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E-Worksheets Based on Ethno-Modeling and Tri-N to Improve Mathematical Critical Thinking Skills of Grade VII Students

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Abstract

Mathematical critical thinking remains an essential yet underdeveloped competency in 21st-century mathematics learning, particularly when instruction lacks meaningful cultural context. At SMP Pembangunan Piyungan, number-topic instruction predominantly emphasizes procedural over contextual and reflective thinking, signaling an urgent need for culturally-grounded, innovative learning media. This study examines the improvement trend in seventh-grade students' mathematical critical thinking ability through E-Worksheets integrating Ethno-Modeling—connecting mathematical concepts with Piyungan's local cultural context—and the Tri-N approach (*Niteni*, *Nirokke*, *Nambahi*), which systematically guides students through observing, imitating, and developing ideas. Employing a time-series design, data were collected via mathematical critical thinking tests administered at each intervention meeting and analyzed quantitatively by tracking average score trends over time. Results demonstrate a consistent upward trend, with average scores rising from 89.09 at the first meeting to 96.18 at the seventh—indicating that E-Worksheets grounded in local cultural contexts and structured Tri-N learning stages effectively foster students' mathematical critical thinking development. These findings position Ethno-Modeling-based E-Worksheets integrated with Tri-N as a promising alternative medium for meaningful and culturally responsive mathematics learning.

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INTRODUCTION

The development of 21st-century education demands that mathematics learning be oriented not only toward mastery of procedures but also toward developing students' critical mathematical thinking skills (Szabo, et al., 2020; Whitney-Smith,

et al., 2022). However, in practice, mathematics learning has not fully reflected these demands. This can be seen in that Mathematics, as a science that deals with abstract concepts, is structured hierarchically, and requires deductive reasoning, is often learned mechanically, so students tend to memorize steps to solve problems without understanding the underlying concepts (Ernie et al., 2023; Widodo, Irfan, et al., 2025). As a result, students experience difficulties when faced with non-routine and contextual problems that require higher-level reasoning (Sujadi et al., 2025; Widodo, Hidayat et al., 2025). This condition indicates that mathematics learning has not fully developed the ability to think deeply, systematically, and in accordance with curriculum requirements (Jamil et al., 2024; Sachdeva & Eggen, 2021), so the critical mathematical thinking skills of students in Indonesia are still relatively low.

Critical thinking skills are an essential competency in 21st century learning and are part of the 4C skills: critical thinking, communication, collaboration, and creativity (Elvianasti et al., 2024; Sulistyowati et al., 2022; Tohani & Aulia, 2022). In mathematics learning, this ability plays a crucial role in helping students understand concepts deeply, connect mathematical ideas, analyze problems, and make logical decisions (Jamil er al., 2024). Other research also confirms that critical and creative thinking skills are important aspects that must be developed in mathematics learning (Sosa-Gutierrez et al., 2023; Sachdeva & Eggen, 2021). Therefore, developing critical mathematical thinking skills is an important aspect to improve the quality of learning and student learning outcomes.

Students' low mathematical critical thinking skills are also reflected in international assessment results. TIMSS results show that Indonesian students' mathematics scores remain below the international average. In TIMSS 2015, Indonesia scored 397, while in TIMSS 2023, Indonesian students' mathematics scores remained in the 390's and remained below the international average (Afgani & Paradesa, 2021; Kusmaryono & Kusumaningsih, 2023; OECD, 2016, 2023). This trend strengthens the indication that students' mathematical competencies have not yet developed optimally, particularly in aspects that require deeper conceptual understanding and higher-order reasoning. Besides that, these results indicate that most students still experience difficulties in understanding basic mathematical concepts and solving contextual problems that require critical thinking skills.

One way to address this issue is through the use of digital learning media in the form of e-worksheets (Sujatmika et al., 2019; Suroyaningsih et al., 2024; Widodo et al., 2023). E-worksheets allow for interactive presentation of material through text, images, videos, and simple simulations, thereby increasing student engagement and understanding. However, in practice, the use of e-worksheets in schools generally focuses on the digitalization of the media and does not optimally integrate local cultural contexts or the stages of students' thinking processes.

The Ethno-Modeling approach offers a contextual foundation for mathematics learning by connecting mathematical concepts to local cultural practices familiar to students, allowing abstract ideas to emerge from meaningful real-life experiences (Hidayat et al., 2025). Complementarily, the Tri-N concept—*Niteni* (observing), *Nirokke* (imitating), and *Nambahi* (developing)—provides structured cognitive stages that guide students from contextual exploration to formal mathematical reasoning (Latifah et al., 2024; Suroyaningsih et al., 2024; Widodo et al., 2024; Wijayanti et al., 2021). While Ethno-Modeling supplies contextual substance, Tri-

N organizes the thinking process required for abstraction, generalization, and critical analysis. Within this study, both are integrated as a unified pedagogical pathway for constructing mathematical understanding: Ethno-Modeling functions as the contextual entry point through cultural activities and problem situations, which are then systematically processed through the Tri-N stages. *Niteni* directs students to observe patterns and relationships embedded in cultural practices (Latifah et al., 2024; Suroyaningsih et al., 2024); *Nirokke* enables them to reconstruct these ideas into mathematical representations (Suroyaningsih et al., 2024; Widodo et al., 2024); and *Nambahi* encourages refinement, generalization, and extension into more formal reasoning (Widodo et al., 2024; Wijayanti et al., 2021). Through this sequence, cultural knowledge is transformed into structured mathematical concepts, positioning students as active constructors of knowledge and establishing a coherent conceptual bridge between contextual experience, cognitive processing, and formal mathematical abstraction.

