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The relationship between creative thinking skills, opportunity identification skills, and problem-solving abilities among biology education students

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Abstract
Understanding of the relationship among creative thinking, opportunity identification, and problem-solving skills among biology education students remains limited. These competencies are essential for fostering innovative, contextual, and SDG-oriented biology learning. This study aims to analyze the relationship between creative thinking skills, opportunity identification skills, and problem-solving abilities among biology education students. The study was motivated by the limited number of studies that simultaneously integrate these three skills within the context of biology education. The research employed a quantitative approach with a correlational design. The research sample consisted of 405 biology education students from several universities in East Java, selected using simple random sampling. The research instruments comprised tests and questionnaires that had been validated for validity and reliability. Data analysis utilized prerequisite tests (normality, linearity, and multicollinearity), Pearson's correlation test and multiple linear regression. The results indicated that creative thinking skills ($r = 0.175$; $p < 0.05$) and opportunity identification skills ($r = 0.228$; $p < 0.05$) had a positive and significant relationship with problem-solving abilities. Simultaneously, both variables had a significant effect ($F = 15.824$; $p < 0.05$) with a contribution of 7.3% ($R^2 = 0.073$), whereby the ability to identify opportunities had a more dominant influence. These findings highlight the importance of developing these skills in an integrated manner within biology education to support the Sustainable Development Goals (SDGS).

Keyword: correlation; creative thinking; opportunity identification skills; problem-solving ability; biology education students

Abstrak. Pemahaman mengenai hubungan antara keterampilan berpikir kreatif, identifikasi peluang, dan pemecahan masalah pada mahasiswa pendidikan biologi masih terbatas. Padahal, ketiga keterampilan tersebut merupakan kompetensi penting untuk mendukung pembelajaran biologi yang inovatif, kontekstual, dan berorientasi pada pencapaian SDGs. Penelitian ini bertujuan untuk menganalisis hubungan antara keterampilan berpikir kreatif, keterampilan mengidentifikasi peluang, dan keterampilan pemecahan masalah pada mahasiswa pendidikan biologi. Penelitian ini dilatarbelakangi oleh masih terbatasnya kajian yang mengintegrasikan ketiga keterampilan tersebut secara simultan dalam konteks pendidikan biologi. Penelitian menggunakan pendekatan kuantitatif dengan desain korelasional. Sampel penelitian berjumlah 405 mahasiswa pendidikan biologi dari beberapa perguruan tinggi di Jawa Timur yang dipilih menggunakan teknik simple random sampling. Instrumen penelitian berupa tes dan angket yang telah diuji validitas dan reliabilitasnya. Analisis data menggunakan uji prasyarat (normalitas, linearitas, dan multilkolinearitas), uji korelasi Pearson dan regresi linear berganda. Hasil penelitian menunjukkan bahwa keterampilan berpikir kreatif ($r = 0,175$; $p < 0,05$) dan keterampilan mengidentifikasi peluang ($r = 0,228$; $p < 0,05$) memiliki hubungan positif dan signifikan dengan keterampilan pemecahan masalah. Secara simultan, kedua variabel berpengaruh signifikan ($F = 15,824$; $p < 0,05$) dengan kontribusi sebesar 7,3% ($R^2 = 0,073$), di mana keterampilan mengidentifikasi peluang memiliki pengaruh yang lebih dominan. Temuan ini menunjukkan pentingnya pengembangan keterampilan tersebut secara terintegrasi dalam pembelajaran biologi untuk mendukung tujuan Pembangunan Berkelanjutan (SDGs).

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INTRODUCTION

Creative thinking, opportunity identification, and Problem-solving abilities are part of Higher Order Thinking Skills (HOTS), which are key requirements in 21st-century education. Creative thinking skills are an essential aspect that prospective biology teacher trainees must possess. This is because prospective teachers are not only required to master biological concepts. This is due to the demands of the teaching role, which requires not only mastery of biological concepts but also the ability to design innovative, adaptive, and contextual learning (Alberto et al., 2024; Rahmawati & Turista, 2026).

