13 (3) (2024) 180-188

**Unnes Science Education Journal**

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# Fostering Creativity to Enhance Physics Achievement: An Analysis of the Relationship Between Creative Thinking Ability and Student Learning Outcomes

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**DOI: http://dx.doi.org/10.15294/usej.v13i1.14516**

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## Article Info

Submitted 2024-07-11
Revised 2024-08-03
Accepted 2024-08-28

## Keywords

Creative Thingking Ability; Learning Oucomes; Survey; Physics Education

## Abstract

The ability to think creatively is crucial for improving students' learning outcomes. However, in reality, many students whose learning outcomes are low and do not meet the minimum competency criteria. Therefore, this research aims to determine the relationship between creative thinking ability and physics learning outcomes. The study employed survey methods with a correlational approach. The population of this study included 248 students from the XI MIPA class at State Senior High School 9 Gowa. The sample was drawn through simple random sampling, totaling 105 students. The instruments used in this research comprised tests measuring creative thinking and learning outcomes. Descriptive analysis results indicated that the average score for creative thinking ability was categorized as moderately creative, while the average score for learning outcomes was deemed good. The conclusion of this research revealed a significant, positive correlation between creative thinking ability and physics learning outcomes in elasticity and Hooke's law among the XI-grade students. This research may encourage teachers to create more creative learning environments.

## How to Cite

Said, M. A., Ilham, I., & Kadir, M. F. A. (2024). Fostering Creativity to Enhance Physics Achievement: An Analysis of the Relationship Between Creative Thinking Ability and Student Learning Outcomes. *Unnes Science Education Journal*, 13(3), 180-188.

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p-ISSN 2252-6617
e-ISSN 2502-6232

# INTRODUCTION

Modern education emphasizes creativity as a critical component of effective learning. The ability to think creatively, which involves the development of new ideas and innovative solutions, is essential for improving students' learning outcomes, especially in complex subjects like physics (Prayogi et al., 2018). Creativity can enable students to deeply understand physical concepts and apply them in novel situations (Sidek et al., 2020). However, despite this growing recognition, many students struggle to achieve adequate physics learning outcomes, frequently falling short of minimum competency standards (Batlolona et al., 2019). This issue highlights the urgent need to further investigate the impact of creative thinking on physics learning outcomes.

One of the primary challenges in physics education is low academic performance, with many students not meeting minimum competency criteria (Fraser et al., 2014; Tawil et al., 2023). Despite various educational interventions aimed at improving performance, many of these initiatives rely on conventional teaching methods, which often overlook the potential of creativity to enhance problem-solving skills and learning outcomes. Methods such as traditional lectures and routine exercises often fail to engage students or foster the critical thinking skills required for physics (Affandy et al., 2019; Marcinauskas et al., 2024). Previous research indicates a persistent gap in understanding how creativity directly improves academic achievement, despite pedagogical efforts (Widya et al., 2023).

Furthermore, most existing studies do not address the specific relationship between creative thinking and physics learning outcomes, creating a gap in understanding the factors influencing academic performance. While creativity is recognized as important, its specific effect on physics outcomes remains underexplored (Lee et al., 2015; Gunawan et al., 2020; Badeleh, 2021). Research by Widya et al. (2023) proposes that creativity catalyzes learning by fostering innovative problem-solving. Therefore, further exploration into enhancing students' creativity could yield valuable strategies to address low physics performance. Bridging this gap could enhance our understanding of academic achievement factors and improve teaching strategies to boost physics performance.

Existing literature highlights creativity's positive impact on academic performance. Research shows that students engaged in creative activities often develop stronger critical thinking and problem-solving skills essential for physics (Piffer, 2012). A study by Prabaningtias et al. (2021) demonstrated that creative problem-solving improves students' understanding of complex physics concepts. Additionally, learning strategies that integrate creativity boost motivation, engagement, and subsequently learning outcomes (Sarioglan & Ozkaya, 2023). This literature highlights the significant potential of creativity in physics education, but most research remains generalized and not physics-specific.

