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Digitalization of Ethnomathematics through the STEM Approach: Langgar Etnomatematika Digital (LEDI) Card Based on Augmented Realistics

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ABSTRACT

Purpose - This study aims to describe the development stages and test the feasibility, effectiveness, and practicality of the LEDI Card (Langgar-Ethnomatematika Digital) media, based on Augmented Reality (AR) and a STEM approach, as a contextual and meaningful innovation in geometry learning.

Methodology - This study employed a Research and Development approach using the ADDIE model. The trial involved two subject matter experts, two media experts, and 31 fifth-grade elementary school students as the primary subjects. Data analysis was conducted comprehensively using qualitative and quantitative approaches.

Findings - The results of the study show: (1) AR-based LEDI Card media was successfully developed through five systematic stages of the ADDIE model by integrating STEM elements and ethnomathematics of Jepara's 'Langgar' architecture. (2) LEDI Card media was declared very valid based on the results of the material expert validity test (80.3%) and the results of the media expert validity test (91%). The results of the paired-sample T test showed a significant difference between pretest and posttest learning outcomes (Sig. 0.000 < 0.05), while the N-Gain test result of 0.60 was in the moderate category, indicating a fairly effective interpretation. (3) The media was considered very practical based on teacher responses (81%) and student responses (85.4%).

Contribution - Particularly by demonstrating that integrating ethnomathematics, STEM, and AR technology can reduce cognitive load, reduce math anxiety, and present mathematics as a contextual, inclusive, and enjoyable discipline while honoring local cultural roots.

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INTRODUCTION

Mathematics is a fundamental core subject in elementary school. Mastery of basic mathematical concepts is not only crucial for progressing to the next level of education, but also serves as a foundation for facing the challenges of everyday life in the era of globalization (Setiyani et al., 2025). However, international data shows that Indonesian students' mathematical abilities remain a concern. In the 2022 PISA (Philosophy of International Student Assessment), Indonesian students scored an average of 366 points in mathematics, far below the OECD average of 472 points, with only 18% achieving at least Level 2 mathematics proficiency compared to the OECD average of 69% (Nadjamuddin et al., 2025). This situation is exacerbated by the fact that abstract concepts such as plane and spatial shapes often pose challenges for students, especially when the delivery fails to connect the material to real-world contexts and local culture (Fauzi et al., 2020). This is where innovation in learning media is key to creating more meaningful, engaging, and relevant learning experiences.

The realistic ethnomathematics approach serves as a theoretical foundation for integrating culture with mathematical materials (Darmawan et al., 2023; Nahdi, 2019; Wahyudin et al., 2024; Yogi et al., 2024). Teachers can use materials and examples from local cultures and real-world problems to teach mathematical concepts, so students can practically learn how mathematics is used in everyday life (Haryadi & Kansaa, 2021; Tutiareni et al., 2021; Zahwa & Syafi'i, 2022). This approach also helps students build awareness and appreciation of their own culture.

The integration of local wisdom values into mathematics learning is also increasingly important for maintaining cultural relevance amid technological advances. With digital advancements, students tend to be more interested in global culture and various digital features, potentially replacing local culture. Augmented Reality (AR) technology provides new opportunities to modernize the mathematics learning process. Various studies have concluded that AR can improve learning outcomes, conceptual understanding, motivation, and student engagement, especially in geometry and measurement topics that require high visualization. (Batiibwe, 2024) More specifically, a quasi-experimental study of fifth-grade elementary school students demonstrated that a mobile AR geometry system significantly improved students' learning achievement and motivation compared to traditional teaching materials, while reducing cognitive load. (Voulgari et al., 2024) .

This technology is capable of visualizing abstract concepts through three-dimensional representations, thus helping students gain a more concrete understanding (Aristiantika & Widiono, 2024; Nurfadhillah et al., 2021; Zhang, 2025). Furthermore, the use of AR provides an opportunity to integrate critical thinking into learning, as students are invited to analyze, explore, and solve problems interactively in virtual environments (Huda, 2024; Isrokatun et al., 2020; Sejati & Hardi, 2023).

