

The influence of local wisdom-based gamification on students' literacy and numeracy in mathematics learning

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Abstract: Literacy and numeracy are essential skills for student preparation in further education, enabling understanding, analysis of information, and problem-solving. They are critical indicators of student success and provide a foundation for future challenges. This study aims to examine the effect of local wisdom-based gamification on students' literacy and numeracy skills in mathematics learning. This study used an experimental design, namely a one-group pretest-posttest. The sample of this study was 30 seventh-grade students. The instruments in this study consisted of two types, namely a questionnaire to measure literacy skills and a test to measure numeracy skills. The pretest-posttest difference test used a paired t-test. The local wisdom-based gamification media developed was validated by material experts with an average of 85.56%, and media and design experts with an average of 93.58%, indicating the media is valid for use. These findings indicate that local wisdom-based gamification has a positive influence on improving student literacy, which is indicated by a shift in some students from the moderate category to the high category after the intervention was given (sig. = 0.001). Local wisdom-based gamification was also able to positively improve students' numeracy skills, marked by a shift in students from the low and moderate categories to the higher categories (sig. = 0.001). Thus, the implementation of local wisdom-based gamification was proven to have a significant impact on improving students' literacy and numeracy skills.

Keywords: Gamification, local wisdom, mathematics learning, traditional game

Abstrak: Literasi dan numerasi merupakan keterampilan penting dalam persiapan siswa di pendidikan tinggi, yang memungkinkan pemahaman, analisis informasi, dan pemecahan masalah. Keduanya merupakan indikator penting keberhasilan siswa dan memberikan landasan untuk tantangan di masa depan. Penelitian ini bertujuan untuk menguji pengaruh gamifikasi berbasis kearifan lokal terhadap keterampilan literasi dan numerasi siswa dalam pembelajaran matematika. Penelitian ini menggunakan desain eksperimental, yaitu pretest-posttest satu kelompok. Sampel penelitian ini adalah 30 siswa kelas tujuh. Instrumen dalam penelitian ini terdiri dari dua jenis, yaitu kuesioner untuk mengukur keterampilan literasi dan tes untuk mengukur keterampilan numerasi. Uji perbedaan *pretest-posttest* menggunakan uji t berpasangan. Media gamifikasi berbasis kearifan lokal yang dikembangkan divalidasi oleh ahli materi dengan perolehan rata-rata 85,56%, dan ahli media dan desain dengan perolehan rata-rata 93,58%, yang menunjukkan bahwa media tersebut valid untuk digunakan. Temuan ini menunjukkan bahwa gamifikasi berbasis kearifan lokal memiliki pengaruh positif dalam meningkatkan kemampuan literasi siswa, yang ditunjukkan oleh pergeseran beberapa siswa dari kategori sedang ke kategori tinggi setelah intervensi diberikan (sig. = 0,001). Gamifikasi berbasis kearifan lokal juga mampu meningkatkan kemampuan numerasi siswa secara positif, ditandai dengan pergeseran siswa dari kategori rendah dan sedang ke kategori yang lebih tinggi (sig. = 0,001). Dengan demikian, implementasi gamifikasi berbasis kearifan lokal terbukti memiliki dampak signifikan dalam meningkatkan kemampuan literasi dan numerasi siswa.

Kata kunci: Gamifikasi, kearifan lokal, pembelajaran matematika, permainan tradisional

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INTRODUCTION

Literacy and numeracy are essential competencies that must be developed to equip students to continue their education to the next level (Hoogland, 2023; Nasir et al., 2024;

Wathoni et al., 2026). Literacy and numeracy skills are two crucial components of education because they influence the understanding and analysis of information, as well as the resolution of everyday problems. Both are key indicators of student success in learning and preparation for facing future challenges. However, student literacy and numeracy skills in Indonesia remain low, especially at the junior high school level. The 2023 PISA results still place Indonesia in the low ranking. The average PISA score in numeracy literacy was 366 points, 106 points below the global average. In fact, numeracy literacy is the area with the highest number of students still having low-level skills below level two, amounting to 82 percent (Yuda & Rosmilawati, 2024).

