

SUMEREP: A BANYUMASAN CULTURE-BASED ETHNOMATHEMATICS GAME TO ENHANCE JUNIOR HIGH SCHOOL STUDENTS' MATHEMATICAL LITERACY

SUMEREP: PERMAINAN ETNOMATEMATIKA BERBASIS BUDAYA BANYUMASAN UNTUK MENINGKATKAN LITERASI MATEMATIKA SISWA SEKOLAH MENENGAH PERTAMA

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Abstract

Low mathematical literacy among Indonesian students, as reflected in the 2022 PISA results, highlights the need for learning approaches that are more contextual, interactive, and closely connected to students' cultural experiences. Prior research shows that digital educational games can improve mathematics learning, but most target generic learning outcomes rather than mathematical literacy specifically, while existing ethnomathematics-based media rarely incorporate digital game mechanics; no previous study has embedded Banyumasan cultural content into an educational game designed specifically to strengthen mathematical literacy. This study addresses that gap by examining the effectiveness of SUMEREP (Sinau Matematika Bareng IPA), a Banyumasan culture-based educational game that embeds ethnomathematical content — such as the begalan tradition, kenthongan, batik motifs, and local cuisine — directly into its game mechanics and problem contexts. Using a mixed-methods, exploratory-sequential design, the study began with a qualitative exploration through observation and interviews, followed by a quantitative quasi-experiment using a one-group pretest-posttest design. It was conducted with 113 grade VIII students from four junior high schools in Banyumas Regency during the odd semester of 2025/2026, using a mathematical literacy test validated through expert judgment (content validity 95.31–96.09%, “very valid”). A paired-samples t-test showed a significant increase in mathematical literacy scores from pretest ($M = 36.28$, $SD = 12.72$) to posttest ($M = 78.34$, $SD = 6.78$), $t(112) = 34.22$, $p < .001$, $d_z = 3.22$, with an average N-Gain of 0.65 (moderate category; 58% of students in the “effective” category). Qualitative findings indicated that students' engagement and motivation increased when culturally familiar contexts were embedded in the game, and teachers reported that Banyumasan references helped make abstract mathematical concepts more relatable. Because the design did not include a control group, these findings indicate that SUMEREP has the potential to improve students' mathematical literacy rather than establishing definitive causal effectiveness. This study contributes to mathematics education, ethnomathematics, and game-based learning by offering a concrete model for embedding local cultural knowledge into digital game mechanics as a strategy for strengthening mathematical literacy.

Keywords: Ethnomathematics, Educational Game, Mathematical Literacy, Banyumasan Culture.

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Abstrak

Rendahnya literasi matematika siswa Indonesia menurut hasil PISA 2022 menunjukkan perlunya pembelajaran yang lebih kontekstual, interaktif, dan dekat dengan budaya siswa. Penelitian terdahulu menunjukkan bahwa permainan edukasi digital dapat meningkatkan pembelajaran matematika, tetapi umumnya menysasar hasil belajar umum, bukan literasi matematika secara khusus, sementara media etnomatematika yang ada jarang berbentuk permainan digital; belum ada penelitian yang mengintegrasikan budaya Banyumasan ke dalam permainan edukasi untuk memperkuat literasi matematika. Penelitian ini mengisi kesenjangan tersebut dengan menguji efektivitas SUMEREP (Sinau Matematika Bareng IPA), permainan edukasi berbasis budaya Banyumasan yang mengintegrasikan konten etnomatematika, seperti tradisi begalan, kenthongan, motif batik, dan kuliner lokal, ke dalam mekanisme permainan. Menggunakan desain *mixed-methods* eksploratori-sekuensial, penelitian diawali eksplorasi kualitatif melalui observasi dan wawancara, dilanjutkan kuasi-eksperimen *one-group pretest-posttest* terhadap 113 siswa kelas VIII dari empat SMP/MTs di Kabupaten Banyumas semester ganjil 2025/2026, menggunakan tes literasi matematika tervalidasi ahli. Uji-t sampel berpasangan menunjukkan peningkatan signifikan skor literasi matematika dari *pretest* ($M = 36,28$, $SD = 12,72$) ke *posttest* ($M = 78,34$, $SD = 6,78$), $t(112) = 34,22$, $p < 0,001$, $dz = 3,22$, dengan rata-rata *N-Gain* 0,65 (kategori sedang; 58% siswa berkategori efektif). Temuan kualitatif menunjukkan peningkatan keterlibatan dan motivasi siswa ketika konteks budaya diintegrasikan dalam permainan, dan guru melaporkan konsep matematika abstrak menjadi lebih mudah dipahami melalui referensi budaya Banyumasan. Karena tanpa kelompok kontrol, temuan ini menunjukkan potensi, bukan efektivitas kausal definitif, SUMEREP dalam meningkatkan literasi matematika siswa. Penelitian ini berkontribusi bagi pendidikan matematika, etnomatematika, dan pembelajaran berbasis permainan melalui model pengintegrasian budaya lokal ke dalam mekanisme permainan digital.

Kata kunci: Etnomatematika, Permainan Edukasi, Literasi Matematika, Budaya Banyumas.