Although there is substantial evidence that creativity enhances academic performance, there is a significant gap in the literature regarding the specific impact of creative thinking on physics learning outcomes. Previous research has seldom explored the direct connection between creativity and physics outcomes (Fadhil et al., 2021; Nurlaela et al., 2021). Most existing studies use qualitative analyses or case studies, limiting generalizability. Asriadi & Istiyono (2020) noted a focus on theoretical or non-physics creativity applications, leaving gaps in understanding creativity's role in physics achievement.

This study examine how creative thinking correlates with physics learning outcomes. Thus, this research is expected to enhance understanding of creativity's role in physics education and inform teaching practices to improve student achievement.

# METHOD

This study employed a survey-based correlational design. The was to examine the relationship between creative thinking abilities and students' physics learning outcomes. This study involves two variables: an independent variable and a dependent variable. The independent variable was creative thinking ability, while the dependent variable was physics learning outcomes.

The population comprised 248 eleventh-grade students from State Senior High School 9 Gowa. The sampling technique employed was Simple Random Sampling, ensuring every individual in the population had an equal chance of selection. The sample was selected based on Krejcie and Morgan's table, with 105 students chosen at a 5% significance level.

The data analysis employed descriptive analysis to assess students' creative thinking ability and physics learning outcomes. Descriptive statistics were used, including measures such as mean, standard deviation, maximum and minimum values, and variance. A linearity test was subsequently performed to confirm if the relationship between the variables followed a linear trend. This test assessed whether variations in physics learning outcomes corresponded proportionally to changes in creative thinking ability. The linearity test was conducted using SPSS version 16, with a significance value above 0.05 indicating linearity.

The instruments used included tests for both variables (X and Y). The study's design is depicted in the following model:

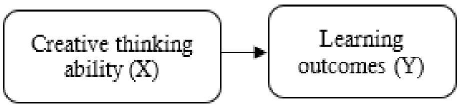


**Figure 1.** The Relationship between Creative Thinking Ability and Learning Outcomes

Essay tests were utilized as instruments. These tests measure four aspects of creative thinking: fluency, flexibility, originality, and elaboration. The indicators corresponding to each aspect are outline (Table 1).

The blueprint for the research instrument provided a framework for crafting test items aligned with the creative thinking indicators. The developed research instrument was validated by two experts and assessed for validity and reliability through the Gregory test. The instrument was then pilot-tested to evaluate question difficulty, and further analyzed for validity and reliability. Ultimately, eight items were deemed valid, with a reliability coefficient of 0.592. For variable Y, seven items were validated, yielding a reliability coefficient of 0.623.

**Table 1.** Indicators of Creative Thinking Aspects

| No | Aspects of creative thinking | Indicators |
|---|---|---|
| 1 | Fluency | Generating many ideas, responses, problem solutions, and questions smoothly |
| 2 | Flexibility | Producing a variety of ideas, answers, or questions |
| 3 | Originality | Being able to create new and unique expressions |
| 4 | Elaboration | Bnriching and developing an idea or product |

## RESULT AND DISCUSSION

This study yielded data on students' creative thinking abilities and physics learning outcomes. Creative thinking ability was measured based on four key aspects: fluency, flexibility, originality, and elaboration. The survey questions assessing creative thinking ability are summarized in the Table 2.

**Table 2.** Research Survey Questions

| No | Aspects of creative thinking | Indicators | Questions |
|---|---|---|---|
| 1 | Fluency | Generating many ideas, responses, problem solutions, and questions smoothly | 1. After learning about elasticity and Hooke's law, what comes to your mind?<br>2. Can you explain what is known and what is being asked in the question? |
| 2 | Flexibility | Producing a variety of ideas, answers, or questions | 1. Do you understand what the question is asking? |
| 3 | Originality | Being able to create new and unique expressions | 1. Have you ever solved a similar question before?<br>2. Do you have alternative ways to answer the question? |
| 4 | Elaboration | Bnriching and developing an idea or product | 1. When solving the question, did you use logical reasoning, or did you just answer randomly? |

Physics learning outcomes were evaluated by examining students' comprehension of key topics, specifically elasticity and Hooke's law. This assessment aimed to gauge students' grasp of these concepts and their ability to apply them in relevant contexts. To provide a detailed understanding of the data collected, a descriptive analysis was conducted, which offered a comprehensive overview of the variables under study. This analysis included critical statistical parameters such as the mean, maximum and minimum values, variance, and data distribution, enabling a thorough examination of the results. A summary of the descriptive statistical analysis, encompassing both creative thinking ability and physics learning outcomes, is presented in the Table 3.