Learning media such as that developed by Wiranti (Muhaimin & Zumrotun, 2023) namely, snakes-and-ladders media with flat and spatial forms based on ethnomathematics, has been used as a learning tool that combines elements of play and local wisdom. Digitizing traditional games such as Langgar into technology-based media not only increases student motivation but also instills an appreciation for cultural values through gamification (Firdaus et al., 2024).

Although research on AR and ethnomathematics is growing rapidly, these two lines of research have so far proceeded relatively separately. On the one hand, a systematic review of AR studies in mathematics learning shows that most research treats AR as a general visualization tool for abstract concepts, without explicitly linking it to students' local cultural contexts (Erşen & Alp, 2024). On the other hand, ethnomathematics research in Indonesia largely relies on traditional games in printed or other conventional formats, failing to fully utilize the interactivity of digital technology. Even when these two elements begin to converge, their scope remains very limited: Sunzuma & Umbara's (2025) systematic review of 23 technology-based ethnomathematics articles in Indonesia, only a handful of studies truly integrate AR with ethnomathematics, and these studies generally target secondary school students or pre-service teachers (Richardo et al., 2023), rather than elementary school students.

Meanwhile, the Ethno-STEM approach itself has actually begun to develop in Indonesia, but its application is still dominant in the realm of science literacy (IPA) through the context of culinary or local traditions, not in AR-based mathematical geometry (Listiyani et al., 2025). A bibliometric review of PjBL and Ethno-STEM studies from 2016 to 2025 also emphasized that the integration of the three, as well as immersive technology, ethnomathematics, and the STEM framework, is still rarely studied as a whole in a single learning medium. Thus, there is a clear research gap. There has not been a study that holistically combines (1) Augmented Reality technology, (2) realistic ethnomathematics based on local culture, and (3) the STEM approach in a single game media (local game-based media) for geometry learning at the elementary school level. This research aims to fill this gap by developing the LEDI Card (Langgar Ethnomathematika Digital), specifically designed to address these limitations by integrating the three elements simultaneously within the context of Jepara culture.

Through AR-based LEDI Cards, students are not only invited to visualize flat and spatial shapes in depth, but also to learn about culture and stimulate critical thinking skills through interactive exploration and analysis. In this study, the approach used is realistic ethnomathematics in developing the media design Langgar (Snakes and Ladders of Flat and Spatial Shapes) based on Augmented Reality. With this approach, it is hoped that LEDI Cards can become a learning medium that aligns with the concept of realistic ethnomathematics for elementary school students.

Based on the background explained, the research problems in this study are: First, what are the stages for developing the LEDI Card media design based on Augmented Reality by integrating the concept of realistic ethnomathematics? Second, what is the level of feasibility of the media design, and to what extent is the media effective in improving student learning outcomes? Third, what is the level of practicality of the Digital Langgar-Ethnomatematics (LEDI) Card media based on Augmented Reality as studied from the responses of teachers and students in the learning process in elementary schools?

Through this research, it is hoped that innovative learning media can be created that effectively synergize local wisdom with digital technology. The urgency of this research is further strengthened by global research showing that the use of AR in mathematics learning consistently increases engagement and understanding of geometric concepts among elementary school students (Pahmi et al., 2023; Wu et al., 2024) , and that the integration of ethnomathematics has been shown to build meaningful relationships between local culture and students' mathematical competence (Richardo et al., 2023; Sunzuma & Umbara, 2025) .