INTRODUCTION

Realizing the Golden Indonesia 2045 vision requires improving the quality of human resources through education, particularly in mathematics and science, so that Indonesia's future generation can generate knowledge, drive technological innovation, and compete globally. In general, mathematical literacy refers to the ability to understand and apply mathematical concepts in a variety of everyday situations and to use them to solve problem (Wahyuningtyas & Amir, 2025). Mathematical literacy skills help develop citizens who actively participate in solving local and global problems. Unfortunately, the mathematical literacy skills of Indonesian students, as obtained in the 2022 Programme for International Student Assessment (PISA) conducted by the Organisation for Economic Co-operation and Development (OECD, 2023), ranked 11th out of 81 countries, with only 18% of students reaching level 2 or above, significantly lower than the OECD average (69%). Furthermore, it was stated that almost no Indonesian students achieved top achievement (beyond Level 5 or 6) in mathematics, while the OECD average was 9%. The 2024 National Education Report also shows that the average numeracy literacy ability of General Junior High Schools (SMP) is 68.27% in the moderate category, while at the Ministry of Religion's SMP, it is 58.36% in the moderate category (Kemendikdasmen, 2024).

The issue of numerical literacy among students in general junior high schools and Islamic junior high schools (MTs) at the Ministry of Religious Affairs in Banyumas Regency remains quite complex. Despite their relatively good average performance on the Computer-Based National Assessment (ANBK)

and the Indonesian Madrasah Competency Assessment (AKMI) (Kemendikdasmen, 2024), many students still struggle to think critically and apply scientific concepts. Although data show that students' numerical literacy in Banyumas Regency is relatively good, the reality on the ground is not always ideal. There are still significant gaps between schools, especially between urban and suburban areas. Furthermore, students' abilities to think critically, analyze, and solve real-world problems are also not fully developed. This difficulty in problem-solving is often influenced by differences in students' cognitive styles (Mardika & Maulidya, 2023), thus requiring learning approaches and media capable of accommodating these diverse characteristics. Subject matter often feels distant from everyday life because it is not connected to students' local culture and experiences.

One ongoing academic challenge in mathematics education is how to make it truly meaningful for students. Many students learn formulas and concepts mechanically, without feeling the connection between the lessons they receive and the world they experience. This is where the ethnomathematics theory developed by Ubiratan D'Ambrosio provides a new direction: that mathematics is not just a collection of abstract formulas, but is also present in the culture, traditions, and practices of local communities. Through this approach, learning can be more contextual and personal, and can touch on students' identities (D'Ambrosio, 2001).

In addition to presenting contextual material, school learning needs to be adapted to the characteristics of technology-savvy students. Therefore, the use of technology in the learning process needs to be optimized. However, not all technological innovations can be adopted by teachers. The large administrative burden teachers must handle leaves them with little time to develop innovative, interactive technology-based learning media.

To anticipate this, academics in higher education are needed to develop appropriate technology. One product that has been tested for validity and attractiveness is the SUMEREP (Sinan Matematika bareng IPA) application. The SUMEREP application is a development in the form of a learning media that presents Mathematics and Science materials integrated with the Banyumasan culture. The learning process begins by introducing local culture as an entry point, then explores scientific concepts, and invites students to solve real-life problems that are close to home. More than just a learning medium, SUMEREP serves as a bridge between science and life, logic and culture, school and the roots of identity. This form of learning not only encourages literacy but also fosters a sense of ownership and a passion for learning among students.

Banyumas Regency comprises 27 sub-districts and has a rich cultural heritage (BPS, 2022). The culture in Banyumas Regency can serve as a source of learning, especially in mathematics material, namely geometry (Ayu, 2020; Dewi & Kusuma, 2019; Kumala, 2022). Previous research has also proven that the

integration of cultural artifacts, such as traditional building ornaments (Fitriza, 2018), can present geometric concepts in a concrete and more easily understandable form. The cultural approach used in mathematics, or ethnomathematics, can serve as a vehicle for building national character (Wahyuni et al., 2013). In addition, research by Rahayu et al., (2019) concluded that mathematical material is easier to understand when linked to students' cultural contexts. Furthermore, learning mathematics becomes more enjoyable, thus increasing students' interest and mathematical abilities (Fajriyah, 2018).

Beyond Banyumas, the use of local culinary traditions as a vehicle for ethnomathematics has also been documented elsewhere in Indonesia. Meika et al., (2024) identified flat and spatial geometric concepts embedded in Pandeglang's traditional foods, such as white apem, opak, block cake, and pasung cake, and argued that these culturally familiar objects can serve as meaningful entry points for mathematics instruction. This finding reinforces the premise underlying SUMEREP: that everyday cultural artifacts, including local cuisine, carry latent mathematical structure that becomes pedagogically productive when deliberately embedded into learning media.

Through the use of SUMEREP educational games, it is hoped that they can meet the needs of students who are accustomed to rapid use of digital media, thereby influencing how they think, learn, and interact. SUMEREP educational games in the form of Android (.apk) and Windows (.exe) applications can also be used anytime, anywhere. In addition, the development of the SUMEREP application also considers the character of students who are more interested in challenging things, for example, through games. Therefore, the SUMEREP application is designed with three (3) game levels that present challenges to students to learn Mathematics and Science materials.

Educational games are designed to stimulate students' thinking skills, improve concentration, and enhance problem-solving. The benefits of educational games include training in subject matter comprehension, concentration, motor skills, and the concept of cause and effect (Handriyantini, 2009). Additionally, the study of Yunus et al., (2015) has shown that the use of educational games has enhanced learning by increasing students' interest in learning to count. Educational games can help students play and learn.

