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Students' Problem-Solving Skills: A Descriptive Study in High School Biology Education

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ABSTRACT

Problem-solving skills are essential competencies in biology learning, which have a broad and complex scope closely related to real-life phenomena. Students are expected not only to understand biological concepts theoretically but also to apply them in formulating solutions to contextual problems. This study aims to analyse students' problem-solving skills in biology learning at the senior high school level. The research employed a quantitative descriptive method with a sample of 105 students from SMA Negeri 11 Makassar, selected through random sampling. The research instrument consisted of 16 essay items developed based on eight indicators of problem-solving skills proposed by Greenstein. Data were analysed descriptively by calculating the percentage of achievement for each indicator. The results show that students' problem-solving skills fall into the low category with an average percentage of 51.62%. The highest achievement was found in the 'identifies solutions' indicator (57.50%), while the lowest was in the 'evaluates solutions' indicator (47.86%). These findings highlight students' difficulties in identifying complex biological problems, applying systematic problem-solving steps, evaluating the effectiveness of solutions, and connecting them to real-life contexts. Therefore, students' problem-solving skills need to be improved through innovative, problem-based, and contextual learning strategies. This study emphasises the significance of active learning approaches in ensuring that biological concepts are not only understood conceptually but also applied meaningfully to address real-world challenges.

INTRODUCTION

Biology is a branch of science that studies living organisms, encompassing structure, body function, adaptation, development, and interactions with the environment (Shen et al., 2018). The field of biology has a broad and continually evolving scope, in line with ongoing advancements in scientific research. The complexity of biological content is evident

in its close relationship with real-life issues concerning science, the environment, technology, and society (Darmawan et al., 2021). Problem-solving skills play a crucial role in learning biology, as students are required to analyze natural phenomena, understand life processes, and devise solutions to various environmental challenges. These skills are particularly crucial for enabling students to integrate abstract biological concepts into real-life contexts, thereby making the acquired knowledge more meaningful and applicable.

Problem-solving skills are defined as the ability to identify a problem, evaluate information, and develop solutions based on that information (Greenstein, 2012). Process-oriented abilities that use critical thinking and methodical observation to identify suitable solutions that accomplish particular objectives are known as problem-solving skills (Wismath et al., 2014). The problem-solving process integrates analytical and critical thinking, reasoning, creativity, and experience (Reeve, 2013).

Problem-solving is a vital competency for individuals to overcome challenges in the workplace and in broader life contexts (Mahanal et al., 2022). For students, these skills are essential in helping them manage their learning and develop their own critical thinking abilities (Ismet et al., 2020). Confident, creative, and independent thinkers are individuals who demonstrate strong problem-solving skills; therefore, these skills must be fostered and empowered (Özreçberoğlu & Çağanağa, 2018).

Integrating problem-solving skills into the school curriculum is crucial for preparing students to face life's challenges that require swift and precise action (Rahman, 2019). Active and structured learning environments that encourage student autonomy and develop a better comprehension of the problem-solving process might help students develop their problem-solving abilities (Wismath et al., 2014). Innovative problem-based learning techniques can be used to develop problem-solving abilities. Problem-based learning in contextual settings encourages students to develop critical thinking skills for addressing real-life problems (Gorghiu et al., 2015).

The importance of problem-solving skills has also been highlighted in initial observations conducted at SMAN 11 Makassar, which indicated that students' skills in this area need improvement. Students demonstrated limited ability to correctly apply problem-solving steps, as well as difficulties in identifying and evaluating solutions based on given texts. Low problem-solving skills are also linked to learning processes that mainly emphasize memorization techniques and focus on textual materials, without involving problem-solving activities (Franestian et al.,

2020). This is consistent with previous studies, which reported that students' problem-solving skills remain low — for example, in Spain, 23% (Polo-Blanco et al., 2024), and in Turkey, 54.6% (OCAK et al., 2022). Similar patterns are evident in Indonesian students' problem-solving skills: in Jakarta, 50% of students were categorized as low (Nuraeni et al., 2020), and in Surabaya, the average percentage of students in the low category reached 33% (Meisaroh et al., 2020).

Various previous studies have focused on the effectiveness of learning models in empowering students' problem-solving skills. Descriptive research that maps students' problem-solving skills in the field of biology learning, particularly in high school, remains limited. Mapping students' initial abilities is crucial as a basis for educators to design appropriate learning strategies.

Based on these findings, problem-solving skills must be strengthened as an essential competency for students to adapt and thrive in today's dynamic and challenging era. These skills enable students not only to resolve problems related to scientific facts in biology but also to address the complexities of real-life issues in the modern world. Therefore, this study was conducted to analyze students' problem-solving skills in biology learning at the senior high school level. The results of this study are expected to provide empirical information about students' problem-solving skills, enabling educators to design appropriate learning strategies that empower high-level thinking skills and improve students' learning achievement.