Several previous studies have shown that the use of e-worksheets is effective in increasing student engagement and understanding. Puspita & Dewi (2021) found that e-worksheet based on a mathematical investigation approach positively influenced critical thinking skills. Furthermore, the use of e-LKPD has also been shown to improve students' mathematical literacy (Mulyasari, 2022; Sari et al., 2023; Purnama & Suparman, 2020). While the Tri-N approach has been shown to increase student engagement and critical and creative thinking skills, most of this research has examined each approach separately.

Based on the description, there is a research gap related to the integration of E-Worksheet, Ethno-Modeling, and Tri-N in one mathematics learning tool, especially on number material at the junior high school level. Therefore, this study aims to examine the trend of improvement using E-Worksheet based on Ethno-Modeling and Tri-N in improving the mathematical critical thinking skills of seventh grade students of Junior High School Pembangunan in Piyungan.

RESEARCH METHODS

This research uses a quantitative approach with a single-phase time series experiment. Quantitative methods focus on collecting and analyzing numerical data or measuring a variable (Afif et al., 2023; Sofwatillah et al., 2024). This study was designed and implemented in accordance with time series research standards, characterized by sequential data collection at multiple time points to observe patterns of change, trends, and the consistency of treatment effects (Wang et al., 2024; Wauchope et al., 2021). Each measurement stage was conducted systematically with the same instrument (Pandiangan & Albina, 2025; Saputra, 2025), allowing for comparative analysis across time and ensuring the validity of interpretations of the dynamics of the research results (Rachmad et al., 2024).

Subject selection was conducted using a purposive sampling technique by considering the homogeneity of student characteristics (Obilor, 2023). The criteria used in determining the subjects included relatively similar initial abilities, comparable prior achievement levels, and a consistent background in mathematics learning. This approach was intended to ensure that the participants represented a group with equivalent academic readiness, thereby reducing variability that could potentially influence the research results. The total number of subjects involved in

this study was 29 students who met the predetermined criteria. Their selection was based on their relevance to the objectives of the study and their suitability for observing changes over the course of the intervention. By involving students with relatively uniform characteristics, the study aimed to obtain more accurate and reliable data regarding the implementation and impact of the learning intervention being examined.

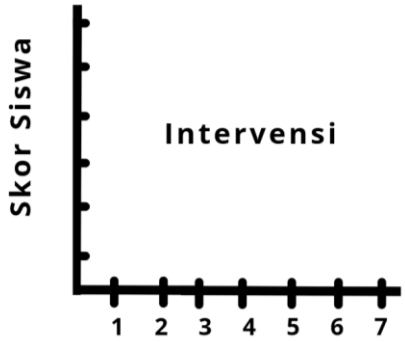

Figure 1. Time Series Research Design

The research design used was a single-phase time series design, specifically the intervention phase (Beard et al., 2025; Darby et al., 2023). In this design, student scores were measured repeatedly seven times during the intervention process (See Figure 1). These repeated measurements aimed to observe changes in student scores over time as a result of the intervention (Bedard et al., 2018; von Ende, 2020). Based on the measurement results, student scores showed a pattern of change during the intervention phase, reflecting a response to the treatment implemented.

Subject of Research

The research participants were chosen through a purposive sampling method, which is the selection of subjects adjusted to the characteristics and objectives of the research as well as the researcher's considerations, while still observing the research code of ethics (Campbell et al., 2020; Dahal et al., 2024). The subjects of this study were 29 seventh-grade students of SMP Pembangunan Piyungan in the odd semester of the 2025/2026 academic year. The selection of subjects was carried out by considering that these students were studying the material of numbers and arithmetic operations of real numbers and had learning needs that were in line with the research objectives. This research is directed at improving mathematical critical thinking skills through the use of E-Worksheets based on Ethno-Modeling with the Tri-N approach. Thus, the selection of subjects is in line with the research objective, which is to examine the improvement of students' mathematical critical thinking skills in the material of numbers and arithmetic operations of numbers.

Data Collection

Data collection in this study was conducted through interviews, observations, and tests. Interviews were used to obtain initial information regarding the learning conditions and characteristics of the research subjects. Meanwhile observations were conducted systematically during each learning session to document student engagement during the implementation of Ethno-Modeling and Tri-N-based E-Worksheets. The primary instrument for measuring students' critical mathematical

thinking skills was a written test administered repeatedly over seven sessions during the intervention phase. Test items were developed based on key indicators of critical mathematical thinking, including the ability to analyze algorithms, identify and justify concepts, and generalize (Harti & Agoestanto, 2019; Korkmaz, 2012; Setiana et al., 2021). The repeated testing generated time series data that was analyzed chronologically to examine trends, stability, and the level of improvement in students' critical mathematical thinking skills during the intervention.

Data Analysis

After the researcher collected all the required data, the next stage was to conduct data analysis. Data calculations were assisted by using Microsoft Excel, while the presentation of tables and figures was compiled manually. This study applied analysis in conditions, namely analysis conducted in the intervention phase. The elements used in the condition analysis consist of: (1) the duration of the condition; (2) the direction of the trend; (3) the level of stability, determined by calculating the proportion of data points that fall within ±50% of the mean; (4) the rate of change, obtained by identifying the difference between the initial and final data points; (5) the data path or trace; and (6) the range, defined as the distance between the first and last data points, which is calculated based on the highest score in the condition using a stability criterion of 0.15 (Freeman & Eagle, 2011; Gast & Ledford, 2010; Widodo et al., 2021).