Prospective biology teachers are required to possess pedagogical, professional, social, and personal competencies integrated with 21st-century skills such as creativity, critical thinking, and problem-solving. Creative thinking skills enable prospective teachers to develop new ideas in designing engaging and meaningful biology lessons. Creative teachers are also able to link biological concepts to real-world phenomena and devise varied teaching methods that can enhance student engagement and active participation (Mróz & Ocetkiewicz, 2021).

The skill of identifying opportunities is a strategic skill that supports the professionalism of prospective biology teachers. This skill enables students to recognise the potential of the environment, contextual issues, and relevant learning resources to be utilised in teaching. In the context of biology education, the skill of identifying opportunities is closely linked to everyday life and environmental issues. Consequently, the ability to spot opportunities is crucial to ensure that learning is more contextual, relevant, and meaningfu(Faizah et al., 2024; Jeronen & Jeronen, 2026).

The ability to find solutions to problems is an essential competence for prospective biology teachers. The biology learning process often involves complex problems, whether in conceptual aspects, practical activities, or their application in real life. Therefore, prospective teachers are required to be able to analyse problems systematically, evaluate various alternative solutions, and determine the appropriate solution based on scientific principles. Problem-solving abilities play a crucial role in supporting effective and responsible decision-making in the learning process (Nguyen et al., 2017; Todorova et al., 2025).

These three skills are interrelated within an integrated thinking process. Creative thinking plays a role in generating a variety of alternative ideas; the skill of identifying opportunities helps to select and capitalise on promising ideas; whilst the skill of problem-solving serves to implement these ideas into effective and practical solutions. The link between creativity and problem-solving has been extensively demonstrated in various studies, which show that creativity contributes significantly to Problem-solving abilities (Amin et al., 2020; Purwanti et al., 2024). Strengthening these competencies is also in line with the objectives of the Sustainable Development Goals (SDGs), particularly Goal 4 (*Quality Education*)**,** which aims to ensure inclusive and quality education. In this context, biology education plays a strategic role in supporting the achievement of the SDGs through the development of creative thinking skills and the ability to find solutions to problems based on sustainability issues (Anwar et al., 2025; Saseendran & Thomas, 2025). Learning that integrates the context of the SDGs has been shown to enhance students' creativity, critical thinking skills, and Problem-solving abilities (Pamungkas et al., 2025; Reviola et al., 2026).

Previous studies have shown that creative thinking and Problem-solving abilities are key competencies in biology education and sustainable education. Nurwidodo et al. (2023) found that improvements in creative thinking skills contribute to Problem-solving abilities among prospective biology teachers. Furthermore, other studies have also shown that innovative learning approaches such as STEM and design thinking can significantly enhance creativity and Problem-solving abilities (Hu et al., 2025; Pamungkas et al., 2025). However, the majority of existing studies tend to examine these skills in isolation or focus primarily on creativity and problem-solving as distinct entities. There is a noticeable scarcity of research that simultaneously integrates "opportunity identification skills" as a mediating variable within the context of biology teacher education. This skill acts as a crucial bridge converting creative potential into actionable solutions yet it remains underexplored in pedagogical literature. Consequently, a comprehensive analysis of how these three variables interact is missing.

The development of SDG-based learning systems also emphasises the importance of integrating creative thinking and Problem-solving abilities within science education (Pinareswati et al., 2025; Taufik et al., 2026). However, the majority of these studies still focus on the development or enhancement of skills in isolation, and have not yet comprehensively examined the relationships between these skills. In particular,

the skill of identifying opportunities has rarely been studied as a key variable in the context of biology education, even though this skill acts as a bridge between creativity and problem-solving. This indicates a research gap in the form of a lack of studies analysing the relationship between creative thinking skills, the skill of identifying opportunities, and Problem-solving abilities simultaneously among biology education students. Yet, an understanding of the relationship between these three skills is vital as a foundation for designing learning that can develop various competencies simultaneously. Therefore, this research is important to provide both theoretical and practical contributions in designing an integrated curriculum for biology teacher education.

