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The Effect of Project-Based Learning (PjBL) Integrated with STEAM on the Creative Thinking Skills of Fifth-Grade Elementary School Students Regarding the Human Respiratory System

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Abstract: This study aims to analyze the effect of Project-Based Learning (PjBL) integrated with STEAM on the creative thinking skills of fifth-grade elementary school students regarding the human respiratory system. The study employed a quantitative approach using a quasi-experimental pretest-posttest control group design. The sample consisted of 46 students divided into an experimental class (n = 21) and a control class (n = 25) at a public elementary school in West Jakarta. The research instrument was a creative thinking ability test comprising 20 items, analyzed using the Rasch model via the Winsteps 4.8.2 application. The analysis results showed an improvement in ability in both classes following the intervention. The control class improved from 1.51 logits on the pretest to 2.48 logits on the posttest, with a gain of 0.97 logits. Meanwhile, the experimental class showed a greater increase, rising from 2.48 logits to 4.82 logits, with a gain of 2.34 logits. The Rasch analysis results also showed that all test items had a good level of fit with the model (infit and outfit MNSQ values were in the range of 0.5–1.5), so the data were deemed valid and suitable for use. Based on these results, it can be concluded that PjBL-based STEAM learning is more effective in improving students' creative thinking skills than conventional learning when teaching the human respiratory system.

Keywords: Creative thinking skills; Project Based Learning (PjBL); Rasch model; STEAM

Introduction

Learning in the 21st century is designed to prepare students for the demands and challenges of a rapidly changing world. This approach emphasizes the development of 4C skills, namely critical thinking, communication, collaboration, and creativity (Azzahrah et al., 2022). These competencies are essential for enabling students to compete in a globalized environment and to develop higher-order thinking skills. In addition, advances in technology, globalization, and shifting social needs require education systems to equip learners with creative thinking, critical thinking, problem-solving, communication, and collaboration skills (Ahiri et al., 2025). Such skills are increasingly important as students are expected to adapt to the era of disruption, in which many types of work are gradually being replaced by machines, robotics, and artificial intelligence.

Creative thinking is a thought process that takes place continuously and consistently in producing ideas that are original and relevant to the needs or problems faced (Wasahua, 2021). This ability is important to be developed on an ongoing basis because it cannot be acquired instantly (Wafiyah et al., 2025). These abilities play an important role in helping students find solutions

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to the problems they face and prepare them to become effective problem solvers in daily life (Prabawati & Yamtinah, 2025). Education plays a strategic role in preparing the next generation. While education used to focus more on routine and basic cognitive skills, current industrial developments now require mastery of higher-order thinking skills that cannot easily be replaced by technology (Mu'minah, 2021). Therefore, schools in the era of the Fourth Industrial Revolution need to provide learning experiences that foster critical thinking, problem-solving, collaboration, communication, and creativity (Febianti & Sukmawati, 2024; Izzati & Sukmawati, 2024; Hartomo & Sukmawati, 2024; Putri & Sukmawati, 2024; Saputri & Sukmawati, 2024; Fitria & Sukmawati, 2024; Khairi & Sukmawati, 2025).

This study focuses on the IPAS curriculum, specifically the science component covering the human respiratory system. This topic was chosen because it is closely related to daily life and requires conceptual understanding that goes beyond mere memorization; it also demands creative thinking to comprehend organ functions, the respiratory process, and health issues related to the system (Ramadhanti & Sukmawati, 2025). Science instruction within the IPAS curriculum should be directed toward activities that provide students with opportunities to think actively and creatively and to connect concepts to real-world problems (Hayat et al., 2024). Based on observations, the learning process remains teacher-centered. This situation tends to make students passive, as they primarily receive explanations without active involvement. Furthermore, learning places greater emphasis on final outcomes than on the process itself, so students' opportunities to construct knowledge independently remain limited. This results in the suboptimal development of students' creative thinking skills.

Developing creative thinking skills requires space for students to express their ideas through various learning activities (Mulder et al., 2023). These skills can be measured through indicators such as fluency, flexibility, originality, and elaboration (Ellianawati et al., 2025). One approach that can support the development of these skills is Project-Based Learning (PjBL), as it engages students in experiments, problem-solving, and the completion of science projects (Sucilestari et al., 2023). Another relevant approach is STEAM (Science, Technology, Engineering, Arts, and Mathematics). STEAM-based learning has been shown to help students understand scientific concepts more deeply through hands-on experiences (Oktavia & Sukmawati, 2025). The integration of various disciplines within STEAM enables learning to be more comprehensive and contextual (Kismawardani et al., 2022). In addition, STEAM also emphasizes collaboration, communication, and active student engagement (Hermanto & Sukmawati, 2025). The application of STEAM learning needs to be supported by the use of technology that is able to provide a more interactive and meaningful learning experience (Sukmawati et al., 2026).

