Journal of Biology Learning
Vol. 8., No. 1, March 2026, pp. 11-18
ISSN 2623-2243 (print), 2623–1476 (online)
http://journal.univetbantara.ac.id/index.php/jbl/index

Ethnoscience-Based STEM Learning on Science Process Skills, Learning Interests, and Learning Outcomes of Students at SMAN 1 Girimarto

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Received July 10, 2026; accepted March 31, 2026; published March 31, 2026

ABSTRACT

This study aims to analyze the effect of implementing STEM-based learning integrated with ethnoscience on improving science process skills, learning interest, and learning outcomes of students at SMAN 1 Girimarto. This study uses a quantitative approach with a quasi-experimental research type. The research design used is One Shot Case Study, which is a design that only involves one experimental group without a control group. The population in this study were all students in grade XI at SMA Negeri 1 Girimarto. The research sample was 32 students in grade XI D. The sampling technique used purposive sampling. The results of observations of basic science process skills (KPSD) show varying achievements across five main indicators, with patterns that reflect the level of cognitive difficulty of each skill. The overall average score of 73.06 (medium category) indicated that students collectively responded positively to the integration of local wisdom values in science learning, although individual variability remained. The distribution of student learning outcomes shows very encouraging academic achievement with a dominance of good to very good categories, indicating the success of the implementation of ethnoscience-based STEM learning in improving understanding of excretory system concepts. It can be concluded that the implementation of STEM learning based on ethnoscience on the excretory system material has a positive impact on the three aspects of learning studied with varying levels of success.

KEYWORDS

Science process skills,
STEM,
Ethnoscience,
Learning outcomes

1. Introduction

Learning is a fundamental process that facilitates understanding, skill development, and internalization of values needed in life. Ideal learning creates a conducive, relevant, and interesting learning atmosphere for students by accommodating various learning styles and encouraging active participation to develop students' optimal potential (Jankowska et al., 2008; Liu et al., 2024; Nguyen et al., 2021). An interactive, inclusive, and enjoyable learning approach can be supported through the implementation of mindful learning, meaningful learning, and joyful learning which not only helps students understand the material but also fully involves students in a lighter and more enjoyable learning process (Kusumadani et al, 2025, Huda, et al, 2022).

Science education in Indonesia still faces substantial challenges, particularly related to the low quality of the learning process and student learning outcomes (Trinova et al., 2022). This is reflected in the results of the 2022 Program for International Student Assessment (PISA), which ranked Indonesia 65th out of 81 countries in scientific literacy with a score of 395, far below the international average of 485 (Pursitasari et al., 2022). This low achievement indicates a significant gap in the development of science process skills and interest in learning science among Indonesian students.

One contributing factor to this problem is the lack of contextualization of science learning in schools and the lack of integration with technology, engineering, and mathematics relevant to students' daily lives (Wu & Rau, 2019). This conventional and fragmented learning makes it difficult for students to understand the connections between scientific concepts and their applications in real-world contexts. As a result, students lack motivation and struggle to develop the higher-order thinking skills needed to solve complex problems in the modern era.

Biology as a branch of science provides a deep understanding of life phenomena. The essence of biology learning is to provide a comprehensive understanding of life and the biological processes that occur around us (Woese, C. R, 2004). In addition to focusing on mastering theoretical concepts, biology learning also emphasizes the development of practical skills through a scientific approach, which is reflected in Science Process Skills (SPS), as well as fostering interest in learning and improving learning outcomes (Rosa et al, 2025).

Biology learning in high schools currently faces several fundamental problems. First, the lack of attention to interactive and activity-based learning approaches. Limited learning time means that students do not have enough opportunities to conduct experiments or observation activities. Second, laboratory facilities that have not been optimally utilized are an obstacle in implementing experimental or observation activities (Astuti & Kurniawati, 2021). Third, learning that still focuses on theory and tends to be teacher-centered results in low student activity and involvement in scientific activities. These conditions lead to low interest in learning, less than optimal learning outcomes, and weak science process skills of students. Some students consider biology as a memorization lesson that is difficult to understand and irrelevant in everyday life. In 21st-century education, science learning not only emphasizes mastery of material, but also develops critical thinking skills, problem solving, and application of knowledge in everyday life (Bailin, S. (2002); Fitria et al, 2025).

