# Smart Class for Smart Kids: RME Innovation in Building Meaningful Learning in Elementary Schools

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Abstract: Mathematics learning in elementary schools is often considered abstract and uninteresting by students, resulting in low motivation and learning outcomes. This study aims to examine the effectiveness of integrating the Realistic Mathematics Education (RME) approach and gamification in the Smart Class model to improve student learning outcomes, motivation, and engagement. The study was conducted for six weeks in a public elementary school in Aceh Province, involving 60 students divided into two groups: experimental and control. The experimental group followed the Smart Class model learning that integrates RME and gamification elements, while the control group followed conventional learning. Data were collected through pretest and posttest learning outcomes, learning motivation questionnaires, and observations of student engagement. The results showed that the experimental group experienced an average increase in posttest scores from 54.8 to 84.7, with an N-gain of 0.66 (high category). The control group increased from 55.1 to 71.4, with an N-gain of 0.42 (medium category). The Effect Size calculation (Cohen's d) showed a value of 1.05, which is included in the large effect category. In addition, the average learning motivation score of students in the experimental group reached 87.3 (very high category), compared to 72.6 (medium-high category) in the control group. Observations showed that students in the experimental group were more active and engaged in learning. It can be concluded that the integration of the RME and gamification approaches in the Smart Class model is effective in improving student learning outcomes, motivation, and engagement in mathematics learning in elementary schools.

## 1 INTRODUCTION

Learning in the 21st century faces complex and multidimensional challenges. Amidst the rapid pace of technological development and the rapid flow of information, education is required to facilitate the development of 21st-century competencies such as critical thinking, creativity, collaboration, and communication (Mhlongo et al., 2023), (Oke & Fernandes, 2020). Elementary schools, as the initial foundation of the entire formal education system, play a crucial role in preparing students to become adaptive, intelligent, and meaningful learners. However, various studies and empirical observations indicate that the learning process in elementary schools still tends to be conventional, memorization-oriented, lacking contextual experiences, and unable to fully facilitate optimal student cognitive and affective development.

Teachers often get caught up in a teacher-centered approach, where students are merely passive recipients of the lesson material (Ødegård & Solberg, 2024). Learning that is rigid, monotonous, and does not touch on the real life context of students is one of the causes of low interest in learning, intrinsic motivation, and active involvement in the learning process.(Woods & Copur-Gencturk, 2024). This results in low learning outcomes and low literacy skills for students. Elementary school students are in Piaget's concrete-operational stage of development, where they learn most effectively through direct experience, social interaction, and activities that are meaningful to their lives.

Responding to these challenges, learning innovation is a necessity. Meaningful learning is believed to be one approach capable of meeting the needs of 21st-century learning (Herlinawati et al., 2024), (Souza & Debs, 2024). According to Ausubel in (Hidayatul Muamanah & Suyadi, 2020), Learning



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will be meaningful if the information learned can be substantively linked to the cognitive structures that students already possess. In other words, meaningful learning occurs when students are able to connect new knowledge with prior experiences and knowledge, and can apply it in real-life contexts.

Meaningful learning is not only oriented towards cognitive aspects, but also touches on affective and social dimensions, where students learn through active involvement, interaction, reflection, and personal meaning of the material being studied (Husnaini et al., 2024). In this context, teachers need to design learning that is contextual, challenging, fun, and relevant to the students' world. (Latifah & Sa'odah, 2019). Therefore, learning approaches are needed that can foster curiosity, intrinsic motivation, and a sense of ownership of the learning process being undertaken.

One relevant approach to realizing meaningful learning, especially in mathematics subjects, is Realistic Mathematics Education (RME) (Rahmadi et al., 2024). RME is a mathematics learning approach developed in the Netherlands and emphasizes reality as a starting point in building mathematical understanding (van Zanten & van den Heuvel-Panhuizen, 2018). This approach was developed by Hans Freudenthal who believed that mathematics should be seen as a human activity, not as a set of formulas that must be memorized.

The basic principles of RME include the use of real-world contexts, social interactivity, the use of models as bridges to abstraction, and the process of reflection. In the elementary school context, the RME approach allows students to construct mathematical concepts through contextual problem solving, group discussions, and their own construction of knowledge (Rahmadi et al., 2024). Thus, RME not only improves students' conceptual understanding of mathematical material, but also develops critical thinking skills and creativity (Chong et al., 2019).