METHODOLOGY

Research Design

This study uses a research and development design with the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. This model was chosen because it enables the systematic development of learning products, from needs analysis to evaluation. First, the analysis stage was carried out to analyze the learning needs of elementary school students regarding geometry material, analyze the applicable curriculum, and identify the potential of traditional architecture 'Langgar' as an ethnomathematics object. Second, the design stage focused on developing a prototype of the LEDI Card media component, including the main box, interactive mission cards, the educational game Snakes and Ladders, teaching modules, and product assessment instruments. Third, the development stage is the step of realizing the design into a physical product of the media card size 2×3 Moreover, integrating AR technology and digital barcodes is followed by a validity test by material experts and media experts to ensure product feasibility. Fourth, the implementation stage involved integrating the AR-based LEDI Card media into the classroom learning process after students completed the pretest questions to measure its effectiveness. Fifth, the evaluation stage is the final stage for analyzing post-test question data, conducting inferential statistical tests, calculating N-Gain scores, and processing teacher and student response questionnaires to measure the achievement of media development objectives.

The research and development procedure essentially consists of three main objectives, namely: 1) developing the product, 2) testing the effectiveness of the product in achieving its objectives, and 3) the practicality of the Augmented Reality (AR)-Based Langgar-Ethnomatematika Digital Card (LEDI) in improving geometry learning outcomes. Thus, in development research, a product is not only designed according to field needs, but will also be developed according to those needs and then tested in the field (Fahlevi & Yuliani, 2021).

Research Subjects

This research was conducted at MI Miftahul Huda Tegalsambi, located on Jalan Sunan Mantingan RT 08 RW 02 Tegalsambi Jepara. The selection of MI Miftahul Huda Tegalsambi as the research location was based on the consideration that this school had never integrated Augmented Reality (AR)-based learning media or ethnomathematics approaches in mathematics learning. In addition, the school's location in the Jepara area provides geographical and cultural proximity to the ethnomathematics object under study (the traditional architecture 'Langgar'), making it easier for students to contextualize geometry materials within their surrounding environment. The research began with initial observations on January 25, 2026, and continued until data processing on April 20, 2026.

The subjects of this development research consisted of expert judgment and product testing. The expert testing involved three expert validators: one subject-matter expert lecturer who teaches mathematics, one classroom teacher who practices mathematics instruction in schools, and one media expert lecturer. The involvement of these three areas of expertise aimed to ensure the product's theoretical, practical, and technical feasibility before implementation.

Meanwhile, the product test subjects in this study were 31 fifth-grade students of MI Miftahul Huda Tegalsambi. The selection of fifth-grade students as research subjects was based on the cognitive development characteristics of students aged 10-11 years, who are in the transition period from the concrete operational stage to the formal operational stage according to Piaget's theory. At this stage, students need a strong visual bridge to understand the abstract concept of spatial geometry. In addition, based on the applicable curriculum, more complex spatial geometry materials (such as spatial figures and their visualization) begin to be taught in depth at the fifth-grade level, so the arrangement of this AR-based LEDI Card media is considered the most appropriate and needed to stimulate students' spatial understanding in that class.

Data Collection

Data collection in this study used a questionnaire (survey) developed by the researcher, adopting and modifying the standard media feasibility indicators according to BSNP and Kuncoro's practicality scale. This questionnaire instrument is divided into two types of details, namely the expert validation questionnaire and the user response questionnaire. The validation questionnaire was aimed at expert test subjects (1 materials expert and 2 media experts) to assess aspects of the curriculum, material quality, visual appearance, and ease of media learning. Meanwhile, the user response questionnaire was aimed at 1 fifth-grade teacher and 31 students to measure aspects of media practicality, comfort of use, readability, and the appeal of the LEDI Card educational game. Before being used in the field, all of these questionnaire instruments were tested for construct validity through an expert-judgment process by the supervising lecturer and experts until they were deemed valid and suitable for data collection.

On the other hand, to measure the impact of media implementation, a test instrument consisting of pre-test (initial test) and post-test (final test) questions was developed by the researcher, independently prepared based on the applicable curriculum learning objectives. The test instrument consisted of 10 multiple-choice questions, specifically aimed at 31 fifth-grade students as the main subjects of the product trial. The aspects measured through this test instrument focused on students' geometric calculation (numeracy) abilities, with achievement indicators including the ability to identify the properties of flat shapes, calculate the area and perimeter of flat shapes, and analyze the volume and surface area of space shapes based on the architectural

ethnomathematics of 'Langgar'. The level of empirical validity of the test questions was assessed using the Product-Moment correlation to ensure each item was valid. At the same time, the reliability was calculated using the Cronbach's Alpha formula to ensure the consistency of the test instrument before being administered to students.

