AKSIOMA: Jurnal Program Studi Pendidikan Matematika
Volume 14, No. 4, 2025, 1398–1412

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

DEVELOPMENT OF AN RME-BASED GAME WITH LOCAL WISDOM CONTENT AND DEEP LEARNING STRATEGIES FOR MATHEMATICS LEARNING

Rahmi Hayati[1*], Edi Syahputra[2], Edy Surya[3], Nuraina[4], Rohantizani[5]

[1] Universitas Almuslim, Bireuen, Indonesia
[2,3] Universitas Negeri Medan, Medan, Indonesia
[4,5]Universitas Malikussaleh, Aceh Utara, Indonesia
*Corresponding author.

E-mail: hayatirahmi027@gmail.com [1*)]
edisyahputra01.es@gmail [2)]
edysurya@unimed.ac.id [3)]
rohantizani@unimal.ac.id [4)]
nuraina@unimal.ac.id [5)]

Received 03 October 2025; Received in revised form 30 November 2025; Accepted 17 December 2025

Abstract

The main problem in elementary school mathematics learning is the low student motivation and learning outcomes caused by conventional approaches that tend to be abstract and lack connections to real-life contexts. This study aims to develop an educational game based on Realistic Mathematics Education (RME) with the integration of Acehnese local wisdom to improve students' motivation and learning outcomes. The research employed a modified Research and Development (R&D) model of Borg & Gall, which consisted of needs analysis, design, expert validation, limited trial, revision, main field trial, and final revision. The research subjects included 30 fifth-grade students in the limited trial stage and 90 students from three different elementary schools in the main field trial, using a quasi-experimental design with a pretest-posttest control group. The instruments used were student response questionnaires, expert validation sheets, and achievement tests. Expert validation results indicated that the product was in the "highly valid" category. The limited trial showed that 90% of students considered the game easy to use and 85% felt more motivated, with learning achievement increasing from an average pretest score of 62 to 78 in the posttest; a paired-sample t-test yielded $t(29) = 5.84$, $p < 0.001$. The main field trial demonstrated a significant improvement, where the experimental class increased from an average score of 61 to 84, while the control class only increased from 63 to 72; the ANOVA results showed $F(1,88) = 12.35$, $p < 0.01$ with an effect size of 0.82 (large category). It is concluded that the RME-based educational game with Acehnese local wisdom is effective in enhancing students' motivation and learning outcomes, and it has the potential to be further developed by adding adaptive and interactive features to strengthen student engagement.

Keywords: Deep Learning; Game; Local Wisdom; RME

Abstrak

Permasalahan utama dalam pembelajaran matematika di sekolah dasar adalah rendahnya motivasi dan hasil belajar siswa akibat pendekatan konvensional yang cenderung abstrak serta minim keterkaitan dengan konteks nyata kehidupan sehari-hari. Penelitian ini bertujuan mengembangkan game edukatif berbasis Realistic Mathematics Education (RME) dengan integrasi kearifan lokal Aceh untuk meningkatkan motivasi dan hasil belajar siswa. Metode penelitian menggunakan Research and Development (R&D) model Borg & Gall yang dimodifikasi, melalui tahapan analisis kebutuhan, perancangan, validasi ahli, uji coba terbatas, revisi, uji coba lapangan utama, hingga revisi akhir. Subjek penelitian melibatkan 30 siswa kelas V SD pada tahap uji terbatas dan 90 siswa dari tiga sekolah dasar berbeda pada tahap uji lapangan dengan desain quasi-experiment menggunakan pretest-posttest control group design. Instrumen yang digunakan meliputi angket respon siswa, lembar validasi ahli, serta tes hasil belajar. Hasil validasi ahli menyatakan produk berada pada kategori sangat valid. Uji terbatas menunjukkan 90% siswa menilai game mudah digunakan dan 85% merasa lebih termotivasi,

AKSIOMA: Jurnal Program Studi Pendidikan Matematika
Volume 14, No. 4, 2025, 1398–1412

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

dengan peningkatan hasil belajar dari skor rata-rata pretest 62 menjadi 78 pada posttest; analisis uji t berpasangan menghasilkan t(29)=5,84, p<0,001. Uji lapangan menunjukkan peningkatan signifikan, di mana kelas eksperimen meningkat dari skor rata-rata 61 menjadi 84, sedangkan kelas kontrol hanya meningkat dari 63 menjadi 72; hasil ANOVA F(1,88)=12,35, p<0,01 dengan effect size 0,82 (kategori besar). Disimpulkan bahwa game edukatif berbasis RME dengan kearifan lokal Aceh efektif meningkatkan motivasi dan hasil belajar siswa, serta berpotensi dikembangkan lebih lanjut dengan penambahan fitur adaptif dan interaktif untuk memperkuat keterlibatan siswa.