**Table 3.** Descriptive statistics for creative thinking ability and physics learning outcomes

| Statistics | Creative thinking ability | Physics learning outcomes |
|---|---|---|
| Number of samples | 105 | 105 |
| Mean | 77.81 | 78.33 |
| Minimum value | 45.00 | 45.00 |
| Maximum value | 95.00 | 94.00 |
| Range | 50.00 | 49.00 |
| Variance | 98.41 | 83.13 |
| Standard deviation | 9.92 | 9.12 |

Based on the data in Table 1, the descriptive analysis of creative thinking ability and physics learning outcomes provides a detailed overview of the characteristics of the sample, which consists of 105 students. The analysis reveals that the mean score for creative thinking ability is 77.81, with a standard deviation of 9.92. Meanwhile, the mean score for physics learning outcomes is 78.33, with a standard deviation is 9.12.

A smaller standard deviation compared to the mean value indicates that the data on students' creative thinking ability tends to be homogeneous. This means there is little variation in the level of creative thinking among the students, suggesting that the majority of students possess a relatively similar level of creativity (Astawan et al., 2023). This finding is consistent with previous research, which shows that a small standard deviation often indicates consistency in students' performance in certain aspects, such as creativity (Ekayana et al., 2024). In other words, the data on creative thinking ability does not show significant variation among students, indicating that many students exhibit nearly identical levels of creativity.

In contrast, the analysis shows that although the mean score for physics learning outcomes is close to the mean score for creative thinking ability, the standard deviation for physics learning outcomes is slightly larger (9.12) compared to creative thinking ability (9.92). This indicates that there is somewhat greater variation in physics learning outcomes among students. Previous research suggests that differences in standard deviation relative to the mean can reflect variability in understanding and applying concepts, which may be influenced by various external and internal factors (Pont-Niclos et al., 2023).

These findings provide insight that, despite the consistency in levels of creative thinking ability among students, there is greater variation in their physics learning outcomes. This suggests that, although creativity is an important factor, other elements such as teaching methods, individual skills, and external support also influence physics learning outcomes (Parpala et al., 2022).

The indicators of creative thinking ability used in this study are fluency, flexibility, originality, and elaboration. These four indicators were selected because they collectively reflect the core components of creative thinking ability, namely:

1. Fluency: This indicator measures the extent to which students can generate a large number of ideas or solutions when faced with a problem. This is important because the quantity of ideas is an initial indicator of the creative process
2. Flexibility: This indicator assesses students' ability to produce various ideas or solutions without focusing solely on one way of thinking
3. Originality: This indicator evaluates students' ability to generate unique and unconventional ideas, which is a hallmark of true creativity
4. Elaboration: This indicator measures students' ability to develop ideas by adding details or expanding on existing concepts

The description of each indicator of creative thinking ability is conducted by calculating the total score for each indicator and then expressing it as a percentage of the ideal score for each indicators (Figure 2).

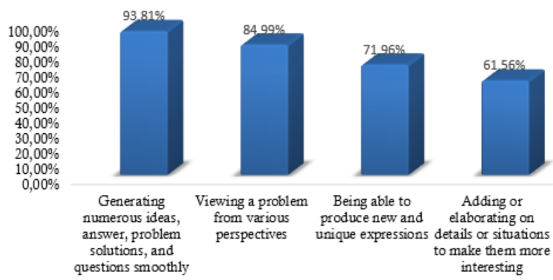


**Figure 2.** Percentage Diagram for Each Indicator of Students' Creative Thinking Ability

Based on the diagram, it can be concluded that the percentage of students demonstrating creative thinking skills across various indicators is as follows: 93.81% of students successfully generated numerous ideas, provided multiple answers, offered various problem solutions, and asked many questions fluently. This percentage reflects a high level of creativity in idea and solution generation, as well as strong questioning skills (Heard et al., 2023). Additionally, 84.99% of students were able to view problems from multiple perspectives, indicating their ability to think flexibly and consider different viewpoints (Karunarathne & Calma, 2024).