Science education needs to be developed through contextual and problem-based approaches so that students can relate concepts to real life (Tsabitah & Sukmawati, 2025). The integration of STEAM and PjBL can provide a more meaningful learning experience because students are engaged in exploration, investigation, collaboration, and problem-solving (Wilujeng & Rahmawati, 2024). The PjBL model has also been shown to improve learning outcomes, creativity, and student motivation in science education at the elementary school level (Pangestu et al., 2024). as well as to have a significant impact on creative thinking skills compared to direct instruction (Biazus & Mahtari, 2022).

STEAM-based learning encourages students to build understanding independently through the interconnection of various fields of study with real life and the use of relevant technology (Sutisna et al., 2024). The implementation of STEAM-integrated project-based learning has the potential to improve the quality of the learning process while developing the competencies needed by students to face future challenges (Zaky et al., 2024). Through creative thinking skills, students can find innovative ways to solve problems and generate meaningful ideas (Sutisna et al., 2024). The application of STEAM in science learning can be a relevant strategy for developing 21st century skills, particularly creativity and problem-solving (Nadhiroh et al., 2023; Gracia et al., 2024).

STEAM gives students the freedom to think broadly, express ideas, feel safe in learning activities, determine what to explore, and work collaboratively (Habibi, 2023). The model that is in line with this approach is Project Based Learning (PjBL), the PjBL model has a significant influence on improving students' creative thinking skills compared to direct learning so that the integration of STEAM and PjBL is expected to be able to create fun learning and optimize student potential (Sutisna et al., 2024). This model is relevant to the STEAM approach because it encourages students to actively learn, work together in groups, and understand science concepts through more fun activities (Septiani & Sukmawati, 2025). Students are directed to produce works or products related to solving real problems in the surrounding environment (Sukmawati et al., 2025). The Project Based Learning model can be an effective learning strategy to develop the creative thinking skills of elementary school students from an early age (Nita & Irwandi, 2021). However, most studies still focus on either STEAM or PjBL separately, and limited research has examined their integration specifically in elementary

science learning, especially using Rasch model analysis to measure creative thinking development.

Therefore, the novelty of this study lies in three aspects. First, this study integrates STEAM-based learning with the Project-Based Learning model in a single instructional framework. Second, it focuses specifically on creative thinking skills in the context of the human respiratory system material in elementary school science learning. Third, this study applies Rasch model analysis to provide more objective measurement of students' creative thinking development through logit-based evaluation. Thus, this research is expected to contribute to the development of innovative learning models that strengthen 21st-century skills in elementary education.

Method

This study uses a quantitative approach with a quasi-experiment design of the Pretest-Posttest control group design to determine the effect of STEAM learning based on the Project Based Learning model on the creative thinking skills of grade V elementary school students on the material of the human respiratory system. The data analysis in this study uses the Rasch Model approach because it is able to provide more objective, accurate, and in-depth measurement results on the ability of respondents and the quality of research instruments.

The following is the pretest-posttest pattern used in the study.

E	O1	X1	O2
K	O3	X2	O4

Figure 1. Pattern of pretest-posttest control design

The research was carried out in one of the West Jakarta public elementary schools in the even semester of the 2025/2026 school year. The population in this study is all students of class V consisting of two classes with a total of 46 students.

The sampling technique used is non-probability sampling with purposive sampling.

Table 1. Research sample

Classes	Number of Pupils	Remarks
V-A	25	Controls
V-B	21	Experiment

Class V-A is used as a control class that obtains conventional learning, while class V-B is used as an experimental class that obtains STEAM learning based on the Project Based Learning model. The research instrument was in the form of a multiple-choice test of 20 questions prepared based on indicators of creative thinking skills in human respiratory system material. The instrument was developed based on the learning outcomes of elementary school science which includes the ability to understand the concept of the human respiratory system, identify the function of the respiratory organs, analyze the human respiratory process, and develop creative ideas in solving problems related to the material.