RESEARCH RESULTS

The results of the measurement of students' mathematical critical thinking skills on number topics during the intervention phase showed scores ranging from 89 to 96. The assessment of mathematical critical thinking skills was based on indicators including the ability to analyze algorithms, identify and justify concepts, and generalize. This phase involved mathematics learning using e-worksheets as the primary learning medium. Repeated measurements were conducted to monitor changes in students' abilities over time, as presented in Table 1.

Table 1. Mathematical Critical Thinking Skill Score

Session	Score	Average
1	980	89.09
2	1004	91.27
3	1015	92.27
4	1020	92.73
5	1036	94.18
6	1048	95.27
7	1058	96.18

Based on Table 1, the score represents critical mathematical thinking skills, not just answer accuracy, because the assessment process focuses on the quality of reasoning demonstrated by students during problem-solving. Assessment focuses not only on the correctness of the final result, but also on students' ability to analyze algorithms, identify and justify the concepts used, and generalize based on mathematical patterns or relationships (Harti & Agoestanto, 2019; Korkmaz, 2012;

Setiana et al., 2021). The instrument used comprehensively assesses students' thinking processes, including clarity of solution steps, accuracy of concept use, strength of argument, and ability to draw logical conclusions. Therefore, students still receive a score when they demonstrate a rational and structured thinking process, even if the final answer is not entirely correct. Furthermore, the use of e-worksheets as a learning medium is designed to encourage exploration of strategies, explanation of reasons, and reflection on the solution process. Therefore, the increase in scores in each session reflects the development of mathematical reasoning and higher-order thinking skills, not just the accuracy of calculations.

Furthermore, based on Table 1, it can be seen that the accumulation of students' critical thinking ability scores during the implementation of learning in the intervention phase shows a consistent upward trend. At the first meeting, the total score obtained was 980 with an average value of 89.09. Furthermore, at the second to fourth meetings, there was a gradual increase in the total score from 1004 to 1020, accompanied by an increase in the average score from 91.27 to 92.73. A more significant increase was seen at the fifth and sixth meetings, with the total score increasing from 1036 to 1048 and the average score increasing from 94.18 to 95.27. At the seventh meeting, the score increased again to 1058 with an average value of 96.18. The data in Table 1 shows that students' critical thinking ability experienced an increase during the intervention phase and can then be presented in graphical form as shown in Figure 2.

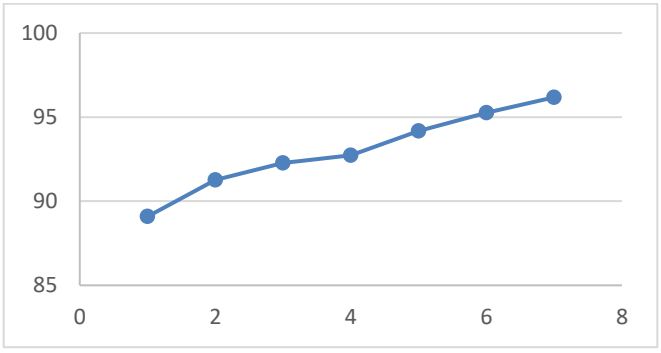

Figure 2. Trend of critical thinking ability score

Analysis in Condition

The duration of the condition indicates the number of sessions in each research condition. In this study, there was only one condition, namely the intervention phase, which was implemented in seven measurement sessions. This intervention phase aimed to observe the development of students' abilities in mathematical critical thinking through mathematics learning using E-Worksheet. Directional trend estimation was used to determine the tendency of student ability development from session to session in one research condition (Blankenship et al., 2019; van Norman & Nelson, 2019; van Norman & Ysseldyke, 2020). The results of the analysis showed an increasing trend at the beginning of the intervention phase, which then developed into a horizontal trend, indicating the stabilization of students' ability to recognize numbers after several learning sessions using E-Worksheet in Figure 3.

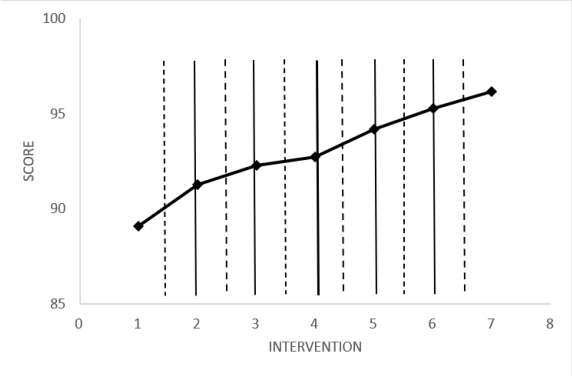

Figure 3. Estimated Trend Direction

To examine the pattern of improvement more systematically, a condition analysis was conducted including duration, trend direction, stability level, mean level, and rate of change.

Table 2. Summary of Condition Analysis in the Intervention Phase

Component	Result	Interpretation
Trend Direction	+	Increasing score pattern
Stability Level	100%	All data within 15% stability criterion
Mean Level	93	High average performance
Rate of Change	96.18 - 89.09 =7.09 (+)	Gradual improvement

The analysis shows a positive trend direction across sessions. Stability analysis using the 15% criterion indicates that all data points fall within the stability range, resulting in 100% stability, which suggests a consistent and controlled improvement pattern. The rate of change between the first and final sessions was +7.09, reflecting a steady increase in students' mathematical critical thinking scores during the intervention. Overall, the time series data demonstrate a gradual, stable, and positively directed improvement trend in students' mathematical critical thinking skills throughout the implementation of the Ethno-Modeling and Tri-N-based E-Worksheet.