However, for the indicator of generating new and unique expressions, the percentage of students is 71.96%. This suggests that, while many students are able to come up with new ideas, there is still room for improvement in terms of the originality of the expressions produced. This finding aligns with research by Anderson & Graham (2023), which notes that although many students demonstrate creativity, specific aspects such as the ability to produce truly unique expressions still require further development.

Meanwhile, for the indicator of adding or detailing aspects to make a situation more interesting, the percentage is 61.56%. This indicates that, although most students can add details and enrich situations, there are challenges in enhancing content with engaging details. This finding is consistent with research by Luthfia (2024), which shows that students often struggle with enriching details and creating engaging contexts in the creative thinking process.

The research results show that the percentage scores for each creative thinking indicator vary. This is because each aspect measures a different dimension of the creative process and requires distinct skills. These differences are explained in more detail as follows:

1. Fluency: This indicator received the highest score because many students were able to generate a large number of ideas in a short period of time. This is consistent with the findings of Ramankulov et al. (2021), who stated that fluency is often easier for students to achieve since they are only required to produce as many ideas as possible without considering the quality or originality
2. Flexibility: This indicator also scored high, as students were able to think from several different perspectives. According to Rahayu et al. (2022), this flexibility reflects the cog nitive ability to shift from one idea to anot her, which becomes easier for students once they are a ccustomed to tasks that stimulate creativity
3. Originality: This indicator, which measu res the ability to generate unique ideas, had a lower score. This indicates that although students can produce many ideas, only a small portion of them are truly new or original. This aligns with Permana et al. (2023) findings, which suggest that originality is one of the most difficult components of creativity to develop and requires practice and deeper thinking
4. Elaboration: This indicator received the lowest score, indicating that students still struggle to expand ideas or add significant details. According to Khoeriyah et al. (2019), elaboration often requires a deep understanding and the ability to see connections between various elements of an idea, which explains why students may find this aspect challenging.

In measuring physics learning outcomes, a descriptive test was used to provide a more comprehensive picture of the extent to which students understand and can apply physics concepts, making it more aligned with the study's goal of achieving deep learning outcomes. According to research conducted by Harlina et al. (2020), descriptive tests are one of the best ways to evaluate students' deep understanding and analytical abilities in science, as these tests offer students the flexibility to explain concepts in their own way and demonstrate a broader understanding. Descriptive tests give students the opportunity to show higher-order thinking skills, such as conceptual understanding, analysis, and application. This aligns with the research objective, which is not only to determine the extent of students' mastery of the material, but also how they can apply physics concepts in practical contexts, a crucial part of physics learning. The depiction of each indicator of physics learning outcomes is carried out by calculating the total score for each indicator, then expressing it as a percentage of the ideal score for each respective indicator. The description of each physics learning outcomes indicator is done by calculating the total score for each indicator and then expressing it as a percentage of the ideal score for each indicator:

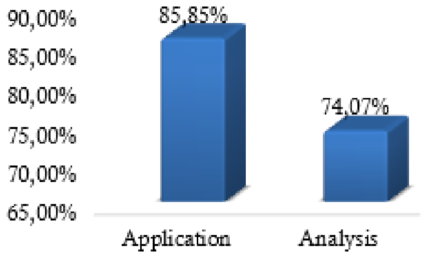


**Figure 3.** Percentage for Each Indicator of Students' Physics Learning Outcomes

Based on the table above, there is a significant difference in the indicators of students' physics learning outcomes. The data show that the most prominent indicator is students' ability to apply physics concepts (C3), while the lowest indicator is their ability to analyze information (C4). The difference between application (C3) and analysis (C4) suggests that students tend to be more successful in using their knowledge (C1) and understanding (C2) to apply physics concepts, but face challenges when required to analyze (C4) more complex physics problems. According to Permana et al. (2019), applying physics concepts is often easier for students because they only need to use the knowledge (C1) and understanding (C2) they have acquired, whereas information analysis requires higher-order critical thinking skills, which are more difficult to master. This indicates that although students have achieved good levels of knowledge (C1) and understanding (C2), they need more practice to improve their analytical skills (C4), which involve breaking down physics concepts into smaller parts and logically connecting them.

