Deep Learning Approach in Toraja Culture-Based Mathematics Learning and its Effect on Primary Students' Problem-Solving Skills

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Abstract

This study aims to explore the Deep Learning approach in Toraja culture-based mathematics learning on the problem-solving skills of junior high school students. The research used an embedded sequential explanatory mixed methods design, with a quantitative approach as the primary method and a qualitative approach as supplementary. The subjects consisted of an experimental group and a control group. Quantitative data were collected through pre- and post-treatment essay tests and analyzed using ANCOVA, while qualitative data were obtained through interviews analyzed thematically. The results indicate that the Toraja culture-based Deep Learning approach had a significant effect on improving problem-solving skills ($F(1,54)=48.206$; $p<.001$) with a large effect size ($\eta_p^2=0.471$). Qualitative data reinforce these findings by showing increased student engagement, reflection, and metacognitive awareness. The integration of Toraja culture into Deep Learning strengthens the meaning, relevance, and transfer of mathematical knowledge within students' socio-cultural context.

Keywords: Deep Learning, Culture-Based Learning, Toraja Culture, Mathematics.

Introduction

Education in the 21st century demands individuals to demonstrate higher-order thinking skills, with problem-solving ability as one of the most crucial competencies. The Indonesian education system continues to face serious challenges in improving students' problem-solving performance. Results from the Programme for International Student Assessment (PISA) show that Indonesian students' mathematical literacy remains far below the international average, with a score of 366 (OECD, 2023). This indicates students' limited capacity to formulate, apply, and solve mathematical problems in real-life contexts. One contributing factor to this condition is the use of instructional strategies that lack contextual relevance.

Field observations in mathematics classrooms in Toraja, particularly at the junior secondary level, reveal that learning remains dominated by memorization and the mechanical application of formulas without deep conceptual understanding. Telegin & Mt-Kltyik (2025), found that students taught primarily through memorization struggle to connect mathematical concepts across topics, limiting their ability to apply knowledge more broadly. Such instructional practices also hinder students from transferring and using concepts in new or unfamiliar contexts (Orón & Lizasoain, 2023), although rote strategies may still be helpful in multiplication when solving more complex tasks (Dotan & Zviran-Ginat, 2022). Consequently, an appropriate pedagogical approach is needed to address low levels of higher-order thinking skills.

Toraja, as an ethnic group rich in cultural heritage, offers strong potential for integration into mathematics learning. Culture-based learning has increasingly been recognized as a vital strategy for making instruction more relevant to learners' socio-cultural contexts (Komalasari et al., 2018; Smith et al., 2022). Cultural elements can function as a medium of communication, a transitional bridge, and an emancipatory tool in mathematics classrooms. Aikenhead (2017), demonstrated that culturally responsive mathematics education can improve academic achievement for both Indigenous and non-Indigenous students. Similarly, Fyhn & Nutti (2023) illustrated how intangible cultural heritage, such as traditional measurement and navigation practices, can be meaningfully integrated into mathematics curricula. Such a culture-based approach holds strong potential to optimize learning effectiveness in an era of rapid societal change.

In response to ongoing educational challenges, the Government of Indonesia through the Kementerian Pendidikan Dasar dan Menengah Republik Indonesia (2025) implemented a deep learning approach as part of the national curriculum reform. Deep learning is conceptualized as a pedagogical approach that emphasizes mindful, meaningful, and joyful learning through holistic engagement of students' cognitive, emotional, aesthetic, and physical dimensions (Mahrunnisya, 2025). This approach encourages learners not merely to memorize content but to understand and internalize concepts at a deeper level (Putri, 2024). In contrast to surface learning approaches that rely on rote memorization and mechanical application of formulas, deep learning promotes relational understanding (Chin & Brown, 2000). Learners are encouraged to connect new concepts with prior knowledge and real world contexts, which is fundamental to effective problem solving.

Integrating deep learning with Toraja cultural contexts enables mathematics instruction that emphasizes conceptual mastery while simultaneously cultivating local values and contextual reasoning. Such integration offers opportunities for students to interpret mathematical ideas meaningfully and in relation to their socio-cultural environment. Despite its theoretical promise, empirical evidence regarding the effectiveness of this integrated approach remains limited, especially at the basic education level.