Research on the use of digital learning media, such as educational games, has been widely conducted. Kustiyarto & Marhaeni (2025) found that Construct 2-based educational game media improved understanding of mathematical concepts and digital literacy. The similarities lie in the use of educational games, while the differences lie in the variables measured and the cultural contexts addressed. Other research by Meliana et al., (2025) shows that digital learning media are effective in increasing numeracy literacy, but that study used a systematic literature review, whereas this study employs an experimental design. Satrio (2020) developed an Android-based educational game, Math

Kingdom, that focuses on power and exponents to improve the quality of mathematics learning. The similarities lie in the media used, but the differences lie in the content, as this research combines mathematical and scientific contexts. Research by Fahira (2023) proves that game-based interactive multimedia effectively improves junior high school students' scientific literacy on the excretory system. The similarity lies in the use of educational games, while the difference lies in the material presented. Meanwhile, Murti & Handayani (2022) developed the "Robot Petualang Nusantara" game, which effectively improves elementary school students' scientific literacy. This connection is made through the use of cultural elements in educational games, but differs in terms of the method and level of students targeted by the research.

Taken together, these five studies point to a consistent pattern that this study addresses. Educational-game studies such as those of Kustiyarto & Marhaeni (Kustiyarto & Marhaeni, 2025) and Satrio (Satrio, 2020) measure generic concept understanding or digital literacy rather than mathematical literacy in the PISA sense. Studies that do target numeracy or mathematical-literacy outcomes, including a recent meta-analysis showing that ethnomathematics-based learning has a strong effect on mathematical literacy (Pratama & Yelken, 2024), rarely employ digital, game-based delivery; ethnomathematics-based materials remain predominantly print or worksheet-based, even in recent interactive-game adaptations (Assegaf & Bonyah, 2024). Studies that do combine games with local-culture content, such as Murti & Handayani (Murti & Handayani, 2022) and Fahira (Fahira, 2023), target elementary-level science or general cultural literacy rather than junior high school mathematical literacy, and none situates that content within Banyumasan culture specifically. This leaves three gaps unaddressed simultaneously: a game-based medium, explicitly targeting mathematical literacy, built around Banyumasan cultural content.

Overall, previous studies show that game-based digital media can be effective for improving mathematics-related outcomes, but none has combined a digital educational game, mathematical literacy as the specific outcome, and Banyumasan cultural content in a single intervention. This study addresses that combined gap by testing the effectiveness of the Banyumasan culture-based SUMEREP educational game on students' mathematical literacy.

What distinguishes SUMEREP from prior work is not the use of culture, games, or mathematics education individually, but the way these three elements are combined. Unlike conventional educational games, which typically present mathematics in a culturally neutral setting, SUMEREP builds its problem contexts directly around Banyumasan cultural references, such as the begalan ceremonial exchange, the kenthongan signal drum, batik motifs, and local culinary traditions, so that cultural content is embedded in the game mechanics rather than added as illustration. Unlike existing ethnomathematics learning

media, which are predominantly static print materials or worksheets, SUMEREP delivers this content through an interactive, level-based Android and Windows game. And unlike previous mathematical-literacy interventions, which have generally been evaluated independently of any specific regional culture, SUMEREP was designed and tested specifically within the Banyumasan cultural context of Banyumas Regency. This combination is the study's central novelty and the basis for its contribution to mathematics education, ethnomathematics, and game-based learning research.

Based on this gap, the study addresses the following research questions:

1. How is the SUMEREP educational game implemented in junior high school mathematics learning in Banyumas Regency?
2. What challenges are encountered in implementing SUMEREP in classroom learning?
3. Does the use of SUMEREP significantly improve students' mathematical literacy?

RESEARCH METHODS

Research Design

This research used a mixed-methods approach with an exploratory sequential design, starting with the collection and analysis of qualitative data, then proceeding to quantitative data to strengthen and explain the initial findings (Akkaya, 2016). Qualitative data were collected through an exploratory case study to examine the implementation process and classroom challenges of SUMEREP, using observation and interviews. Meanwhile, quantitative data were collected through a quasi-experiment using a one-group pretest-posttest design, with no control group. In this design, mathematical literacy skills were measured twice: a pretest and a posttest. The goal was to determine the effect of the SUMEREP educational game on mathematical literacy by comparing pretest and posttest scores. This design can be illustrated as follows (Sugiyono, 2022).

Because this design does not include a control group, it is susceptible to threats to internal validity such as testing effects, maturation, and concurrent classroom instruction; consequently, observed pretest-posttest changes are interpreted as evidence of the potential effectiveness of SUMEREP rather than as proof of a causal effect attributable to the intervention alone. This limitation, and the steps taken to reason carefully about it, are discussed further in the Discussion section.

Pretest	Treatment	Posttest
O ₁	X	O ₂

Figure 1. Research Design

Description:

- O₁ : measurement of mathematical literacy before using the SUMEREP educational game in learning
 O₂ : final measurement of mathematical literacy in the experimental group
 X : treatment in the form of using the SUMEREP educational game

Time and Location of Research

This research was conducted in junior high schools/Islamic junior high schools in Banyumas Regency, namely: 1) SMP N 1 Ajibarang; 2) SMP N 1 Cilongok; 3) MTs N 1 Banyumas; and 4) SMP N 1 Sokaraja, from 19 to 29 August 2025 (odd semester of the 2025/2026 academic year).

Research Target, Subjects, Population, and Sample

Schools were selected through purposive sampling based on regional-equity considerations, so that the four schools represented different sub-districts across Banyumas Regency rather than being clustered in one area. Within each school, one existing grade VIII (phase D) class was selected as the research subject together with the class's Mathematics and Science teachers; because randomly assigning individual students was not feasible within the schools' existing class structure, this class-level selection functioned as intact-group (convenience) sampling, a common approach in classroom-based quasi-experiments. A total of 132 students were enrolled across the four classes (SMP N 1 Ajibarang, class VIII E, $n = 32$; SMP N 1 Cilongok, class VIII D, $n = 32$; MTs N 1 Banyumas, class VIII B, $n = 36$; SMP N 1 Sokaraja, class VIII E, $n = 32$). Only students who were present for the full sequence of learning sessions, the pretest, and the posttest were included in the quantitative analysis, yielding a final analytic sample of 113 students (25, 26, 31, and 31 from the four schools, respectively).