The ability to apply concepts (C3) is an essential skill in physics learning, as students must be able to use their knowledge to solve problems and answer relevant questions in practical contexts. Research by Safarati & Lubis (2022) emphasizes that the ability to apply concepts is often reflected in better learning outcomes, as students who can effectively apply their knowledge demonstrate a deep understanding and the capability to use concepts in new situations. This finding is consistent with the data showing that the application of concepts is the most prominent indicator in students' physics learning outcomes.

On the other hand, the ability to analyze information (C4) is a more complex skill that requires students not only to understand the material but also to evaluate and interpret data critically. Research by Kuncoro et al. (2022) indicates that analytical skills often pose challenges for students because they demand higher-order thinking and the ability to connect various pieces of information to make informed decisions. The finding that analysis (C4) is the lowest indicator may reflect the difficulties students face in developing these skills, which aligns with the research by Fadly (2021) noting that many students struggle with analytical skills due to their complexity and the need for critical thinking.

This is also supported by research from Permana et al. (2019), which shows that analytical skills often require more time and practice to develop compared to application skills. They noted that while students may feel comfortable with more straightforward concept applications, analytical skills involving synthesis and evaluation of information often need more in-depth teaching approaches and intensive support.

To determine whether there is a linear relationship between creative thinking ability and physics learning outcomes, a linearity test was conducted using SPSS version 16. This test is crucial to ensure that the relationship between the variables can be considered linear, meaning that the relationship between the variables is not merely coincidental or random but follows a predictable linear pattern. In this context, data is considered linear if the significance value is greater than 0.05 (sign > 0.05) (Tabachnick & Fidell, 2019).

The results of the linearity test showed a significance value of 0.056. This value is greater than the threshold of 0.05. In other words, the significance value indicates that there is not enough evidence to reject the hypothesis that the relationship between the variables is linear. This finding supports the notion that the relationship between creative thinking ability and physics learning outcomes can be described by a linear model, consistent with the initial expectations of this analysis.

This study emphasizes the importance of linearity tests in data analysis to ensure the validity of the statistical model used. For instance, research by Nolan & Herbert (2015) highlights that ensuring a linear relationship is a crucial step in regression analysis to avoid biased or inaccurate conclusions. Thus, the results of the linearity test provide a solid foundation for further analysis on how creativity relates to physics learning outcomes in a linear fashion.

comes in a linear fashion.

Based on the inferential analysis, the correlation coefficient obtained is 0.792. This coefficient indicates a significant positive relationship between creative thinking ability and students' physics learning outcomes. In other words, there is a strong and positive correlation between the two variables, where an increase in creative thinking ability tends to be associated with an increase in physics learning outcomes. A correlation coefficient of 0.792 suggests that approximately 79.2% of the variation in physics learning outcomes can be explained by the variation in creative thinking ability, while the remaining 20.8% is influenced by other factors not measured in this study (Cohen et al., 2021; Field, 2022).

Research by Akpur (2020) also supports this finding, showing a positive relationship between creativity and academic achievement, including in subjects like physics. The study found that creativity plays a significant role in enhancing the understanding and application of scientific concepts, which is consistent with the analysis showing a substantial impact of creativity on physics learning outcomes.

Additionally, research by Putri et al. (2024) underscores the importance of creativity in the learning process, demonstrating that creative thinking ability not only improves learning outcomes but also enriches the overall learning experience for students. This finding aligns with the correlation coefficient results, indicating that creativity significantly contributes to academic achievement in physics.

However, despite the significant positive relationship indicated by the correlation coefficient, it is important to note that 20.8% of the variation in physics learning outcomes cannot be explained by creative thinking ability. This suggests that other factors, such as teaching methods, student motivation, and environmental factors, also influence learning outcomes and need to be considered in further analysis (Lin & Wu, 2016).

