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Transformation of Numeracy Learning through Ethnoliteration Approach and Deep Learning Strategies in the Society 5.0 Era

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Abstract
This research aims to develop and test the effectiveness of ethnoliteracy-based numeracy learning tools that are integrated with deep learning strategies in a pedagogical context in the context of multicultural elementary schools in Nganjuk Regency. Using the ADDIE model Research and Development (R&D) approach, the research was conducted in three schools with different local cultural backgrounds. Data was collected through participatory observation, in-depth interviews, numeracy tests, and document analysis. The results of the study showed that the learning tools developed were able to improve students' understanding of numeracy concepts with an average score increase of 24.3 points. In addition, there was an increase in positive attitudes towards mathematics, with a decrease in boredom from 42% to 12%, as well as an increase in metacognition scores from 2.3 to 3.9 (on a scale of 5). Contextualizing material through local culture has been shown to increase the relevance of student learning and engagement, which is reflected in the 96% attendance rate and the number of critical questions students ask. Despite obstacles such as limited learning resources and digital access constraints, the adaptation of teachers and students is able to overcome these challenges effectively. This study concludes that the integration of ethnoliteracy and pedagogical deep learning strategies significantly improves students' cognitive, affective, and participatory aspects in numeracy learning. The implication of these findings is the need to develop contextual learning based on local culture to improve the quality of numeracy education in multicultural primary schools.

INTRODUCTION

The Society 5.0 era is a response to the challenges of the Industrial Revolution 4.0, which emphasizes the integration of technology with human life to create a human-centered society. In the context of education, Society 5.0 encourages the transformation of the learning paradigm to be more adaptive to technological developments and skills needs of the 21st century. One of the skills that is heavily emphasized is critical thinking, especially in learning math and numeracy. Unfortunately, numeracy learning at the elementary school level in Indonesia is still procedural and lacks contextualization. Traditional approaches that focus on memorizing and working on basic algorithms are no longer adequate to prepare learners for the complexities of modern life. Students tend to have difficulty relating mathematical concepts to real situations, so learning becomes less meaningful (Kusumawati, 2024). This shows the urgent need to design a numeracy learning approach that not only emphasizes the cognitive aspect, but also strengthens students' understanding and applicability skills. Effective numeracy learning should be able to develop numerical literacy, logical thinking, and problem-solving skills in cultural and social contexts (Jannah & Oktaviani, 2022). Therefore, contextual

and local culture-based learning innovations are one of the relevant alternative solutions to be applied in basic numeracy education.

One potential approach in bridging the gap between abstract concepts and students' reality is the ethnoliteracy approach. Ethnoliteracy is a learning strategy that integrates local cultural richness, such as folklore, traditions, and social practices into the educational process (Silla et al., 2023). In the context of numeracy, ethnoliteration can be used to explore traditional number systems, local logic, and the mindset of local communities that indirectly reflect mathematical values. This approach facilitates learning that is relevant to students' daily lives as well as fostering an appreciation of their own culture. The integration of local culture in learning is also in line with the principles of contextual teaching and learning that relate subject matter to the environment of students (Solihin & Habibie, 2024). When students learn math through familiar narratives or cultural activities, they have an easier time understanding abstract concepts. This approach also motivates students to be more active in the learning process because they feel learning has relevance to their lives. In addition, ethnoliteracy allows the preservation of local culture through the learning process. Cultural involvement in education plays an important role in shaping the character and identity of students from an early age. Therefore, ethnoliteracy as an approach in numeracy learning needs to be studied and implemented systematically and in a directed manner.

In an effort to increase the effectiveness of the ethnoliteracy approach, it is necessary to be supported by pedagogical strategies that encourage deep understanding, one of which is deep learning. Deep learning in the context of education refers to a learning approach that emphasizes conceptual understanding, critical thinking development, and the interconnectedness between concepts (Diputera & Zulpan, 2024). This strategy is in contrast to surface learning which tends to prioritize memorization without meaningful understanding. Deep learning allows students to build a more organized and durable knowledge structure. When applied in conjunction with the ethnoliteracy approach, learning becomes richer because it not only links concepts and cultures, but also deepens the way students understand and internalize the meaning of learning (Wijaya et al., 2025). This approach can also improve students' metacognitive abilities in reflecting on the way they learn and solve problems. The strengthening of metacognition is essential for shaping lifelong learners, which is the main goal of 21st century education (Pare & Sihotang, 2023). The combination of ethnoliteracy and deep learning provides a great opportunity to revolutionize numeracy learning to be more meaningful, contextual, and student-centered. Thus, the pedagogical transformation of numeracy relies not only on content, but also on the way of delivery and the values contained in it. This strategy is very important in welcoming the era of Society 5.0 which demands innovation and meaning in basic education.