Previous studies on Toraja culture-based mathematics learning demonstrate a strong tendency toward descriptive qualitative approaches oriented to the identification, exploration, and interpretation of cultural elements as contexts for mathematics learning. Some studies position Toraja culture as a source of values and contextual activities to enhance learning motivation; however, they do not specifically measure its impact on students' mathematical cognitive achievement through rigorous quantitative analysis (Ramopoly, 2020). Other research focuses on revealing mathematical concepts embedded in Toraja cultural artifacts, such as traditional houses and symbolic motifs, without involving instructional interventions or measuring student learning outcomes (Wahyuni et al., 2023).In addition, literature review based studies remain largely conceptual and do not provide empirical evidence grounded in experimental or quasi experimental research designs (Razak et al., 2024).

Studies on the implementation of local culture based deep learning in Indonesia are still predominantly characterized by product development research and descriptive analyses, as reported by Mudjib et al. (2025), who highlight the lack of in depth empirical testing of the methodological effectiveness of this approach. This gap is clearly reflected in the study by Chairani et al. (2025), which places greater emphasis on the design validity of instructional materials using the Research and Development (R&D) method rather than examining their effects on student abilities through experimental or quasi experimental designs. Furthermore, Ginting et al. (2025) emphasize that the existing literature tends to explore the impact of this approach on creative thinking skills, thereby leaving a significant research gap concerning its influence on mathematical problem solving ability.

This study aims to analyze the effect of implementing a deep learning approach integrated with Toraja cultural contexts on junior secondary students' mathematical problem-solving skills. Theoretically, the study contributes to developing a conceptual framework for mathematics instruction that connects deep learning with cultural relevance as a foundation for culturally grounded pedagogical innovation. Practically, the findings are expected to guide teachers in designing meaningful, contextual, and culturally rooted mathematics learning experiences that strengthen students' cultural identity.

Method

This study employed a mixed-methods approach using an *embedded sequential explanatory* design, in which the quantitative phase served as the primary component and the qualitative phase functioned as complementary. Quantitative procedures were conducted through a quasi-experimental design to empirically examine the effect of the deep learning approach integrated with Toraja cultural contexts on students' mathematical problem-solving performance, as well as to estimate the magnitude of its influence through effect size analysis. The qualitative component was conducted to explore and describe in depth how the intervention was implemented in the classroom, providing contextual explanations that enrich the quantitative findings.

Participants

The research was carried out at UPT SMP Satap 2 Bittuang, located in Buttu Limbong, Lembang Buttu Limbong, Bittuang District, Tana Toraja Regency, South Sulawesi Province. The participants in the quantitative phase consisted of Grade VIII students selected using purposive or intact group sampling by utilizing two existing classes. Class VIII A, consisting of 29 students, was assigned as the experimental group and received mathematics instruction using the deep learning approach integrated with Toraja cultural elements. Class VIII B, consisting of 28 students, served as the control group and received instruction through lecture-based teaching. In the qualitative phase, the participants were two mathematics teachers at UPT SMP Satap 2 Bittuang who were directly involved in the instructional process and were selected purposively for in-depth interviews to explore their perceptions, implementation experiences, and challenges in applying the deep learning approach in the experimental class.

Measurement

Data were collected through two different types of instruments tailored to the quantitative and qualitative components. Quantitative data focused on students' mathematical problem-solving performance and were obtained through essay-type tests administered in two stages: pre-test and post-test. The test items were developed based on Polya's problem-solving indicators, covering the ability to understand problems, plan strategies, implement solutions, and evaluate results. The instrument underwent content and construct validation. Content validity was reviewed by three experts in mathematics education, learning evaluation, and mathematics teaching practice, yielding an average expert judgment rating of 4 (high validity). Construct validity was assessed using

Confirmatory Factor Analysis, producing factor loadings ranging from 0.881 to 1.514 with significance values of $p < .001$. Reliability testing using Cronbach's Alpha resulted in a coefficient of 0.93, indicating a very high level of internal consistency.