RESEARCH METHODS

Methods

This study employed a quantitative descriptive research design using a survey method. The population consisted of all students of SMA Negeri 11 Makassar. A total sample of 105 students was selected through random sampling.

Data Collection

Data collection was conducted using a test instrument. The instrument consisted of 16 essay questions that measured students' problem-solving skills, assessed using a rubric adapted from Greenstein (2012) on a scale of 0–4. Before it was used to collect the data, the instrument had undergone construct and content validity tests by experts. An empirical test was conducted to assess the validity and reliability of the instrument. The validity of the test items was assessed using the Pearson product-moment correlation test. The calculated correlation coefficient (r value) ranged from 0.367 to 0.648, while the critical value (r table) was determined to be 0.355. The instrument was reliable, with a Cronbach's alpha of 0.795.

Table 1. Indicators of Problem-Solving Skills

Indicator	Description	Question Number
Identifies the problem	Ability to describe a problem with supporting details related to the situation	1, 9
Applies problem-solving steps	Ability to employ a variety of techniques and methods to address issues	2, 10
Identifies solutions	Ability to identify possible solutions to a problem	3, 11
Evaluates solutions	Ability to assess and examine potential options before deciding on the most practical one	4, 12
Defends solutions	Ability to analyze a solution and then choose the most effective one, demonstrating individual understanding of the problem and its outcome	5, 13
Real-world applications	Ability to demonstrate problem-solving skills in real-life situations outside of school	6, 14
Inductive reasoning	Ability to recognize and evaluate pertinent data and facts that support findings	7, 15
Deductive reasoning	Ability to work with a topic's fundamental ideas and use pertinent generalizations to reach a conclusion	8, 16

Source: Greenstein (2012)

Students completed the essay test in written form, and scoring was carried out according to the problem-solving rubric. The indicators of problem-solving skills were based on Greenstein (2012). The problem-solving skills questions in this study were arranged according to eight indicators, as described in **Table 1**.

Data Analysis

Data obtained from students' problem-solving essay tests were analyzed descriptively by calculating percentages (%). The percentage was calculated using formula.

$$P = \frac{f}{n} \times 100\%$$

Description:

P = percentage

f = score obtained

n = maximum score (Riduwan, 2011)

Percentages were interpreted based on the categories in **Table 2.**

Table 2. Interpretation of Students' Problem-Solving Skills Scores

Percentage (%)	Category
$X \leq 50.75$	Very Low
$50.75 < X \leq 65.25$	Low
$65.25 < X \leq 79.75$	Moderate
$79.75 < X \leq 94.25$	High
$94.25 < X^b$	Very High

[b]Total score of students

Source: Jua et al. (2018)

RESULTS AND DISCUSSION

Figure 1 presents students' digital literacy scores in biology learning, ranging from 47.86 to 57.50 across indicators. Detailed percentages are shown in **Table 3**. **Table 3** demonstrates that the average percentage of students' problem-solving skills in biology learning, as measured through essay tests, was categorized as low (51.62%). The highest percentage was achieved in the indicator 'identifies solutions' (57.50%). The lowest percentage was in 'evaluates solutions' (47.86%).

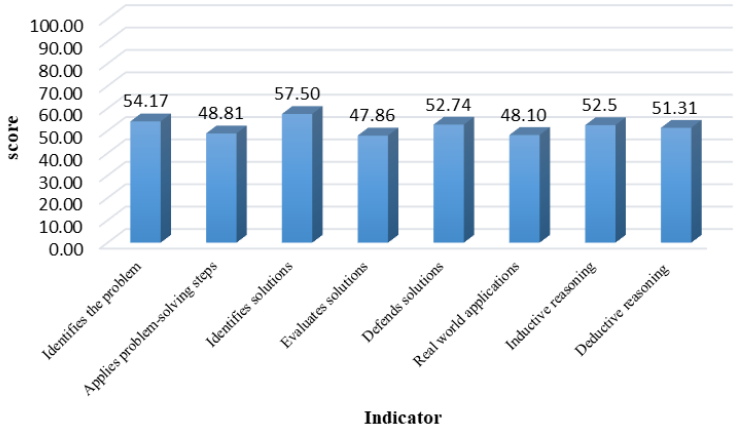

Figure 1. Average Score of Each Indicator of Students' Problem-Solving Skills
Source: Author's Document