Figure 2. Conventional learning (Control class)

Figure 3. Application of STEAM learning with PjBl (Experimental class)

Data collection was carried out through the provision of creative thinking skills tests before learning or pretest and after learning or posttest in experimental classes and control classes. The data obtained was then analyzed using the Rasch Model with the help of the Winsteps application version 4.8.2. The analysis was carried out to evaluate the quality of the instruments and the ability of students based on the values of person reliability, item reliability, separation, and the suitability of the data to the measurement model.

Rasch analysis was also used to compare changes in students' creative thinking skills before and after learning through stacking techniques. This technique allows the observation of the change in the value of each student's measure between the pretest and posttest in both research classes. The criteria for the suitability of items and respondents refer to the INFIT MNSQ and OUTFIT MNSQ values with an ideal range of 0.05–1.5.

In addition, the results of the analysis were used to identify the level of students' creative thinking skills and the quality of question items in the human respiratory system material after the application of STEAM learning based on the Project Based Learning model.

Result and Discussion

Result

The Results of the Rasch Model Analysis

Data analysis in this study was carried out using the Rasch Model with a stacking technique through the Winsteps application. The Rasch method can be used to analyze changes in students' abilities before and after learning treatment (Arrauyani & Sukmawati, 2025). The Rasch model has several advantages over classical analysis, including being able to identify inappropriate responses, predict missing data, detect possible guesses of learners, and provide more accurate information about the quality of the instrument and the ability of the respondent (Sulsilah et al., 2023). Therefore, the Rasch Model is one of the effective approaches in the validation process of educational research instruments (Sirait, 2023). The use of the Rasch Model in this study aims to analyze the quality of instruments for measuring students' creative thinking skills (Mulyanti et al., 2022).

The data analyzed was obtained from the results of the pretest and posttest in two classes, namely class 5A which consisted of 25 students and class 5B which consisted of 21 students in one of the public elementary schools in West Jakarta. Through the stacking technique, each student has two measurements, namely during the pretest and posttest. The results of the analysis are presented as follows.

Table 2. Comparison of Person measure pretest and posttest results of control and experiment classes

Classes	Measure Pretest	S.E Pretest	Measure Posttest	S.E Posttest	Measurement difference
Control	1.51	0.75	2.48	1.18	+0.97
Experiment	2.48	1.05	4.82	1.89	+2.34

Based on the results of the data analysis, in the pretest phase, the control group scored an average of 1.51, while the experimental group scored an average of 2.48, indicating that before the treatment was administered, the experimental group already had a slightly higher initial score than the control group, although the difference was not very significant. After the treatment, both groups showed improvement: the control group's score increased to 2.48, a difference of +0.97, while the experimental group's score rose more significantly to 4.82, a difference of +2.34. This comparison shows that the increase in the experimental group was much greater than that in the control group, indicating a stronger effect of the treatment on the change in scores in the experimental group compared to the change observed in the control group. Additionally, the data distribution in both groups also showed greater variation after the final measurement, particularly in the experimental group. Overall, these results show that although both groups experienced an increase. These results show that the improvement in students' abilities in the experimental class using the Project Based Learning (PjBL)-based STEAM approach is higher than that of the control class.

Based on Figure 4, the relationship between pretest and posttest values in the control class shows a shift in the measure value that does not fully increase consistently. Measurement scores in the posttest condition tended to be higher than those in the pretest condition. The average pretest score was 0.99, while the average posttest score increased to 1.85. This indicates a tendency toward improvement in the follow-up measurement; thus, based on the descriptive data, the changes that occurred were generally positive, although the rate of improvement was not the same across all observations.

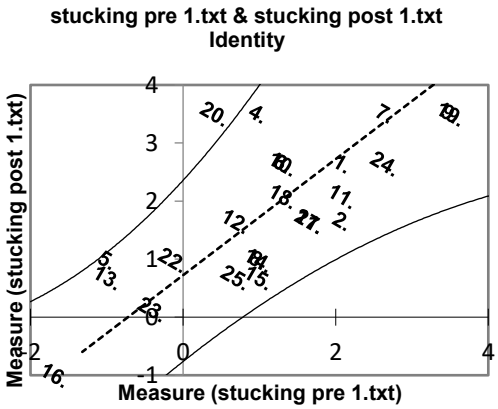

Figure 4. Empirical line plot results stacking control class

In terms of data distribution, the relatively large standard deviation in both conditions indicates that the variation between observations is quite high. This suggests that the responses of each observation unit are not homogeneous, so the observed increase in the mean cannot be interpreted as a uniformly strong pattern across the entire sample. Furthermore, the fact that the estimation error in the post-measurement is slightly higher than in the pre-measurement suggests that the level of uncertainty in the post-measurement condition has also increased.