Research Procedures

Learning with SUMEREP was implemented across three sessions per class, each divided into three phases: orientation and introduction to the game, gameplay and exploration, and a discussion/reflection session linking the in-game experience back to the mathematics content being taught. Teachers acted as both technical facilitators, guiding students in accessing and operating the game, and pedagogical facilitators, connecting gameplay to lesson objectives through apperception at the start of each session and structured worksheets or brief quizzes at the end. SUMEREP itself is delivered as an Android (.apk) and Windows (.exe) application containing three game levels that embed Mathematics and Science content within Banyumasan cultural narratives and imagery.

Data, Instruments, and Data Collection Techniques

The data collection techniques in this study included both qualitative and quantitative methods. The qualitative data consisted of semi-structured interviews with students and teachers of Mathematics and Science subjects, as well as observations and documentation of learning using the SUMEREP educational game. Meanwhile, the quantitative data were collected using written test instruments, in the form of pretests and posttests, to measure students' mathematical literacy.

The instrument validity test consisted of qualitative and quantitative data. Qualitative data validity was maintained through triangulation of methods and sources (teachers, students, and documentation), and member checking was conducted to confirm the interpretation of interview results. Meanwhile, instrument validity was established through content validation, obtained through expert judgment, in accordance with the intended measurement objectives (Bikner-Ahsbabs, 2019). The validity test process involved two experts (validators) in the field of mathematics by providing an assessment of 25 mathematical literacy test questions based on four main aspects, namely: 1) the material aspect, including the suitability of the question content with basic competencies, real-life contexts, and the level of student development; 2) the construction aspect related to the clarity of the formulation, suitability with the rules for writing question items, and the effectiveness of the answer choices; 3) the language aspect, which assesses the readability and clarity of the language used in the questions so as not to give rise to multiple interpretations; and 4) the appearance or practicality aspect, which assesses the neatness of the layout, consistency of writing, and clarity of the instructions for working on the questions.

Each question item is assessed using a four-level scale: 1 = poor, 2 = less good, 3 = good, and 4 = very good. The assessment results from each validator are then calculated using the following formula:

$$\text{Validity percentage} = (\text{Score obtained} / \text{Maximum Score}) \times 100\%$$

Furthermore, the validity categories are as follows:

Table 1. Validity Category	
Percentage	Category
$85\% \leq \text{Validity Percentage} \leq 100\%$	Very Valid
$70\% \leq \text{Validity Percentage} < 85\%$	Valid
$55\% \leq \text{Validity Percentage} < 70\%$	Fairly Valid
$\text{Validity Percentage} < 55\%$	Not Valid

The assessment results of the mathematical literacy pretest instrument, comprising 16 assessment indicators across four aspects (material, construction, language, and appearance or practicality), showed that the first validator had an average validity percentage of 98.44%, while the

second validator had 93.75%, with an overall average of 96.09%, which falls within the "Very Valid" category. All aspects received a very valid category, indicating that the test items are in accordance with basic competencies, meet the rules of question writing, use clear language, and present a practical, easy-to-understand display. Thus, the pretest instrument is deemed suitable for use, with only minor revisions required based on the validator's suggestions.

The posttest instrument assessment showed similar results, with an average validity percentage of 98.44% from the first validator and 92.19% from the second validator, resulting in an overall average of 95.31% and a very valid category. Almost all indicators in the four aspects were categorized as very valid, except for one indicator in the construction aspect, which was categorized as valid and required minor revision. In general, the posttest instrument met the eligibility criteria for content, construction, language, and presentation. Therefore, the posttest instrument was declared very valid and suitable for use as a measure of mathematical literacy in this study.

It should be noted that the validity established for both instruments in this study is content validity based on expert judgment; reliability analysis (e.g., Cronbach's alpha) and item-level psychometric analyses (item difficulty and item discrimination) were not conducted. This is acknowledged as a methodological limitation of the present study; we recommend that future use of this instrument include a pilot administration to compute internal-consistency reliability and item statistics before large-scale deployment (see Limitations in the Conclusion).

Data Analysis Techniques

The data analysis techniques used were N-Gain, qualitative data, and quantitative data. N-Gain is the ratio of the gain score obtained to the maximum possible gain score. The N-Gain formula and its categories are as follows (Kesumawati, 2018).

$$N - Gain = \frac{Posttest\ score - Pretest\ score}{Ideal\ score - Pretest\ score}$$

Table 2. N-Gain Categories

Normalized N-Gain Value	Interpretation
$-1,00 \leq N - Gain < 0,00$	Decreased
$N - Gain = 0,00$	No Decreased
$0,00 < N - Gain \leq 0,30$	Low
$0,30 < N - Gain \leq 0,70$	Medium
$0,70 < N - Gain \leq 1,00$	High

Next, to determine the effectiveness of educational game learning media, the N-Gain score obtained in the previous test was used. The effectiveness of N-Gain can be determined by interpreting

the results of the N-Gain score. According to Hake, the percentage score can be interpreted as follows (Suliarso et al., 2021).

Table 3. Interpretation of the Effectiveness of N-Gain Percentage	
N-Gain Percentage (%)	Interpretation
$N - \text{Gain Percentage} < 40$	Not Effective
$40 \leq N - \text{Gain Percentage} \leq 55$	Less Effective
$56 \leq N - \text{Gain Percentage} \leq 75$	Quite Effective
$N - \text{Gain Percentage} > 75$	Effective

Observation and interview data were analyzed using the Miles and Huberman model, which includes three stages: data reduction, data presentation, and drawing conclusions/verification (Creswell & Poth, 2018). Data validity was maintained through source and technical triangulation, as well as confirmation from key informants. The results of this qualitative analysis aim to provide a deeper understanding of the implementation process and the issues that emerged during learning with SUMEREP.