Data Analysis

The data analysis techniques in this study were conducted using two systematic approaches: qualitative and quantitative. Qualitative data were obtained from the results of initial needs-analysis interviews, field notes from the LEDI Card media development stage, and suggestions and input for improvement from experts. This qualitative data was analyzed descriptively and narratively to inform product revisions and improvements. Meanwhile, quantitative data were obtained from two main instruments: questionnaire scores and student learning outcome test scores. The quantitative data analysis process is outlined sequentially as follows:

Media Feasibility and Practicality (Questionnaire Data)

The score data obtained from the validation questionnaire by material and media experts, as well as the results of the response survey from teachers and students, were first calculated as a percentage using the following formula:

$$P=\frac{f}{N} \times 100\%$$

Explanation:
P = Percentage of validity
f = Total score from data collection
N = Maximum score

The results obtained are then interpreted and categorized to make decisions regarding the level of validity and practicality of the product based on Table 1 and Table 2 below:

Table 1. Percentage of Validity Criteria for Material and Media (Kuncoro, 2020)

Presentation	Category
0% - 20%	Invalid
21% - 40%	Less valid
41% - 60%	Quite valid
61% - 80%	Legitimate
81% - 100%	Very valid

Table 2. Percentage of Criteria for Teacher and Student Response Results

Presentation	Category
0% - 20%	Not practical
21% - 40%	Quite practical
41% - 60%	Quite practical
61% - 80%	Practice
81% - 100%	Very practical

Media Effectiveness Analysis (Test Data)

Quantitative data on student learning outcomes were obtained by comparing pre-test and post-test scores. To test the significance of the improvement in students' geometry learning outcomes, the data were analyzed using the Paired Sample T-Test in SPSS after ensuring they met the normality requirements. Furthermore, to measure the effectiveness of the LEDI Card media in improving geometry learning outcomes,

the improvement value was calculated using the Normalized Gain (N-Gain) test. The N-Gain values obtained were then classified based on the score distribution criteria in Table 3 below:

Table 3. Distribution of N-Gain Scores (Umami et al., 2024)

N-Gain Value	Category
G > 0.7	Tall
0.3 ≤ g ≤ 0.7	Currently
G < 0.3	Low

To see the classical effectiveness of the media in percentage form, the N-Gain value is further interpreted based on the effectiveness criteria in Table 4 below:

Table 4. Interpretation of N-Gain Effectiveness

Percentage (%)	Category
<40	Ineffective
40 – 55	Less Effective
56 – 75	Quite Effective
>76	Effective

FINDINGS

This developmental research aims to describe the stages of development and to test the validity, effectiveness, and practicality of the Langgar-Ethnomathematics Digital (LEDI) Card media based on Augmented Reality (AR) with a STEM (Science, Technology, Engineering, and Mathematics) approach. The development process was carried out using the ADDIE model, which consists of five systematic stages: Analysis, Design, Development, Implementation, and Evaluation. The following are details of the achievements at each stage:

Analysis Stage

In this initial stage, a needs analysis was conducted through in-depth interviews and structured observations with fifth-grade teachers at MI Miftahul Huda Tegalsambi on January 25, 2026. Based on concrete field data, several fundamental problems were identified in mathematics learning, especially in the Geometry Material. Students experienced significant difficulties in MIPAS (Mathematics and Natural Sciences) literacy and Geometry numeracy, especially in visualizing the properties of abstract plane and solid shapes. Initial data showed that low student learning outcomes were due to limited media variety; teachers still tended to rely on conventional methods, using only a few simple teaching aids.