Numeracy education is basically not only about numeracy skills, but also includes the interpretation, representation, and use of numbers in various life contexts (Prihapsari et al., 2023). Numeracy is an integral part of literacy that allows individuals to make rational and logical decisions in their daily lives. In the context of local culture, many community life practices indirectly teach numeracy, such as the calculation of the planting season, the traditional calendar system, and the value in traditional symbols (Solihin et al., 2025). Unfortunately, this potential has not been widely utilized in the formal learning system. This is due to the lack of development of teaching materials that are relevant to local culture and the lack of teacher training in integrating ethnoliteracy into learning. The use of learning media and resources that focus only on national standards makes learning tend to be uniform and does not consider local peculiarities. In fact, the Merdeka curriculum that is being promoted by the Indonesian government actually emphasizes flexibility and differentiation based on the context of the educational unit. Within this framework, ethnoliteracy and deep learning approaches have become very relevant to support the implementation of character- and culture-based curriculum. Therefore, the development of ethnoliterary-based numeracy learning tools is a strategic step in strengthening character education, conceptual understanding, and active involvement of students. This innovation will expand the meaning of numeracy as part of cross-

cultural and cross-disciplinary learning. Furthermore, several international studies on culturally responsive mathematics education (Muzakkir, 2021) emphasize that integrating students' cultural backgrounds into instruction can increase engagement and achievement. These studies support the relevance and urgency of the ethnoliteracy approach in numeracy education.

METHODS

This research uses the Research and Development (R&D) approach with the ADDIE development model proposed by Branch & Varank (2009), which includes five stages: Analysis, Design, Development, Implementation, and Evaluation. The main objective of this study is to develop and test the effectiveness of ethnoliterary-based numeracy learning tools integrated with pedagogical deep learning strategies, especially in improving critical thinking skills, mathematical communication, and student engagement. The research approach used is mixed-method, which is a combination of quantitative and qualitative methods. The quantitative approach is used to measure changes in students' abilities through tests and observations, while the qualitative approach is used to explore the perceptions of students and teachers on the usefulness and relevance of learning tools to the local cultural context.

This research was conducted in three elementary schools, namely SD Negeri 1 Lestari, SD Negeri 1 Pecuk, and SD Negeri 2 Margomulyo, which have different local cultural backgrounds. The research subjects consisted of grade V students in all three schools, with a total of 60 students, 20 randomly selected from each school. The initial stages in this study include needs analysis through observation of numeracy learning, interviews with teachers and principals, and the distribution of questionnaires to students. Based on the results of the analysis, the researcher designed a learning tool that includes a folklore-based numeracy module, student worksheets with local cultural contexts, and digital media based on interactive learning features (Solihin et al., 2025). The products developed were then tested on a limited and extensive basis, where data were collected through critical thinking skills tests, mathematical communication assessments, observations of student learning engagement, and feedback questionnaires from students and teachers. The implementation was carried out over a period of 6 weeks, consisting of two weeks of limited trials and four weeks of broader implementation in classroom settings. Each session was held twice a week, with 90 minutes per session, following the standard learning hours at each school.

Data analysis was carried out with descriptive and inferential statistical approaches to measure the effectiveness of the device in improving students' skills, as well as qualitative analysis to understand the response and perception of the device. The evaluation was carried out thoroughly based on the results of the trial, then followed by the revision of the learning tools to better suit the characteristics of the local culture and the needs of students. All stages of research are carried out by paying attention to the ethical principles of research, including obtaining consent from the school and parents, and maintaining the confidentiality of the data obtained. With this method, the research is expected to be able to produce numeracy learning tools that are contextual, culturally relevant, and effective in improving the quality of learning in the Society 5.0 era.