The results of the scatter plot visualization show that some data points lie above the line of equality, meaning there are observations that showed an increase from the pre- to the post-measurement condition. However, there are still a number of data points that show small changes or inconsistent patterns, so the relationship between the two measurements is not entirely linear or uniform.

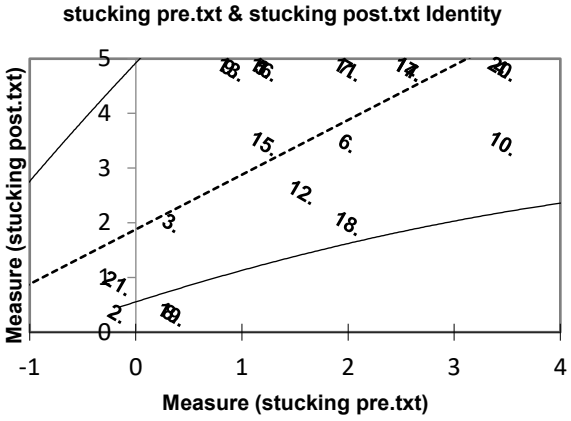

Figure 5. Plot empirical line results stacking experimental class

Based on Figure 5, in the experimental class using the PjBl-based STEAM approach it was found that there was an increase in measurement values from the pre-test to the post-test. The mean value in the pre-test condition was 1.16, while in the post-test condition it increased to 3.36. These findings indicate a trend toward higher values following the treatment or follow-up condition observed in the study. Descriptively, this difference in means indicates a systematic pattern of change not merely random variation since the direction of change consistently shows an increase.

The magnitude of the change is also evident from the average difference (delta measure), which reached 1.83. This reinforces the indication that the increase occurred not only in the central values of the data but was also reflected in the changes between observations. However, the data distribution shows considerable variation, with pre-values ranging from 3.98 to 4.35 and post-values ranging from 0.34 to 6.23. This wide range indicates that the responses across observations are not homogeneous; thus, the observed increase is more accurately understood as a general trend rather than a uniform pattern across the entire sample.

In terms of estimation precision, there is a difference in the level of uncertainty between the pre- and post-conditions, with the uncertainty values in the post-condition tending to be higher than those in the pre-condition. This indicates that although there was an increase in the mean value, the variation in the data in the post-condition also increased, resulting in a wider distribution of values.

Table 3. Summary of Rasch statistics control and experiment class model

Aspects	N Measured	Mean Measure	Infit MNSQ	Outfit MNSQ	Separation	Reliability
Person Control	50	50	1.00	0.90	1.38	0.66
Item Control	20	20	1.00	0.90	2.37	0.85
Person Experiment	42	42	1.00	0.97	1.05	0.53
Item Experiment	20	20	1.00	0.97	1.63	0.73

Based on the results of the Rasch model statistical summary, the analysis was conducted on two groups the control group and the experimental group each of which consisted of person and item analyses. It should be noted that the number of respondents (N measured) in the control group analysis was 50 and in the experimental group was 42. The value of 50 for the control group was derived from the combined pretest and posttest data analyzed as a single model; similarly, the value of 42 for the experimental group represents the total number of unique respondents analyzed within that group for both the pretest and posttest measurements.

In the control group, the mean measure was 1.00, with an Infit MNSQ of 0.90 and an Outfit MNSQ of 0.90. These values indicate that the control group's data exhibits good model fit, as both the Infit and Outfit values fall within the ideal Rasch range (approximately 0.5 to 1.5). A separation value of 1.38 with a reliability of 0.66 indicates that the ability of respondents in the control group exhibits a relatively low to moderate level of category separation, as well as reliability that is still classified as moderate.

In the experimental group, the person value showed a mean measure of 1.00 with an Infit MNSQ of 0.97 and an Outfit MNSQ of 0.97. These values also indicate a good model fit that is more stable than that of the control group. However, a separation value of 1.05 with a reliability of 0.53 indicates that the ability of respondents in the experimental group exhibits a lower level of differentiation, and reliability remains relatively low. This suggests that the variation in ability among respondents within the experimental group tends to be more homogeneous.