***Kata kunci**: Deep Learning; Game; Kearifan Lokal; RME*

PENDAHULUAN

Mathematics is a subject often considered abstract by most students. Its emphasis on symbols, formulas, and procedures often makes it difficult for students to grasp the meaning behind them (Rahmadi et al., 2024). In fact, mathematics is closely related to everyday life. Many phenomena, activities, and even local cultures are imbued with mathematical concepts (Saputra et al., 2022). However, in reality, mathematics learning in the classroom is often disconnected from the real-life context of students' lives. This results in low learning motivation and a lack of in-depth conceptual understanding (Tong et al., 2022).

One rapidly developing approach to addressing this problem is Realistic Mathematics Education (RME). RME emphasizes the connection of mathematical concepts to real-world situations so that students can build understanding through contextual experiences (Rezeki et al., 2021). This approach allows students to start from real problems, then carry out horizontal and vertical mathematization processes (developing representations into formal concepts. RME has been proven to have a positive impact on increasing understanding, critical thinking, and interest in learning mathematics (Gravemeijer & Doorman, 2018).

On the other hand, Indonesia boasts an extraordinary wealth of local wisdom. Traditional games, folktales, batik motifs, and even everyday economic activities can provide meaningful contexts for mathematics learning (Dianlestari & Kusno, 2024). Several studies have shown that integrating local culture can increase students' sense of connection with the material and foster an appreciation for their cultural identity (Nabila et al., 2022; Muzakkir, 2021). Unfortunately, the use of local wisdom in mathematics learning is still limited to printed media or conventional learning, and has not been processed into interactive digital media.

The development of digital technology, especially artificial intelligence and deep learning, opens up new opportunities for learning innovation. In the last decade, deep learning algorithms have proven effective in personalizing learning systems, as they are able to analyze student behavior data in real time and adapt content to individual needs (Naseer et al., 2024). This is relevant to current educational trends that emphasize adaptive learning, tailored to each student's abilities, interests, and learning style.

Combined, the development of an RME-based educational math game that utilizes local wisdom as context and utilizes deep learning strategies for

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

learning adaptation has the potential to become a new innovation. However, a literature review indicates that this combination is still rare.

Several studies in the past ten years have touched on elements related to this topic, although they have not been fully integrated. Research on the application of RME in digital media has been conducted by, among others, (Edo & Tasik, 2019) who developed an RME application for fractions. The results showed improved conceptual understanding, but the application was still static and less interactive. A similar study was conducted by Prahmana (2022) which showed that using real-world contexts in RME games can increase student engagement. However, these two studies did not integrate artificial intelligence technology or local cultural elements.

On the other hand, the integration of local wisdom in mathematics learning is beginning to receive attention shows that batik motifs can be used to teach geometric concepts, utilized Acehnese folklore to explain comparison and ratio (Muzakkir, 2021). Both studies confirmed that students understand concepts more easily when presented in a cultural context they are familiar with. However, the media used were still printed teaching materials and had not yet been developed into an interactive digital format. Meanwhile, research progress on deep learning in personalized learning is also significant. Alsadoon et al. (2022) developing a deep learning-based adaptive gamification system that is able to adjust the difficulty level of questions according to student performance even integrating AI-based tutor dialogue into math games. While the results are positive, this research is global, does not incorporate local contexts, and is not based on explicit pedagogy like RME.

This research aims to fill this gap by offering novelty in three areas: integrating the RME approach into an interactive digital game; inserting Indonesian local wisdom as a learning context, so that the game is not only educational but also strengthens cultural identity; and applying deep learning to make the game adaptive to students' abilities and learning needs. With this combination, the research is expected to contribute to the pedagogical, cultural, and technological realms.

Furthermore, this research is expected to contribute to the field of educational technology by providing a deep learning-based adaptation model that can be used in educational games. This personalization makes learning more effective because it adapts to individual abilities. Finally, this research also aims to provide practical recommendations for teachers and media developers, demonstrating that the integration of pedagogical approaches, culture, and modern technology can deliver more meaningful, enjoyable, and contextual mathematics learning.

RESEARCH METHODS

This research uses a Research and Development (R&D) approach because its primary focus is to produce an innovative product in the form of an educational game based on Realistic Mathematics Education (RME) integrated with local wisdom content and deep learning strategies. The R&D approach was chosen because it allows researchers not only to design the product but also to test, validate, and refine it until it is suitable for use in real-life classroom learning.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

The first stage was a preliminary study. In this stage, researchers conducted a literature review related to RME-based mathematics learning, educational games, the integration of local wisdom, and the use of deep learning algorithms in education. This study was supplemented by observations in elementary and junior high schools and interviews with mathematics teachers to identify field needs, student difficulties, and local cultural potential that could be utilized as a learning context. The results of this study served as the basis for determining the direction of product development.