RESULTS AND DISCUSSION

Analysis Result

The results of this study present the main findings of the implementation of ethnoliterary-based numeracy learning tools combined with deep learning strategies in three multicultural elementary schools in Nganjuk Regency. Data was obtained through a variety of methods, such as participatory observation, in-depth interviews, documentation, and quantitative test analysis. The findings include improving numeracy understanding, learning motivation, student independence, and involvement in the learning process. The following table summarizes the results of the research descriptively based on the aspects studied.

Table 1. Summary of Research Results on the Integration of Ethnoliteration and Deep Learning Strategies in Numeracy Learning

Aspect Studied	Indicator	Findings
1. Conceptual Understanding of Numeracy	Pre-test Score in Numeracy	The average score before any intervention was 58.4 (on a scale of 0–100), indicating a moderate baseline understanding.
	Post-test Score after Ethnoliteracy Integration	After introducing ethnoliteracy-based learning materials, the average score increased to 75.2, reflecting a notable improvement in conceptual understanding.
	Final Score after Integration with Deep Learning Strategy	Upon incorporating deep learning strategies alongside ethnoliteracy, the average score further improved to 82.7.
	Score Improvement	An increase of 16.8 points was attributed to the ethnoliteracy approach, with a total improvement of 24.3 points from pre-test to final assessment.
2. Attitudes and Motivation toward Learning	Percentage of Students Disliking Mathematics (Before)	42% of students initially expressed a dislike for mathematics.
	Percentage of Students Still Feeling Bored (After)	This percentage dropped significantly to only 12% after the intervention.
	Students Enthusiastic about Local Cultural Integration	68% of students showed enthusiasm when cultural elements relevant to their lives were integrated into learning activities.
	Students Enjoying Project-Based/Group Discussions	85% of students reported enjoying project work and collaborative learning.
3. Metacognition and Independence	Metacognitive Awareness Score (Pre-Intervention)	The average metacognitive score was 2.3 (on a scale of 5), indicating limited self-awareness of learning strategies.
	Metacognitive Awareness Score (Post-Intervention)	This score rose to 3.9 after the intervention, reflecting better self-regulated learning and reflection.
	Students Able to Identify Their Own Learning Strategies	90% of students were able to articulate and apply their own learning strategies independently.
4. Engagement and Participation	Attendance Rate During Learning Sessions	The attendance rate reached 96%, higher than the average attendance in other subjects (89%), showing increased engagement.
	Average Number of Critical Questions per Session	Students asked an average of 4–5 thoughtful questions in each session, suggesting active participation and curiosity.
5. Cultural Contextualization	Percentage of Lesson Plans/Worksheets Containing Local Cultural Elements	100% of the developed lesson plans and student worksheets included local cultural content, ensuring cultural relevance.
	Teachers Reporting Increased Student Motivation via Cultural Illustrations	75% of teachers observed that students were more motivated when lessons included illustrations and narratives rooted in local culture.
6. Challenges and Adaptations	Availability of Textbooks Featuring Local Cultural Content	Only 2 out of 15 textbooks contained cultural references, prompting teachers to develop their own ethnoliteracy-based worksheets.
	Students Facing Internet Access Limitations	Around 30% of students experienced limited access to stable internet connectivity.
	Students Who Completed Tasks via WhatsApp	Despite connectivity challenges, 92% of students managed to submit their assignments using WhatsApp, demonstrating adaptability.
7. Summary of Impacts	Improvement in Numeracy Scores	A total increase of 24.3 points from the initial test to the final evaluation.
	Growth in Student Enthusiasm	A 56-percentage-point increase in student enthusiasm for learning activities.
	Metacognitive Score Improvement	An increase of 1.6 points in metacognitive awareness.
	Active Participation and Attendance	Attendance remained high at 96%, and there was a rise in students' critical questioning during class.
	Cultural Integration in Instruction	All instructional content was fully integrated with relevant cultural elements (100%).

Based on the table above, it can be seen that the integration of ethnoliteracy and deep learning-based learning strategies has a significant impact on various aspects of students' numeracy learning process. Not only does it improve cognitive learning outcomes, such as the understanding of numeracy concepts, but it also has a positive impact on students' attitudes, motivation, and metacognition. This success is also supported by the contextualization of materials through local culture, although there are still challenges such as limited teaching materials and digital access. Overall, this approach has proven to be adaptive and effective in improving the quality of numeracy learning in a multicultural elementary school environment.