To overcome these problems, a more integrated and contextual learning approach is needed. STEM (Science, Technology, Engineering, and Mathematics) learning is a potential solution that is right for creating more active, contextual, and meaningful learning. STEM learning emphasizes integration between various disciplines that help students understand the relationship between science, technology, engineering, and mathematics (Chalmers et al, 2017). This approach provides contextual learning, helps students develop mathematical attitudes both affectively and psychomotorically, and encourages them to become flexible, cooperative, and collaborative individuals (Bassachs et al, 2022).

The application of STEM learning can be strengthened by integrating ethnoscience that considers local wisdom and culture of students in learning. Ethnoscience-based learning can create a more interesting learning atmosphere (Hikmawati et al, 2021). The application of ethnoscience in learning is used as a means of motivation, stimulation of students, and overcoming boredom and difficulties in learning science (Puspasari et al., 2019).

Several studies have shown the effectiveness of STEM and ethnoscience learning in improving various aspects of learning. Yulaikah's (2022) research shows that STEM learning is effective in improving understanding of science concepts. (Khoiriyah et al, 2021) in their research on the ethnoscience learning approach with the method of collecting learning interest data using the ARCS questionnaire (attention, relevance, confidence, satisfaction) showed an increase in learning interest in the experimental class compared to the control class. (Herak et al, 2021) also showed that the application of the STEM learning model succeeded in improving science learning outcomes in the excretion material.

Research Pandiangan (2025); Nugraha & Rachmadiarti (2022). proves that STEM learning is effective in increasing the interest and learning outcomes of high school students in biology, by inviting students to be more active, think critically, and be able to connect science concepts with everyday life. (Firdaus et al, 2023) shows that the application of STEM learning has an effect on science process skills by 16.9% compared to scientific learning. (Trianah et al, 2020) in their research on ethnoscience learning on science process skills showed quite high achievement compared to conventional learning.

This study is important because it examines the influence of ethnoscience-based STEM learning on three crucial aspects of biology learning, namely science process skills, learning interests, and learning outcomes. STEM learning in this study is adjusted to the local context and needs of students in high schools, so it is expected to be able to provide real contributions to the development of a contextual, meaningful, and local wisdom-based science learning model.

Based on this background, this study aims to analyze the effect of implementing STEM (Science, Technology, Engineering, and Mathematics)-based learning integrated with ethnoscience on improving science process skills, learning interests, and learning outcomes of students at SMAN 1 Girimarto. Through this integrated approach, it is expected to identify the extent to which the STEM learning model contributes to developing scientific competence and fostering students' enthusiasm for learning in the field of science. The findings of this study are expected to provide a theoretical foundation for further research on locally context-centered science learning with an interdisciplinary approach. Furthermore, this study provides practical guidance for schools in optimizing the use of local resources and laboratories to support more effective science learning, thereby helping improve the quality of science education in Indonesia and narrowing the gap between scientific literacy achievement and international standards.

2. Method

This study uses a quantitative approach with a quasi-experimental research type. According to (Yogaswara 2019), this type of research is an experiment that uses all subjects in the intact group to be treated, but does not allow full control over the variables that can affect the validity of the experiment. The research design used is One Shot Case Study, which is a design that only involves one experimental group without a control group. The results of this study are a preliminary or initial exploratory study that requires further research with a more rigorous experimental design to validate the findings and strengthen claims about the influence of learning interventions on science process skills, learning interest, and student learning outcomes.

In this design, the research subjects were given treatment in the form of ethnoscience-based STEM learning, then the results were measured through post-tests and other instruments. No initial measurements (pre-tests) were carried out, so that the assessment of the effectiveness of the treatment was only based on the measurement results after the treatment was given. Although this design has limitations in terms of internal validity, this design was chosen because it is in accordance with the conditions and limitations in the research field.

The population in this study were all students of class XI at SMA Negeri 1 Girimarto. The research sample was 32 students of class XI D. The sampling technique used purposive sampling, which is a sampling technique based on certain considerations that are relevant to the research objectives. Considerations for selecting samples were based on recommendations from biology educators at SMA Negeri 1 Girimarto and the availability of classes that were in accordance with the focus of the research. Class XI D was chosen as a sample because it is the only biology class at SMA Negeri 1 Girimarto that allows for the implementation of ethnoscience-based STEM learning on the excretory system material.