Qualitative data collection, embedded within the study, aimed to obtain an in-depth understanding of the implementation of the deep learning approach based on Toraja culture from the teachers' perspectives. The primary qualitative instrument was the researcher as human instrument, supported by interview guides and observation sheets. Data were gathered using several techniques: (1) semi-structured in-depth interviews with two mathematics teachers to explore their perceptions, strategies for integrating Toraja culture, classroom implementation processes, and challenges encountered; and (2) non-participant classroom observations in the experimental group to observe teacher–student interactions, student engagement levels, and the concrete application of deep learning within a cultural context.

Data analyze

Quantitative data analysis began with descriptive statistics to present the distribution of pre-test and post-test scores. This analysis included the mean scores to indicate central tendency, minimum and maximum values to show the range, and standard deviations to measure the dispersion of the data. The inferential analysis employed Analysis of Covariance (ANCOVA) to examine the effect of the instructional model on students' mathematical problem-solving skills. By selecting the instructional model as the independent variable and post-test scores as the dependent variable, this method allowed for the statistical control of students' initial ability (pre-test scores), which served as the covariate. To ensure the validity of the ANCOVA model, four key assumptions were rigorously tested prior to hypothesis testing: normality of residuals (Shapiro–Wilk test), homogeneity of variances (Levene's test), linearity between the covariate and the dependent variable, and homogeneity of regression slopes. Finally, the practical significance of the findings was assessed by calculating the effect size using Partial Eta Squared.

Qualitative data were analyzed using thematic analysis through the stages of verbatim transcription, data reduction and coding, presentation of emergent themes such as cultural integration strategies, implementation challenges, and teacher perceptions and drawing conclusions with verification. Data credibility was strengthened through source triangulation between teachers and methodological triangulation across interviews, observations, and documentation. Integration of qualitative and quantitative findings was carried out during interpretation to provide comprehensive insights into the effectiveness and instructional dynamics of the Toraja culture-based deep learning approach.

Results

Implementation of Toraja Culture-Based Deep Learning

The instructional intervention was implemented on the topics of exponents and roots by utilizing visual representations of Toraja cultural artifacts. The artifacts included Pa'ssura' carvings to represent repeated multiplication, the Tongkonan roof structure to illustrate exponential growth, and grid patterns found in rice barns (Alang) and woven cloth to represent square and root concepts. The learning process was designed based on the Deep Learning framework encompassing Mindful, Meaningful, and Joyful dimensions and was organized into three sequential learning phases.

Phase 1: Contextual Orientation (Aperception)

In the initial phase, the teacher established a visual and conceptual context without introducing formal mathematical notation. Digital visualizations, including photographs and videos of Tongkonan structures and Pa'ssura' motifs, were used as learning stimuli. The teacher posed guiding questions that directed students to observe repetition patterns and numerical regularities. Classroom observations indicated that students were able to identify visual patterns and articulate the need for more efficient numerical representations.

Phase 2: Activity and Exploration (Experience)

Students engaged in directed observation of the displayed cultural artifacts. Activities included identifying geometric shapes, recognizing recurring motifs, and examining layered structures in the Tongkonan roof and Pa'ssura' carvings. With teacher guidance, students converted visual observations into quantitative forms through counting and grouping basic units. Observational data showed that students represented complex patterns as the result of repeated use of identical elements.

Phase 3: Reflection and Conceptualization

In this phase, students expressed their observations using formal mathematical representations. Counting units were first defined, such as one Pa'ssura' motif or one bamboo layer. Repeated patterns were then written as repeated multiplication, for example $4 \times 4 \times 4$, and subsequently expressed in exponential notation as 4^3. The concept of roots was developed by tracing back the number of basic units from a given total area of woven cloth. Student work de

Descriptive Statistics

Tabel 1. Pretest-Posttest Problem Solving Skils

Statistic	Experiment		Control	
	Pretest	Posttest	Pretest	Posttest
Mean	57.48	64.97	58.04	61.07
Min	42	49	48	51
Max	71	78	70	75
St.Dev	6.52	6.23	5.54	5.05

Table 1 presents the pre-test and post-test scores for both groups. The initial mean scores of the two groups were relatively comparable, with the experimental group scoring 57.48 and the control group scoring 58.04, indicating no substantial difference in baseline problem-solving ability. After the intervention, the experimental group showed a higher post-test mean score (64.97) compared to the control group (61.07). In terms of gain scores, the experimental group improved by 7.49 points, while the control group improved by only 3.03 points. The standard deviation values for both groups remained relatively stable, suggesting that the variability of students' scores did not change drastically after the intervention.