This research is important because its results are expected to provide both theoretical and practical contributions. Theoretically, this study can enrich the literature on the relationships between higher-order thinking skills in biology education. Practically, the findings can serve as a basis for educators and curriculum developers in designing learning models capable of integrating the development of creativity, the ability to identify opportunities, and Problem-solving abilities simultaneously. Furthermore, this study supports efforts to achieve SDG 4 through the enhancement of the quality of education for prospective biology teachers.

Based on the above, *the state of the art* of this research lies in the integration of 21st-century skills with the context of SDG-based biology education within a correlational approach. The novelty of this research lies in simultaneously examining the relationship between creative thinking skills, opportunity identification skills, and Problem-solving abilities, whilst positioning opportunity identification skills as a variable that has rarely been studied in biology education. This study aims to analyse the relationship between creative thinking skills, opportunity identification skills, and Problem-solving abilities among biology education students.

RESEARCH METHODS

The type of research used is quantitative research with a correlational approach. This study aims to determine the relationship between creative thinking skills, opportunity identification skills, and Problem-solving abilities among biology education students. The variables in this study consist of creative thinking skills (X_1), opportunity identification skills (X_2), and Problem-solving abilities (Y). A diagram illustrating the relationship between the three variables is presented in Figure 1.

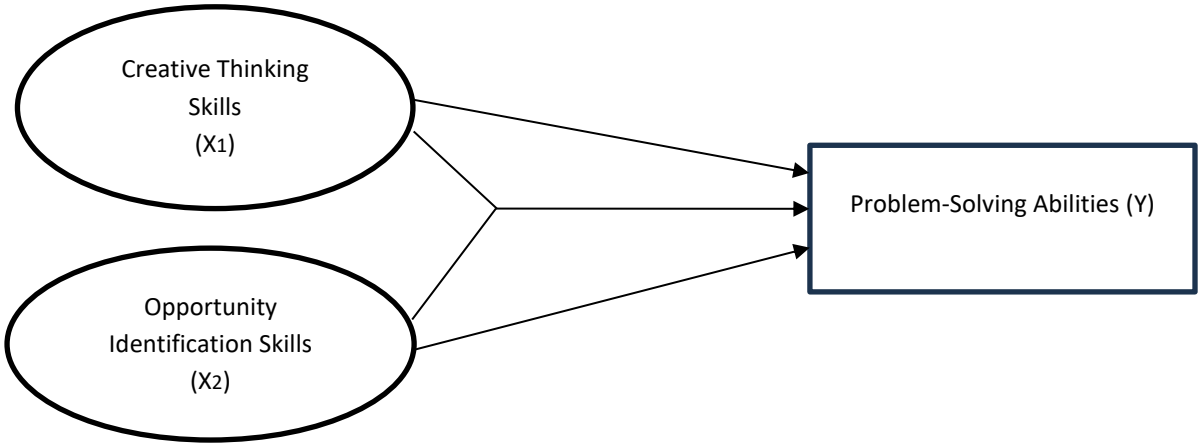


Figure 1 Diagram of relationships between research variables

The study was conducted among students on the Biology Education programme at universities in East Java Province, Indonesia. The sample for this study was selected using *simple random sampling* from a population of 1,481 students on the Biology Education programme from several universities in East Java, Indonesia, namely Malang State University, Muhammadiyah University of Malang, Muhammadiyah University of Surabaya, Muhammadiyah University of Jember, Tribhuwana Tunggadewi University, and

Insan Budi Utomo University. A random number generator was utilized to select 405 students from the complete population list. The sample comprised 405 students who had completed at least one semester of study on biology-related material (specifically plant biology courses), and were therefore considered to have learning experience relevant to the variables under investigation. The use of *simple random sampling* aimed to provide equal opportunity for every member of the population to be selected as a sample and to minimise bias in the selection of respondents.