The next stage is planning, which involves developing a conceptual design for the educational game. At this stage, learning objectives are formulated, mathematics material relevant to the students' developmental level is selected, and local cultural elements are identified to serve as the context for the problems within the RME framework. Furthermore, this stage also prepares a technical design for integrating a deep learning algorithm, which functions as a game adaptation mechanism, allowing the game to adjust its difficulty level based on students' learning performance.

After the planning is complete, initial product development begins. At this stage, researchers begin designing a game prototype using development software, incorporating contextual problem scenarios based on local wisdom and mathematized according to RME principles. A deep learning algorithm is embedded to analyze student interactions, such as error patterns, completion time, and solution strategies, so the game can adapt to subsequent challenges.

Product validation was conducted by three groups of experts: media experts, material experts, and learning experts. Each expert provided an assessment using a 1–5 Likert scale, with assessment aspects including appearance, content suitability, learning integration, and usability. The resulting prototype then underwent an expert validation phase. Several experts were involved, including mathematics education experts, local culture experts, technology/game experts, and artificial intelligence experts. The experts were asked to provide assessments and input regarding content suitability, cultural contextual accuracy, game display quality, and the feasibility of adaptive algorithms. The validation results were used to revise the prototype to make it more usable.

The next stage was a limited trial conducted with a small group of students. The goal was to assess the game's comprehension and engagement, while also identifying any technical and pedagogical challenges. Data was obtained through conceptual understanding tests, motivation questionnaires, and observations during game use. The results of the limited trial served as the basis for further revisions.

After improvements were made, the game was tested on a broader scale through a main field trial. This stage involved more students from several schools to obtain a more representative picture of the product's effectiveness. The research at this stage used a quasi-experimental design, comparing an experimental group using the game with a control group learning with conventional methods. Data analysis was conducted to assess the extent to which the game improved students' understanding of mathematical concepts, motivated them, and strengthened their engagement in local culture-based learning.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

The results of the field trials were used to refine the product. The game was further adjusted in terms of content, visual appearance, and algorithm adaptation mechanisms. After refinement, the product was then comprehendsively tested for feasibility, involving learning effectiveness tests using statistical analyses such as t-tests and N-Gain, as well as descriptive analysis of student motivation.

The final stage is product implementation and dissemination. The educational games that have been developed and declared suitable for use are then introduced to partner schools. These products are also prepared for wider access through digital learning platforms, allowing them to be utilized by teachers and students in various regions. The development of these educational games not only produces technology-based learning media but also presents innovations grounded in RME, highlighting local wisdom as a learning context, and utilizing deep learning strategies to personalize learning.

RESULTS AND DISCUSSION

1. Potential and Problems

Preliminary studies indicate that mathematics learning in elementary schools is still dominated by conventional methods, with an emphasis on memorizing formulas and monotonous practice problems. To strengthen these findings, a preliminary study was conducted in three elementary schools in Bireuen Regency (SDN 1 Bireuen, SDN 3 Jeumpa, and SDN 6 Juli). Data were obtained through diagnostic questionnaires completed by 90 fifth-grade students and through classroom observations.

The questionnaire results showed that approximately 70% of students reported difficulty understanding abstract mathematical concepts, particularly those related to fractions, geometric shapes, and ratios. This data was supported by observations, where students appeared passive during learning activities and tended to simply copy formulas without understanding the context in which they were applied.

Furthermore, interviews with six elementary school mathematics teachers revealed the limitations of innovative learning media that integrate Realistic Mathematics Education (RME) principles with local wisdom. Teachers still predominantly use textbooks and blackboards, thus hindering students' meaningful learning experiences. This fact underscores the need to develop educational game-based learning media that are not only enjoyable but also provide a real-world context through the integration of local culture and support students' conceptual understanding.

2. Data Collection

Data collection in this study involved questionnaires, classroom observations, and analysis of curriculum documents. Questionnaires were distributed to 90 fifth-grade students from three elementary schools in Bireuen Regency: SDN 1 Bireuen, SDN 3 Jeumpa, and SDN 6 Juli. These students were selected using purposive sampling to represent public schools willing to participate in the study. Additionally, 15 mathematics teachers from the same schools completed the questionnaires to obtain a picture of their learning needs from the educators' perspective. The questionnaire analysis revealed that 85% of students preferred game-based learning over conventional methods, as they considered them more

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

engaging, enjoyable, and facilitated conceptual understanding. Among the teachers, 80% (12) stated that they had never used Realistic Mathematics Education (RME)-based educational games with local wisdom content, but preferred to utilize simpler media such as pictures, concrete objects, or student worksheets.