Further descriptive analysis was conducted for the experimental group (N = 29) to examine improvements by gender. Male students showed an average increase of 8.08 points (from 55.92 to 64.00), while female students showed an average increase of 7.06 points (from 58.59 to 65.65). These findings indicate that the intervention had a positive impact on both male and female students, with only a slight difference in gain scores between genders.

Inferential Statistical Analysis

Prior to hypothesis testing, assumption tests were conducted. The Shapiro–Wilk normality test showed significance values of 0.88 for the experimental group's post-test scores and 0.57 for the control group, indicating normal distribution. The Levene's Test for homogeneity produced a statistic of 1.46 with a significance value of 0.23, indicating that both datasets were homogeneous. Furthermore, the assumption of linearity was verified; the relationship between the pre-test (covariate) and post-test scores was significantly linear ($F = 189.70$; $p < .001$) with no significant deviation from linearity ($p = .945$). These results confirm that the data met all necessary requirements for parametric testing, specifically ANCOVA.

Table 2. Summary of Inferential Statistical Results

Source of Variation	F	Sig. (p)	Partial Eta Squared (η_p^2)	Interpretation
Pre-test (Covariate)	445.770	.000	0.892	Significant effect
Group (Treatment)	48.206	.000	0.471	Significant effect
Corrected Model	240.707	.000	0.899	Significant effect

"The ANCOVA results presented in Table 2 indicate that, after controlling for pre-test scores, there was a significant difference between the experimental and control groups with respect to post-test problem-solving scores ($F(1,54) = 48.206$; $p < .001$). The Partial Eta Squared value for the treatment variable was 0.471, indicating that 47.1% of the variance in post-test scores was explained by the treatment after controlling for pre-test scores. According to Cohen (1988) classification, this represents a large effect size.

The covariate (pre-test) also had a significant effect on post-test scores ($F(1,54) = 445.770$; $p < .001$), confirming that initial ability strongly contributed to students' final performance. However, even after statistically controlling for these initial differences, the treatment effect remained significant. To clarify the magnitude of this difference, Table 3 compares the raw means and the adjusted means (Estimated Marginal Means), which remove the influence of the covariate.

Table 3. Summary of Inferential Statistical Results

Group	N	Raw Mean (M)	Std. Dev (SD)	Adjusted Mean (Madj)*	Std. Err (SE)
Experimental	29	64.97	6.23	65.22	0.37
Control	28	61.07	5.05	61.52	0.38

As shown in Table 3, the experimental group achieved a significantly higher adjusted mean ($M_{adj} = 65.22$; $SE = 0.37$) compared to the control group ($M_{adj} = 61.52$; $SE = 0.38$). This confirms that the improvement in the experimental group was directly attributable to the Toraja culture-based Deep Learning intervention rather than baseline ability.

Teacher Interview Findings

1. Teacher Perceptions of the Deep Learning Approach

The interviews revealed that teachers initially had a limited understanding of the deep learning concept in mathematics instruction. Teachers described deep learning as an additional workload and expressed concerns about its feasibility in schools with limited resources.

Teacher 1st:

"*Sebelumnya, saya memandang deep learning sebagai beban pekerjaan tambahan dan akan sulit diwujudkan di sekolah dengan fasilitas terbatas seperti kami*. (before used this approach, I viewed deep learning as an additional workload that would be difficult to use in a school with limited facilities like ours.)"

Teachers also reported that their early understanding of deep learning came primarily from training sessions, without direct experience in applying it, especially in combination with local culture.

Teacher 2nd:

"*Awalnya hanya melalui pelatihan dari dinas. Saya memahami deep learning sebagai pembelajaran yang mendorong siswa menggali lebih dalam, tapi belum tahu cara menerapkannya secara sistematis, apalagi mengintegrasikannya dengan budaya lokal.* (Initially, it was only through training from the education department. I understand deep learning as learning that encourages students to explore more deeply, but I don't know how to apply it systematically, let alone integrate it with local culture.)"