A normality test is performed as a prerequisite analysis to verify whether the pretest-posttest difference scores are normally distributed. This test is crucial for determining the type of hypothesis analysis to be performed, whether parametric or non-parametric (Ghasemi & Zahediasl, 2012). Both the Kolmogorov-Smirnov (with Lilliefors correction) and Shapiro-Wilk tests were computed in SPSS version 22; because Shapiro-Wilk is generally more appropriate for the present sample size, it was used for interpretation. The normality test hypothesis is as follows:

H_0 : normally distributed data

H_1 : data is not normally distributed

Data are normally distributed if the p-value is ≥ 0.05 .

The Paired t-Test is used to compare two averages derived from measurements of the same variable at different times, namely pretest and posttest (Field, 2018). H_0 : There is no significant difference between the pretest and posttest scores of students' mathematical literacy. H_a : There is a significant difference between the pretest and posttest scores of students' mathematical literacy. If the significance value is < 0.05 , then H_0 is rejected, indicating a significant difference between the pretest and posttest scores after using the SUMEREP educational game.

RESEARCH RESULTS AND DISCUSSION

The implementation of the SUMEREP educational game in the mathematics and science learning process at the junior high school level in Banyumas Regency proceeded through several stages, as follows:

Planning Stage

The planning stage begins with scheduling and coordinating with the curriculum team to align the activity schedule with the academic calendar, ensuring that the game's implementation does not conflict with other school activities and allowing students to learn optimally. This aligns with the principles of context-based learning planning, as explained by (Plomp & Nieveen, 2007), where teacher readiness, time adjustment, and integration with the curriculum are key to the successful implementation of educational products. This coordination also reflects collaborative practices between stakeholders, which can increase the effectiveness and relevance of learning media in the classroom (Vlcek & Somerton, 2024). The time allocation for implementing the SUMEREP game is divided into three stages: orientation and introduction to the game, play and exploration activities, and discussion and reflection sessions. These stages are designed to ensure that students understand the learning objectives, actively engage in the exploration process, and then reflect on their experiences through discussions.

The second preparation is infrastructure. Infrastructure is a crucial aspect before implementing the SUMEREP educational game. At SMP N 1 Cilongok and SMP N 1 Ajibarang, computer labs provide students with easy access to devices, in line with the principle of practicality (Plomp & Nieveen, 2007) about the role of structured learning spaces in increasing motivation. Teachers also prepared equipment such as laptops, projectors, and internet access, and conducted trials to avoid technical difficulties. This step aligns with the validation stage (Plomp & Nieveen, 2007) and is supported by Suryani et al., (2019), who emphasize the importance of infrastructure readiness for the effectiveness of digital media. In schools that permit the use of mobile phones, such as SMP N 1 Sokaraja and MTs N 1 Banyumas, teachers adapt their instruction so students can use their personal devices. This approach is consistent with constructivism (Bruner, 1996), which holds that the use of personal devices increases motivation, flexibility, and learning engagement.

The third stage of preparation is the development of teaching modules, where teachers create lesson plans (RPP) that integrate the SUMEREP game as a learning medium. The module contains learning objectives, activity flow, and cognitive assessment instruments, and is structured based on Nieveen's principles of validity, practicality, and effectiveness. The module also includes stages of game use, time management, and reflection activities to link playing experiences to the concepts being learned. This approach aligns with Bruner's constructivism, which emphasizes active and reflective learning, and is supported by research showing that interactive media can improve concept mastery and critical thinking skills.

Implementation Stage

The implementation of SUMEREP educational game media in Mathematics and Science learning at junior high schools in Banyumas Regency is an innovative effort to provide a more interactive, contextual learning process that aligns with the demands of the Merdeka Curriculum. The research findings, based on interviews and observations, are as follows. Thus, the implementation of SUMEREP not only meets curriculum standards but also adapts learning strategies to the characteristics of each school and students' needs.

Table 4. Method of Implementation

School	Method of Implementation
SMP N 1 Sokaraja and SMP N 1 Ajibarang	Games are used in integrated learning of Mathematics and Science in regular classes, so that students practice understanding cross-disciplinary concepts simultaneously
MTs N 1 Banyumas	Games are used in special science classes as material enrichment, so their role is more in deepening concepts
SMP N 1 Cilongok	The use of games in school literacy programs as co-curricular activities emphasizes the creative strengthening of numeracy literacy

The learning process begins with an apperception related to the Mathematics or Science material, and the teacher introduces the SUMEREP game as the media to be used. The teacher explains the learning objectives and rules of the game before students begin playing. As one teacher said, *"I start by explaining what SUMEREP is, then I connect it to the material to be learned so that the children know that this is not just a game"* (Interview, Mrs. Lulu, MTs N 1 Banyumas). This statement shows that the teacher positions SUMEREP as a central part of the learning process rather than just an additional activity.

Student Engagement and Initial Response

Students' initial response to SUMEREP was very positive. They demonstrated enthusiasm, high curiosity, and increased motivation to learn when the game was introduced. Teachers observed that students were more engaged compared to conventional learning. As one teacher stated, *"The children were immediately curious, many asked how to play. They seemed more enthusiastic than usual"* (Interview, Mrs. Dyah, MTs N 1 Banyumas). This indicates that SUMEREP effectively captured students' attention and increased student engagement from the beginning of the lesson.