In the context of the STEM approach, an initial integration analysis was conducted: (1) Science: Analyzing how geometry concepts can train students' logical-scientific thinking skills. (2) Technology: Identifying the need to utilize digital technology in the form of Augmented Reality (AR) and quick response (QR) codes. (3) Engineering: Analyzing the traditional architectural structure of Jepara's 'Langgar' as a design object. (4) Mathematics: Identifying the material on flat and spatial shapes in the fifth-grade curriculum that is in line with the structure of the Langgar. Therefore, it was concluded that teachers and students need innovative learning media that are interactive, concrete, and fun. The development of Langgar-Ethnomathematics Digital (LEDI) Card media, based on Augmented Reality (AR) and a STEM approach that integrates the local architectural context of Jepara's Langgar, was chosen as a solution to improve students' literacy and numeracy skills.

Design Stage

The second stage focuses on designing a product concept based on a combination of ethnomathematics and four STEM components, where, in the development of the LEDI Card media, planning is carried out. In

the design stage, the task is to create a design plan and design the LEDI Card media components. The LEDI Card media components are designed in detail, including the main box, mission cards, user guides, student worksheets, interactive educational games in the form of snakes and ladders, and material books designed using the Canva application. The STEM design arrangement at this stage includes: (a) Conceptual Design (Science & Mathematics): Compiling a concept map of geometry material (area, circumference, volume) and mission cards containing numeracy problem-solving challenges. (b) Technical Design (Technology & Engineering): Designing the architecture of a large 2×3 meter-sized snakes-and-ladders game as an exploration board, placing visual marker points to trigger 3D AR objects on the device, and compiling STEM-based teaching modules. The visual design combines several elements of Jepara City. It is adapted to the characteristics of elementary school students, making them interested in using the LEDI Card media, including images, colors, and shapes. At this stage, the preparation of learning activity plans or teaching modules, as well as product assessment instruments, is also carried out.

Development Stage

In the development stage, the designed media components are combined into a 2 x 3 m rectangle. User instructions, worksheets, and material books are digitized into barcodes to enhance visual appeal. This media also includes boards that show geometric concepts (plane and solid shapes), markers, erasers, educational games, and mission cards related to the properties of plane and solid shapes, with the mission to explore Jepara City presented in Figure 1, and a Snakes and Ladders game board that represents geometric shapes in local cultural architecture, as presented in Figure 2.

Figure 1. Visual of STEM-Based LEDI Card, Mission Card, the LEDI Card Snakes, and Ladders Educational Game Board

Before being implemented in learning, the LEDI Card media was first validated by material and media experts to ensure its feasibility as a product. The results of the expert assessment were then analyzed quantitatively, producing the following product validity test results:

Table 1. Material Expert Validation Results

Assessment Aspects	Test Subject		Total Score	Maximum Score	Percentage	Category
	expert 1	expert 2				
Curriculum	8	8	16	20	80%	Very valid
Material	20	20.5	40.5	50	81%	Very valid
Evaluation	8	8	16	20	80%	Legitimate
Total			75	90	80.3%	Very valid

Based on Table 1, the content experts' validation results indicate that the learning material is considered very valid overall, with a total validation percentage of 80.3%. In detail, the curriculum aspect received a high

rating of 80%, indicating that the material is very valid with the applicable curriculum; the content aspect received a validation percentage of 81%, indicating that the material is very valid. The evaluation aspect achieved an 80% validation percentage, placing it in the valid category. This validation achievement is consistent with international findings from studies developing AR-based media using ADDIE for elementary school science, showing that validation by content and media experts generally yields scores above 80% as an indicator of strong feasibility, confirming that the LEDI Card media has met widely recognized feasibility standards. The results of media validation by experts are shown in

Table 2. Media Expert Validation Results

Assessment Aspects	Test Subject		Total Score	Maximum Score	Validation	Category
	Expert 1	Expert 2				
Appearance	13	15	28	30	93.3%	Very valid
Learning	18	18	36	40	90%	Very valid
Evaluation	9	9	18	20	88%	Very valid
Total			81	90	91%	Very valid