The research instruments were first tested for validity and reliability empirically. Prior to the main study, the instruments underwent content validation by three expert judgments in biology education. Subsequently, a trial was conducted. Validity was tested using the product-moment correlation test, whilst reliability was tested using Cronbach's Alpha coefficient. The validity test results indicated that all items in the creative thinking test were valid with correlation coefficients ranging from 0.312 to 0.675, the opportunity identification questionnaire items ranged from 0.330 to 0.720, and the problem-solving test items ranged from 0.305 to 0.680 (all r-values > r-table). The reliability test results showed that the instruments were reliable with Cronbach's Alpha values of 0.85 for creative thinking, 0.88 for opportunity identification, and 0.82 for problem-solving (all > 0.7).

The data obtained consisted of quantitative data from the scoring of each variable. Prior to the main analysis, prerequisite tests were conducted to ensure the data met the assumptions for parametric statistics. A normality test using One-Sample Kolmogorov-Smirnov showed a significance value > 0.05, indicating that the data were normally distributed. A linearity test confirmed linear relationships between the independent and dependent variables, and a multicollinearity test showed VIF values < 10, indicating no multicollinearity issues. Data analysis was carried out using the Pearson product-moment correlation test to determine the partial relationships between variables, as well as multiple regression analysis to determine the simultaneous relationships between creative thinking skills and the ability to identify opportunities with the ability to find solutions to problems. Parametric statistical tests were conducted using SPSS 26 statistical software.

RESULTS AND DISCUSSION

The results of the analysis of the mean scores for creative thinking skills, opportunity identification skills, and Problem-solving abilities among biology education students are presented in Figure 2. Based on the results of data processing using statistical analysis, a Pearson Product Moment correlation test was conducted to determine the relationship between variables, as well as multiple linear regression analysis to test the influence of creative thinking skills and opportunity identification skills on problem-solving abilities. A summary of the results of the Pearson Product Moment correlation test is presented in Table 1.

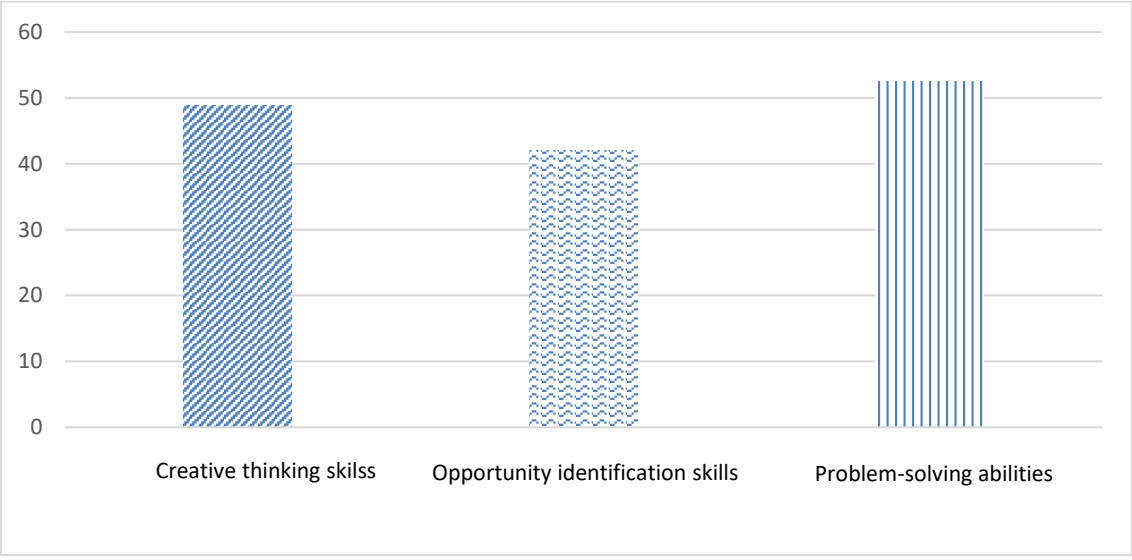


Figure 2 Diagram of the mean scores for creative thinking, opportunity identification, and problem- solving abilities

Table 1 Results of the Pearson Product-Moment Correlation Test between variables

Variable	Problem-solving abilities		
	Pearson Correlation	Sig. (2-tailed	N
Creative thinking skills	0.175	0.000	405
Opportunity Identification Skills	0.228	0.000	405

The results of the Pearson Product Moment correlation analysis indicate that there is a significant relationship between creative thinking skills, the ability to identify opportunities, and Problem-solving abilities among biology education students. The results of the analysis of the relationship between creative thinking skills and Problem-solving abilities yielded a correlation coefficient of 0.175 with a significance level of 0.000 ($p< 0.05$), indicating a significant positive relationship with low strength. Although statistically significant, the relatively low correlation suggests that while creative thinking contributes to problem-solving, it is not the sole determinant. This might imply that students may possess creative potential but struggle to apply it effectively to structured biological problems without additional cognitive support.