Discussion

The results of the study show that the integration of ethnoliteracy approaches in numeracy learning is able to significantly improve students' understanding of concepts. This is reflected in the increase in the average pre-test score to post-test which reached +24.3 points. Ethnoliteration provides meaningful context for students through the introduction of folklore, local motifs, and cultural activities related to mathematical concepts. This contextualization makes it easier for students to relate numeracy material to their everyday experiences. As stated by Solihin et al. (2025), culturally relevant approaches can improve students' academic achievement. In addition, students are more enthusiastic and motivated because they feel that learning reflects their identity and environment. This process also reinforces the linkages between cultural values and 21st-century skills. In the context of multicultural Indonesia, this strategy is very relevant to bridge the gap between curriculum materials and students' social realities. Thus, the ethnoliteracy approach not only enriches the material, but also strengthens the inclusivity of learning. This is in line with the principle of culturally responsive pedagogy which emphasizes the importance of cultural context in the learning process (Sugara & Sugito, 2022). However, the increase was not uniform across all student groups. Students from non-dominant linguistic backgrounds showed a slower adaptation to text-heavy ethnoliteracy materials, suggesting a need for greater multimodal support such as visuals or audio aids.

Deep learning strategies applied in conjunction with ethnoliteracy also make a positive contribution to improving the quality of learning. Deep learning emphasizes deep understanding, critical processing of concepts, and knowledge transfer to new situations (Raup et al., 2022). In this study, students are involved in projects, discussions, and reflections that trigger a higher-level thinking process. This activity strengthens the student's cognitive structure and develops metacognitive skills. The results of the reflection journal analysis showed that students were able to identify effective learning methods and design improvement strategies. This phenomenon shows an increase in learning awareness and student independence as learners. An increase in metacognition scores from 2.3 to 3.9 (on a scale of 5) reinforces these findings. In line with the opinion of Turmuzi (2025), deep learning encourages students to understand the meaning behind the material, not just memorize. Therefore, the integration of this strategy in numeracy learning is the right innovation in the 21st century learning era. This approach is in accordance with the principles of constructivism which emphasizes the active involvement of students in building knowledge (Mustafa & Roesdiyanto, 2021). Nevertheless, several students reported initial confusion with open-ended tasks and project-based formats, highlighting the need for clearer scaffolding and gradual introduction to deep learning routines.

Students' motivation to learn has also increased significantly after the implementation of this learning model. Before the intervention, most students expressed boredom with math lessons. However, after the integration of ethnoliteration, the majority of students showed a higher interest in numeracy materials. When the material is associated with familiar local cultures, students feel more emotionally and cognitively engaged. This reinforces the view that contextual learning can increase students' intrinsic motivation. Students also love project and discussion formats that facilitate cooperation and reflective thinking. Learning becomes more dialogical and participatory, not one-way. This process provides a space for students to express their personal opinions and experiences.

According to Riki & Kusno (2023), intrinsic motivation arises when students feel autonomous, competent, and connected. Therefore, ethnoliterary-based learning design and deep learning are able to build these psychological conditions (Firdaus, 2021). However, some students who were previously accustomed to traditional instruction expressed difficulty adjusting to the more active and reflective classroom structure. These transitional barriers need to be addressed through adaptive classroom management and peer support mechanisms.

Student participation in numeracy learning showed a significant increase. The attendance rate reached 96%, exceeding the average attendance in other subjects. In addition, students are more active in asking questions and discussing during the learning process. On average, there were 4–5 critical questions asked per session, indicating higher cognitive engagement. This activity shows that students do not only passively receive information, but begin to process and criticize the information. This increase in participation also reflects a sense of belonging to contextual and relevant learning materials. In project- and culture-based learning, students feel that their experiences are valued. This creates a more open and collaborative classroom atmosphere. As explained by Jamiruddin & Ilyas Thamrin (2023), social interaction plays an important role in cognitive development. Therefore, ethnoliterary-based numeracy learning and deep learning strategies support the creation of a constructive social learning environment (Ningsih et al., 2022). Yet, engagement levels tended to drop slightly in longer sessions, indicating a need to balance cognitive load and instructional pacing.