Learning Motivation

Beyond the initial spike in curiosity, teachers also reported a sustained shift in motivation across sessions. Students who typically grew bored quickly during mathematics lessons stayed focused for longer when SUMEREP was used, and several teachers noted that students asked to continue playing after time

was up. As one teacher explained, *"Usually when learning mathematics the children get bored quickly, but when we used SUMEREP they were enthusiastic and did not notice the time passing"* (Interview, Mrs. Ari, SMP N 1 Ajibarang). This pattern suggests that SUMEREP's effect on motivation was not limited to a novelty response on first use, but persisted as students became more familiar with the game.

Collaborative Learning Experience

The majority of teachers use SUMEREP in groups due to limited equipment and to encourage student discussion. As one teacher stated, *"I ask the children to play in groups so they can discuss. Individual play is a bit difficult because of the limited equipment"* (Interview, Mrs. Cici, SMP N 1 Ajibarang). Some teachers also combine group work and individual sessions to allow students to continue exploring their individual understanding. At MTs N 1 Banyumas, collaborative activities are conducted through Team Game Tournaments, with rewards given to the team with the highest score. This approach is based on the principles of blended learning that balances personal and collaborative activities.

Teachers provided step-by-step technical guidance so students could access and play SUMEREP correctly. Some teachers projected tutorials, while others guided each group directly. Instructions included how to open the application, run the game, and connect it to the lesson material. As one teacher explained, *"I first showed the steps using the projector, then the students tried it themselves. If anyone had difficulty, I assisted them"* (Interview, Mr. Hanif, SMP N 1 Sokaraja). This demonstrates that teachers not only act as technical facilitators but also as guides, ensuring that play activities remain aligned with learning objectives.

Cultural Relevance

The integration of Banyumasan culture is one of SUMEREP's strengths. Teachers explain that local cultural elements emerge through the language, illustrations, and context of the questions, allowing students to feel more connected to the material because it is relevant to their lives. As one teacher put it, *"This game is unique because it contains Banyumas culture, so the children feel connected. They learn about culture while also learning science and mathematics"* (Interview, Mrs. Listia, SMP N 1 Cilongok). This integration aligns with the principles of local wisdom-based education, which encourage strengthening cultural identity and the understanding of academic concepts.

Overall, the interview results indicate that the SUMEREP implementation was structured: it began with apperception, students responded enthusiastically, learning was generally conducted in groups, teachers provided clear technical guidance, and Banyumasan culture was successfully presented as a learning context. These findings confirm that SUMEREP not only increased student engagement but also enriched learning by reinforcing relevant and meaningful local values.

Evaluation Stage

Overall, the evaluation was conducted through observation of engagement, monitoring of changes in motivation, assessing understanding through worksheets or discussions, and post-learning tests. The results showed that SUMEREP not only increased student enthusiasm but also strengthened conceptual understanding in a more meaningful way.

Although the implementation of the SUMEREP educational game had a positive impact on student engagement and motivation, teachers also encountered several recurring challenges, which can be grouped into five themes: infrastructure, teacher readiness, variation in student response, learning time, and cultural unfamiliarity.

Learning Challenges

Infrastructure and facilities. Teachers in several schools reported that limited devices were a major obstacle: not all students had access to a supporting device, and the number of school laptops and computer-laboratory workstations was also limited, so students often had to access SUMEREP in turns or in groups, which reduced the amount of time each student could spend interacting with the game directly.

Teacher readiness. Not all teachers were equally accustomed to using interactive digital media such as SUMEREP, which slowed the integration of the game into lesson plans. Several teachers reported needing additional time to learn the game's flow and connect it to their existing teaching materials, which in turn affected their confidence in using the technology in class.

Variation in student response. While most students showed high enthusiasm, some became absorbed in the entertainment aspect of the game and lost focus on the learning objectives, occasionally forgetting to record their work or complete the accompanying worksheet. This required teachers to give clearer upfront instructions and to insert reflection sessions after gameplay so that the entertainment and learning functions of SUMEREP remained balanced.

Learning time. The stages of implementation, orientation, gameplay, and discussion/reflection, required more time than a single lesson period typically allowed, so reflection or discussion segments were sometimes cut short before students had fully processed what they had learned. Teachers suggested strategies such as flipped-classroom scheduling or extending the activity into extracurricular time to address this constraint.

Cultural unfamiliarity. Some students were not familiar with the Banyumasan cultural terms, symbols, or narratives embedded in the game (for example, references to begalan or specific local culinary traditions), which could lead to confusion unless teachers provided additional explanation. When teachers did explain the cultural context, students were able to connect the academic content with the cultural meaning behind it, rather than treating the cultural elements as mere decoration.

The SUMEREP educational game was used to improve students' mathematical literacy in four schools: SMP N 1 Ajibarang, SMP N 1 Cilongok, MTs N 1 Banyumas, and SMP N 1 Sokaraja. Descriptive statistics for the mathematical literacy pretest and posttest scores in the experimental class ($N = 113$) are presented in Table 5.

Table 5. Descriptive Statistics of Mathematical Literacy Pretest and Posttest Scores ($N = 113$)

Statistic	Pretest	Posttest
N	113	113
Highest Score	60	96
Lowest Score	4	60
Mean	36.28	78.34
Standard Deviation	12.72	6.78

Table 5 shows that mathematical literacy scores in the experimental class rose substantially after the SUMEREP intervention: the average score increased from 36.28 ($SD = 12.72$) at pretest to 78.34 ($SD = 6.78$) at posttest, and the highest individual score rose from 60 to 96. Learning in the experimental class was conducted across three sessions using the SUMEREP educational game between the pretest and posttest administrations.