At the item level, both the control and experimental groups showed the same mean measure of 1.00, with Infit and Outfit values of 0.90 for the control group and 0.97 for the experimental group. This indicates that, in general, the items used in the research instrument fit the

Rasch model well and do not show any statistically problematic items.

In terms of item separation, the control group showed a value of 2.37 with a reliability of 0.85, indicating that the items had good and stable discriminatory power in distinguishing respondents' ability levels. Meanwhile, in the experimental group, the item separation value of 1.63 with a reliability of 0.73 indicated that the items' discriminatory power was still quite good, although slightly lower than that of the control group.

Overall, the results of the Rasch analysis show that the measurement model used has a good level of fit for both the control and experimental groups, as indicated by stable Infit and Outfit values. However, differences were observed in terms of reliability and separation, particularly in the person measure for the experimental group, which showed a lower level of reliability. This indicates that the variation in respondents' abilities within the experimental group was more homogeneous than that in the control group.

Discussion

The results of this study indicate that the implementation of a Project-Based Learning (PjBL) model integrated with the STEAM approach has a more effective impact on improving students' creative thinking skills compared to conventional learning. This finding is evident from the higher average improvement in the experimental class compared to the control class, where the experimental class showed an increase of 2.34 logits, while the control class only increased by 0.97 logits. This difference indicates that project-based learning combined with STEAM not only improves learning outcomes but also more significantly fosters the development of students' higher-order thinking skills. (Ozkan & Umdu, 2021).

From a pedagogical perspective, these findings can be explained by the characteristics of PjBL, which places students at the center of the learning process (student-centered learning). During the learning process, students do not merely passively receive information but are actively engaged in exploring, designing, and completing projects. These activities provide opportunities for students to develop creative ideas, conduct investigations, and connect scientific concepts to real-life contexts. The integration of STEAM reinforces this process by bringing together various disciplines in an interdisciplinary manner, allowing students to view scientific concepts in a broader, more contextual, and practical way (Putri et al., 2023).

Furthermore, the results of the Rasch analysis indicate that both the instrument and the research data exhibit a good level of fit with the measurement model. The MNSQ infit and outfit values fall within the ideal range (0.5–1.5), confirming that the data obtained are valid and suitable for further analysis. This strengthens the credibility of the research findings, as the results regarding the improvement in ability are not merely descriptive but are also supported by instruments with good measurement quality (Tran et al., 2021).

The observed differences between the control and experimental classes can also be understood from the perspective of learning dynamics. In the control class, the improvement in ability was limited and uneven across students, indicating that conventional learning does not provide sufficient stimulation to optimally develop creative thinking skills. Conversely, in the experimental class, the distribution of improvement was more consistent, and many students showed score increases above the identity line in the scatterplot analysis, indicating a more stable and systematic change in ability following the intervention.

Nevertheless, the results of the Rasch analysis also revealed variations in student responses, as reflected by the person reliability coefficients for both classes, which fell into the moderate-to-low range. This suggests that, despite an overall improvement, students' ability levels remain heterogeneous. In the context of project-based STEAM learning, this heterogeneity is to be expected, as each student possesses different levels of creativity, learning experiences, and problem-solving skills when completing projects.

Theoretically, the results of this study align with various previous studies stating that PjBL and STEAM make significant contributions to enhancing students' creativity and higher-order thinking skills. The integration of these two approaches provides a more meaningful learning experience because students not only understand concepts theoretically but also apply them in the form of real products or solutions. This reinforces the argument that project-based learning integrated with STEAM is a relevant strategy for 21st-century learning, particularly in enhancing creative thinking skills at the elementary school level.

Thus, it can be concluded that the implementation of STEAM-based PjBL is more effective than conventional learning in enhancing students' creative thinking skills, particularly when teaching the human respiratory system. However, the still-high level of individual variation indicates that this learning approach needs to be further optimized through differentiated instruction so that every student can reach their full creative potential.

Conclusion

Based on the research findings, it can be concluded that the implementation of the Project-Based Learning (PjBL) model integrated with the STEAM approach is

more effective in enhancing students' creative thinking skills compared to conventional learning. This is demonstrated by the higher score increase in the experimental class (2.34 logits) compared to the control class (0.97 logits), indicating a significant difference in impact between the two learning approaches. The results of the Rasch analysis also show that the research instrument has good measurement quality, with infit and outfit MNSQ values within the ideal range, so the data are deemed valid and suitable for further analysis. Additionally, the Rasch model provides a more objective picture of changes in students' abilities before and after learning through a logit-based measurement approach. Although both groups showed an increase in ability, the experimental class demonstrated a more consistent and higher pattern of improvement. However, the presence of individual variation in the measurement results indicates that students' creative thinking abilities remain heterogeneous, necessitating a more adaptive learning approach to accommodate these differences in ability.