Table 3. Percentage of Students' Problem-Solving Skills in Biology Learning

No.	Indicator	Total Score	Mean Score	Percentage	Category
1	Identifies the problem	455	54.17	54.17%	Low
2	Applies problem-solving steps	410	48.81	48.81%	Very Low
3	Identifies solutions	483	57.5	57.50%	Low
4	Evaluates solutions	402	47.86	47.86%	Very Low
5	Defends solutions	443	52.74	52.74%	Low
6	Real-world applications	404	48.10	48.10%	Very Low
7	Inductive reasoning	441	52.5	52.5%	Low
8	Deductive reasoning	431	51.31	51.31%	Low
Total		3469	412.98		
Average		433.63	51.62	51.62%	Low

The descriptive analysis revealed variations across indicators. The indicators identify the problem, propose solutions, defend solutions, and employ inductive and deductive reasoning, which were categorized as low. Meanwhile, applying problem-solving steps, evaluating solutions, and real-world applications were categorized as very low.

The low performance in problem-solving skills was attributed to students' limited ability to correctly apply problem-solving steps, identify and evaluate solutions, and connect these to contextual situations. This finding is consistent with previous studies, which indicate that conventional learning in schools often emphasizes memorization and text-based approaches, with minimal problem-solving practice (Franestian et al., 2020). Teachers frequently provide questions whose answers can be directly retrieved from the internet, which do not stimulate higher-order thinking (Chandra & Heryadi, 2020). Conventional teacher-centered methods, such as lectures, also limit student engagement in the learning process (Meisaroh et al., 2020). These conditions hinder the development of problem-solving skills, which instead require active and structured learning

environments (Wismath et al., 2014).

Problem-solving skills need to be systematically integrated into the school curriculum to prepare students for life challenges that demand speed and Accruracy (Rahman, 2019). Strengthening these skills requires learning environments that are active and structured, allowing students to construct their own knowledge and develop a deep understanding of problem-solving processes (Wismath et al., 2014). Innovative, problem-based instructional models such as phenomenon-based learning can help students practice problem-solving using contextual issues (Gorghiu et al., 2015).

Problems in biology have complex characteristics because they are closely related to real-life issues such as biodiversity conservation, environmental pollution, land conversion, and viral threats affecting human and organismal health (Darmawan et al., 2021; Hainzelin & Nouaille, 2013; Sengupta et al., 2021). Therefore, in addition to theoretical understanding, students must also be able to examine natural phenomena and devise relevant solutions. Problem-solving thus becomes a key competence in biology education, as it helps integrate abstract concepts into real-life contexts, making learning more meaningful (Erdoğan, 2019; Rahman, 2019). Teachers, in this regard, hold a strategic role in designing problem-based active learning strategies that foster logical, critical, and evaluative thinking (Kardoyo et al., 2020).

Students' problem-solving skills for the indicator, which identifies the problem, were categorized as low. This indicator reflects students' ability to identify problems with supporting details related to the context of the given discourse (Greenstein, 2012). Accurately identifying the problem encourages students to seek appropriate solutions (Gustavson et al., 2016). Systematic problem identification influences the quantity, quality, creativity, and types of solutions generated (Mahanal et al., 2022). The findings indicated that students struggled to identify complex and contextual problems, supported by ideas from the given texts. Analyzing problems and phenomena from a discourse helps students develop scientific thinking habits for problem-solving (Fitriyani et al., 2019). Since biology learning is directly connected to real-life phenomena, accurate problem identification serves as a foundation for critical thinking and decision-making (Anggraeni et al., 2023; Turan et al., 2019).

Students' problem-solving skills on the indicator, as measured by applying problem-solving steps, were in the very low category. This indicator reflects students' ability to apply systematic steps of problem-solving to find solutions (Greenstein, 2012). Students should be able to operationalize the problem-solving process, rather than merely

memorizing theories, by using strategies and steps to solve problems. The results showed that students experienced difficulties in applying the problem-solving steps they had learned. Students often skipped several steps in solving problems. Problem-solving is crucial for developing critical thinking, making informed decisions, and identifying effective solutions (Rahman, 2019; Szabo et al., 2020; Xu et al., 2023). It is necessary to use teaching strategies that motivate students to solve problems actively, thoughtfully, and methodically.

Students' problem-solving skills on the indicator, as identified solutions, were categorized as low. This indicator measures students' ability to generate solutions (Greenstein, 2012). Ideally, students provide at least four alternative solutions to identified problems. Findings showed that many students struggled to formulate clear solutions in biology contexts. Some only wrote one or two, which were inaccurate and not true alternatives. This reflects limited divergent thinking. Learning strategies that foster creativity and flexibility are crucial for generating diverse and relevant solutions (Fatmawati et al., 2022; Hsia et al., 2021). Such skills are useful for real problems, for example, strategies to reduce plastic waste. The low results indicate that students are not yet accustomed to divergent thinking for biological problem-solving.