In addition to the questionnaire, data was obtained through classroom observations conducted during nine mathematics lessons in fifth grade. The observations focused on teacher and student activities, the use of learning methods, and the level of student engagement. Observations revealed that learning was still dominated by conventional methods emphasizing lectures and practice exercises, resulting in students being passive and experiencing difficulties when given contextual problems. This finding aligns with the questionnaire results, which indicated the low use of innovative media in mathematics learning.

Another source of data was obtained from an analysis of curriculum documents, both the Independent Curriculum (Kurikulum Merdeka) and the Curriculum 13 (K-13) still being implemented in several schools. This analysis aimed to ensure the alignment of the content of the educational games to be developed with the core competencies established in the curriculum. The analysis revealed that the material on fractions, geometric shapes, and ratios is highly relevant for contextualization with Acehnese local wisdom, for example through the distribution of traditional cakes, the shape of traditional houses, and buying and selling activities in the market. The findings from these three data sources complement each other and confirm the urgent need to develop RME-based educational games with local wisdom content, from the perspective of students, teachers, and the existing curriculum.

3. **Product Design**

The product developed in this research is an educational mathematics game designed based on the Realistic Mathematics Education (RME) approach, integrating Acehnese local wisdom content and deep learning strategies. This game aims to provide a fun, contextual, and in-depth learning experience for elementary school students, particularly in topics related to fractions, geometric shapes, and ratios.

In terms of cultural content, this game presents various contexts close to the lives of students in Aceh, such as a local version of the traditional game dakon, carved motifs on traditional Acehnese houses used in introducing plane and spatial figures, and simulations of buying and selling activities in traditional markets relevant to the topic of comparison and fractions. This integration of local wisdom is expected to foster a sense of belonging to regional culture while helping students understand mathematical concepts through real-world experiences.

From a pedagogical perspective, this game applies the problem-solving principle of the RME approach, where students are invited to solve contextual problems before moving on to formalizing mathematical concepts. For example, students are asked to calculate the portions of a traditional meuseukat cake that are divided equally among several people, or to determine the price comparison of goods in the market. These activities not only encourage active student engagement but also foster critical and creative thinking skills.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

Furthermore, this game incorporates deep learning strategy features that support in-depth and sustained understanding. First, there's a spaced repetition mechanism that helps students remember important concepts through repetition at specific intervals. Second, scaffolding is provided in the form of step-by-step instructions, allowing students to learn independently while still receiving support when they encounter difficulties. Third, there's a self-assessment feature that allows students to assess their own understanding of the material. Thus, this educational game serves not only as an educational entertainment medium but also as a meaningful, mindful learning tool that supports the mastery of higher-order thinking skills.

4. Design Validation

The summary results can be seen in Table 1.

Table 1. Product Design Validation Results

Validator Aspect	Number of Experts	Mean Score	Category	Aiken's V
Media Experts	3	4.45	Highly Valid	0.86
Material Experts	3	4.60	Highly Valid	0.88
Learning Experts	2	4.40	Highly Valid	0.87
Total Average	**8**	**4.48**	**Highly Valid**	**0.87**

Validation Results Description

Based on the validation results, the average score from the three expert groups ranged from 4.40 to 4.60, which is considered highly valid. Media experts assessed that the educational game's graphics, navigation, and interactivity were attractive and suited to the characteristics of elementary school students, although some suggested improvements in icon and color consistency to make it more user-friendly.

Content experts gave the highest score, 4.60, indicating that the RME-based mathematics content combined with Acehnese local wisdom is highly relevant to the elementary school curriculum. They assessed that cultural integration, such as traditional house carving motifs and buying and selling activities in local markets, successfully enriched the context of mathematics learning.

Meanwhile, learning experts gave an average score of 4.40, also considered highly valid. They emphasized that integrated deep learning strategies, such as spaced repetition, scaffolding, and self-assessment, can help students achieve deeper understanding. However, they recommended that self-reflection be presented in a simpler format for easier understanding by elementary school students.

The quantitative analysis using Aiken's V showed a value of 0.87, which is considered very high. This confirms the finding that this educational game product has excellent content, media, and learning validity, making it worthy of further testing.

5. Design Revision

Based on validation results and expert input, several revisions were made to refine the educational game design to better suit the characteristics of elementary school students. First, game instructions were simplified by using short sentences, conversational language, and visual icons to facilitate understanding for lower-grade students. Second, variations were added to questions based on local contexts, such

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

as calculations in traditional Acehnese games, buying and selling activities in markets, and geometric patterns in songket motifs. This aimed to provide students with a richer learning experience that was more relevant to everyday life. Third, the color and interface were adjusted using a bright color palette, consistent icons, and a simpler layout to make it more child-friendly and enhance the enjoyment of playing and learning.

With these revisions, the educational game became more engaging, easier to use, and further strengthened its integration of RME principles, local wisdom, and deep learning strategies.