Based on Table 2, the validation results from media experts indicate that the media is considered very valid overall, with a total validation percentage of 90%. In detail, the appearance aspect received the highest rating, namely 93.3%, indicating that the media appearance is very valid; the learning aspect received a validation percentage of 90%; and the evaluation aspect received a validation percentage of 88%, which falls within the valid category. The conclusion from this interpretation is that the product developed not only has a very attractive and adaptive visual packaging for elementary school students, but also meets technical standards and instructional feasibility as an interactive learning medium, ready for implementation in the classroom.

Implementation Stage

The implementation stage was carried out in practice in class V MI Miftahul Huda Tegalsambi, involving 31 students as the main subjects for the product trial. The implementation of this trial was designed to see the effectiveness of the STEM-AR-based LEDI Card media in actual learning situations. The implementation process was carried out in a structured manner through three main steps, namely pre-learning, core, and post-learning activities. Learning begins with a pretest to measure students' initial geometry abilities. Next, the core step is for students to carry out learning using the LEDI Card media through a STEM approach that requires active activities. Students are divided into several groups to conduct science and mathematics experiments using game boards, scan QR codes to display concrete geometric building visualizations (technology), and solve building reconstruction challenges or calculate the architectural dimensions of the Langgar (engineering). Through this interdisciplinary approach, students are directly involved in exploratory and contextual learning.

After using the media, students will complete a response questionnaire about their experiences with the taught media and take a post-test to measure progress toward learning outcomes. The fifth-grade homeroom teacher of MI Miftahul Huda Tegalasambi completed the teacher response questionnaire regarding the LEDI card media. The findings from this questionnaire will be used to assess the media's practicality. The following table shows the results of the teacher response questionnaire:

Table 3. Teacher Response Results

Score		Percentage	Category
scores obtained	maximum score		
49	60	81%	Very practical

Table 3 shows teacher responses to the LEDI Card media. The score was 49 out of 60, yielding a practicality percentage of 81%. Based on the established categories, these results indicate that teachers considered the LEDI Card media very practical. Meanwhile, student responses are shown in Table 4.

Table 4. Student Response Results

Number of Students	Score		Percentage	Category
	Scores obtained	Maximum score		
31	1599	1860	85.7%	Very practical

Table 4 shows student response data to the LEDI Card media. These responses were collected from 31 fifth-grade students at MI Miftahul Huda Tegalsambi. The score obtained from the student responses was 1599, compared to the maximum score of 1860. Based on calculations, the media's practicality percentage reached 85.7%. These results indicate that the developed LEDI Card media was considered very practical by students.

Evaluation Stage

The final stage is evaluation. After implementing the media and delivering the material, students are asked to complete a post-test or evaluation questions and fill out a student response questionnaire as feedback on the use of the LEDI Card media. Furthermore, at this stage, a normality test is conducted on the pre-test and post-test scores to determine whether the research is normally distributed or not. This study uses the Shapiro-Wilk test in SPSS 16.0 for Windows. Decision making: If the significance value is > 0.05, then the pretest and post-test data are normally distributed, and if the significance value is < 0.05, then the pretest and post-test data are not normally distributed. The following table shows the results of the normality test:

Table 5. Normality Test Results

Learning Outcome Data	Statistics	df	Significance (Sig.)	Information
Pre-test	0.934	31	0.056	Normally Distributed
Post-test	0.951	31	0.167	Normally Distributed

In this study, the pretest and post-test had significance values of 0.056 and 0.167, indicating that the pretest and post-test results are normally distributed because the significance values are> 0.05. These results indicate that all data on students' geometry learning outcomes, both before (pre-test) and after (post-test) receiving treatment using the STEM-AR-based LEDI Card media, are normally distributed. Assuming the data are normally distributed, hypothesis testing to assess the media's effectiveness can proceed using parametric statistical analysis, specifically a Paired-Samples T-Test.