This study uses one independent variable and three dependent variables. The independent variable is ethnoscience-based STEM learning, while the dependent variables include: (1) science process skills, (2) learning interest, and (3) student learning outcomes. The treatment given is the implementation of an ethnoscience-based STEM learning model on the excretory system material during the specified learning period.

This study used three types of instruments to measure the three dependent variables. First, the science process skills observation sheet used to observe student engagement during the learning process. This instrument is compiled based on five indicators of science process skills which include the ability to observe, formulate hypotheses, design experiments, collect data, and draw conclusions. Second, a learning interest questionnaire consisting of 20 questions arranged using a Likert scale with a scale of 1-5. This questionnaire covers four main indicators of learning interest, namely feelings of pleasure, attention, interest, and active involvement of students in biology learning. Third, a learning outcome test (post-test) consisting of 10 multiple-choice questions and 5 essay questions used to measure students' mastery of concepts after receiving ethnoscience-based STEM learning treatment.

The research procedure was carried out in several stages. The first stage is preparation, which includes the preparation of research instruments, instrument validation, and coordination with the school. The second stage is the implementation of treatment in the form of implementing ethnoscience-based STEM learning on the excretory system material. During this stage, observations were made using science process skills observation sheets to measure student involvement in learning activities. The third stage is data collection which is carried out after the entire learning series is complete. At this stage, students fill out a learning interest questionnaire and take a learning outcome test (post-test). Data collection was carried out to determine the effect of treatment on the three variables studied, namely science process skills, learning interest, and learning outcomes.

The collected data were analyzed using descriptive statistics to provide an overview of the characteristics of the data from each variable. Descriptive analysis includes calculating the average value (mean), percentage, and frequency distribution for each variable studied. For science process skills data, the percentage of achievement was calculated based on the results of observations. Learning interest data were analyzed based on the average score and percentage of achievement of each indicator. Meanwhile, learning outcome data were analyzed based on the average value, percentage of completion, and distribution of student scores. The assessment criteria for each variable were determined based on applicable school standards and relevant theoretical references. The results of the data analysis were then

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interpreted to describe the effect of ethnoscience-based STEM learning on science process skills, learning interest, and student learning outcomes.

3. Results and Discussion

3.1. Basic Science Process Skills (KPSD) of Students

Measurement of basic science process skills is carried out through observation during the learning process. Observations are carried out based on five KPSD indicators which include: (1) observing, (2) measuring, (3) classifying, (4) predicting, and (5) communicating. The results of the observations show different variations in achievement for each indicator (Table 1).

Table 1. Observation Results of Basic Science Process Skills

No	*KPSD Indicator*	*Average*	*Score Percentage*	*Category*
1	Observed	3.8	76%	Good
2	Measuring	3.7	74%	Good
3	Classifying	2.9	58%	Enough
4	Predict	2.8	56%	Enough
5	Communicating	3.1	62%	Enough
	Average Total	3.26	65.2%	Enough

Source: author's data processing, 2025

The results of observations of basic science process skills (KPSD) (Table 1) show varying achievements across five main indicators, with patterns that reflect the level of cognitive difficulty of each skill. The observing indicator achieved the highest achievement with an average score of 3.8 (76%) and the measuring indicator obtained a score of 3.7 (74%), both of which are in the good category, indicating that students have mastered direct observation and quantitative measurement skills well in the context of ethnoscience-based STEM learning. This is understandable because both skills are concrete and can be directly observed, making them easier for students to master. In contrast, the other three indicators classifying (2.9/58%), predicting (2.8/56%), and communicating (3.1/62%) are in the sufficient category, indicating greater challenges in science process skills that require analysis, synthesis, and high-level thinking skills. The low scores on the predicting (56%) and classifying (58%) indicators indicate that students still have difficulty in processing information from observations to make systematic categorizations and logical predictions based on observed data patterns.

3.2. Students' Learning Interests

The measurement of learning interest was conducted using a questionnaire consisting of 20 questions with a Likert scale of 1-5. This questionnaire measures four indicators of learning interest, namely feelings of pleasure, attention, interest, and active involvement of students in biology learning. Distribution of learning interests based on category can be seen in Table 2.