DISCUSSION

The results of the study indicate that the use of E-Worksheets based on Ethno-Modeling and the Tri-N approach is Trend of Improvement the mathematical critical thinking skills of seventh-grade students at SMP Pembangunan Piyungan. This is evident from the tendency for an increase in the average score of students' mathematical critical thinking skills at each meeting during the intervention phase. At the first meeting, the average score was 89.09 and gradually increased to 96.18 at the seventh meeting. This increasing trend indicates that the implementation of E-Worksheets integrated with the local cultural context and the Tri-N learning

stages can have a positive impact on the development of students' mathematical critical thinking skills.

Based on a time series research design, measurements were taken repeatedly on the same subjects to observe changes in mathematical critical thinking skills over time. The research data showed that the average score increased consistently at each meeting. This indicates that the applied learning had a sustainable impact, not just a temporary improvement. The increase in scores from meeting to meeting indicates that students were increasingly accustomed to a learning pattern that requires active engagement, reasoning, and the ability to analyze mathematical problems in greater depth.

The improvement of students' critical mathematical thinking skills is inseparable from the characteristics of the Ethno-Modeling-based E-Worksheet used. The presentation of mathematical problems linked to local culture makes the concepts of numbers and real number arithmetic operations more contextual and closer to students' lives (Andrian et al., 2020; Acharya et al., 2021; Yanti, 2025). This condition helps students understand concepts more meaningfully, so they are not only memorizing solution procedures but also able to analyze and evaluate the problems given (Al-Mutawah et al., 2019; Nilmaa, 2023). This is in line with the view that contextual mathematics learning can improve students' conceptual understanding and higher-order thinking skills (Abdullah et al., 2025; Arnellis et al., 2021; Ismail et al., 2018).

In addition, the implementation of the Tri-N approach, which includes *Niteni* (observing), *Nirokke* (imitating), and *Nambahi* (developing), also plays a role in improving students' critical mathematical thinking skills (Latifah et al., 2024; Suroyaningsih et al., 2024; Widodo et al., 2024; Wijayanti et al., 2021). In the *Niteni* stage, students are directed to observe contextual problems presented in the E-worksheet, so they are able to identify important information and understand the problem situation (Latifah et al., 2024; Suroyaningsih et al., 2024). The *Nirokke* stage helps students understand the steps for solving problems through examples presented systematically (Suroyaningsih et al., 2024; Widodo et al., 2024). Furthermore, in the *Nambahi* stage, students are given the opportunity to develop their own problem-solving strategies, thus encouraging students to think critically, creatively, and independently in solving mathematical problems (Widodo et al., 2024; Wijayanti et al., 2021).

The relatively stable pattern of average grade increase from meeting to meeting indicates that students are able to adapt to the applied learning model. Although the increase in some meetings was not significant, the overall data trend remains positive. The increase in mathematical critical thinking ability scores in the subjects did not appear to be a significant jump because this ability develops gradually through practice, reflection, and habituation, rather than instantaneously (Jablonka, 2020; Dolapcioglu & Doganay, 2022). The learning intervention using e-worksheets emphasized the processes of analysis, justification, and generalization (Hasnunidah et al., 2022; 2025), so the impact appeared in the form of steady improvement from session to session, rather than drastic changes in a short period of time. Furthermore, students' initial scores, which were already in the relatively high category, indicated that they already had a sufficient foundation of abilities, thus limiting the scope for improvement. Students' adaptation to the use of media and the demands of reflective thinking also took time, contributing to the slow

increase in scores. On the other hand, assessments that focused on the quality of reasoning, rather than simply the accuracy of the final answer, meant that improvement only occurred when conceptual understanding and argumentation skills truly developed. Therefore, the moderate pattern of improvement actually reflects a consistent and ongoing process of strengthening critical thinking skill. This indicates that the Ethno-Modeling and Tri-N-based E-Worksheet not only improves learning outcomes quantitatively but also shapes students' thinking processes in a gradual and sustainable manner.

The findings of this study are in line with the results of previous studies which stated that the use of digital learning media, such as E-Worksheets, can improve students' activeness, conceptual understanding, and mathematical critical thinking skills (Agustin et al., 2024; Sari et al., 2024). In addition, the integration of local cultural contexts in mathematics learning has been proven to be able to help students relate mathematical concepts to real life (Andrian et al., 2020; Acharya et al., 2021; Widdiharto et al., 2025; Yanti, 2025), so that learning becomes more meaningful. The difference between this study and previous studies lies in the application of E-Worksheets based on Ethno-Modeling and the Tri-N approach which are combined in an integrated manner in one learning design with a time series approach, so that changes in students' mathematical critical thinking skills can be observed continuously (Hidayat et al., 2025).

Thus, the results of this study indicate that the use of E-Worksheets based on Ethno-Modeling and Tri-N is trend of improvement as an alternative mathematics learning media to improve the mathematical critical thinking skills of seventh-grade students at SMP Pembangunan Piyungan especially on number material. This finding provides implications that mathematics teachers can utilize contextual digital learning media that are oriented towards students' thinking processes to support more meaningful mathematics learning and are in accordance with the demands of 21st-century learning.