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Conflicts of Interest

The author states that there is no conflict of interest in this study. The entire research process is carried out objectively without any personal, financial, or other relationships that can affect the results of the research. The funder, if any, has no role in the research design, data collection, data analysis, interpretation of results, manuscript writing, or decision to publish research results.

References

Ahiri, Y., Ahiri, J., Lewa, M. J., Syata, W. M., & Harjun, H. (2025). Systematic Literature Review: Penerapan Model Project Based Learning (PjBL) untuk meningkatkan kemampuan berpikir kreatif mahasiswa. *STRATEGY: Jurnal Inovasi Strategi dan Model Pembelajaran*, *5*(3), 266–276. https://doi.org/10.51878/strategi.v5i3.6595

Arrauyani, S., & Sukmawati, W. (2025). The Effect of the Use of HBA Media (Human Body Anatomy) on the Understanding of the Human Body Skeleton Concept in Grade VI Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *11*(9), 926–933. https://doi.org/10.29303/jppipa.v11i9.11690

Azzahrah, H., Umar, N. F., & Anas, M. (2022). Pengaruh Keterampilan 4C (Critical Thinking, Creativity, Collaboration, and Communication) Guru Bimbingan dan Konseling terhadap Keterlaksanaan Layanan Dasar Bimbingan dan Konseling di Sekolah. *Bulletin of Counseling and Psychotherapy*, *4*(3), 547-556. https://doi.org/10.51214/bocp.v4i3.373

Biazus, M. D. O., & Mahtari, S. (2022). The Impact of Project-Based Learning (PjBL) Model on Secondary Students' Creative Thinking Skills. *IJECE*, *1*(1), 38–48. https://doi.org/10.36312/ijece.v1i1.752

Ellianawati, E., Subali, B., Putra, B. R., & Wahyuni, S. (2025). Critical Thinking and Creativity in STEAM-Based Collaborative Learning on Renewable Energy Issues. *Journal of Education and Learning (EduLearn)*, *19*(1), 112–119. https://doi.org/10.11591/edulearn.v19i1.21638

Febianti, F. A., & Sukmawati, W. (2024). Improving Students' Science Literacy Skills Through Treasure Hunting Games with Problem Based Learning Model. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6363–6375. https://doi.org/10.29303/jppipa.v10i9.7996

Fitria, A., & Sukmawati, W. (2024). The Influence of Magnetic Media Usage on Improving Reading Literacy Skills in Material Understanding of Objects in Second Grade Elementary School. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6426–6433. https://doi.org/10.29303/jppipa.v10i9.7991

Gracia, E., Nurohman, S., Wilujeng, I., & Gracia, E. (2024). Analysis the Implementation of STEAM Approach on Creative Thinking Ability in Science Learning. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 757–763. https://doi.org/10.29303/jppipa.v10i11.7782

Habibi, M. A. M. (2023). The Effect of the STEAM Method on Children's Creativity. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 315–321. https://doi.org/10.29303/jppipa.v9i1.2378

Izzati, T. G., & Sukmawati, W. (2024). Increasing Science Literacy Through Make a Match Learning Media on Human Growth Materials in Class V of Elementary School. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6541–6551. https://doi.org/10.29303/jppipa.v10i9.7995

Hartomo, R. M., & Sukmawati, W. (2024). The Effect of Digital Flipbook Media on Improving Science Literacy on Human Digestive System Materials

Among Elementary School Students. *Journal of Science Education Research*, *10*(9), 6260–6270. https://doi.org/10.29303/jppipa.v10i9.7994

Hayat, M. S., Rita, E., & Dewi, S. (2024). Students' Creative Thinking Skills with STEAM-SDGs Approach to Energy Concept: Rasch Model Analysis. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 11152–11161. https://doi.org/10.29303/jppipa.v10i12.9532

Hermanto, A. M., & Sukmawati, W. (2025). Changes in Energy Material Learning Outcomes and Their Changes through the Team Games Tournament (TGT) Cooperative Learning Model in Grade IV Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *11*(9), 919–925. https://doi.org/10.29303/jppipa.v11i9.11688