Table 2. Distribution of Learning Interests Based on Category

No.	*Category*	*Score Range*	*Number of Students*	*Percentage*
1	Very High	81-100	6	18.75%
2	Height	71-80	12	37.5%
3	Medium	61-70	11	34.37%
4	Low	51-60	3	9.38%
5	Very Low	≤50	0	0%

Source: author's data processing, 2025

The distribution of students' learning interests showed a relatively positive profile with a dominant tendency in the high to very high categories, reflecting the effectiveness of the ethnoscience-based STEM learning approach in motivating academic engagement. The data showed that the majority of students (37.5%) were in the high interest category, followed by the medium category (34.37%), the very high category (18.75%), and only 9.38% in the low category with no students in the very low category. The overall average score of 73.06 (medium category) indicated that students collectively responded positively to the integration of local wisdom values in science learning, although individual variability remained. However, learning differentiation and personalization strategies are still needed to optimize learning interests, especially to elevate the 43.75% of students in the medium and low categories to a higher level through increasing content relevance, varying learning methods, and strengthening connections between science materials and deeper local cultural experiences.

3.3. Student Learning Outcomes

Learning outcome measurement is done through a post-test consisting of 10 multiple-choice questions and 5 essay questions. This test is designed to measure students' mastery of concepts after receiving ethnoscience-based STEM learning treatment on the excretory system material. Distribution of learning outcomes by category presented in Table 3.

Table 3. Distribution of Learning Outcomes by Category

No.	Category	Range of Values	Number of Students	Percentage
1	Very Good	85-100	10	31.25%
2	Good	70-84	16	50%
3	Enough	60-69	3	9.38%
4	Less	<60	3	9.38%

Source: author's data processing, 2025

The distribution of student learning outcomes (Table 3) shows very encouraging academic achievement with a dominance of good to very good categories, indicating the success of the implementation of ethnoscience-based STEM learning in improving understanding of excretory system concepts. The data shows that half of the total students (50%) achieved the good category with a score range of 70-84, and almost a third of students (31.25%) managed to achieve the very good category with a score of 85-100, resulting in an impressive completion rate of 81.25% (26 of 32 students) which significantly exceeds the minimum learning completion standard. Although there are still a small number of students in the sufficient (9.38%) and less (9.38%) categories with a total of 18.75% who have not achieved completion, this proportion is relatively low and still within reasonable limits for the variability of individual abilities within a class. This success can be attributed to the effectiveness of the ethnoscience-based STEM approach which is able to bridge the gap between modern scientific knowledge and students' local cultural experiences, thereby creating more relevant, meaningful, and easy-to-understand learning through the concretization of abstract concepts with analogies and examples familiar from students' daily lives.

3.4. Basic Science Process Skills in Ethnoscience-Based STEM Learning

The results of the study showed that students' basic science process skills reached an average of 65.2% with a sufficient category. The highest achievement was in the observing (76%) and measuring (74%) indicators, while the classifying (58%), predicting (56%), and communicating (62%) indicators were still in the sufficient category. This finding is in line with Firdaus' (2023) research which showed that the application of STEM learning had an effect on science process skills by 16.9% compared to scientific learning. The dominance of the ability to observe and measure can be explained because these two skills are basic skills that are more concrete and easy to observe directly during the learning process.

The low achievement in the aspects of classifying, predicting, and communicating reveals a complex pedagogical phenomenon, where students still face significant challenges in mastering high-level science process skills that require sophisticated in-depth analysis and cognitive synthesis skills. This gap indicates a suboptimal transition from concrete observation and measurement skills to higher-level thinking skills that require more complex abstraction, generalization, and metacognitive abilities. This finding is in line with Trianah's (2020) research which confirms that although ethnoscience-based learning shows relatively high achievement compared to conventional learning, more targeted and systematic special strategies are still needed to develop complex science process skills, which indicates that the integration of local wisdom alone is not enough without being supported by appropriate pedagogical scaffolding.