Both teachers recognized that Toraja culture contains mathematical elements that could strengthen contextualized learning.

Teacher 2nd:

"Budaya Toraja sangat kaya dengan pola, simbol, dan struktur matematis... Ini semua adalah konteks autentik yang membuat matematika menjadi hidup bagi siswa. (Toraja culture is rich in patterns, symbols, and mathematical structures… These offer authentic contexts that bring mathematics to life for students)"

2. Teachers' Experiences in Implementing the Approach

Teachers stated that the easiest part of implementing deep learning was conducting culturally based aperception activities because the materials were prepared beforehand. The most challenging aspect was facilitating deep reflection.

Teacher 2nd:

"Yang paling mudah diterapkan adalah tahap apersepsi budaya... Yang paling sulit itu memandu refleksi mendalam. (The easiest part to implement was the cultural aperception stage... The most difficult part was guiding students through deep reflection)"

The teachers observed that students became more active, especially when sharing cultural experiences or identifying patterns from Toraja motifs.

Teacher 1st:

"*Siswa yang biasanya pasif menjadi aktif bercerita tentang tradisi keluarganya*. (Students who were usually passive became active in sharing their family traditions)."

3. Challenges in Implementation

Teachers faced several challenges, including limited time for facilitating deep discussions and diverse levels of students' familiarity with Toraja cultural knowledge.

Teacher 2nd:

"*Alokasi waktu terbatas untuk diskusi mendalam... beberapa siswa kurang familiar dengan budaya sendiri karena modernisasi.* (There is limited time for deep discussions… some students are less familiar with their own culture due to modernization)."

Additionally, students accustomed to rote learning initially found it difficult to adapt to a reflective and inquiry-based approach.

"*Awalnya beberapa siswa bingung karena terbiasa langsung ke rumus... tetapi ketika mulai mengidentifikasi pola, mereka mulai tertarik.* (At the first, some students were confused because they were used to going straight to formulas… but when they began identifying patterns, they became more interested)."

4. Reflections and Learning Impact

Teachers noted positive impacts of the deep learning approach on both students and their own teaching practice. Students increasingly connected mathematical concepts with cultural contexts.

Teacher 1st:

"*Misalnya, ketika menghadapi soal cerita, siswa tidak langsung menghitung, tetapi bertanya: 'gambar apa yang sama dengan soal ini?* (For example, when working on word problems, students did not immediately start calculating; instead, they asked, 'Which cultural pattern resembles this problem?)"

Teachers also described a significant shift in their teaching roles from knowledge transmitters to facilitators.

Teacher 1st:

"*Saya belajar bahwa guru bukan satu-satunya sumber pengetahuan... justru saya belajar dari perspektif budaya siswa.* (I learned that the teacher is not the one of knowledge source… in fact, I learned from the cultural perspectives of my students)"

Discussion

Effect of the Deep Learning Approach on Problem-Solving Ability

The ANCOVA results indicate that, after controlling for pre-test scores, there was a significant difference between the experimental and control groups in post-test mathematical problem-solving performance ($F(1,54) = 48.206$; $p < .001$). The Partial Eta Squared value of 0.471 reflects a substantial treatment effect, where 47.1% of the variance in outcomes was explained by the instructional intervention. This confirms that the integration of deep learning with Toraja cultural contexts meaningfully enhanced students' problem-solving skills.

The robustness of this finding is further supported by the adjusted means analysis, which statistically removed the influence of initial ability. The experimental group achieved a significantly higher adjusted post-test score ($M_{adj} = 65.22$) compared to the control group ($M_{adj} = 61.52$). This specific advantage suggests that the combined approach of deep learning and culture-based instruction encouraged students to interpret, connect, and contextualize mathematical concepts more effectively than conventional methods, regardless of their starting point. These findings align with prior studies by Putri (2024) and Sari et al. (2023), which showed that deep learning and ethnomathematics-based learning stimulate students to investigate mathematical ideas more actively and meaningfully.