This was followed by a paired-samples t-test and an N-Gain test using SPSS 16.0 for Windows, to determine the effectiveness of developing LEDI Card media in improving geometry learning outcomes in elementary schools. The Paired Sample T-Test involves a decision-making process: if the significance value is >0.05, there is a significant difference between the learning outcomes in the pretest and posttest data; if the significance value is <0.05, there is no significant difference between the learning outcomes in the pretest and posttest data. The results of the Paired Sample T-Test are presented in Table 6.

Table 6. Paired Samples Test

		Paired Differences							
1.					95% Confidence Interval of the Difference				
		Means	Standard Deviation	Standard Error of the Mean	Lower	On	T	Df	Sig. (2 tails)
Couple 1	PRETEST - POST-TEST	-30.97E1	11.65471	2.09325	-35.24272	-26.69276	-14,794	30	0,000

Based on Table 6, the average difference between the pretest and posttest data was -30.97, with a standard deviation of 11.65 and a standard error of the mean of 2.09. The 95% confidence range for the difference in learning outcomes is from the lower limit (Lower) of -35.24 to the upper limit (Upper) of -26.69. The results of this calculation produce a t-value of -14.794 with a degree of freedom (df) of 30 and a significance value (Sig. 2-tailed) of 0.000. Because the p-value of 0.000 is much smaller than the specified significance level of 0.05, the null hypothesis is rejected, indicating a statistically significant difference in learning outcomes between students' scores before (pretest) and after (posttest) using the learning media. This empirical study demonstrates that the digitalization of ethnomathematics through STEM-AR-based LEDI Card media is highly effective in improving students' geometry learning outcomes in elementary schools. The results of the N-Gain test are as follows:

Table 7. N-Gain Test Results

	N	Minimum	Maximum	Means	Standard Deviation
Gain	31	0.11	0.88	0.6007	19510
Valid N values	31				

Based on Table 7, the N-Gain test results show an average of 0.6007, which falls within the moderate category. Meanwhile, the N-Gain results, when presented as percentages, average 60%, which is considered quite effective. This indicates that although there is a statistically significant increase in learning outcomes, the relative increase is interpreted as quite effective. Thus, the LEDI Card media is effective in improving geometry learning outcomes in elementary schools, although the relative increase is quite significant. This is consistent with research integrating ethnomathematics and AR in elementary schools, which found that more than 90% of students were very enthusiastic and actively used the AR feature to view 3D objects, particularly in the contextual conceptual understanding indicator (Supli & Yan, 2024).

DISCUSSION

The development of the LEDI Card (Digital Ethnomathematics) media based on Augmented Reality (AR) provides a new perspective in overcoming cognitive barriers in geometry learning. The success of the LEDI Card in improving geometry learning outcomes proves that the effectiveness of learning media depends not only on technological sophistication but also on how the technology organizes cognitive information. Fundamentally, the effectiveness of this media lies not only in the use of AR technology, but also in its ability to transform abstract geometric concepts into concrete representations that students can manipulate. This is in line with Piaget's theory of cognitive development, which posits that elementary school students are at the concrete operational stage, so that visualizing 3D objects through AR can bridge the gap between abstract thinking and the reality of the material being studied (Faqih et al., 2024). This mechanism aligns with cognitive load theory, in which students' mental load is reduced through intuitive, interactive visualization, allowing

their working memory to focus on understanding geometric concepts rather than on visualizing difficult-to-reach shapes (Hayat et al., 2024; Zhu et al., 2026).