Mathematics subjects play a major role in shaping students' literacy and numeracy abilities (Chang, 2023; Landong et al., 2026). Mathematics is a science that emphasizes understanding patterns, relationships between concepts, and the ability to process quantitative information systematically. In Indonesia, mathematics is one of the core subjects in the education curriculum, especially at the junior high school level. Nirfayanti et al. (2023) explained that mathematics is an important science to study because mathematics is a science that has the characteristics of being a science that has abstract objects, is patterned on axiomatic deductive thinking, and is also based on truth. Therefore, mathematics is closely related to the development of students' literacy and numeracy, which is an important part of the basic skills of the 21st century. According to Nurhikmah et al. (2025) mathematical literacy is an individual's ability to formulate, use and interpret mathematics in various real life contexts. These abilities include logical reasoning as well as the use of mathematical concepts, procedures and tools.

Despite their important role, the reality on the ground shows that many junior high school students have not yet mastered literacy and numeracy well. They still struggle to apply mathematical concepts in practical contexts or in problems that require in-depth reasoning. This low ability is evident from the results of learning evaluations and the findings of various studies that show that students tend to memorize formulas without understanding their meaning or application. Based on the results of a preliminary study conducted in the even semester in November 2024 at SMP Islam Amir Panyula, students' literacy and numeracy skills are still relatively low. From data obtained from 30 class VII A students, it was found that approximately 47% of students' learning outcomes in mathematics did not reach the standard score for achieving learning objectives, because many students experienced difficulty understanding questions, reading information well, analyzing problems, and performing basic calculations. Furthermore, the applied learning approach is still conventional, minimal interactive activities, and does not involve contextual problem-solving, causing students to lose enthusiasm in participating in learning. Classes become passive, the teacher dominates, while students only take notes and memorize, without truly understanding the meaning of the material presented.

This poses a serious challenge to improving the quality of mathematics education at the secondary level. One of the main challenges in developing literacy and numeracy in schools is low student interest in the material presented. Traditional approaches, still widely used, tend to focus on memorizing formulas and procedures, without actively engaging students in the thinking process and conceptual understanding (Bature, 2020; Lo & Hew, 2020; Voskoglou & Salem, 2020). As a result, many students feel bored, stressed, and even afraid of mathematics (Amoah et al., 2023; Argaruri et al., 2023; Bekker et al.,

2023). This situation leads to decreased learning motivation, which directly impacts low literacy and numeracy achievement.

One strategy that can be used to improve literacy and numeracy skills is to implement a more interactive and enjoyable learning approach, such as gamification. Interactive teaching materials based on innovative technology can enhance students' conceptual understanding and thinking skills, and can overcome obstacles in the learning process (Nurfadillah et al., 2023). Gamification encourages more structured, measurable, and results-oriented learning management, while creating a fun learning environment and motivating students to actively engage. Through gamification, learning activities can be organized in the form of challenges, levels, points, or rewards that stimulate students' enthusiasm for learning (Alt, 2023; Legaki et al., 2020). Specifically, this approach supports the effectiveness of the teaching and learning process as mandated by management standards.

Previous research has shown that gamification-based learning can make the learning process more engaging, interactive, and effective in improving student skills. This is evidenced by improvements in students' literacy and numeracy skills (Wulandari & Widiensyah, 2023). In research Rosydiana et al. (2023), gamification has also been proven to be effective in improving problem-solving abilities, creativity, and other 21st century skills that are important in the digital era, also showing that learning packaged in the form of games/gamification can improve literacy and numeracy (Duraismamy & Ali Mohammed, 2024; Fahmi et al., 2025; Feriyanto et al., 2024; Ni'mah et al., 2026). Utilizing gamification in learning requires strategies in using it such as game mechanics, aesthetics, and game thinking to engage people, provide encouragement and motivation, and learn to solve problems (Sobrino-Duque et al., 2022).