6. Product Trial (Limited)

A limited trial was conducted with 30 fifth-grade elementary school students in Bireuen Regency after the educational game product was declared valid by experts. Data was obtained through student response questionnaires and learning outcome tests.

The results of the response questionnaire showed that 90% of students stated that the game was easy to use and 85% felt more motivated in learning mathematics. This data was sourced from an analysis of Likert-scale questionnaire responses given to all students after using the game. The results data can be seen in Table 2.

Table 2. Analysis of student responses to the educational game

No	Statement	Positive Score (Agree & Strongly Agree)	Percentage (%)
1	The game is easy to use	27 students	90%
2	The game makes me more motivated to learn mathematics	26 students	85%
3	The game helps me understand mathematics material better	25 students	83%
4	The game's appearance is attractive and suitable for children's world	28 students	93%
5	I would like to use this game again in the next mathematics learning	27 students	90%
Average Positive Student Response			**88,2%**

Number of Students (N) = 30

To determine the game's effectiveness, a pretest and posttest were conducted on the fractions and geometric shapes material, aligned with the core competencies. The result of student's pretest and posttest can be seen in Table 3 and the result of

Table 3. Student Pretest and Posttest Results (N=30)

Statistic	Pretest	Posttest
Mean	62	78
Standard Deviation	8,5	7,9

Based on Table 3, it can be seen that the average pretest score was 62, while after learning using the game, it increased to 78 in the posttest. This result showed the increasing of learning mathematics outcomes after using RME-based educational game with Acehnese local wisdom. Then, the result of t-test can be seen in Table 4.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

Table 4. Paired sample t-test results

Variable	t-hitung	df	Sig. (p)	Description
Pretest–Posttest	5,84	29	< 0,001	There is a significant improvement ($p < 0.05$)

Based on Table 4, the calculation results showed $t(29) = 5.84$ with $p < 0.001$, indicating a significant improvement in learning outcomes after students used the RME-based educational game with Acehnese local wisdom. Thus, the findings from the limited trial demonstrate that the questionnaire response data and pretest–posttest results both support the conclusion that this game is effective in increasing student motivation and learning outcomes.

7. Product Revision

Product revisions were made based on the results of the limited trial. Improvements focused on adding an automatic feedback feature, allowing students to immediately know whether an answer was correct or incorrect, along with explanations. Furthermore, a gradual difficulty level was added to make the game more adaptable to student abilities, ranging from simple to complex questions. With these revisions, the game is more interactive, supports independent learning, and adapts to the learning needs of each student.

8. Usage Trial (Main Field)

Conducted on 90 students from three different elementary schools. The research design used a quasi-experimental design with a pretest-posttest control group design. Student Learning Outcomes can be seen in Table 5. Then, the statistical analysis can be seen in Table 6.

Table 5. Student learning outcomes in the main field trial

Group	N	Pretest Mean	Posttest Mean	Improvement	Description
Experimental (RME Game)	45	61	84	+23	Using the game
Control (Conventional)	45	63	72	+9	Traditional method

Table 6. Statistical Analysis

Statistical Test	Result	Description
Normality test & Homogeneity Test	Met	Data are eligible for parametric testing
ANOVA satu arah	$F(1,88) = 12,35$, $p < 0,01$	There is a significant difference between the experimental and control classes
Effect Size (Cohen's d)	0,82	Large category → The RME game has a strong impact on improving learning outcomes

Thus, these results show that RME-based educational games with Acehnese local wisdom are effective in significantly improving mathematics learning outcomes compared to conventional methods.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

9. Final Product Revision

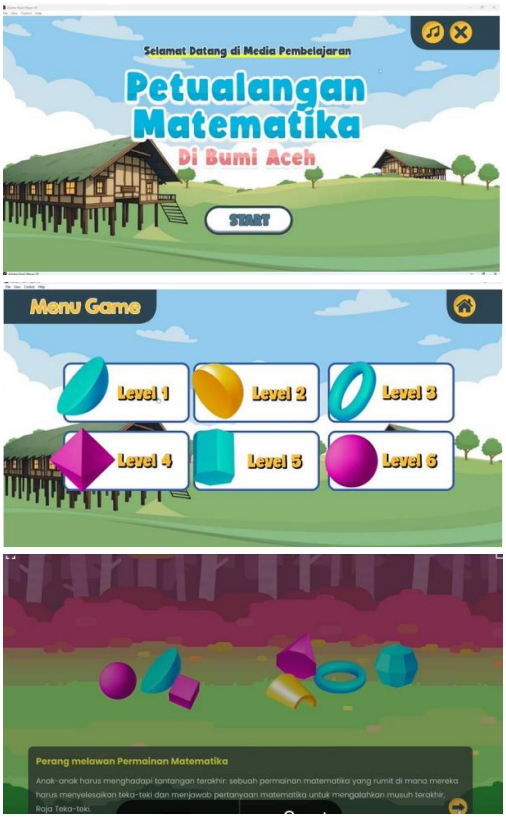

Figure 1. Gamification product

The final product revision was based on findings from the field trial. Although the game proved effective in improving mathematics learning outcomes, several improvements were still needed. These improvements focused on adding a multiplayer feature to strengthen social interaction among students while playing and learning. Furthermore, the development team also fixed technical bugs to ensure the game runs more stably, responsively, and comfortably on various devices. With these revisions, the final product is expected to be more adaptive, collaborative, and ready for widespread use in elementary schools.