Paradoxically, the integration of ethnoscience in STEM learning should be a very effective bridge to improve these abilities, considering that local wisdom inherently contains systematic classification processes (such as grouping medicinal plants based on their properties, planting seasons, or processing methods), empirical prediction processes (such as weather forecasts based on natural phenomena, crop yield predictions based on lunar cycles, or disaster anticipation based on environmental indicators), and traditional communication systems rich in symbolism and meaning (such as storytelling, rituals, and hereditary practices) all of which can be organically connected to modern scientific concepts. The main

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challenge lies in the ability of educators to make explicit and facilitate the transfer of learning from the context of local wisdom to formal scientific applications, which requires a more elaborate learning design with systematic bridging strategies, gradual scaffolding, and authentic assessments that can measure the progression from concrete operational thinking to formal operational thinking in the context of science, so that the potential of local wisdom as a cognitive anchor can be maximized to develop higher-order thinking skills which are the main goals of 21st century science education.

3.5. Learning Interest and Student Involvement

Students' interest in learning showed quite encouraging results with an average of 73% in the moderate category. Data distribution shows that the majority of students (37.5%) have a high interest in learning, followed by the moderate category (34.37%) and very high (18.75%). This finding supports the research results of Khoiriyah et al. (2021) and Nisa et al. (2024) which showed an increase in interest in learning in the experimental class that applied the ethnoscience approach compared to the control class. This increase in interest in learning can be explained because ethnoscience-based STEM learning is able to present a context that is familiar and relevant to students' daily lives.

However, there are still 9.38% of students who have low learning interest, indicating the need for differentiation strategies in learning. According to Puspasari et al. (2019), the application of ethnoscience in learning is used as a means of motivation and stimulation for students to overcome boredom and difficulties in learning science. This shows that although the ethnoscience-based STEM approach is generally effective, its implementation needs to be adjusted to the individual characteristics of students to maximize its impact on learning interest.

3.6. Learning Outcomes and Concept Mastery

The learning outcomes of students showed the most satisfactory achievement with an average of 78.4 and a percentage of completion of 81.25%. The distribution of results showed that 50% of students obtained good scores (70-84) and 31.25% obtained very good scores (85-100). This finding is in line with Pandiangan's research (2025) which proved that STEM learning is effective in improving the learning outcomes of high school students in biology subjects. This success can be explained because STEM learning invites students to be more active, think critically, and be able to connect science concepts with everyday life (Nelson et al., 2019; Semanko & Ladbury, 2020).

Herak's (2021) research also supports this finding by showing that the application of the STEM learning model successfully improved science learning outcomes in excretion material. Other studies have also shown that hands-on learning can optimize mastery of scientific concepts and process skills (Novitasari et al., 2025; Freeman et al., 2014). The integration of ethnoscience in STEM learning seems to provide added value because it helps students understand abstract concepts through concrete and familiar contexts. However, there are still 18.76% of students who have not achieved completion, indicating the need for improvements in learning strategies to accommodate the needs of all students.

3.7. Effectiveness of Ethnoscience-Based STEM Learning

Comparison of the results of the three research variables shows that ethnoscience-based STEM learning is most effective in improving learning outcomes (78.4%), followed by learning interest (73%), and science process skills (65.2%). This pattern is consistent with the constructivist learning theory which emphasizes that meaningful learning occurs when students can relate new knowledge to previous experiences. Yulaikah's (2022) research shows the effectiveness of STEM learning in improving understanding of science concepts, which supports the findings of this study.

The superiority of ethnoscience-based STEM learning in improving learning outcomes can be explained through a holistic approach that integrates science, technology, engineering, and mathematics with local wisdom. This is in line with the objectives of STEM learning according to Gao et al. (2020), namely to develop factual and contextual knowledge and help develop students' skills. However, the relatively lower achievement of science process skills indicates the need for improvements in the methodology and learning strategy aspects to develop students' scientific thinking skills.

The results of this study have several important implications for science education practices in Indonesia. First, ethnoscience-based STEM learning has proven effective as an alternative learning approach that can improve the quality of science education, especially in the context of Indonesia which is rich in local wisdom. Second, there is a need to develop specific strategies to improve high-level science process skills, especially in the aspects of classifying, predicting, and communicating results.

Third, the implementation of ethnoscience-based STEM learning requires thorough preparation from educators, including a deep understanding of local wisdom and the ability to integrate it with modern science concepts. Fourth, the need for the development of more comprehensive assessment instruments to measure the impact of ethnoscience-based STEM learning holistically. Fifth, the results of this study can be the basis for the development of a curriculum and teaching materials that are more contextual and in accordance with the characteristics of Indonesian students.