Creative thinking ability can be developed through the implementation of learning strategies that integrate creativity into the learning process. The following are several strategies that can be applied:

1. Real-world problem-solving: Engaging students with real-world problems encourages fluency, flexibility, and originality. Teachers can present physics scenarios that require innovative solutions to deepen students' understanding and stimulate their creativity
2. Digital tools: Utilizing digital tools such as virtual laboratories can create interactive environments where students experiment with concepts like elasticity and Hooke's Law without fear of failure
3. Collaborative activities: Group activities that promote discussion and collaborative problem-solving can help students refine their elaboration and flexibility skills by considering diverse perspectives

This study has limitations that should be considered for future research, namely the limitation of the sample and the generalization of the results, as the study only involved eleventh-grade students from state senior high school 9 Gowa as the sample. Although the simple random sampling technique was applied to ensure good representation of the school's population, the findings of this study may not be generalizable to student populations in other schools, both within and outside the Gowa region. Therefore, future research could involve a larger and more diverse sample, including schools from different regions and other educational levels, such as middle school or other high school grades.

## CONCLUSION

Based on the analysis and discussion of the research results presented, it can be concluded that the creative thinking ability of eleventh-grade students at state senior high school 9 Gowa falls into the category of fairly creative, with an average score of 77.81. This indicates that while the students possess good creative thinking skills, there is still room for further development in their creativity. Additionally, the physics learning outcomes for the same class are categorized as good, with an average score of 78.33, reflecting adequate academic achievement in the subject. Furthermore, this study reveals a significant positive relationship between creative thinking ability and physics learning outcomes, particularly concerning elasticity and Hooke's law. This suggests that improvements in creative thinking ability contribute to better physics learning outcomes, emphasizing the importance of fostering creativity as an integral part of the learning process to achieve higher academic performance. These findings provide a strong foundation for designing teaching strategies that focus on enhancing creativity to support overall student academic achievement.

## REFERENCES

Affandy, H., Aminah, N. S., & Supriyanto. (2019). Analisis keterampilan berpikir kritis siswa pada materi fluida dinamis Di SMA Batik 2 Surakarta. *Jurnal Materi dan Pembelajaran Fisika*, 9(1), 25-33. https://doi.org/10.20961/jmpf.v9i1.31608

Akpur, U. (2020). Critical, reflective, creative thinking and their reflections on academic achievement. *Thinking Skills and Creativity,* 37, 1-8. https://doi.org/10.1016/j.tsc.2020.100683

Anderson, R. C., & Graham, M. (2021). Creative potential in flux: The leading role of originality during early adolescent development. *Thinking Skills and Creativity*, 40, 1-21. https://doi.org/10.1016/j.tsc.2021.100816

Asriadi, M., & Istiyono, E. (2020). Exploration of creative thinking skills of students in physics learning. *Journal of Educational Science and Technology*, 6(2), 151-158. https://doi.org/10.26858/est.v6i2.12737

Astawan, I. G., Suarjana, I. M., Werang, B. R., Asaloei, S. I., Sianturi, M., & Elele, E. C. (2023). STEM-Based scientific learning and its impact on students' critical and creative thinking skills: An empirical study. *Jurnal Pendidikan IPA Indonesia*, 12(3), 482-492. https://doi.org/10.15294/jpii.v12i3.46882

Badeleh, A. (2021). The effects of robotics training on students' creativity and learning in physics. *Education and Information Technologies*, 26, 1353-1365. https://doi.org/10.1007/s10639-019-09972-6

Batlolona, J. R., Diantoro, M., Wartono., & Latifah, E. (2019). Creative thinking skills students in physics on solid material elasticity. *Journal of Turkish Science Education*, 16(1), 48-61.

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2013). *Applied multiple regression/correlation analysis for the behavioral sciences*. Routledge.

Ekayana, A. A. G., Parwati, N. N., Agustini, K., & Ratnaya, I. G. (2024). Enhancing creative thinking skills and student achievement: An innovative approach through integrating project-based learning in steam and self-efficacy. *Pegem Journal of Education and Instruction*, 14(4), 19-29. https://doi.org/10.47750/pegegog.14.04.03

Fadhil, M., Kasli, E., Halim, A., Evendi., Mursal., & Yusrizal. (2021). Impact of project based learning on creative thinking skills and student learning outcomes. *Journal of Physics: Conference Series*, 1940, 1-8. doi. 10.1088/1742-6596/1940/1/012114

Fadly, W. (2021). Profile of students analytical thinking skills in learning style for completing substance pressure problems. *Jambura Physics Journal,* 3(1), 1-15. https://doi.org/10.34312/jpj.v3i1.9792

Field, A. (2009). *Discovering statistics using SPSS.* Sage Publications.