This study has several limitations that should be considered when interpreting the findings. First, the single-phase time series design, without a baseline phase or control group, limits the study's ability to demonstrate a causal relationship between the intervention and improvements in students' mathematical critical thinking skills. The results are more appropriately interpreted as a trend of improvement rather than conclusive evidence of effectiveness. Second, the relatively limited number of study subjects, drawn from a single educational institution, requires caution in generalizing the findings to a broader population. Third, the study's focus solely on numbers and arithmetic operations limits the scope of the results, making it impossible to ensure the consistency of the findings across other mathematics topics with different characteristics.

In addition to these limitations, this study also has several methodological weaknesses. The measurement of mathematical critical thinking skills was primarily based on written tests, thus failing to fully capture the dynamics of students' thinking processes in depth, as cognitive interviews or direct analysis of problem-solving processes might. Variations in individual student characteristics, such as learning motivation, readiness to use digital media, and prior learning experiences, also have the potential to influence the study results, but have not been comprehensively analyzed. Furthermore, the relatively short duration of the intervention means that the observed improvements may not represent long-term

changes in ability. Therefore, future research is recommended to use a more robust experimental design, involve a more diverse sample, extend the duration of the intervention, and combine quantitative and qualitative approaches to obtain a more comprehensive picture of the development of students' mathematical critical thinking skills.

CONCLUSION

The results of the study indicate a trend of improvement in the critical thinking skills of seventh-grade students in mathematics through the use of Ethno-Modeling-based E-Worksheets with the Tri-N approach on number topics at SMP Pembangunan Piyungan. This is indicated by a tendency to increase the average value of students' mathematical critical thinking skills gradually at each meeting during the intervention phase. Through a time series research design, changes in students' mathematical critical thinking skills can be observed continuously, which shows a positive and consistent influence of the application of the E-Worksheet. The integration of Ethno-Modeling and the Tri-N stages helps students understand concepts contextually and systematically, so that learning becomes more meaningful and oriented towards the development of higher-order thinking skills. However, given that this study employed a single-phase time series design without the inclusion of a baseline phase or comparison group, the findings should be interpreted with caution. Accordingly, the results are more appropriately understood as indicating a trend of improvement in students' critical thinking skills rather than providing conclusive evidence of causal effectiveness. Future research is recommended to use more rigorous experimental designs with larger samples to further strengthen the empirical evidence of this approach.

REFERENCES

Abdullah, A. H., Abd Rahman, S. N. S., Ibrahim, N. H., & Hamzah, M. H. (2025). Enhancing Form-One Students' Higher Order Thinking Skills (HOTS) Through the GeoGebra-Assisted Contextual Learning Strategy. In *2025 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1-7). IEEE. https://doi.org/10.1109/EDUCON62633.2025.11016304

Acharya, B. R., Kshetree, M. P., Khanal, B., Panthi, R. K., & Belbase, S. (2021). Mathematics Educators' Perspectives on Cultural Relevance of Basic Level Mathematics in Nepal. *Journal on Mathematics Education*, *12*(1), 17-48. https://jme.ejournal.unsri.ac.id/index.php/jme/article/view/3730

Afgani, M. W., & Paradesa, R. (2021). PISA-Like problems using Islamic ethnomathematics approach. *Infinity Journal*, *10*(2), 203–216. https://doi.org/10.22460/infinity.v10i2.p203-216

Afif, Z., Azhari, D. S., Kustati, M., & Sepriyanti, N. (2023). Penelitian ilmiah (kuantitatif) beserta paradigma, pendekatan, asumsi dasar, karakteristik, metode analisis data dan outputnya. *INNOVATIVE: Journal Of Social Science Research*, *3*(3), 682-693. https://j-innovative.org/index.php/Innovative/article/view/2260

Agustin, R., Masita, E., & Pranoto, N. W. (2024). E-worksheet to improve critical thinking and scientific argumentation skills: A systematic literature

review. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 277-283. https://doi.org/10.29303/jppipa.v10i6.7327

Al-Mutawah, M. A., Thomas, R., Eid, A., Mahmoud, E. Y., & Fateel, M. J. (2019). Conceptual understanding, procedural knowledge and problem-solving skills in mathematics: High school graduates work analysis and standpoints. *International journal of education and practice*, *7*(3), 258-273. https://doi.org/10.18488/journal.61.2019.73.258.273

Andriani, D., Widada, W., Herawaty, D., Ardy, H., Nugroho, K. U. Z., Ma'rifah, N., & Anggoro, A. F. D. (2020). Understanding the number concepts through learning Connected Mathematics (CM): A local cultural approach. *Universal Journal of Educational Research*, *8*(3), 1055-1061. https://doi.org/10.13189/ujer.2020.080340

Arnellis, Fauzan, A., Arnawa, I. M., & Yerizon. (2021). Analysis of high order thinking skill of students in contextual problems solving. In *Journal of Physics: Conference Series* (Vol. 1742, No. 1, p. 012021). IOP Publishing. https://doi.org/10.1088/1742-6596/1742/1/012021

Beard, E., Brown, J., & Shahab, L. (2025). Sample size requirements to evaluate policies in addiction research using interrupted time series analysis (ITS): Tools and guidance. *Addiction*, *121*(3). https://doi.org/10.1111/add.70220

Bedard, C., Bremer, E., Campbell, W., & Cairney, J. (2018). Evaluation of a direct-instruction intervention to improve movement and preliteracy skills among young children: A within-subject repeated-measures design. *Frontiers in pediatrics*, *5*, 298. https://doi.org/10.3389/fped.2017.00298