Pedagogically, the results support the premise that meaningful learning strengthens knowledge transfer to new contexts and fosters higher-order thinking (Mystakidis, 2021). The approach is also consistent with Experiential Learning Theory, which emphasizes learning through experience, reflection, and conceptualization (Kolb et al., 1999). Antonio et al. (2025) further argue that students more readily grasp concepts when they are presented through cultural or experiential contexts familiar to them. Within this framework, teachers do not merely transmit knowledge but facilitate meaning-making through cultural symbols, values, and practices that resonate with students' lived experiences.

Challenges and Constraints

The interviews reveal that teachers faced challenges in allocating sufficient time for reflection a core component of deep learning. Deep reflection requires extended discussion, conceptual exploration, and meaning construction, which are difficult to accommodate within limited class periods. This constraint forced teachers to balance depth of learning with curriculum coverage.

Another challenge concerned the diverse levels of cultural familiarity among students. While some students were highly engaged due to strong cultural exposure, others lacked familiarity with Toraja symbols and traditions. This variation made it difficult for teachers to create equally meaningful cultural connections for all learners. Banks (1975) emphasizes that integrating cultural knowledge in instruction is essential for shaping identity, empathy, and multicultural awareness, but such integration requires ensuring equitable cultural access among students.

Students' learning habits also posed a barrier. Many were initially conditioned to focus on memorizing formulas and obtaining final answers rather than engaging in inquiry-driven or reflective processes. The shift toward pattern recognition, contextual reasoning, and cultural interpretation required an adjustment period. However, once students began identifying cultural patterns and linking them to mathematical ideas, their engagement and interest increased. Motivation, as highlighted by Suharnadi et al. (2024), is a key driver of learning persistence and performance.

Learning Dynamics and Contribution of Processes to Quantitative Findings

Qualitative findings reinforce and help explain the quantitative outcomes. The increase in students' problem-solving skills was not merely the result of instructional procedures but stemmed from deeper cognitive shifts in how students made sense of mathematics. By engaging with Toraja cultural objects, symbols, and narratives, students constructed conceptual meanings grounded in real-life experience, thereby enabling deeper learning and long-term cognitive retention (Bryce & Blown, 2024; Mystakidis, 2021).

The learning activities also fostered metacognitive growth. Students demonstrated cognitive monitoring by questioning whether their strategies were appropriate, reflecting Flavell (1979), concept of metacognition as "thinking about one's own thinking." Increased metacognitive awareness strengthens problem-solving ability because students regulate their strategies more effectively both inside and outside the classroom.

The substantial effect size ($\eta_p^2 = 0.471$) can therefore be understood as a synergistic product of conceptual understanding, cultural contextualization, and reflective engagement. These elements collectively deepened students' learning processes and contributed to measurable improvements in mathematical problem solving.

Implication of Study

Theoretical implications of this study indicate that integrating deep learning with local cultural approaches expands the conceptual foundation of deep learning pedagogy.

The findings demonstrate that incorporating local cultural knowledge strengthens the relationship between personal meaning and conceptual understanding. This integration enriches the deep learning model by embedding values, identity, and cultural relevance into the learning process. The study provides empirical support for culturally grounded deep learning as a pedagogical framework capable of enhancing cognitive depth while fostering cultural awareness.

Practically, the results highlight the importance of incorporating local cultural contexts into classroom teaching to promote reflection, exploration, and meaningful dialogue. Teachers are encouraged to utilize cultural artifacts, symbols, and practices as mediating tools to facilitate deep meaning-making in mathematics learning. Curriculum developers may use this model to contextualize learning outcomes according to regional cultural characteristics, particularly in mathematics instruction that benefits from the richness of cultural patterns and structures.

However, this study presents limitations. The research was conducted in a single school with a relatively short intervention duration, limiting the generalizability of findings. Broader studies across multiple schools and extended implementation periods are needed to validate the findings and explore long-term impacts.

Conclusion and Suggestion

This study demonstrates that the Deep Learning approach integrated with Toraja cultural contexts has a significant effect on improving junior secondary students' mathematical problem-solving abilities. The ANCOVA results confirm a meaningful difference between the experimental and control groups, with a large effect size ($\eta_p^2 = 0.471$). Crucially, the analysis of adjusted means demonstrates that the experimental group outperformed the control group significantly, even after accounting for differences in initial problem-solving abilities. This approach not only strengthened students' conceptual understanding but also fostered reflective and metacognitive awareness through the exploration of cultural values, symbols, and practices.