In the context of Indonesia, which is rich in culture and local wisdom values, a local wisdom-based learning approach has great potential to strengthen cultural identity, shape character, and increase student engagement (Damopolii et al., 2024; Horota et al., 2023). Local wisdom becomes a contextual and meaningful learning resource because it comes from real life that is close to students (Rahayu et al., 2025; Syahrul et al., 2026). The integration of local cultural elements into learning provides a relevant and easy-to-understand experience (Nunaki et al., 2023; Silahooy et al., 2024). Combining local wisdom with gamified learning is an innovative strategy to improve literacy and numeracy while preserving culture (Amaliyah & Santoso, 2025; Basuki et al., 2026; Landong et al., 2026; Lee Yan & Mohd Matore, 2023; Putri & Surayanah, 2025). Local wisdom enriches the learning experience through cultural and environmental contexts. Its application in learning has been proven to increase learning interest and strengthen the link between theory and practice (Khasanah, 2023).

In the context of numeracy, culture-based activities such as traditional games can be a learning medium that trains numeracy, logical thinking, and problem-solving skills. Traditional games not only build basic numerical knowledge in children but also foster social interaction and cognitive skills (Jayadi et al., 2021). Fun learning through traditional games can overcome student boredom and restore active and creative playtime in the classroom (Wulansari & Dwiyantri, 2021). Local wisdom-based gamification is a digital learning strategy that combines game mechanics with local cultural content for educational purposes and character building (Ibda et al., 2023). Local wisdom-based gamification is a

learning approach that integrates game elements (such as goals, rules, competition, and challenges) into technology-based educational media, incorporating local values, culture, and traditions (Siswoyo et al., 2023). The traditional game *Madendde* was developed as a means to integrate local wisdom with mathematics learning through a gamification approach. This research is expected to demonstrate that local wisdom-based gamification not only increases motivation but, more importantly, facilitates the construction of meaningful knowledge. When literacy and numeracy are presented in a familiar cultural context, learning becomes more reflective, collaborative, and relevant to students' lives.

METHOD

This study used an experimental design, namely a one-group pretest-posttest. A one-group pretest-posttest design is a research design in which only one group is observed. Measurements were taken twice: before treatment (pretest) and after treatment (posttest). This study was conducted in the odd semester of the 2025/2026 academic year at Amir Islam Panyula Middle School. The study population is presented in Table 1.

Table 1. Research population

NO	Class	Gender		Number of students	
		Male	Female		
1	VII	VII A	16	14	30
		VII B	15	15	30
2	VIII	VIII A	11	17	28
		VIII B	17	11	28
3	IX	IX A	12	10	22
		IX B	13	11	24
Total					162

The sampling technique used in this study was purposive sampling. Purposive sampling was used because the researcher wanted to select classes that truly met the research needs. In this case, the researcher deliberately selected one class to receive the local wisdom-based gamification treatment.

This selection was not random, but based on certain considerations, such as equivalency of student ability levels, a balanced student population, and available study time. This way, the results of the treatments could be compared more fairly and accurately. Therefore, the sample for this study was 30 students in grade VII A.

Table 2. Sample

Class	Male	Female	Total
VII A	16	14	30 Students

The instruments used in this study consisted of two types: questionnaires and tests. The literacy questionnaire consisted of a series of written questions given to respondents to obtain data according to the research needs. In this study, questionnaires were administered to students before and after the local wisdom-based gamification learning

activity to explore their literacy skills, including perceptions, understanding, motivation, and responses to the learning process.

In addition, this study also used a numeracy test, administered in the form of questions, to assess students' mastery of the learning material. The tests were administered at the beginning (pretest) and at the end (posttest) to determine changes or improvements in students' numeracy skills after participating in the local wisdom-based gamification learning. Before conducting inferential statistical analysis, a series of prerequisite statistical analysis tests were conducted to ensure that the data met the basic assumptions for further analysis. These prerequisite tests included a normality test and a paired t-test for pretest-posttest differences.

RESULTS AND DISCUSSION

During the research at the school, the researchers first developed the learning media that would be used in the research process. These included a *Madendde'* game field design printed on a banner, a set of questions displayed through the Baaboozle platform, and a modified *Madendde'* game guide video integrated with mathematics learning materials.

A prototype of the traditional *Madendde'* game-based learning media was developed as a means of integrating local wisdom with mathematics learning through a gamification approach. This prototype incorporates the main components of the traditional game combined with modern learning elements, such as interactive digital questions, a points system, and visual guides designed using the Canva application, making them easier for students to understand. To clarify the components and functions of each part of the prototype, a detailed description of the *Madendde'* learning media is presented in Table 3.