This research aims to develop a Realistic Mathematics Education (RME)-based educational mathematics game integrated with Acehnese local wisdom and utilizing deep learning strategies. The results demonstrate that the resulting product is not only theoretically valid through expert assessment, but also practically applicable in learning, and has proven effective in improving elementary school student learning outcomes. The following discussion outlines the research findings, linking them to theory, empirical findings, and implications for elementary school mathematics learning.

In the initial stages of the research, a preliminary study revealed both potential and challenges in elementary school mathematics learning. Observations at three schools in Bireuen Regency revealed that the majority of students still have difficulty understanding abstract mathematical concepts, particularly in fractions, geometric shapes, and ratios. Data obtained through a needs questionnaire indicated that 70% of students reported difficulties in understanding this material. Teachers also acknowledged that innovative learning media, particularly those integrating RME and local wisdom, are still very limited. This aligns with previous research confirming that elementary school mathematics learning still tends to emphasize procedures and memorization, rather than meaningful conceptual understanding (Q. Wang, 2024; H. Wang et al., 2024). Therefore, these findings reinforce the urgency of developing learning media that can present real, relevant, and life-like contexts to students, enabling them to more easily construct mathematical meaning.

Further data collection through questionnaires and classroom observations yielded consistent results. As many as 85% of students stated they preferred learning with game-based media, while 80% of teachers admitted

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

they had never used RME-based educational games integrated with local wisdom. This data confirms the significant need among students for engaging and interactive media. This situation also indicates a gap between these needs and actual learning practices. Within the framework of constructivist theory, engaging, meaningful, and contextual learning experiences are crucial for building a deep understanding of concepts (Legaki et al., 2020) and (Ariffin et al., 2022). Thus, this basic need strongly supports the development of a product in the form of an RME-based educational game.

The product designed incorporates Acehnese cultural content, such as traditional games, traditional house motifs, and the context of buying and selling in traditional markets. This cultural integration not only enriches the learning experience but also strengthens students' local identity. As stated (Anggraeni et al., 2023), Mathematics is inseparable from culture, so incorporating local wisdom into learning media can increase relevance and meaningfulness. Furthermore, games are designed with deep learning strategies such as spaced repetition, scaffolding, and self-reflection. These strategies aim to strengthen students' long-term memory and develop higher-order thinking skills.

Validation of the product design by experts showed excellent results. The average score from media experts, material experts, and learning experts was in the "very valid" category. Further analysis using Aiken's V showed a value of 0.87, indicating a very high level of expert agreement regarding the product's feasibility. This high validity indicates that the product has met the standards for content, presentation, and pedagogy. These findings align with previous research on learning media development, which emphasized the importance of expert validation to ensure product quality before implementation in the field.

Input from the validators prompted design revisions, including simplifying the game's instructions, adding a variety of questions based on local contexts, and adjusting the color and display to make it more child-friendly. This is important considering that the game's primary users are elementary school students who are still in the concrete operational stage. Simple instructions and an attractive display can improve product usability and student learning motivation.

A limited trial with 30 fifth-grade elementary school students yielded positive results. Student responses indicated that 90% found the game easy to use and 85% felt more motivated to learn mathematics. These results demonstrate that the product is not only theoretically valid but also practically applicable in practice. These findings are supported by student learning outcome data. The average score increased from 62 in the pretest to 78 in the posttest. A paired sample t-test yielded $t(29) = 5.84$ with $p < 0.001$, indicating a significant improvement in student learning outcomes after using the game. This improvement demonstrates the game's effectiveness in helping students understand the concepts of fractions and geometric shapes. This aligns with RME theory, which emphasizes the importance of context-based learning and problem-solving activities in enhancing conceptual understanding (Alt, 2023).

Next, product revisions were made by adding automatic feedback features and a gradual increase in difficulty. Automatic feedback is

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

important so students can immediately know the correctness of their answers, allowing them to learn from mistakes. Meanwhile, the gradual increase in difficulty provides adaptive challenges that match students' abilities, thus preventing boredom and frustration. This principle aligns with the zone of proximal development theory (Morcom, 2014)and (Smagorinsky, 2018) which emphasizes the importance of providing support tailored to students' developmental needs.