Fraser, J. M., Timan, A. L., Miller, K., Dowd, J. E., Tucker, L., & Mazur, E. (2014). Teaching and physics education research: Bridging the gap. *Reports on Progress in Physics IOP Publishing*, 77, 1-17.

Gunawan., Susilawati., Dewi, S. M., Herayanti, L., Lestari, P. A. S., & Fathoroni. (2020). Gender influence on students creativity in physics learning with virtual laboratory. *Journal of Physics: Conference Series*, 1471, 1-6. Doi. 10.1088/1742-6596/1471/1/012036

Harlina., ramlawati., & Rusli, M. A. (2020). Deskripsi kemampuan literasi sains peserta didik kelas IX DI SMPN 3 Makassar. *Jurnal IPA Terpadu*, 3(2), 96-107. https://doi.org/10.35580/ipaterpadu.v3i2.12320

Heard, J., Krstic, S., & Richardson. (2023). Evidencing creativity in educational settings. *Journal of Creativity,* 33(1), 1-7. https://doi.org/10.1016/j.yjoc.2023.100046

Karunarathne, W., & Calma, A. (2024). Assessing creative thinking skills in higher education: De cits andimprovements. *Studies in Higher Education*, 49(1), 157-177. https://doi.org/10.1080/03075079.2023.2225532

Khoeriyah, U., Nurlaela, A., & Solehat, D. (2019). Model brain based learning untuk meningkatkan keterampilan berpikir kreatif siswa pada materi hukum Newton. *JIPVA (Jurnal Pendidikan Ipa Veteran)*, 3(2), 179-191. https://doi.org/10.31331/jipva.v3i2.1012

Kuncoro, K. S., Harini, E., & Trimono, D. A. (2022). Bloom's taxonomy analyze category: the analysis of students' analytical skills based on gender. *Unnes Journal of Mathematics Education,* 11(2), 156-165. https://doi.org/10.15294/ujme.v11i2.58473

Lee, Y-N., Walsh, J. P., & Wang, J. (2015). Creativity in scientific teams: Unpacking novelty and impact. *Research Policy*, 44(3), 684-697. doi: 10.1016/j.respol.2014.10.007

Lin, C.-S., & Wu, R. Y.-W. (2016). Effects of web-based creative thinking teaching on students' creativity and learning outcome. *Eurasia Journal of Mathematics, Science and Technology Education*, 12(6), 1675-1684. https://doi.org/10.12973/eurasia.2016.1558a

Luthfia, S. (2024). The enhancement of creative thinking skill using creative problem solving learning model. *International Journal of Education and Teaching Zone,* 3(1), 107-118. https://doi.org/10.57092/ijetz.v3i1.197

Marcinauskas, L., Iljinas, A., Cyviene, J., & Stankus, V. (2024). Problem-Based Learning versus Traditional Learning in Physics Education for Engineering Program Students. *Education Science,* 14(2), 1-10. https://doi.org/10.3390/educsci14020154

Nolan, C., & Herbert, S. (2015). Introducing linear functions: An alternative statistical approach. *Mathematics Education Research Journal*, 27, 401-421. https://doi.org/10.1007/s13394-015-0147-x

Nurlaela., Doyan, A., & Gunada, I. W. (2021). Pengaruh model pembelajaran quantum teaching terhadap kemampuan berpikir kreatif dan hasil belajar fisika peserta didik kelas XI MIA

SMA Negeri 2 Labuapi. *Orbita: Jurnal Pendidikan dan Ilmu Fisika*, 7(1), 199-204. https://doi.org/10.31764/orbita.v7i1.4363

Parpala, A., Mattsson, M., Herrmann, K. J., Bager-Elsborg, A., & Hailikari, T. (2022). Detecting the variability in student learning in di erentdisciplines a person-oriented approach. *Scandinavian Journal Of Educational Research,* 66(6), 1020-1037. https://doi.org/10.1080/00313831.2021.1958256