Khairi, H. I., & Sukmawati, W. (2025). The Influence of Comic Media in the Team Games Tournament (TGT) Model to Improve Science Literacy in Elementary School Class III Animal Life Cycle Materials. *Jurnal Penelitian Pendidikan IPA*, *11*(8), 622–628. https://doi.org/10.29303/jppipa.v11i8.11538

Kismawardani, A., Tukiran, T., & Hariyono, E. (2022). Science Technology Engineering Arts Mathematics (STEAM) Approach for Learning Science in Junior High School. *Studies in Learning and Teaching*, *3*(1), 55-61. https://doi.org/10.46627/silet.v3i1.101

Mu'minah, L. H. (2021). Studi Literatur: Pembelajaran Abad-21 Melalui Pendekatan STEAM (Science, Technology, Engineering, Art, and Mathematics) dalam Menyongsong Era Society 5.0. *Prosiding Seminar Nasional Pendidikan*, 584–594. Retrieved from https://prosiding.unma.ac.id/index.php/semnasfkip/article/download/654/537

Mulder, W. R. S. P., Khoiri, N., & Hayat, M. S. (2023). Analysis of the Characteristics of the Development of Web- Based Science Learning Media with the STEAM Approach. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9586–9592. https://doi.org/10.29303/jppipa.v9i11.5095

Mulyanti, S., Setiowati, H., & Ningrum, L. S. (2022). Validity Analysis Using the Rasch Model in the Development of Alkane Concept Test Instruments. *Jurnal Penelitian Pendidikan IPA*, *8*(3). https://doi.org/10.29303/jppipa.v8i3.1383

Nadhiroh, S. U., Kristanti, F., & Suprapti, E. (2023). Creative Thinking Ability in Mathematics Learning Based on Munandar Aspects. *Journal of Education and Teaching(JET)*, *4*(1), 98–109. https://doi.org/10.51454/jet.v4i1.135

Nita, R. S., & Irwandi, I. (2021). Peningkatan Keterampilan Berpikir Kreatif Siswa Melalui Model Project Based Learning (PjBL). *BIOEDUSAINS: Jurnal Pendidikan Biologi dan Sains*, *4*(2), 231–238. https://doi.org/10.31539/bioedusains.v4i2.2503

Oktavia, N., & Sukmawati, W. (2025). STEM Learning Using the RADEC Model on Elementary School Students' Electrical Materials in Improving Students' Science Literacy Skills. *Jurnal Penelitian Pendidikan IPA*, *11*(8), 636–643. https://doi.org/10.29303/jppipa.v11i8.11541

Ozkan, G., & Umdu, U. (2021). Exploring the Effectiveness of STEAM Design Processes on Middle School Students' Creativity. *International Journal of Technology and Design Education*, *31*(1), 95–116. https://doi.org/10.1007/s10798-019-09547-z

Pangestu, K., Malagola, Y., Robbaniyah, I., & Rahajeng, D. (2024). The Influence of Project Based Learning on Learning Outcomes, Creativity and Student Motivation in Science Learning at Elementary Schools. *Jurnal Prima Edukasia*, *12*(2), 194–203. https://doi.org/10.21831/jpe.v12i2.63208

Prabawati, M. A., & Yamtinah, S. (2025). Validity of the Development of PjBL-Based Science Teaching Modules Containing Ethno-STEAM to Empower Creative Thinking Skills on Ecology and Biodiversity Materials in Indonesia. *Jurnal Penelitian Pendidikan IPA*, *11*(4), 736–744. https://doi.org/10.29303/jppipa.v11i4.10952

Putri, A. S., Prasetyo, Z. K., Purwastuti, L. A., & Kolonial, A. (2023). Effectiveness of STEAM-Based Blended Learning on Students' Critical and Creative Thinking Skills. *IJERE*, *12*(1), 44–52. https://doi.org/10.11591/ijere.v12i1.22506

Putri, N. T., & Sukmawati, W. (2024). Improving Science Literacy in Elementary Schools Through the Application of the RADEC Model. *Jurnal Penelitian Pendidikan IPA*, *10*(8), 6230–6238. https://doi.org/10.29303/jppipa.v10i8.7993

Ramadhanti, C. A., & Sukmawati, W. (2025). The Effect of the Use of Kosica Media (Light Properties Box) on the Understanding of the Concept of Light Properties in Grade 4 Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *11*(8), 644–650. https://doi.org/10.29303/jppipa.v11i8.11540