The main field trial was conducted on 90 students from three elementary schools using a quasi-experimental pretest-posttest control group design. The results showed a greater improvement in the experimental class (using the RME game) compared to the control class (using conventional learning). In the experimental class, the average score increased from 61 to 84, while in the control class, it increased from 63 to 72. Statistical analysis using one-way ANOVA yielded $F(1,88) = 12.35$, $p < 0.01$, indicating a significant difference between the two groups. The Cohen's d effect size calculation of 0.82 indicates a large category, indicating that the game has a strong influence on student learning outcomes. These findings align with previous research showing that game-based media can improve student motivation, engagement, and achievement (Hakeu et al., 2023).

The implications of these findings are significant. First, from a pedagogical perspective, RME-based games incorporating local wisdom have been shown to bridge students' difficulties in understanding abstract mathematical concepts by presenting them with real-life contexts relevant to their lives. Second, from a psychological perspective, the use of games makes the learning process more enjoyable and meaningful, thereby increasing students' intrinsic motivation. Third, from a cultural perspective, the integration of local wisdom into the game helps preserve Acehnese culture while strengthening students' identities. Thus, the development of this media not only impacts academic aspects but also character development and cultural awareness.

However, the research results also indicate room for improvement. Field trials demonstrated that while the game was effective, students needed stronger social interaction. Therefore, revisions to the final product were made to add a multiplayer feature, allowing students to play and learn collaboratively. This feature is highly relevant considering that 21st-century learning emphasizes the development of the 4C competencies: critical thinking, creativity, collaboration, and communication. Social interaction in game-based learning can strengthen students' collaboration and communication skills.

Furthermore, technical revisions were made to fix bugs discovered during the trial. This demonstrates that the product development process is iterative and continuous, in line with the research and development (R&D) model. With these improvements, the final product is more mature, stable, and ready for wider use in elementary schools.

Overall, the discussion of this research demonstrates that the development of an RME-based educational game incorporating Acehnese local wisdom is a valid, practical, and effective innovation. The results also enrich the literature on cultural integration in mathematics learning and the application of deep learning strategies through game-based media.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

Thus, this research not only contributes to the academic realm but also has broad practical implications for elementary education in Indonesia, particularly in facing the challenges of 21st-century learning..

CONCLUSIONS AND SUGGESTIONS

The development of an RME-based mathematics game enriched with Acehnese local wisdom successfully produced a learning medium that is engaging, culturally meaningful, and pedagogically effective for elementary school students. Throughout the development process—starting from needs analysis to the final product revision—the game consistently demonstrated strong validity from experts and positive responses from students. Learners found the game easy to navigate, visually appealing, and helpful in understanding mathematical concepts presented through familiar cultural contexts.

As for recommendations, this study still has room for further development, particularly in terms of technical and pedagogical features. The development of multiplayer features that enable social interaction between students needs to be strengthened, so that it not only develops cognitive aspects but also collaboration and communication skills. Furthermore, further research with a broader subject coverage and longer intervention duration is highly recommended to obtain a more comprehensive picture of the long-term impact of this game's use on various aspects of student abilities, including creativity, critical thinking, and cultural awareness. Future research could also explore the integration of artificial intelligence (AI) technology to provide personalized learning tailored to student needs. Thus, the development of this educational game based on RME and local wisdom not only contributes to improving the quality of mathematics learning in elementary schools but can also serve as a model for learning innovation relevant to the national education context.

DAFTAR PUSTAKA

Alsadoon, E., Alkhawajah, A., & Suhaim, A. Bin. (2022). Effects of a gamified learning environment on students' achievement, motivations, and satisfaction. *Heliyon*, *8*(8), 1–28. https://doi.org/10.1016/j.heliyon.2022.e10249

Alt, D. (2023). Assessing the benefits of gamification in mathematics for student gameful experience and gaming motivation. *Computers and Education*, *200*(July), 1–7. https://doi.org/10.1016/j.compedu.2023.104806

Anggraeni, D. P., Fitriana, V., Wardani, K. U., & Zuliana, E. (2023). Kajian Etnomatematika Motif Batik Tulis Asli Pesantren Tambakromo Pati. *Jurnal Pendidikan Matematika*, *1*(02), 139–150. https://ojs.um-palembang.ac.id/index.php/differential/article/view/104

Ariffin, N. A. N., Ramli, N., Alam, N. M. F. H. N. B., Yusof, Y., & Suparlan, A. (2022). Effectiveness of gamification in teaching and learning mathematics. *Journal on Mathematics Education*, *13*(1), 173–190. https://doi.org/10.22342/jme.v13i1.pp173-190

Dianlestari, & Kusno, K. (2024). Etnomatematika Pada Pola Batik Gumelem Melalui Analisis Geometri Transformasi. *Jurnal*