Table 3. Local wisdom-based gamification prototype (*Madendde'* traditional game)

Component	Technical Specifications	Function in Learning
<i>Madendde'</i> playing field	The visual media is a 200 x 300 cm banner, consisting of 8 functional squares and 1 semicircle, designed using the Canva platform.	It serves as the primary medium for facilitating kinesthetic activities, developing physical coordination, and strengthening conceptual understanding of mathematics through a playful approach.
<i>Madendde'</i> game guide		It aims to facilitate research subjects' understanding of game regulations, minimize the potential for procedural errors, and ensure the consistency and validity of gamification implementation.
Gacuk	The instructional document, presented in Canva video format, includes game rules, standard operating procedures, implementation flow, and a structured scoring scheme.	It serves as an instrument for evaluating the accuracy and accountability of throwing, while also serving as a mechanism for determining turn-taking between groups fairly.

Digital question cards	The physical objects, in the form of small flat stones, are accompanied by specific usage instructions integrated into the game guide.	It serves as a digital-based formative or summative assessment instrument for evaluating mastery of mathematical concepts through a playful framework.
Timer	The math problems are based on the Boombalze platform, synchronized and visualized on a game board (projector/digital screen).	It is essential for developing research subjects' time management capabilities, encouraging quick thinking, and cognitive efficiency in problem-solving.
Point system	A digital timer (using the teacher's smartphone or an online timer app), with a time allocation of 3 minutes per question.	It acts as a reward mechanism that motivates active participation in research subjects, while simultaneously incorporating a constructive, competitive atmosphere into the learning environment.
Playing groups	Scoring is 15 points for each correct answer, 5 points for good explanation/reasoning, and 10 points for group work.	It is designed to optimize teamwork skills, facilitate interactive communication, and build effective collaboration among members in achieving common goals.