Qualitative findings further reveal that culturally integrated learning promotes engagement, motivation, and a stronger sense of ownership in the learning process. Thus, the combination of Deep Learning and local culture provides an effective pedagogical model for creating meaningful, contextualized, and culturally grounded mathematics learning experiences. Nonetheless, limited instructional time and variations in students' initial abilities present challenges that must be addressed for broader implementation.

References

Aikenhead, G. S. (2017). Enhancing School Mathematics Culturally: A Path of Reconciliation. *Canadian Journal of Science, Mathematics and Technology Education*, *17*(2), 73–140. https://doi.org/10.1080/14926156.2017.1308043

Antonio, M., Garc, V., Beatriz, E., Duarte, J., Mogoll, X., Andrea, P., Solano, E., & Patricia, M. (2025). *Does the Cultural Context Influence on Reading Does the Cultural Context Influence on Reading Comprehension ? September 2024*. https://doi.org/10.70082/esiculture.vi.1359

Banks, J. A. (1975). *Teaching Strategies for Ethnic Studies*. Allyn and Bacon, Inc., Longwood Division.

Bryce, T. K. ., & Blown, E. . (2024). Ausubel's meaningful learning re-visited. *Current Psychology*, *43*(5), 4579–4598. https://doi.org/10.1007/s12144-023-04440-4

Chairani, A., Afifah, A. P., Khasanah, A. Z., Susilawati, W., & Sholihah, W. (2025). Desain Bahan Ajar Etnomatematika Arsitektur Rumah Gadang Melalui Pendekatan Deep Learning. *EQUALS: Jurnal Ilmiah Pendidikan Matematika*, *8*(2), 150–158. https://doi.org/10.46918/equals.v8i2.2773

Chin, C., & Brown, D. E. (2000). Learning in Science : A Comparison of Deep and Surface Approaches. *Journal of Research in Science Teaching*, *37*(2), 109–138. https://doi.org/https://doi.org/10.1002/(SICI)1098-2736(200002)37:2<109::AID-TEA3>3.0.CO;2-7

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.). Routledge. https://doi.org/10.4324/9780203771587

Dotan, D., & Zviran-Ginat, S. (2022). Elementary math in elementary school: the effect of interference on learning the multiplication table. *Cognitive Research: Principles and Implications*, *7*(1). https://doi.org/10.1186/s41235-022-00451-0

Flavell, J. H. (1979). Metacognition and Cognitive Monitoring: A New Area of Cognitive--Developmental Inquiry. *American Psychologist*, *34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Fyhn, A. B., & Nutti, Y. J. (2023). Intangible Cultural Heritage as a Resource for a Sámi Mathematics Curriculum. *Australian and International Journal of Rural Education*, *33*(2), 16–31. https://doi.org/10.47381/aijre.v33i2.455

Ginting, S. S. B., Dewi, I., & Napitupulu, E. E. (2025). Pendekatan Deep Learning Berbasis Budaya Terhadap Kemampuan Berpikir Kreatif Matematis Siswa: Sebuah Paradigma Transformatif Abad ke-21. *PROSIDING SANTIKA 5: Seminar Nasional Tadris Matematika UIN K.H. Abdurrahman Wahid Pekalongan*, 372–381. https://proceeding.uingusdur.ac.id/index.php/santika/article/view/santika52529

Kementerian Pendidikan Dasar dan Menengah Republik Indonesia. (2025). *Peraturan Menteri Pendidikan Dasar dan Menengah Republik Indonesia Nomor 13 Tahun 2025 tentang Perubahan atas Peraturan Menteri Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 12 Tahun 2024 tentang Kurikulum pada Pendidikan Anak Usia Dini, Jenjang Pend*. Kementerian Pendidikan Dasar dan Menengah Republik Indonesia. https://jdih.kemendikdasmen.go.id