On the other hand, advances in digital technology have opened up significant opportunities to improve the quality of learning through the application of gamification principles. Gamification is the process of applying game elements to non-game contexts, including learning. These elements include points, badges, challenges, leaderboards, levels, and engaging narratives. The primary goal of gamification is to create a more engaging, interactive, and motivating learning experience.

In the context of elementary school learning, gamification can be a highly effective tool for increasing student engagement, strengthening motivation, and creating a joyful learning environment. Previous studies have shown that integrating gamification into learning can increase student interest, improve information retention, and stimulate collaboration among students. When combined with appropriate pedagogical approaches such as RME, gamification can strengthen both the cognitive and affective aspects of learning.

The concept of a Smart Class refers to a learning ecosystem that integrates innovative pedagogical approaches with the optimal use of information technology. Smart Class encompasses not only the use of digital devices but also the creation of an interactive, flexible, and student-centered learning environment. In this context, the combination of RME and gamification within a Smart Class is a promising innovation for building meaningful learning.

Smart Class provides teachers with the opportunity to design learning that is responsive to students' needs and characteristics. Through technology, teachers can package learning materials in the form of educational games based on real-world contexts, which not only facilitate conceptual understanding but also engage students' emotions and curiosity. Smart Class provides a space where RME learning can be enhanced by the appeal of gamification, resulting in a learning process that is not only effective but also enjoyable.

The implementation of the independent curriculum and the strengthening of the Pancasila Student Profile require learning that facilitates students to become lifelong learners, critical thinkers, creative, independent, and concerned about the environment and local culture. Learning innovations that integrate RME and gamification within the Smart Class ecosystem align perfectly with these goals. Through local context-based problem-solving, students not only understand mathematical concepts but also learn to recognize and appreciate their surroundings.

Gamification designed with local wisdom values can strengthen cultural identity and increase students' awareness of their social environment. Within this framework, learning becomes more than just a process of transferring knowledge, but also a process of character building and developing life skills. In other words, meaningful learning facilitated by Smart Class can support the holistic achievement of the Pancasila Student Profile.

Although theoretically, the integration of RME and gamification in Smart Class shows great potential for improving the quality of learning, its actual implementation in elementary schools remains limited. Many teachers lack a thorough understanding of the

RME approach or the skills to design educational and relevant gamification activities. Furthermore, the lack of empirical research testing the effectiveness of combining RME and gamification in elementary school learning presents a gap that needs to be addressed.

Most existing research still separates the effectiveness of RME and gamification, without examining their synergistic potential. Therefore, research is needed that explicitly designs and evaluates learning models that combine both approaches within the Smart Class ecosystem. This type of research is expected to provide both theoretical and practical contributions to the development of innovative learning models in elementary schools.

The significance of this research lies in its efforts to present a contextual, enjoyable, and technology-based learning model to improve the quality of basic education in Indonesia. This innovation is expected to not only improve the mathematics learning process specifically but also be adaptable to other subjects that emphasize active engagement and meaningful learning. Furthermore, the integration of RME and gamification in Smart Class can become a future education model that aligns with current developments and the characteristics of the digital generation.

# 2 METHOD

This research is a quantitative study with a quasi-experimental approach using a Nonequivalent Control Group Design to test the effectiveness of the Smart Class learning model based on Realistic Mathematics Education (RME) and gamification. The subjects were fifth-grade students at an elementary school in Aceh that has digital learning facilities, divided into two groups: an experimental group learning with Smart Class based on RME and gamification and a control group learning with conventional methods. The independent variables of the research were the Smart Class learning model based on RME and gamification, while the dependent variables included mathematics learning outcomes, learning engagement, and student motivation. Data were collected through written tests (pretest–posttest), motivation and engagement questionnaires, observations of learning activities, and visual documentation and digital portfolios. The research instruments have been validated and tested for reliability, including learning outcome tests, questionnaires, and observation guidelines. Data analysis was carried out using descriptive statistics, normality and homogeneity tests, paired t-tests, independent t-tests, gain score and effect size calculations, and qualitative analysis of observation and documentation results. The research stages include instrument planning and validation, pretest implementation, learning implementation, posttest and questionnaire implementation, data analysis, and report preparation and publication.