Blankenship, T. L., Slough, M. A., Calkins, S. D., Deater-Deckard, K., Kim-Spoon, J., & Bell, M. A. (2019). Attention and executive functioning in infancy: Links to childhood executive function and reading achievement. *Developmental science*, *22*(6), e12824. https://doi.org/10.1111/desc.12824

Campbell, S., Greenwood, M., Prior, S., Shearer, T., Walkem, K., Young, S., bywaters, D., & Walker, K. (2020). Purposive sampling: complex or simple? Research case examples. *Journal of research in Nursing*, *25*(8), 652-661. https://doi.org/10.1177/1744987120927206

Dahal, N., Neupane, B. P., Pant, B. P., Dhakal, R. K., Giri, D. R., Ghimire, P. R., & Bhandari, L. P. (2024). Participant selection procedures in qualitative research: Experiences and some points for consideration. *Frontiers in Research Metrics and Analytics*, *9*, 1512747. https://doi.org/10.3389/frma.2024.1512747

Darby, R. J., Taylor, E. P., & Cadavid, M. S. (2023). Phase-based psychological interventions for complex post-traumatic stress disorder: A systematic review. *Journal of Affective Disorders Reports*, *14*, 100628. https://doi.org/10.1016/j.jadr.2023.100628

Dolapcioglu, S., & Doğanay, A. (2022). Development of critical thinking in mathematics classes via authentic learning: an action research. *International Journal of Mathematical Education in Science and Technology*, *53*(6), 1363-1386. https://doi.org/10.1080/0020739X.2020.1819573

Elvianasti, M., Widodo, S. A., & Hanum, E. (2024). Effectiveness of project-based learning on STEAM-based student's worksheet analysis with ecoprint technique. *International Journal of Educational Methodology*, *10*(1), 123-135. https://doi.org/10.12973/ijem.10.1.923

Ernie, K., LeDocq, R., Serros, S., & Tong, S. (2023). Mathematical reasoning: Challenging students' beliefs about mathematics. In *Exploring Signature Pedagogies* (pp. 260-279). Routledge. https://doi.org/10.4324/9781003444732

Freeman, K. A., & Eagle, R. F. (2011). Single-subject research designs. In *Understanding Research in Clinical and Counseling Psychology* (pp. 129-154). Routledge. https://doi.org/10.4324/9780203831700

Gast, D. L., & Ledford, J. R. (2010). *Single subject research methodology in behavioral sciences* (p. 276). New York, NY: Routledge.

Harti, L. S., & Agoestanto, A. (2019). Analysis of algebraic thinking ability viewed from the mathematical critical thinking ablity of junior high school students on problem based learning. *Unnes Journal Of Mathematics Education*, *8*(2), 119-127. https://doi.org/10.15294/ujme.v8i2.32060

Hasnunidah, N., Fadiawati, N., Herlina, K., & Dewi, P. S. (2025). Development and Validation of ADI-STEM-Based Biotechnology e-Liveworksheets to Enhance Student Argumentation Skills. *Jurnal Pendidikan MIPA*, *26*(4), 2224-2245. https://doi.org/10.23960/jpmipa.v26i4.pp2224-2245

Hasnunidah, N., Maulina, D., & Ismi, R. (2022). Development of Project-Based Argumentative Model with Blended Learning Approach for Junior High School Students.

Hidayat, Wahyu, Usman Aripin, and Sri Adi Widodo. "Integration of ethno-modelling and 3N: An innovative digital worksheet framework to enhance students' mathematical critical thinking skills." *Infinity Journal* 14.4 (2025): 1019-1042.

Ismail, Suwarsono, S., & Lukito, A. (2018). Critical thinking skills of junior high school female students with high mathematical skills in solving contextual and formal mathematical problems. In *Journal of Physics: Conference Series* (Vol. 953, No. 1, p. 012205). IOP Publishing. https://doi.org/10.1088/1742-6596/953/1/012205

Jablonka, E. (2020). Critical thinking in mathematics education. In *Encyclopedia of mathematics education* (pp. 159-163). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-15789-0_35

Jamil, M., Bokhari, T. B., & Iqbal, J. (2024). Incorporation of critical thinking skills development: A case of mathematics curriculum for grades I-XII. *Journal of Asian Development Studies*, *13*(1), 375-382. https://doi.org/10.62345/jads.2024.13.1.32

Korkmaz, Ö. (2012). The impact of critical thinking and logico-mathematical intelligence on algorithmic design skills. *Journal of Educational Computing Research*, *46*(2), 173-193. https://doi.org/10.2190/EC.46.2.d

Kusmaryono, I., & Kusumaningsih, W. (2023). Evaluating the Results of PISA Assessment: Are There Gaps Between the Teaching of Mathematical Literacy at Schools and in PISA Assessment? *European Journal of Educational Research*, *12*(3). https://doi.org/10.12973/eu-jer.12.3.1479

Latifah, D. A. R. B., Widodo, S. A., Istiqomah, I., & Perbowo, K. S. (2024). Does E-Worksheet Based on Tri-N Principles Give Support to Improve Students' Ability to Think Critically and Creatively? *Jurnal Pendidikan Matematika (Kudus)*, *7*(1).