Permana, I. P. Y. S., Parno., Purwaningsih, E., & Ali, M. (2023). Analysis creative thinking ability of student's on the topic of momentum and impulsein senior high school. *Jurnal Penelitian Pendidikan IPA*, 9(12), 11359–11367. https://doi.org/10.29303/jppipa.v9i12.4581

Permana, T. I., Hindun, I., Rofi'ah, N. L., & Azizah, A. S. (2019). Critical thinking skills: The academic ability, mastering concepts, and analytical skill of undergraduate students. *Jurnal Pendidikan Biologi Indonesia*, 5(1), 1-8. https://doi.org/10.22219/jpbi.v5i1.7626

Piffer, D. (2012). Can creativity be measured? An attempt to clarify the notion of creativity and general directions for future research. *Thinking Skills and Creativity*, 7(3), 258-264. https://doi.org/10.1016/j.tsc.2012.04.009

Pont-Niclos, I., Martin-Ezpeleta, A., & Echegoyen-Sanz, Y. (2023). The turning point: Scientific creativity assessment and its relationship with other creative domains in first year secondary students. *Jurnal Pendidikan IPA Indonesia*, 12(2), 221-231. https://doi.org/10.15294/jpii.v12i2.42835

Prabaningtias, D. A., Istiyono, E., mahmuda, D., Arman, D., & Arifiyanti, F. (2022). Creative thinking physics: A review and bibliometric analysis. *Jurnal Ilmu Pendidikan Fisika*, 7(3), 264-275. http://dx.doi.org/10.26737/jipf.v7i3.2599

Prayogi, S., Yuanita, L., & Wasis. (2018). Critical inquiry based learning: a model of learning to promote critical thinking among prospective teachers of physic. *Journal of Turkish Science Education*, 15(1), 43-56. doi: 10.12973/tused.10220a

Putri, V. N., Sundari, P. D., Hufri., & Sari, S. Y. (2024). Physics teaching materials based on the creative problemsolving model with concept maps: The effect on students' learning outcomes. *Jurnal Penelitian Pendidikan IPA*, 10(4), 1907-1915. https://doi.org/10.29303/jppipa.v10i4.5805

Rahayu, S., Setyosari, P., Hidayat, A., & Kuswadi, D. (2022). The effectiveness of creative problem solving-flipped classroom for enhancing students' creative thinking skills of online physics educational learning. *Jurnal Pendidikan IPA Indonesia*, 11(4), 649-656. https://doi.org/10.15294/jpii.v11i4.39709

Ramankulov, S. Z., Dosymov, E., & Mintassova, A. S. (2019). Assessment of student creativity in teaching physics in a foreign language. *European Journal of Contemporary Education*, 8(3), 587-599. doi: 10.13187/ejced.2019.3.587

Safarati, N., & Lubis, R. H. (2022). Students' conceptual understanding and critical thinking skills through online learning using a virtual laboratory. *Jurnal Ilmu Pendidikan Fisika*, 7(1), 42-49. http://dx.doi.org/10.26737/jipf.v7i1.2221

Sarioglan, A. B., & Ozkaya, O. S. (2023). Web integrated STEM learning: Effects on students' academic achievement, creativity and metacognitive awareness. *Journal of Science Learning*, 6(3), 315-326. https://doi.org/10.17509/jsl.v6i3.56477

Sidek, R., Halim, L., Buang, N. A., & Arsyad, N. M. (2020). Fostering scientific creativity in teaching and learning science in schools: A systematic review. *Jurnal Penelitian dan Pembelajaran IPA*, 6(1), 13-35. http://dx.doi.org/10.30870/jppi.v6i1.7149

Tabachnick, B. G., & Fidell, L. S. (2019). *Using multivariate statistics (7th ed.).* Pearson.

Tawil, M., Said, M. A., & Suryansari, K. (2023). Exploration of conceptual understanding of science teachers and students: Gap conception of current, voltage in Indonesia. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, 9(1), 163-182. https://doi.org/10.21009/1.09115

Widya., Andriani, R., Sudirman., Hidayat, A. T., & Elisyah, N. (2023). The effectiveness of physics e-modules based on creative problem-solving learning model integrated with 21st-century skills. *Indonesian Journal of Science and Mathematics Education*. 6(1), 48-58. http://dx.doi.org/10.24042/ijsme.v6i1.14584