Kolb, D. A., Boyatzis, R. E., & Mainemelis, C. (1999). Experiential Learning Theory: Previous Research and New Directions. In *Perspectives on Thinking, Learning, and Cognitive Styles*. Routledge. https://doi.org/10.4324/9781410605986-9

Komalasari, K., Abdulkarim, A., & Saripudin, D. (2018). Culture-based social studies learning model in developing student multiculturalism. *New Educational Review*, *51*(1), 173–183. https://doi.org/10.15804/TNER.2018.51.1.14

Mahrunnisya, D. (2025). Implementing the Three Pillars of Deep Learning as a Quality Learning Strategy. *E3J: Economic Education and Entrepreneurship Journal*, *8*(1), 89–93. https://doi.org/http://dx.doi.org/10.23960/E3J/ v8.i1.89-93

Mudjib, R., Wastralangkara, W. W., Syalsabilla, A. A., & Susilawati, W. (2025). Problematika Teknologi dalam Pendekatan Deep Learning Matematis di Indonesia. *POLINOMIAL: Jurnal Pendidikan Matematika*, *4*(4), 991–1005. https://ejournal.papanda.org/index.php/jp

Mystakidis, S. (2021). Deep Meaningful Learning. *Encyclopedia*, *1*(3), 988–997. https://doi.org/10.3390/encyclopedia1030075

OECD. (2023). *Indonesia Student performance (PISA 2022)*. https://gpseducation.oecd.org/CountryProfile?primaryCountry=IDN&treshold=10&topic=PI

Orón, J. V., & Lizasoain, I. (2023). Achieving Transfer from Mathematics Learning. *Education Sciences*, *13*(2), 1–13. https://doi.org/10.3390/educsci13020161

Putri, R. (2024). Inovasi Pendidikan dengan Menggunakan Model Deep Learning di Indonesia. *Jurnal Pendidikan Kewarganegaraan Dan Politik (JPKP)*, *2*(2), 69–77. https://doi.org/https://doi.org/10.61476/186hvh28

Ramopoly, I. H. (2020). Meningkatkan Motivasi Belajar Matematika Siswa Kelas V SDN 2 Rantepao dengan Menerapkan Pembelajaran Kontekstual Berbasis Etnomatematika Suku Toraja. *Elementary Journal: Jurnal Pendidikan Guru Sekolah Dasar*, *3*(1), 14–22. https://doi.org/10.47178/elementary.v3i1.982

Razak, F., Tahmir, S., & Thalib, A. (2024). Optimalisasi Eksistensi Budaya Lokal Melalui Pendekatan Ethnomathematics dalam Pembelajaran Matematika. *Histogram: Jurnal Pendidikan Matematika*, *8*(1), 271–280. http://journal.stkip-andi-matappa.ac.id/index.php/histogram/index

Sari, N., Saragih, S., Napitupulu, E. E., Rakiyah, S., Sari, D. N., Sirait, S., & Anim, A. (2023). Applying Ethnomathematics in Learning Mathematics for Middle School Students. *Acta Scientiae*, *25*(5), 250–274. https://doi.org/10.17648/acta.scientiae.7690

Smith, T., Avraamidou, L., & Adams, J. D. (2022). Culturally relevant/responsive and sustaining pedagogies in science education: theoretical perspectives and curriculum implications. *Cultural Studies of Science Education*, *17*(3), 637–660. https://doi.org/10.1007/s11422-021-10082-4

Suharnadi, P., Neviyarni, S., & Nirwana, H. (2024). The Role and Function of Learning Motivation in Improving Student Academic Achievement. *Manajia: Journal of Education and Management*, *2*(1), 1–8. https://doi.org/10.58355/manajia.v2i1.25

Telegin, M., & Mt-Kltyik, A. (2025). The impact of conceptual versus memorization-based teaching methods on student performance. *Journal of Emerging Investigators*, *8*(August). https://doi.org/10.59720/24-254

Wahyuni, N. R. S., Purwanto, A. R., Minarti, S., & Nurhakki, N. (2023). Eksplorasi Etnomatematika Pada Rumah Adat Tongkonan Tana Toraja. *Proximal: Jurnal Penelitian Matematika Dan Pendidikan Matematika*, *6*(2), 306–315. https://doi.org/10.30605/proximal.v5i2.2855