Mulyasari, D. W. (2022). E-LKPD based on Problem Based Learning (PBL) Approach to Measure Mathematics Literacy Ability of Elementary

Students. *International Journal of Elementary Education*, *6*(3), 393-402. https://doi.org/10.23887/ijee.v6i3.47532

Nilimaa, J. (2023). New examination approach for real-world creativity and problem-solving skills in mathematics. *Trends in Higher Education*, *2*(3), 477-495. https://doi.org/10.3390/higheredu2030028

Nurrahmasari, A. T., & Setiawan, D. (2025). Implementation of the Talented Thursday Habituation Program to Encourage Active Participation and Creativity of Elementary School Students. *Mimbar Sekolah Dasar*, *12*(2), 269-288. https://doi.org/10.17509/mimbar-sd.v12i2.25

Obilor, E. I. (2023). Convenience and purposive sampling techniques: Are they the same. *International Journal of Innovative Social & Science Education Research, 11*(1), 1-7.

OECD. (2016). PISA 2015 Assessment and Analytical Framework PISA 2015 Assessment and Analytical Framework. In *OECD Publishing*.

OECD. (2023). *PISA 2022 results (volume I): The state of learning and equity in education*. Paris: OECD. https://doi.org/10.1787/53f23881-en

Pandiangan, D. F., & Albina, M. (2025). Model dan Tahapan Penelitian Kuantitatif: Pendekatan Teoretis dan Praktis dalam Kajian Pendidikan. *IHSAN: Jurnal Pendidikan Islam*, *3*(3), 724-730. https://doi.org/10.61104/ihsan.v3i3.1494

Purnama, A., & Suparman, S. (2020). Studi pendahuluan: E-LKPD berbasis PBL untuk meningkatkan kemampuan literasi matematis peserta didik. *JKPM (Jurnal Kajian Pendidikan Matematika)*, *6*(1), 131-140. http://dx.doi.org/10.30998/jkpm.v6i1.8169

Puspita, V., & Dewi, I. P. (2021). Efektifitas E-LKPD berbasis pendekatan investigasi terhadap kemampuan berfikir kritis siswa sekolah dasar. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *5*(1), 86-96. https://doi.org/10.31004/cendekia.v5i1.456

Rachmad, Y. E., Rahman, A., Judijanto, L., Pudjiarti, E. S., Runtunuwu, P. C. H., Lestari, N. E., ... & Mintarsih, M. (2024). *Integrasi metode kuantitatif dan kualitatif: Panduan praktis penelitian campuran*. PT. Green Pustaka Indonesia.

Sachdeva, S., & Eggen, P. O. (2021). Learners' critical thinking about learning mathematics. *International Electronic Journal of Mathematics Education*, *16*(3), em0644. https://doi.org/10.29333/iejme/11003

Sachdeva, S., & Eggen, P. O. (2021). Learners' critical thinking about learning mathematics. *International Electronic Journal of Mathematics Education*, *16*(3), em0644. https://www.iejme.com/article/learners-critical-thinking-about-learning-mathematics-11003#:~:text=https%3A//doi.org/10.29333/iejme/11003

Saputra, A. (2025). Pengembangan Instrumen Evaluasi. *Ar-raudah: Jurnal Pendidikan Dan Keagamaan*, *2*(4), 1-14. *https://doi.org/10.61891/ar-raudah.v2i4.651*

Sari, N., Prasetyawati, Y., Sukmaningthias, N., & Simarmata, R. H. (2023). Development of e-worksheet based on realistic mathematics education to support mathematical literacy skills of junior high school students. In *E3S Web of Conferences* (Vol. 400, p. 03006). EDP Sciences. https://doi.org/10.1051/e3sconf/202340003006

Sari, R. N., Rosjanuardi, R., Herman, T., Isharyadi, R., & Balkist, P. S. (2024). Development of mathematics interactive E-worksheet. *The Eurasia*

Proceedings of Science Technology Engineering and Mathematics, *28*, 317-325. https://doi.org/10.55549/epstem.1521959

Setiana, D. S., Purwoko, R. Y., & Sugiman, S. (2021). The application of mathematics learning model to stimulate mathematical critical thinking skills of senior high school students. *European Journal of Educational Research*, *10*(1), 509-523. https://doi.org/10.12973/eu-jer.10.1.509

Sofwatillah, S., Risnita, R., Jailani, M. S., & Saksitha, D. A. (2024). Tehnik analisis data kuantitatif dan kualitatif dalam penelitian ilmiah. *Jurnal Genta Mulia*, *15*(2), 79-91. https://ejournal.uncm.ac.id/index.php/gm/article/view/1147

Sosa-Gutierrez, F., Apaza, H. M. V., Valdivia-Yábar, S. V., & Condori-Castillo, W. W. (2023). Critical thinking and teaching mathematics: An analysis from education. *International Journal of Religion*, *4*(2), 387-405. https://doi.org/10.61707/94v23344

Sujadi, I., Suprihatiningsih, S., Irfan, M., & Pepkolaj, L. (2025). Pre-service mathematics teachers: Designing context-based tasks. *Infinity Journal*, *14*(4), 995-1018. https://doi.org/10.22460/infinity.v14i4.p995-1018

Sujatmika, S., Irfan, M., Ernawati, T., Wijayanti, A., Widodo, S. A., Amalia, A. F., Nurdiyanto, H., & Rahim, R. (2019). Designing E-Worksheet Based On Problem-Based Learning To Improve Critical Thinking. *ICSTI 2018, October 19-20, Yogyakarta, Indonesia*, 1–8. https://doi.org/10.4108/eai.19-10-2018.2281282