Fig. 1. *Madendde'* playing field



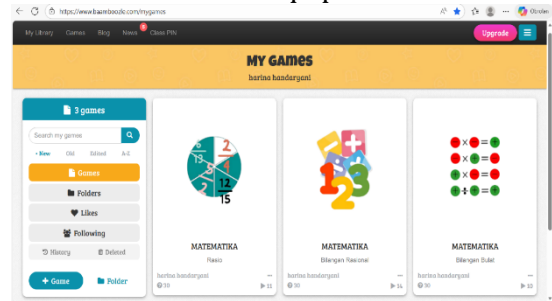
a. Initial View



b. Game Equipment



c. Guide to Addressing Challenges



d. Games in the Boombazle Platform



e. Implementation in the classroom

Fig. 2. Gamification based on local wisdom of the *Madendde'* game

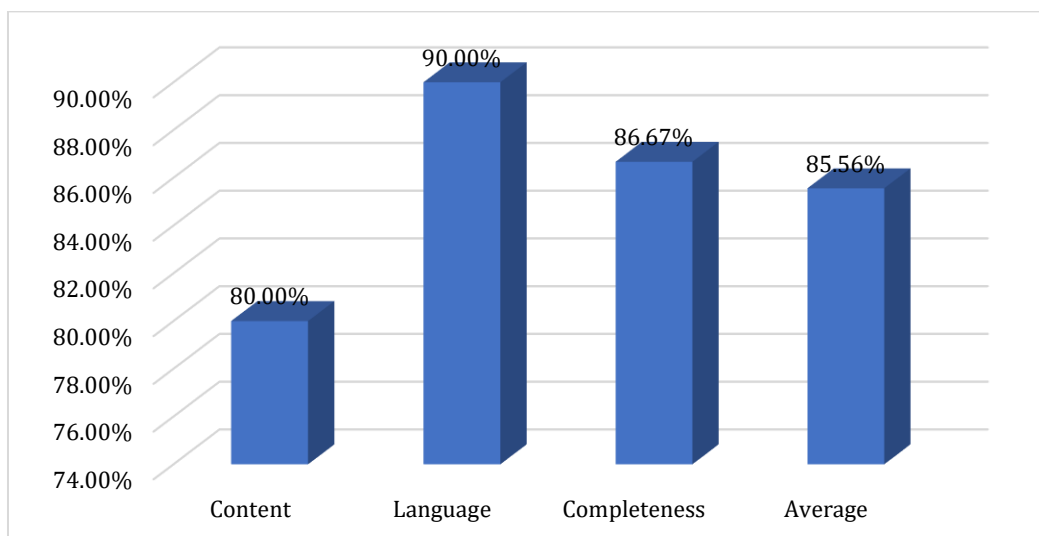


Fig. 5. Student literacy achievement

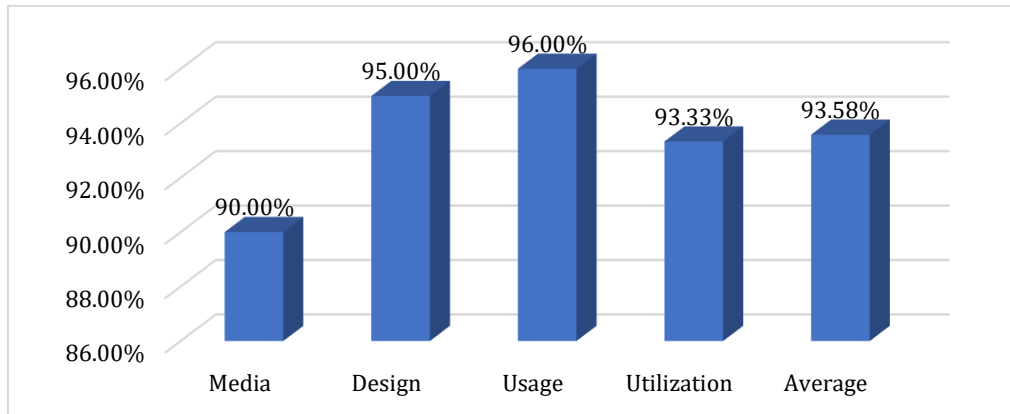


Fig. 4. Validation results by media and design experts

The validation results from material and media experts indicate that the developed product meets the validity criteria. The average assessment from material experts reached 85.56% and from media and design experts 93.58%. The product can be used for learning. Products that have been validated by experts can be used for learning to determine their impact on student performance (Dita et al., 2023).

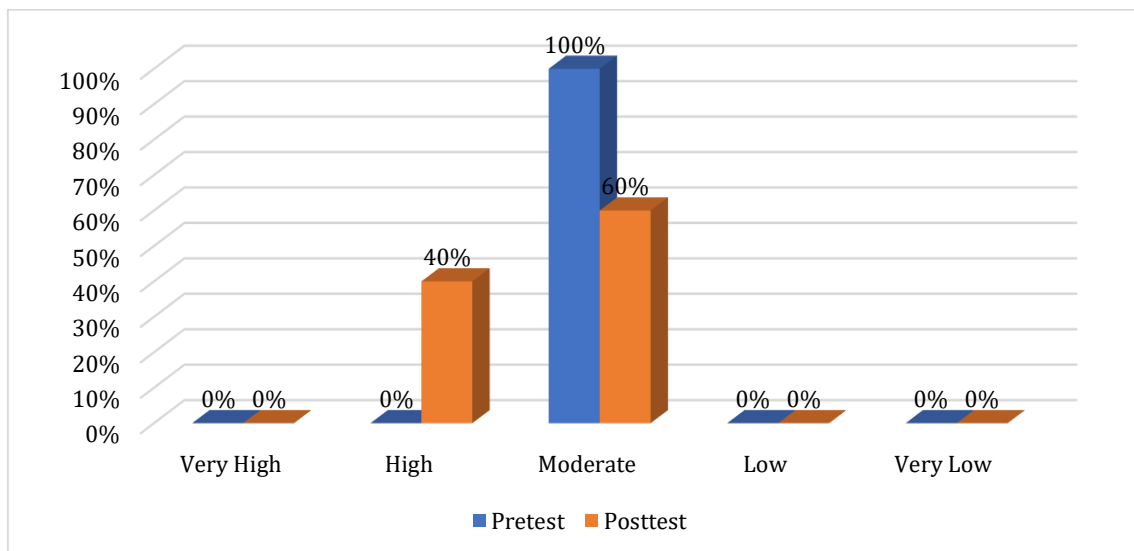


Fig. 5. Student literacy achievement

Based on the pretest and posttest results, it is known that before the implementation of local wisdom-based gamification, all students (100%) were in the moderate category. After the implementation of the learning, there was an increase in literacy skills as indicated by the emergence of 40% of students in the high category, while 60% of students remained in the moderate category. There were no students in the low or very low categories either before or after the treatment. These findings indicate that local wisdom-based gamification has a positive influence on improving student literacy, as indicated by the shift of some students from the moderate category to the high category after the intervention was given.