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

Derivat: Jurnal Matematika Dan Pendidikan Matematika, *11*(2), 81–88. https://doi.org/10.31316/jderivat.v10i2.5737

Edo, S. I., & Tasik, W. F. (2019). Design research on applied Realistic Mathematics Education (RME) approach in teaching math for vocational college. *Jurnal Pendidikan Vokasi*, *9*(3), 294–306. https://doi.org/10.21831/jpv.v9i3.27839

Hakeu, F., Pakaya, I. I., & Tangkudung, M. (2023). Pemanfaatan Media Pembelajaran Berbasis Gamifikasi dalam Proses Pembelajaran di MIS Terpadu Al-Azhfar. *Awwaliyah: Jurnal Pendidikan Guru Madrasah Ibtidaiyah*, *6*(2), 154–166. https://doi.org/10.58518/awwaliyah.v6i2.1930

Legaki, N. Z., Xi, N., Hamari, J., Karpouzis, K., & Assimakopoulos, V. (2020). The effect of challenge-based gamification on learning: An experiment in the context of statistics education. *International Journal of Human Computer Studies*, *144*(December), 1–4. https://doi.org/10.1016/j.ijhcs.2020.102496

Morcom, V. (2014). Scaffolding social and emotional learning in an elementary classroom community: A sociocultural perspective. *International Journal of Educational Research*, *67*(1978), 18–29. https://doi.org/10.1016/j.ijer.2014.04.002

Muzakkir, M. (2021). Pendekatan Etnopedagogi Sebagai Media Pelestarian Kearifan Lokal. *JURNAL HURRIAH: Jurnal Evaluasi Pendidikan Dan Penelitian*, *2*(2), 28–39. https://doi.org/10.56806/jh.v2i2.16

Nabila, G. P., Sucia, M., Aflah, D., W, I. M., Andryan, F. A., & Sidiq, A. (2022). Analisa Elemen Rumah Tradisional Aceh: Studi Kasus Rumah Cot Glie. *Jurnal Vastukara: Jurnal Desain Interior, Budaya, Dan Lingkungan Terbangun*, *2*(2), 169–181. https://doi.org/10.59997/vastukara.v2i2.1740

Naseer, F., Khan, M. N., Tahir, M., Addas, A., & Aejaz, S. M. H. (2024). Integrating deep learning techniques for personalized learning pathways in higher education. *Heliyon*, *10*(11), 1–41. https://doi.org/10.1016/j.heliyon.2024.e32628

Prahmana, R. C. I. (2022). Ethno-Realistic Mathematics Education: The promising learning approach in the city of culture. *SN Social Sciences*, *2*(12), 1–17. https://doi.org/10.1007/s43545-022-00571-w

Rahmadi, J., Wahyu, Y., & Oktari, V. (2024). Implementation of creative problem-solving model with RME approach on mathematics problem-solving ability. *Jurnal Elemen*, *10*(1), 43–54. https://doi.org/10.29408/jel.v10i1.19788

Rezeki, S., Andrian, D., & Safitri, Y. (2021). Mathematics and Cultures: A New Concept in Maintaining Cultures Through the Development of Learning Devices. *International Journal of Instruction*, *14*(3), 375–392.

ISSN 2089-8703 (Print)
ISSN 2442-5419 (Online)

DOI: https://doi.org/10.24127/ajpm.v14i4.14372

https://doi.org/10.29333/iji.2021.14322a

Saputra, E., Mirsa, R., Yanti, P. D., Wulandari, W., & Husna, A. (2022). Eksplorasi Etnomatematika Pada Arsitektur Rumoh Aceh. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *11*(1), 703. https://doi.org/10.24127/ajpm.v11i1.4751

Smagorinsky, P. (2018). Deconflating the ZPD and instructional scaffolding: Retranslating and reconceiving the zone of proximal development as the zone of next development. *Learning, Culture and Social Interaction*, *16*(March), 70–75. https://doi.org/10.1016/j.lcsi.2017.10.009

Tong, D. H., Uyen, B. P., & Ngan, L. K. (2022). The effectiveness of blended learning on students' academic achievement, self-study skills and learning attitudes: A quasi-experiment study in teaching the conventions for coordinates in the plane. *Heliyon*, *8*(12), 1–44. https://doi.org/10.1016/j.heliyon.2022.e12657

Wang, H., Gao, Z., Zhang, X., Du, J., Xu, Y., & Wang, Z. (2024). Gamifying cultural heritage: Exploring the potential of immersive virtual exhibitions. *Telematics and Informatics Reports*, *15*, 4–9. https://doi.org/10.1016/j.teler.2024.100150

Wang, Q. (2024). A study on the design of a deep learning model for classroom based on user participation and game chemistry processes. *Entertainment Computing*, *51*(September), 1–9. https://doi.org/10.1016/j.entcom.2024.100727