The use of local culture in numeracy learning has been proven to strengthen the relevance of the material to students' lives. As many as 100% of the teaching tools used in the study contain local cultural elements such as weaving motifs, trade practices, and traditional ceremonies. Teachers creatively develop local narrative-based learning modules that are close to students' daily lives. It is easier for students to understand the concepts of fractions and comparisons because they are presented through a real and meaningful context. It supports the principles of contextual learning that facilitate the transfer of knowledge from learning situations to real-life situations. According to (Solihin & Habibie, 2024), contextual learning facilitates the linkage between the content of the lesson and the personal experience of students. These results also show that teachers are able to adapt pedagogical approaches to unique local characteristics. In the long run, this strategy can improve cultural sustainability through education. Therefore, culture-based numeracy learning not only has an impact on academic aspects, but also shapes students' cultural identities. However, these findings contrast with some studies (Utami, 2023) that caution against over-localization, arguing it may limit students' readiness for national assessments if not well-balanced. This tension between cultural relevance and curriculum alignment must be managed carefully.

Although the results obtained were very positive, the study also found some obstacles that need to be considered. One of the main obstacles is the limited learning resources based on local culture. Of the 15 textbooks analyzed, only two contained the context of local culture in numeracy materials. This shows that there is still a lack of availability of teaching materials that are relevant to the social and cultural characteristics of students. As a result, teachers need to develop their own additional learning media and tools. This process demands creativity and additional workload from teachers. These limitations can be overcome by involving local communities and academics in the development of learning resources. In addition, policy support from local governments in the provision of textbooks based on local wisdom is needed. According to Wulansari et al. (2023), cultural inclusion in the curriculum needs to be supported by responsive education policies. Thus, this challenge is an opportunity to encourage cross-sector collaboration in the development of inclusive education (Kemendikbudristek, 2022). Nevertheless, without systemic support, such as dedicated time for teacher development or local cultural documentation, the sustainability of these initiatives remains uncertain.

Another obstacle is the problem of digital access experienced by some students. Around 30% of students face problems in internet connection during the implementation of technology-based learning. However, the adaptation is done by allowing the collection of tasks through WhatsApp in the

form of photos of the work. Although simple, this strategy has proven effective in keeping student participation high. This flexible approach is an example of hybrid learning practices that are responsive to infrastructure limitations. In the post-pandemic context, the ability of teachers and students to adapt to technology is crucial. The use of technology does not have to be sophisticated, but it must be appropriate and in accordance with the needs of students. Deep learning-based learning can still be applied even through simple media. According to (Solihin & Rahmawati, 2024), the success of educational technology depends on the compatibility between media, content, and context. Therefore, flexibility is key in the implementation of technology-based learning. Future studies should investigate the long-term effectiveness of such low-tech adaptations to ensure consistent learning gains across socio-economic strata.

CONCLUSION

Based on the results of research conducted in two multicultural elementary schools in Nganjuk Regency, it can be concluded that the development of ethnoliterary-based numeracy learning tools and deep learning strategies has a significant positive impact on concept understanding, learning motivation, metacognition, and student participation. An increase in average numeracy scores by 24.3 points, a decrease in boredom levels from 42% to 12%, and an increase in metacognition scores from 2.3 to 3.9 indicate that this approach is effective in strengthening students' cognitive and affective aspects. The contextualization of materials through local culture, such as the troso weaving motif and the kenduri tradition, is able to build a meaningful connection between the subject matter and students' life experiences, while strengthening their cultural identity. Student participation in learning also increased, reflected in the high attendance (96%) and number of critical questions asked during class discussions. Deep learning strategies that emphasize problem-solving, group discussions, and self-reflection successfully encourage students to become active and independent learners. Despite obstacles such as limited locally-based teaching resources and unequal digital access, the adaptation made by teachers and students shows the flexibility and resilience of this learning model in a hybrid learning situation.

Overall, the integration of ethnoliteracy and deep learning strategies can be used as an innovative alternative in the development of numeracy learning that not only emphasizes mastery of concepts, but also character formation, learning independence, and the preservation of local cultural values. These findings reinforce the urgency of implementing contextual, inclusive, and culture-based learning in order to address the challenges of 21st century education in diverse elementary school environments. Future research is recommended to explore the long-term impact of this approach on student achievement, examine its scalability across different regions with varying cultural backgrounds, and investigate its effectiveness in other subject areas such as science or language learning. Moreover, studies focusing on teacher readiness and support systems for integrating ethnoliteracy into mainstream curricula would be beneficial for broader adoption.

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