Sulistyowati, F., Hartanti, S., Widodo, S. A., & Putrianti, F. G. (2022). Critical Thinking Skills in Phlegmatic Students Using Learning Videos. *Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis Ilmiah di Bidang Pendidikan Matematika*, *8*(2), 119-133. https://doi.org/10.29407/jmen.v8i2.18874

Suroyaningsih, P., Widodo, S. A., Agustito, D., & Perbowo, K. S. (2024). The Effectiveness of Worksheet-Based Tri-N on Students' Mathematical Critical and Creative Thinking Abilities Material on Linear Equations in One Variable. *JIPM (Jurnal Ilmiah Pendidikan Matematika)*, *12*(2), 268. https://doi.org/10.25273/jipm.v12i2.19052

Szabo, Z. K., Körtesi, P., Guncaga, J., Szabo, D., & Neag, R. (2020). Examples of problem-solving strategies in mathematics education supporting the sustainability of 21st-century skills. *Sustainability*, *12*(23), 10113. https://doi.org/10.3390/su122310113.

Tohani, E., & Aulia, I. (2022). Effects of 21st century learning on the development of critical thinking, creativity, communication, and collaboration skills. *Journal of Nonformal Education*, *8*(1), 46-53. https://doi.org/10.15294/jne.v8i1.33334

van Norman, E. R., & Nelson, P. M. (2019). The influence of trend estimation method on forecasting curriculum-based measurement of reading performance. *Journal of school psychology*, *74*, 44-57. https://doi.org/10.1016/j.jsp.2019.04.001

van Norman, E. R., & Ysseldyke, J. E. (2020). The impact of data collection frequency and trend estimation method on the consistency of growth estimates from two computer-adaptive tests. *School Psychology Review*, *49*(1), 20-30. https://doi.org/10.1080/2372966X.2020.1716634

von Ende, C. N. (2020). Repeated-measures analysis: growth and other time-dependent measures. In *Design and analysis of ecological experiments* (pp. 113-137). Chapman and Hall/CRC. https://doi.org/10.1201/9781003059813

Wang, Y., Wu, H., Dong, J., Liu, Y., Wang, C., Long, M., & Wang, J. (2024). Deep time series models: A comprehensive survey and benchmark. *arXiv preprint arXiv:2407.13278*. https://doi.org/10.48550/arXiv.2407.13278

Wauchope, H. S., Amano, T., Geldmann, J., Johnston, A., Simmons, B. I., Sutherland, W. J., & Jones, J. P. (2021). Evaluating impact using time-series data. *Trends in Ecology & Evolution*, *36*(3), 196-205. https://doi.org/10.1016/j.tree.2020.11.001

Whitney-Smith, R., Hurrell, D., & Day, L. (2022). The Role of Mathematics Education in Developing Students' 21st Century Skills, Competencies and STEM Capabilities. *Mathematics Education Research Group of Australasia*. https://files.eric.ed.gov/fulltext/ED623713.pdf

Widdiharto, R., Prahmana, R. C. I., Isaeni, N., Widodo, S. A., Mayangwuri, S., & Pramudiani, P. (2025). The theoretical framework of GEMBIRA learning model: An impactful insight for Indonesian numeracy movement. *Union: Jurnal Ilmiah Pendidikan Matematika*, *13*(3), 721-733. https://doi.org/10.30738/union.v13i3.20353

Widodo, S. A., Hidayat, W., Ekawati, R., Irfan, M., & Maarif, S. (2025). The Importance of Creating Mathematical Worksheets and Their Impact on Critical and Creative Thinking Skills. *European Journal of STEM Education*, *10*(1), 31. https://doi.org/10.20897/ejsteme/17487

Widodo, S. A., Irfan, M., Perbowo, K. S., Maarif, S., & Hidayat, W. (2025). *Kemampuan Memecahkan Masalah Matematis: Suatu Konsep Dasar*. Deepublish.

Widodo, S. A., Kustantini, K., Kuncoro, K. S., & Alghadari, F. (2021). Single subject research: Alternatif penelitian pendidikan matematika di masa new normal. *Journal of Instructional Mathematics*, *2*(2), 78-89. https://doi.org/10.37640/jim.v2i2.1040

Widodo, S. A., Wijayanti, A., Irfan, M., Pusporini, W., Mariah, S., & Rochmiyati, S. (2023). Effects of Worksheets on Problem-Solving Skills: Meta-Analytic Studies. *International Journal of Educational Methodology*, *9*(1), 151–167. https://doi.org/10.12973/ijem.9.1.151

Widodo, S. A., Wulandari, I., Ayuningtyas, A. D., Pusporini, W., Kusuma, D. A., & Dwipriyoko, E. (2024). What kind of Relation and Function Worksheet Based Tri-N improve Critical Thinking Skills? *Kreano, Jurnal Matematika Kreatif-Inovatif*, *15*(2), 342–362.

Wijayanti, N., Arigiyati, T. A., Aulia, F., & Widodo, S. A. (2021). Development of E-Worksheet on Linear Equations and Inequalities Topics Based on Tri-N. *Journal of Medives: Journal of Mathematics Education IKIP Veteran Semarang*, *5*(2), 245–260. https://doi.org/10.31331/medivesveteran.v5i2.1650

Yanti, S. (2025). The role of ethnomathematics in enhancing contextual mathematics understanding among students. *International Journal of Humanity Advance, Business & Sciences (IJHABS)*, *2*(4), 321-330. https://doi.org/10.59971/ijhabs.v2i4.402