Furthermore, the relationship between the ability to identify opportunities and the ability to find solutionsto problems showed a correlation coefficient of 0.228 with a significance level of 0.000 ($p < 0.05$). This value indicates a significant positive relationship with a strength ranging from low to approaching moderate, meaning that the ability to identify opportunities contributes to students' ability to find solutions to problems. Overall, the results of this study indicate that all three variables have a positive and significant relationship, albeit with a relatively low strength of association. This suggests that improvements in creative thinking skills and the ability to identify opportunities can support improvements in Problem-solving abilities; however, other factors also influence these skills.

The analysis of the influence of creative thinking skills and opportunity identification skills on problem- solving abilities was conducted using multiple linear regression analysis. This analysis was carried out to test the simultaneous relationship between creative thinking and opportunity identification skills and Problem-solving abilities. A summary of the regression analysis results is presented in Table 2.

Table 2 Summary of multiple linear regression analysis results and summary of the regression model

Variable	B	Std. Error	Beta (B)
(Constanta)	30.681	5.271	-
Creative thinking skills (X_1)	0.183	0.062	0.146
Opportunity Identification Skills (X_2)	0.122	0.034	0.208

The results of the multiple linear regression analysis indicate that creative thinking skills and opportunity identification skills simultaneously have a significant relationship with Problem-solving abilities. This is demonstrated by a correlation coefficient (R) value of 0.270, indicating a positive relationship between the independent variables and the dependent variable. The coefficient of determination (R^2) value of 0.073 indicates that 7.3% of the variation in Problem-solving abilities can be explained by creative thinking skills and opportunity identification skills, whilst the remaining 92.7% is influenced by other factors outside the model.

The relatively low coefficient of determination ($R^2 = 0.073$) suggests that problem-solving ability is a complex construct influenced by numerous variables not examined in this study. In the context of biology education, problem-solving is likely heavily dependent on content knowledge (mastery of biological concepts), critical thinking skills, metacognitive awareness, and prior learning experiences. Students might possess creativity and the ability to identify opportunities, yet struggle to solve biological problems effectively if they lack a strong conceptual understanding of the biological principles involved.

The test results show that the regression model used is significant, with an F-value of 15.824 and a significance level of 0.000 ($p < 0.05$). This means that creative thinking skills and the ability to identify opportunities jointly have a significant influence on Problem-solving abilities.Partially, the coefficient test results show that creative thinking skills have a regression coefficient of 0.183 with a significance value of 0.003 ($p < 0.05$), meaning that creative thinking skills have a positive and significant influence on Problem-

solving abilities. Similarly, the skill of identifying opportunities has a regression coefficient of 0.122 with a significance level of 0.000 ($p < 0.05$), indicating that this variable also has a positive and significant influence on Problem-solving abilities.

Based on the standardised beta coefficients, the ability to identify opportunities ($\beta = 0.208$) has a greater influence than creative thinking skills ($\beta = 0.146$) on Problem-solving abilities. This indicates that the ability to identify opportunities is the more dominant variable in predicting Problem-solving abilities among biology education students. This finding suggests that in the context of biology education, the capacity to see potential solutions or applications in real-world scenarios is a stronger predictor of problem-solving success than merely generating creative ideas. This aligns with the constructivist view, where learning is most effective when students can connect theoretical knowledge to tangible opportunities in their environment.