Students' problem-solving skills on the indicator evaluate solutions in the very low category. This indicator measures the ability to consider and evaluate potential solutions before selecting the best one (Greenstein, 2012). Evaluation ensures the chosen solution is correct, effective, and relevant. Findings showed that students had difficulty analyzing the effectiveness of proposed biological solutions. They also struggled to select the most feasible option. Some chose one solution they believed was effective, without confidence in its validity. This indicates limited evaluative skills, as decisions are not based on systematic analysis. Instruction should train students to compare and weigh solutions rationally (Barana et al., 2022; Özpınar & Arslan, 2023). Evaluative skills are essential in biology, for example, when comparing forest conservation methods or eco-friendly pest control strategies.

Students' problem-solving skills on the indicator defend solutions were categorized as low. This indicator reflects the ability to justify a chosen solution with logical reasoning (Greenstein, 2012). Students should explain the selected solution in detail and compare it with other alternatives. The study found that many students were unable to provide logical justifications for their responses. Their explanations were brief, shallow, and lacked comparison. Students are not yet accustomed to argumentative communication. Biology learning should

train students to defend solutions with evidence-based arguments, as this supports rational and accountable decision-making (Alberida et al., 2022; Siswati et al., 2025). Students' decision-making abilities can be trained through problem-based learning (Agustira et al., 2025). Such skills are important, for example, when defending environmental solutions. The ability to argue with scientific data also reflects scientific literacy.

Students' problem-solving skills in real-world applications were categorized as very low. This indicator measures the ability to apply problem-solving skills in everyday life (Greenstein, 2012). Ideally, students should connect classroom solutions with real situations. Findings showed that students struggled to apply biological solutions meaningfully. They could only solve problems when given explicit guidance, showing that their skills were not yet independent or adaptive. This highlights the need for learning that links concepts to real contexts. Such skills enable students to address complex issues flexibly, creatively, and responsibly in real-life contexts, including health, the environment, and biotechnology (Rahman, 2019; Szabo et al., 2020).

Students' problem-solving skills in inductive reasoning were in the low category. This indicator measures the ability to analyze and interpret facts to form conclusions (Greenstein, 2012). Students are expected to use relevant data accurately and effectively. The study revealed that students frequently failed to select or interpret relevant biological information, resulting in weak or inaccurate conclusions. This reflects limited inductive reasoning. Instruction should emphasize data analysis, filtering information, and drawing valid conclusions. Inductive reasoning is essential for logical and evidence-based problem-solving (Cañadas et al., 2017; Haverty et al., 2000; Kamsurya & Ngadino, 2024). It also trains students to think using scientific facts, which is crucial in biology.

Students' problem-solving skills in deductive reasoning were in the low category. This indicator measures the ability to apply theories or principles to specific cases (Greenstein, 2012). Students should be able to conclude consistently with relevant generalizations. The findings revealed that many conclusions were inconsistent with the underlying principles, indicating a weakness in applying conceptual knowledge. Instruction should reinforce conceptual understanding and train students to apply principles in varied contexts. Deductive reasoning is vital in biology, as it enables students to form logical, structured, and accountable conclusions (Carreira et al., 2020; Józsa et al., 2024).

The findings of this study have significant practical implications for biology

learning in schools. Teachers need to act as facilitators, guiding students in finding and evaluating solutions independently through contextual, problem-based activities. From a school policy perspective, developing curricula and learning tools that explicitly include indicators of problem-solving skills is also necessary. This indirectly shapes students' readiness to face real-life challenges in the 21st century.

CONCLUSION

This study analyzed problem-solving skills of high school students in biology. The results showed that the average score fell into the low category (51.62%). The highest indicator was 'identifies solutions' (57.50%), and the lowest was 'evaluates solutions' (47.86%). These results indicate that students struggled to identify complex problems, apply problem-solving steps, evaluate solutions, and connect them to real-world contexts. The weakness was caused by biology instruction that emphasized memorization, conventional tasks, and limited use of problem-based learning. Teachers are advised to apply innovative learning models, such as Problem-based learning, Project-based learning, or the Ricosre learning model combined with a flipped classroom approach. These strategies encourage critical, creative, and systematic thinking while improving problem-solving skills. Schools should provide teacher training and supportive environments for active, contextual learning. Future research may test the effectiveness of innovative models or include other variables, such as digital literacy and motivation. Strengthening students' problem-solving skills will make biology learning more meaningful and applicable.

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