated in identifying solutions indicator. The answers could have illustrated the flow of student thinking in mapping the problem-solving strategy systematically. The unclear problem-solving steps resulted in a non-optimal solution-finding process. That is because applying problem-solving steps can be a strategy that facilitates students to build knowledge and ideas in a focused manner [29]. An undirected way of organizing problem-solving steps indicates that students need a better knowledge scheme [30].

The average score on the indicator of identifies solutions are also in the low category. Students were asked to find problem-solving solutions based on the given case. Based on the case given, most students needed help to provide alternative solutions to solve the problem explicitly. The answers given by students must provide an overview of conceptualizing problems and biological concepts. Students need to use solution thinking to understand the context of the problem in depth [8]. Solution discovery activities encourage students to associate knowledge from various sources [31]. If students cannot organize the patches of knowledge obtained carefully, it will be easier to solve problems concretely and achieve optimal learning outcomes [7]. Furthermore, ineffective solution discovery plans deprive students of the essential benefits of higher order thinking skills [32].

Evaluated and defended solutions also got an average score that could have been more encouraging. It indicated that students need help evaluating and defending solutions. Students did not describe themselves as problem solvers who can provide logical reasons related to the selection of solutions that will be used to solve the problem. Most of the students' answers did not provide arguments based on biological concepts related to the strengths and weaknesses of the solutions offered. Exploring ideas that needed to be maximized made it easier for students to develop various perspectives, understand, and connect concepts with contextual situations [33]. Whereas idea exploration activities facilitate students to analyze, evaluate, reflect, and conclude various solutions so that self-regulated learning and decision-making skills are formed [11], [34]. Students' ability to evaluate and defend solutions to biological issues was also closely related to metacognitive intelligence [35].

Real-world applications received an average score that was in the very low category. It indicates that students have difficulty demonstrating real-life problem-solving skills. The answers given by students should have described applicable solutions. Students needed to maximize their role in social life to formulate policies. It indicates that students need to be used to being given experiences in real-world problems that put them to make quick decisions, face conflicting solutions, and strengthen supporting evidence [36]. Furthermore, students who need help presenting ideas and organizing evidence systematically make the application of

solutions not optimal [17]. If the noble goal of this indicator is achieved, then the construction of knowledge in the classroom shapes students into individuals capable of handling problems when they are in the world of work [37].

The inductive reasoning and deductive reasoning indicators each obtained a low category. It indicates that students need to have a better ability to provide logical assumptions related to the solution's usefulness. The answers given by students did not include specific examples that showed the validity of the solution given. In addition, most students also needed to display contextual information that connects the solution, the basic principles of the biodiversity and virus material with various aspects of life. At the same time, this inference activity facilitates students to formulate new conclusions and hypotheses regarding unknown things and produce new knowledge [38].

Problem-solving skills are needed to overcome problems in everyday life easily [6]. It is directly related to how students think in the learning process to achieve maximum learning achievement [4]. According to previous research, problem-solving skills have a significant impact on learning achievement because students integrate their imagination, creativity, collaboration spirit, and experimental ability to achieve concept understanding [26]. Someone with good problem-solving skills is formed as a confident, creative, and independent thinker, so it is essential to be empowered [39].

The study material on biodiversity and viruses can stimulate students to perform cognitive performance through information gathering to solve problems. Contextual problems related to the biodiversity and viruses challenge students to be in complex situations. Problem-solving skills refer to the use of procedural knowledge and conceptual knowledge [40]. Accommodating the use of this knowledge requires the application of strategies, approaches and learning models that are innovative, involve active student collaboration, and focus on solving specific problems. Design thinking process is one of the learning models that is believed to empower students' problem-solving skills [33].

## 4 Conclusion

Research findings and data analysis results show that grade X students at SMA Negeri 1 Majene, West Sulawesi have low problem-solving skills. Identifies the problem, identifies solutions, defends solutions, inductive reasoning, and *deductive reasoning indicators are categorized as low, while the other three indicators namely applying problem-solving steps, evaluates solutions, and real-world applications*, classified as very low. Therefore, it can be concluded that all troubleshooting indicators require improvement. This problem-solving skill profile can guide future researchers interested in improving students' problem-solving skills at recommended levels. Investigating and empowering students' problem-solving skills can be through the application of learning models and media that are innovative and based on problem solving. One of the learning models that can be used is the *Design Thinking Process learning model*, which focuses on problem-solving and follows the characteristics of constructivist learning.

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