The results indicate that creative thinking skills and opportunity identification skills have a positive and significant relationship with Problem-solving abilities, both partially and simultaneously. However, the relatively low coefficient of determination ($R^2 = 0.073$) suggests that these two variables only make a limited contribution, implying that other factors also influence students' Problem-solving abilities. Creative thinking skills were found to have a significant influence on Problem-solving abilities. This is consistent with previous research stating that creative thinking forms the basis for generating various innovative and effective alternative solutions(Mróz & Ocetkiewicz, 2021; Nurwidodo et al., 2023). Creativity enables individuals to view problems from various perspectives and generate new ideas relevant to the context of biology learning (Dilekçi & Karatay, 2023; Purwanti et al., 2024). Furthermore, creative thinking skills also play a role in enhancing cognitive flexibility, which is essential in the process of finding Solutions to complex problems (Amin et al., 2020; Chang et al., 2022).

The results of this study also indicate that the skill of identifying opportunities has a more dominant influence than creative thinking skills on the ability to find solutions to problems. These findings reinforce the view that the skill of recognising opportunities is a crucial skill in linking creative ideas with the implementation of real-world solutions (Faizah et al., 2024; Jeronen & Jeronen, 2026). This skill enables students to select the most relevant and applicable solutions based on the conditions they face (Jiatong et al., 2021; Urban, 2020).

In theory, the relationship between creative thinking, identifying opportunities, and finding solutions to problems can be explained through a constructivist perspective, in which students actively construct knowledge through experience in dealing with real-world problems (Jonassen, 2011). Creative thinking can play a role in the early stages of generating ideas, whilst the skill of identifying opportunities plays a role in filtering and selecting potential ideas to be developed into solutions (Rauth et al., 2010). Furthermore, the skill of problem-solving is used to implement these solutions systematically and effectively.

Furthermore, the findings of this study are also consistent with Bandura's social cognitive theory, which states that cognitive skills such as creativity and problem-solving can enhance an individual's confidence in completing tasks (Bandura, 1997; McGee & Peterson, 2019). These skills are crucial as students are confronted with various complex problems related to natural phenomena and everyday life (Hu et al., 2025; Taufik et al., 2026).

In the context of biology education and the achievement of SDG 4 (Quality Education), these findings have significant practical implications. To support SDG-oriented biology learning, educators should not only focus on content mastery but also explicitly teach opportunity identification within the framework of sustainability. For example, when teaching environmental science, students should be encouraged to identify local environmental issues (opportunities for intervention) and creatively design solutions (problem-solving) (Anwar et al., 2025; Rahmawati & Turista, 2026). This approach ensures that education is not just about acquiring knowledge but about applying it to achieve sustainable development goals such as clean water (SDG 6), life on land (SDG 15), and climate action (SDG 13). By integrating these three skills, biology teacher education programs can produce graduates who are ready to face 21st-century challenges (Pamungkas et al., 2025; Widiana et al., 2024).

Overall, this study confirms that creative thinking skills and the ability to identify opportunities are key factors in enhancing Problem-solving abilities among biology education students. Although their

contribution remains relatively low, these two skills remain the primary foundation for the development of 21st-century skills that support prospective teachers' readiness to face future learning challenges.

CONCLUSION

Based on the research findings, it can be concluded that creative thinking skills and opportunity identification skills have a positive and significant relationship with Problem-solving abilities among biology education students. Although opportunity identification skills exert a more dominant influence than creative thinking, both are vital predictors. However, the relatively low contribution (R^2=7.3%) indicates that problem-solving ability is a complex construct influenced by numerous other factors beyond the scope of this study. Practically, these findings suggest that biology teacher education programs should not only focus on content mastery but must also explicitly integrate training in creativity and opportunity identification. Lecturers are encouraged to adopt instructional models like Problem-Based Learning (PBL) or Design Thinking that simulate real-world challenges, thereby training students to recognize opportunities and apply creative solutions within biological contexts. For future studies, it is recommended to investigate other variables that may contribute to problem-solving abilities, such as critical thinking, metacognition, self-efficacy, or digital literacy. Furthermore, qualitative research could be conducted to explore the deeper cognitive processes of how opportunity identification mediates the relationship between creativity and problem-solving in biology education settings.

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