The main strength of the LEDI Card lies in its integration of ethnomathematics with the STEM approach. The use of Jepara's cultural context in literacy and numeracy issues is not merely a complementary element, but a catalyst that makes learning meaningful. When students face contextual problems, their ability to interpret quantitative information improves due to an emotional and cultural attachment to the material. This approach aligns with Batiibwe's (2024) findings that culturally based games can stimulate deeper critical and analytical thinking skills because students do not feel like they are working on "foreign" problems, but rather interacting with their own cultural identity. This research contribution emphasizes that when mathematics is linked to local narratives (in this case, "Langgar" and the City of Jepara), psychological barriers such as math anxiety can be drastically minimized. (Kusuma et al., 2024) . Thus, this research enriches the literature on mathematics education by demonstrating that local wisdom is a powerful driver of greater learning relevance in the digital era.

The significant improvement in learning outcomes (N-Gain) results from a shift in students' roles from passive recipients of information to active builders of knowledge. (Debrenti, 2024) . Through educational game missions and mission card interactions, LEDI Cards force students to engage in high-level cognitive processes in solving geometry problems. The use of media that combines games (gamification) with the Mathematics and Natural Sciences curriculum has been shown to effectively reduce math anxiety, which is often a major obstacle in elementary schools. (Dondio et al., 2022) . In other words, this media not only facilitates the delivery of material but also transforms the classroom atmosphere into a supportive and motivating learning environment.

Regarding practicality, research findings confirm that ideal learning media for elementary school students are those with high readability and an intuitive interface. The practicality of LEDI Cards, assessed by both teachers and students, demonstrates that integrating complex technology (AR) can be accommodated within classroom needs as long as it is designed with a clear game-based structure. (Akbar et al., 2025) . Thus, LEDI Cards shift classroom dynamics from a teacher-centered model to a student-centered one (student-centered learning). With missions in LEDI Cards, students are encouraged to become active problem solvers. However, this study also identified technical limitations, such as the need for a large space and a long work duration. These limitations suggest that future development of similar media must consider scalability for greater flexibility in use across various classroom settings. The use of this media also requires the teacher to act as a facilitator capable of guiding mission-based discussions, rather than simply assigning assignments. Therefore, the implementation of this media not only facilitates improved learning outcomes but also requires increased teacher capacity to manage technology- and game-based learning.

Conceptually, this research strengthens international evidence that integrating ethnomathematics, STEM, and AR technology is a valid, effective, and practical approach for primary education in Indonesia. This learning innovation demonstrates that modernizing education through digital technology need not abandon local cultural roots. The success of this medium provides empirical evidence that, with the right approach, mathematics can be taught through contextual play experiences, transforming students' perception of mathematics from a daunting subject to a fun, inclusive, and meaningful medium of exploration.

CONCLUSION

This study produced three main conclusions that reflect the success of learning innovation in elementary schools. First, the digitalization of ethnomathematics, through the development of the LEDI Card (Langgar Ethnomathematics Digital) media based on Augmented Reality (AR) and the STEM approach, was successfully implemented systematically using the ADDIE development model. This media harmoniously combines the local wisdom values of the traditional architecture of Jepara 'Langgar' into a dynamic structure for the elementary school mathematics curriculum. Second, the most important meaning of this research finding is the empirical demonstration that integrating interactive visual technology, such as AR, with the

local cultural context can reduce students' cognitive load when understanding abstract spatial geometry concepts. The LEDI Card media has been proven to significantly improve students' mathematical literacy and numeracy skills effectively. The theoretical contribution of this study confirms that the STEM approach need not adopt a modern, foreign context for students; instead, local wisdom can be a powerful, relevant catalyst for active, meaningful knowledge construction (meaningful learning), while minimizing math anxiety at the elementary education level.

Third, the high level of practicality in teacher and student responses indicates that complex digital technologies can be seamlessly integrated into elementary classrooms when packaged as intuitive, mission-based educational games (game-based learning). The practical implications of this research provide strong recommendations for education practitioners to begin shifting from conventional teaching methods to student-centered learning. As recommendations for future development, this study suggests the need to increase the physical flexibility of media to be more adaptive to varied classrooms, as well as increasing the capacity of teachers in facilitating this immersive technology-based learning, so that the positive impact of the digitization of local wisdom can be felt more widely and sustainably.

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