Before conducting the paired-samples t-test, a normality test was applied to the difference between the posttest and pretest scores, using the Shapiro-Wilk test in SPSS version 22 (data are considered normally distributed if the significance value is $> .05$). The Shapiro-Wilk statistic for the pretest-posttest difference was .978 ($df = 113$, $p = .061$), which exceeds the .05 threshold, so H_0 is accepted: the difference between the posttest and pretest scores for mathematical literacy is normally distributed. Because this result indicated normality, the parametric assumption was met, and the paired-samples t-test was carried out to determine whether the difference between the pretest and posttest scores was statistically significant.

Table 6. Paired-Samples t-Test Results for Mathematical Literacy Pretest and Posttest Scores

N	Mean Difference	SD	t	df	Sig. (2-tailed)
113	42.05	13.06	34.22	112	0.000

The paired-samples t-test showed a significant difference between the pretest and posttest scores of students, with an average pretest score of 36.28 increasing to 78.34 in the posttest, a mean difference of 42.05 ($SD = 13.06$), $t(112) = 34.22$, $p < .001$. The corresponding effect size, Cohen's $d_z = 42.05 / 13.06 = 3.22$, is very large by conventional benchmarks, indicating that the increase in mathematical literacy

scores after using the SUMEREP educational game was not only statistically significant but also substantively large.

From an ethnomathematics perspective, this improvement can be explained by how SUMEREP embeds mathematical concepts in cultural forms that are already meaningful to students. D'Ambrosio (D'Ambrosio, 2001) describes ethnomathematics as a bridge between formal mathematics and the mathematical practices embedded in a community's culture; in SUMEREP, this bridge takes a concrete form, as problem contexts are built around Banyumasan cultural references such as the begalan ceremonial exchange, the kenthongan signal drum, batik motifs, and local culinary traditions. Framing abstract mathematical operations within these familiar cultural narratives appears to have reduced the cognitive distance between the mathematics being taught and students' everyday experience, made abstract representations more concrete, and increased students' willingness to engage with problems they might otherwise perceive as difficult or irrelevant. The game elements, level-based progression, immediate feedback, and, in some classrooms, team-based competition, add a further motivational layer on top of this cultural relevance, consistent with accounts of why digital, game-based learning increases engagement in mathematics classrooms (Hussein et al., 2022).

These quantitative gains are consistent with, and help explain, the qualitative findings reported earlier. Teachers' observations that students were more enthusiastic, asked more questions, and needed less prompting to stay on task align with the magnitude of the pretest-to-posttest increase, suggesting that the motivational shift observed in the classroom translated into measurable gains in test performance rather than remaining a superficial change in mood. Likewise, the moderate rather than uniformly high N-Gain reported below is consistent with the qualitative finding that a minority of students struggled to move past the entertainment aspect of the game or were unfamiliar with its cultural references; for these students, the game's cultural and ludic elements may not, on their own, have been sufficient to produce the same literacy gains observed for their peers.

To determine the improvement in students' mathematical literacy after using the SUMEREP educational game, an N-Gain test was conducted using the pretest and posttest scores from four sample classes in four schools. The effectiveness of the educational game learning media was also determined by interpreting the N-Gain results.

Table 7. Descriptive Statistics of N-Gain Scores for Mathematical Literacy

Number of Students	113
Highest Score	0.92
Lowest Score	0.30
Mean	0.65
Standard Deviation	0.12

Table 7 shows the N-Gain score for mathematical literacy in the experimental class with 113 students. The highest N-Gain score was 0.92, the lowest was 0.30, and the average N-Gain score was 0.65 (SD = 0.12), which falls in the “moderate” criterion.

Furthermore, the N-Gain results were interpreted using two complementary criteria. Based on the average N-Gain score of 0.65, the increase in mathematical literacy falls in the "moderate" gain category (Kesumawati, 2018). Expressed as an effectiveness percentage, an average N-Gain of 65% falls within the "effective" range of the interpretation criteria in Table 3 (Suliarso et al., 2021). At the individual level, students were distributed across the four effectiveness categories as shown in Table 7 and Figure 3 below. Taken together, these results indicate that the use of the SUMEREP educational game was effective in improving students' mathematical literacy through the Banyumasan culture.

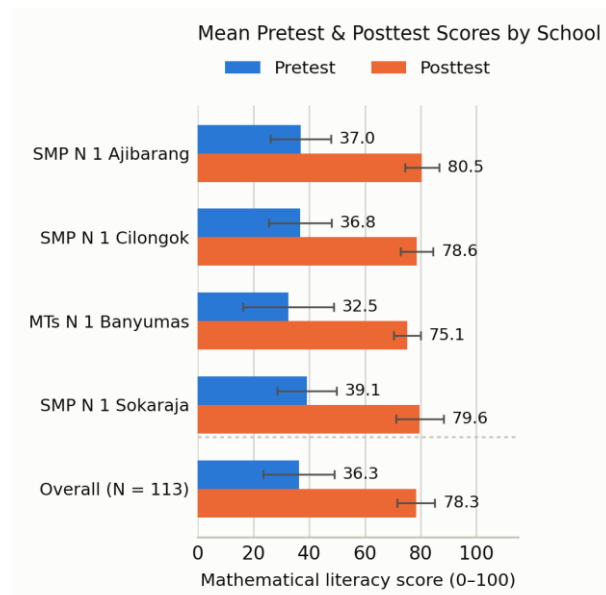


Figure 2. Mean Pretest and Posttest Mathematical Literacy Scores by School (Error Bars = SD)