Saputri, A. L., & Sukmawati, W. (2024). The Influence of the Team Games Tournament (TGT) Learning Model Assisted by Wordwall on the Scientific Literacy of Class V Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *10*(7) ,3787–3798. https://doi.org/10.29303/jppipa.v10i7.7992

Septiani, A. Z., & Sukmawati, W. (2025). The Effectiveness of Digital Learning with the Application of Solar System Scope on the Understanding of Solar System Material Concepts in Grade VI Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *11*(9), 275–283. https://doi.org/10.29303/jppipa.v11i9.11687

Sirait, J. (2023). Development and Validation of Physics Learning Motivation Survey (PLMS) Using Rasch Analysis. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 4063–4069. https://doi.org/10.29303/jppipa.v9i5.3481

Sucilestari, R., Ramdani, A., Sukarso, A. A., Rokhmat, J., Coleman, J. C., & Hammen, C. L. (2023). Project-Based Learning Supports Students' Creative Thinking in Science Education. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 1038–1044. https://doi.org/10.29303/jppipa.v9i11.5054

Sukmawati, W., Adlawan, H. A., & Andarawan, N. D. (2025). Analysis of Science Literacy and Environmental Awareness of Elementary School Students Through the Use of STEM-Based Solar Sprinkle and Ecoburn Media in Science Learning. *Jurnal Penelitian Pendidikan IPA*, *11*(5), 274–281. https://doi.org/10.29303/jppipa.v11i5.11470

Sukmawati, W., Maarif, S., Cianda, F., Burhendi, A., Kadir, K. A., Jamaludin, N. B., Shaari, H., & Adlawan, H. A. (2026). Teachers' Readiness and Perceptions of Augmented Reality for Sustainable STEM Education. *Amplitudo*, *5*(1), 53–66. https://doi.org/10.56566/amplitudo.v5i1.505

Sulsilah, H., Hidayat, A., & Ramalis, T. R. (2023). Analysis of Computational Thinking Instrument for High School Student Using Rasch Model. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1445–1450. https://doi.org/10.29303/jppipa.v9i3.2771

Sutisna, A., Aryanti, N., & Cunandar, D. (2024). Pengaruh Penerapan Pendekatan STEAM Terhadap Kemampuan Berpikir Kreatif Siswa Kelas IV SD. *Jurnal Lensa Pendas*, *9*(1):56–65. https://doi.org/10.33222/jlp.v9i1.3466

Tran, N-H., Huang, C-F., & Hung, J-F. (2021). Exploring the Effectiveness of STEAM-Based Courses on Junior High School Students' Scientific Creativity. *Frontiers in Education*, *6*, 1–8. https://doi.org/10.3389/feduc.2021.666792

Tsabitah, H. K., & Sukmawati, W. (2025). The Effect of the Use of MAGICO Media (Active Magnetics for Games and Cognitive Interaction) on Changes in Understanding the Concept of Magnetism in Grade IV Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *11*(8), 629–635. https://doi.org/10.29303/jppipa.v11i8.11539

Wafiyah, L., Supeno, S., & Rusdianto, R. (2025). Pengaruh Model Project-Based Learning (PjBL) terhadap Creative Thinking dan Creative Performance Siswa SMP dalam Pembelajaran IPA. *Jurnal Pendidikan MIPA*, *15*(2), 425-437. https://doi.org/10.37630/jpm.v15i2.2619

Wasahua, S. (2021). Konsep Pengembangan Berpikir Kritis dan Berpikir Kreatif Peserta Didik di Sekolah Dasar. *Horizon Pendidikan*, *16*(2), 72–82. https://doi.org/10.33477/hp.v16i2.2741

Wilujeng, I., & Rahmawati, L. (2024). Profile of Science Literacy and Cultural Awareness of Students and the Need for Science Teaching Materials Integrated with Local Potential of STEAM-PBL Based Petis in Sumenep. *Jurnal Penelitian Pendidikan IPA*, *10*(9), 6677–6689. https://doi.org/10.29303/jppipa.v10i9.7578

Zaky, M., Jamhari, M., & Zaky, M. (2024). STEM Literacy Proficiency in Prospective Physics Educator: A Comprehensive Analysis Using Rasch Measurement Theory. *Jurnal Penelitian Pendidikan IPA*, *10*(12), 10799–10810. https://doi.org/10.29303/jppipa.v10i12.8970