4. Conclusion

Based on the results of the research and discussion that have been conducted, it can be concluded that the implementation of ethnoscience-based STEM learning on the excretory system material has a positive impact on the three aspects of learning studied with varying levels of success. Student learning outcomes showed the best achievement with an average of 78.4 and a percentage of completion reaching 81.25%, indicating that this approach is very effective in improving mastery of biological concepts. Student learning interest is in the moderate category with a percentage of 73%, indicating that ethnoscience-based STEM learning is able to foster student attention and involvement, although it still requires additional strategies to achieve a higher category. Meanwhile, basic science process skills reached 65.2% in the sufficient category, with indicators of observing and measuring showing good achievement, but aspects of classifying, predicting, and communicating still need improvement. Overall, ethnoscience-based STEM learning has proven to be a promising learning approach in the context of science education in Indonesia, especially in integrating local wisdom with modern science approaches to create more meaningful and contextual learning for students.

The limitation of this study is the use of a One-Shot Case Study design without a pretest and control group, which limits the researcher's ability to determine a definite causal relationship between ethnoscience-based STEM learning interventions and improvements in science process skills, learning interest, and student learning outcomes, so that the research results are descriptive and cannot be generalized to a wider population.

References

Astuti, R., & Kurniawati, E. (2021). Science Process Skills (SPS) Biology Education Students in Histology Practicum Eye Epithelial Tissue Material. Report of Biological Education, 2(2), 55-64.

Bailin, S. (2002). Critical thinking and science education. Science & education, 11, 361-375.

Bassachs, M., Serra, T., Bubnys, R., Cañabate, D., & Colomer, J. (2022). Multimodal approaches to math and physical education within cooperative learning to enhance social attitudes. Sustainability, 14(24), 16961.

Chalmers, C., Carter, M., Cooper, T., & Nason, R. (2017). Implementing "big ideas" to advance the teaching and learning of science, technology, engineering, and mathematics (STEM). International Journal of Science and Mathematics Education, 15, 25-43.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the national academy of sciences*, *111*(23), 8410-8415.

Firdaus, M. D., Rahayu, P., & Nuraeni, F. (2023). Pengaruh Pendekatan Science, Technology, Engineering, and Mathematics (STEM) terhadap Keterampilan Proses Sains Siswa Sekolah Dasar. Fondatia, 7(3), 720-730.

Fitria, D., Asrizal, A., & Lufri, L. (2025). Enhancing 21st-Century Skills through Blended Problem-Based Learning with Ethnoscience Integration: A Mixed-Methods Study in Indonesian Junior High Schools. International Journal of Learning, Teaching and Educational Research, 24(1), 464-480.

Hikmawati, H., Suastra, I. W., & Pujani, N. M. (2021). Ethnoscience-based science learning model to develop critical thinking ability and local cultural concern for junior high school students in Lombok. Jurnal Penelitian Pendidikan IPA, 7(1), 60-66.

Huda, C., Hanief, M., & Hakim, D. M. (2022). Islamic religious education learning strategy with edutainment insight in improving learning motivation of student. Nazhruna: Jurnal Pendidikan Islam, 5(2), 787-805.

Iriani, R., Agustianingsih, N. A. B., Analita, R. N., & Bakti, I. (2024). Analisis Kemampuan Berpikir Kreatif Peserta Didik Pada Materi Sel Elektrokimia Dengan Model Project-Based Learning Berbasis Etnosains. JCAE (Journal of Chemistry And Education), 8(1), 42-54.

Jacinda, A. A., & Surtikanti, H. (2023). Pembelajaran berbasis etnosains pada materi biologi untuk meningkatkan prestasi belajar siswa: kajian literatur. Asian Journal Collaboration of Social Environmental and Education, 1(1).

Jankowska, M., & Atlay, M. (2008). Use of creative space in enhancing students' engagement. Innovations in education and teaching international, 45(3), 271-279.

Khoiriyah, Z., & Qosyim, A. (2021). Efektivitas pendekatan etnosains dalam pembelajaran daring untuk meningkatkan motivasi dan hasil belajar siswa materi kalor. Pensa: e-Jurnal Pendidikan Sains, 9(3), 433-442.