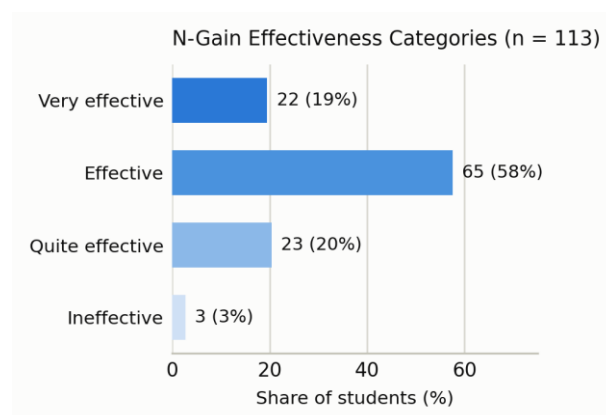


Figure 3. Distribution of N-Gain Effectiveness Categories (N = 113 students)

As shown in Figure 2, the increase from pretest to posttest was consistent across all four schools, with posttest means ranging narrowly from 75.10 (MTs N 1 Banyumas) to 80.48 (SMP N 1 Ajibarang),

suggesting that SUMEREP's effect was not driven by a single school. Figure 3 shows the distribution of individual N-Gain effectiveness categories: 87 of 113 students (77%) reached the “effective” or “very effective” category, 23 students (20%) were in the “quite effective” category, and only 3 students (3%) showed an “ineffective” gain, indicating that the intervention benefited most students consistently while leaving room to better support a small minority.

These results should nonetheless be interpreted with appropriate caution. Because this study used a one-group pretest-posttest design without a control group, the observed improvement cannot be attributed to SUMEREP alone with full certainty: testing effects (students becoming more familiar with the item format on the second administration), maturation over the roughly two-week implementation window, and concurrent classroom instruction may all have contributed to part of the observed gain. The very large effect size and the consistency between the quantitative and qualitative findings make a substantive effect of SUMEREP plausible, but a randomized or matched-control design would be needed to isolate its causal contribution from these competing explanations. We therefore treat the present findings as evidence that SUMEREP has the potential to improve students' mathematical literacy, rather than as definitive proof of a causal effect.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study set out to address a gap in the literature: although digital educational games and ethnomathematics-based learning have each been studied extensively, no prior research had combined them within a single, digitally delivered game embedding Banyumasan cultural content to strengthen junior high school students' mathematical literacy specifically. The findings indicate that SUMEREP has the potential to improve students' mathematical literacy: pretest-to-posttest scores increased significantly, $t(112) = 34.22$, $p < .001$, $d_z = 3.22$, with a moderate average N-Gain of 0.65, and 77% of students falling in the “effective” or “very effective” categories. Because the study used a one-group design without a control group, this finding should be read as evidence of potential rather than a definitive causal claim; nonetheless, the convergence between the quantitative gains and the qualitative evidence of increased engagement, motivation, and perceived cultural relevance strengthens confidence that the observed change reflects a substantive effect of the intervention rather than an artifact of testing or maturation alone.

Theoretically, this study contributes to mathematics education, ethnomathematics, and game-based learning by demonstrating a concrete model for embedding local cultural knowledge, specifically Banyumasan traditions such as begalan, kenthongan, batik motifs, and local cuisine, directly into the

mechanics and problem contexts of a digital educational game, rather than treating culture as an illustrative add-on to an otherwise generic game. This extends D'Ambrosio's (D'Ambrosio, 2001) conception of ethnomathematics as a bridge between formal mathematics and community practice into the domain of digital, game-based delivery, and offers game-based learning researchers a working example of how cultural specificity, rather than generic gamification, can be a source of both engagement and learning gains.

On the implementation side, SUMEREP was used successfully across all four participating schools, though in different configurations, regular classroom instruction, enrichment, and co-curricular literacy programs, reflecting each school's needs and infrastructure. Teachers and students generally responded positively, but implementation also surfaced five recurring challenges: limited devices and computer-laboratory capacity, uneven teacher readiness to integrate digital game-based media, a subset of students who prioritized the game's entertainment value over its learning objectives, insufficient class time for the full orientation-play-reflection cycle, and unfamiliarity with some of the Banyumasan cultural references among students from outside the immediate cultural context.

Recommendations

Based on these findings, we recommend that: (1) schools with limited devices adopt SUMEREP's offline (.apk/.exe) versions and group-based play to reduce dependence on network access; (2) teacher-training institutions and school administrators provide structured training and peer mentoring for teachers before introducing SUMEREP, focused specifically on linking game mechanics to lesson objectives; (3) teachers precede gameplay with clear instructions and follow it with a structured worksheet or reflection session to keep students focused on the intended learning outcomes; (4) schools experiment with flipped-classroom scheduling, moving orientation content outside class time, to free up in-class time for gameplay and discussion; and (5) future versions of SUMEREP include a brief, teacher-led cultural-context segment before or after gameplay so that Banyumasan references are explained rather than assumed.

This study has several limitations. It used a one-group pretest-posttest design without a control group, expert judgment (content validity) rather than empirical reliability analysis (e.g., Cronbach's alpha) to establish instrument quality, and a relatively short implementation window (three sessions per class) within a single semester in one regency. Future research should therefore (a) replicate this study using a randomized or matched-control design to isolate SUMEREP's causal contribution from testing and maturation effects; (b) pilot the instrument with a separate sample to compute internal-consistency reliability and item-level statistics; (c) extend SUMEREP to other mathematical topics, grade levels, and cultural contexts beyond Banyumas to test the generalizability of a culturally embedded, game-based

approach; and (d) examine the long-term retention of both mathematical literacy gains and cultural engagement beyond the immediate post-intervention measurement.

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