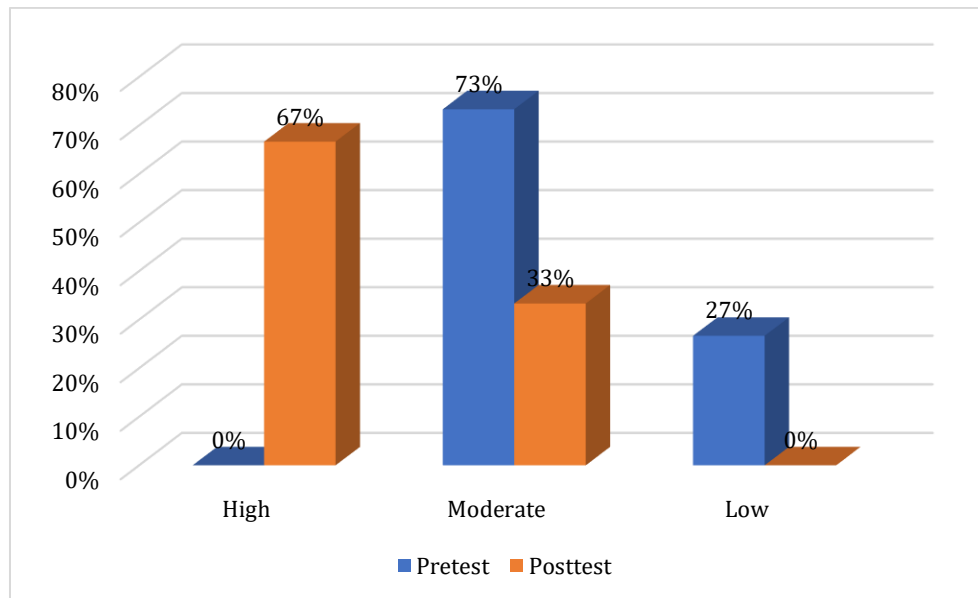


Fig. 6. Capaian kemampuan numerasi siswa

Based on the pretest results, students' numeracy skills were dominated by the moderate category (73%), while 27% of students were in the low category and there were no students in the high category. After the implementation of local wisdom-based gamification, there was an increase in numeracy skills as indicated by an increase in the proportion of students in the high category to 67%, while the moderate category decreased to 33% and the low category to 0%. These results indicate that local wisdom-based gamification was able to positively improve students' numeracy skills, marked by a shift in students from the low and moderate categories to the higher categories.

Table 4. Results of normality tests and paired t-tests for literacy and numeracy data

Variables	Data	Data Normality		Paired t-test		
		Shapiro-Wilk	SD	t	df	Sig.
Literacy	Pretest	0.56	7.099	-6.216	29	0.001
	Posttest	0.138				
Numeracy	Pretest	0.082	4.536	-34.62	29	0.001
	Posttest	0.185				

The results of the Shapiro-Wilk normality test showed that all pretest and posttest data for both literacy and numeracy variables had a significance value greater than 0.05. Therefore, the research data were normally distributed, meeting the assumptions for a parametric test using a paired sample t-test. The results of the paired sample t-test showed that literacy skills obtained a t-value of -6.216 with $p = 0.001$, while numeracy skills obtained a t-value of -34.616 with $p = 0.001$. A significance value less than 0.05 indicates a significant difference between the pretest and posttest results. Therefore, the implementation of local wisdom-based gamification has been proven to have a significant impact on improving students' literacy and numeracy skills.