Kusumadani, A. I., Afandy, H., Agustina, L., Astuti, R., & Waluyo, M. (2025). Evaluation of Higher-Order Thinking Skills of Middle School Students on Vibration and Wave Topic Using Rasch Measurement. Jurnal Penelitian Pendidikan IPA, 11(5), 74-84.

Liu, J., Tahri, D., & Qiang, F. (2024). How does active learning pedagogy shape learner curiosity? A multi-site mediator study of learner engagement among 45,972 children. *Journal of Intelligence*, *12*(6), 59.

Nelson, J., Sachs, R., Foster, S., Rosenberg, J., Poms, L., Lester, J., & Klein, C. (2019, August). Improving STEM Teaching And Learning Through Active Learning. In *Innovations in Teaching & Learning Conference Proceedings* (Vol. 11, pp. Room-A).

Nguyen, K. A., Borrego, M., Finelli, C. J., DeMonbrun, M., Crockett, C., Tharayil, S., ... & Rosenberg, R. (2021). Instructor strategies to aid implementation of active learning: a systematic literature review. *International Journal of STEM Education*, *8*(1), 9.

Novitasari, A., Sintasari, R., Kesumawardani, A. D., & Supriyadi, S. (2025). The Relationship Between Science Process Skills and Concept Mastery Using Practical Methods. *Journal of Biology Learning*, *7*(2), 43-52.

Nugraha, W. H., & Rachmadiarti, F. (2022). Development of stem-based flipbook on biodiversity materials to train critical thinking skills for X-grade students of senior high school. Berkala Ilmiah Pendidikan Biologi (BioEdu), 11(2), 302-311.

Pandiangan, S. M. T., Dharmawan, D., Hariyanto, M., Pujiastuti, E., & Zalogo, E. F. (2025). Resilience Management in Generation Z Entrepreneurs in Medan City. International Journal Of Education, Social Studies, And Management (IJESSM), 5(1), 19-26.

Pursitasari, I. D., Permanasari, A., & Jaenudin, D. (2022). Pelatihan penyusunan e-asesmen literasi sains berbasis akm bagi guru IPA SMP di kabupaten bogor. Jurnal Pemberdayaan Masyarakat, 1(1), 26-33.

Rosa, T. D. M., Aryani, I., Agustina, P., Astuti, R., & Mufanti, R. (2025, March). The effectiveness of the discovery learning model using schoology to improve class x learning outcomes of Muhammadiyah high school. In AIP Conference Proceedings (Vol. 3142, No. 1, p. 020108). AIP Publishing LLC.

Semanko, A. M., & Ladbury, J. L. (2020). Using the reasoned action approach to predict active teaching behaviors in college STEM courses. *Journal for STEM Education Research*, *3*(3), 387-402.

Suprapto, N., Shofiyah, N., & Cheng, T. H. (2024). How does ethnoscience-students' worksheet (ESW) influence in science learning?. *Journal of Education and Learning (EduLearn)*, *18*(2), 403-412.

Trinova, Z., Astuti, R., Perdana, I., Rahman, Y., Jhony, C., Haris, I., & Arifin, A. (2022). Influence of Interest and Discipline on Student Learning Outcomes. Journal of Higher Education Theory & Practice, 22(18).

Woese, C. R. (2004). A new biology for a new century. Microbiology and molecular biology reviews, 68(2), 173-186.

Wu, S. P., & Rau, M. A. (2019). How students learn content in science, technology, engineering, and mathematics (STEM) through drawing activities. Educational Psychology Review, 31, 87-120.

Yogaswara, S. M., Novendra, A. M., Almujab, S., & Ramafrizal, Y. (2019). Analisis Perbandingan Metode Problem Based Learning Dan Problem Solving Untuk Meningkatkan Kemampuan Berfikir Kreatif. Didaktik: Jurnal Ilmiah PGSD STKIP Subang, 5(2), 224-240.

Yulaikah, I., Rahayu, S., & Parlan, P. (2022). Efektivitas pembelajaran STEM dengan model PjBL terhadap kreativitas dan pemahaman konsep IPA siswa Sekolah Dasar (Doctoral dissertation, State University of Malang).