The findings of this study indicate a significant effect of the implementation of local wisdom-based gamification on improving students' literacy and numeracy skills. This improvement occurred because the gamification model was able to create an interactive and challenging learning environment. Local wisdom-based gamification, namely the *Madendde'* game, is a learning approach that integrates game elements (such as points, levels, challenges, and rewards) with local cultural values in the learning process. Local wisdom-based gamification is a learning approach that integrates game elements (such as goals, rules, competition, and challenges) into technology-based educational media, containing local values, culture, and traditions (Siswoyo et al., 2023). This approach has been proven to increase student motivation, engagement, and literacy skills because the learning material becomes more contextual and relevant to their lives (Nitiasih et al., 2022; Nur'Aida et al., 2024).

The findings of this study indicate that the developed learning approach is not only effective in improving literacy or numeracy separately, but is also capable of developing both skills simultaneously. This indicates that the integration of local wisdom elements in gamification can encourage text comprehension and numerical reasoning skills in an integrated manner, thereby supporting the development of students' competencies more comprehensively. This improvement occurs because the gamification model is able to create an interactive and challenging learning environment. Gamification increases student engagement and participation in both classroom and online environments, with experience points, levels, leaderboards, challenges, and badges as game elements (Ahmad et al., 2026; Faiella & Ricciardi, 2015; Manzano-León et al., 2021). Through the *Madendde'* game, students are encouraged to think critically, collaborate, and understand mathematical concepts through hands-on experience. Learning through the *Madendde'* game allows students to better understand numerical concepts because they learn through physical activities and direct experience. Traditional market games can help students learn numerical skills using the problems presented in the games (Kuryanto et al., 2023). Furthermore, the competitive and collaborative elements in the games also help students hone their logical thinking and problem-solving skills.

In the learning process, students, as players, begin the game by throwing a *gacuk* (a traditional tool consisting of a flat stone or small object) toward numbered squares on a game board that has been designed and printed using banner material, according to the numbers strategically chosen by group members (See Figures 1 and 2.e). The researcher, as facilitator, immediately opens the corresponding question box through the Boombazle digital platform, which has been carefully prepared beforehand, containing mathematical questions. Group members on duty then engage in intensive discussion within a limited time to formulate the correct answer, where a successful correct answer will earn 15 points as a competitive reward. After one individual round is completed, the game rotates to the second, third, and so on groups using identical mechanisms. This process continues continuously and structured until all numbered squares on the *Madendde'* game board have been fully utilized, ensuring each group has a fair opportunity to actively participate. This rotation approach not only increases students' intrinsic motivation but also facilitates the strengthening of conceptual understanding through repetition and collaboration between groups. Through enjoyable learning experiences, students not only gain a conceptual understanding of mathematics but also develop essential literacy and numeracy skills in

everyday life. Gamification-based learning activities and local wisdom, such as traditional games, create an interactive and enjoyable environment (Claritas & Ambarwati, 2024; Kuryanto et al., 2023). The application of local wisdom-based gamification also helps foster regional cultural values, mutual cooperation, and sportsmanship, which are essential components of student character education.

Through the game *Madendde'*, students are encouraged to think critically, collaborate, and understand mathematical concepts through hands-on experience. Learning through the game *Madendde'* enables students to better grasp numerical concepts because they learn through physical activity and hands-on experience. Furthermore, the competitive and collaborative elements in the game also help students hone their logical thinking and problem-solving skills. These findings indicate that learning that integrates local cultural elements in the form of traditional games can create a contextual, collaborative, and meaningful learning environment. Through enjoyable learning experiences, students not only gain a conceptual understanding of mathematical material but also develop literacy and numeracy skills essential for everyday life. The application of gamification based on local wisdom also helps foster regional cultural values, mutual cooperation, and sportsmanship, which are important parts of students' character education.

CONCLUSION

This study concludes that the implementation of local wisdom-based gamification in the form of the *Madendde'* game has been proven to have a significant impact on improving students' literacy and numeracy skills. Local wisdom-based gamification has a positive influence on improving student literacy, which is indicated by a shift in some students from the moderate category to the high category after the intervention was given and positive student numeracy skills, indicated by a shift in students from the low and moderate categories to higher categories. The findings of this study indicate that the developed learning approach is not only effective in improving literacy or numeracy separately, but is able to develop both abilities simultaneously. This indicates that the integration of local wisdom elements in the form of the *Madendde'* game in gamification can encourage text comprehension and numerical reasoning skills in an integrated manner, thereby supporting the development of student competencies more comprehensively.

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