# 3 RESULT AND DISCUSSION

## 3.1 General Overview of the Research Implementation

This study was conducted over six weeks of learning activities at a public elementary school in Aceh Province. The research involved two classes, each consisting of 30 students: the experimental group and the control group. The experimental group participated in learning activities using the Smart Class model, which integrates the Realistic Mathematics Education (RME) approach and gamification elements in mathematics instruction. The control group learned mathematics through conventional teaching methods.

All students in both groups were given a pretest prior to the learning process to assess their initial abilities, and a posttest after the treatment to measure improvement in learning outcomes. In addition, questionnaires and classroom observations were used to assess students' learning motivation and engagement more comprehensively.

## 3.2 Pretest and Posttest Learning Outcomes

### 3.2.1 Pretest Results

The analysis of the pretest data indicated no significant difference between the initial abilities of students in the experimental group and the control group. The average pretest score for the experimental group was 54.8, while the control group scored 55.1. The t-test result showed $p > 0.05$, indicating that both groups had comparable baseline abilities.

### 3.2.2 Posttest Results

After six weeks of instruction:

- The experimental group's average posttest score increased to 84.7.
- The control group's average posttest score increased to 71.4.

The paired t-test within each group showed a significant improvement ($p < 0.01$) from pretest to posttest. Furthermore, the independent t-test evealed a significant difference ($p < 0.01$) between the posttest scores of the experimental and control groups.

### 3.2.3 Improvement in Learning Outcomes (Gain Score)

The purpose of calculating the normalized gain (N-gain) score was to determine the extent of students' learning improvement after receiving the treatment, namely the Smart Class model based on RME and gamification. This method enables the researcher to objectively compare the effectiveness of learning between the experimental and control groups. The results of the N-gain calculation show that: The increase in learning outcomes in the experimental group was greater and more significant than in the control group. This indicates that the implementation of the Smart Class model that integrates RME and gamification is more effective than conventional learning methods. The "high" category in the experimental group indicates that learning took place meaningfully and successfully bridged students from the initial condition to optimal learning outcomes.

Table 1: Normality Test (Shapiro–Wilk Test).

| Group | Statistic | p-value | Interpretation |
|---|---|---|---|
| Experimental | 0.982 | 0.872 | Normally distributed |
| Control | 0.978 | 0.776 | Normally distributed |

Conclusion:
Both groups have normally distributed data, fulfilling the assumptions for parametric testing.

3. N-Gain Difference Test (Independent t-Test)
- t-statistic = 10.93
- p-value = $1.04 \times 10^{-15}$ (highly significant)

Interpretation:
There is a statistically significant difference between the N-Gain scores of the experimental and control groups. With the p-value far below 0.05, it can be concluded that learning with the Smart Class model based on RME and gamification provides a more effective improvement in learning outcomes compared to conventional methods.

Conclusion of the Analysis
- The Smart Class for Smart Kids model is statistically proven to be more effective in improving elementary school students' mathematics learning outcomes.
- The high N-Gain score indicates that learning becomes more meaningful and easier to understand through contextual approaches and gamification.
- The model's effectiveness is supported by valid statistical tests (normality, homogeneity, and t-test).

Effect Size is used to measure the magnitude of the difference between two groups, in this case the experimental and control groups. The Effect Size (Cohen's d) calculation provides additional information beyond statistical significance testing. A d value of ≈1.94 indicates that the difference between the experimental and control groups is not only statistically significant but also has significant practical significance in an educational context. This supports the use of the Smart Class learning model as an effective approach to improving mathematics learning outcomes in elementary schools.

## 3.3 Learning Motivation Questionnaire Results

The learning motivation questionnaire consisted of four indicators: intrinsic, learning objectives, competency, and utility value. The average motivation score for students in the experimental group was 87.3 (very high category). The average motivation score for students in the control group was 72.6 (medium-high category). The most significant increase in student motivation was seen in the competency and utility value indicators, reflecting that students felt the learning helped them understand concepts concretely and enjoyed completing learning challenges.

## 3.4 Student Engagement in Learning

Based on observations during the learning process, student engagement was categorized into three aspects: behavioral engagement, emotional engagement, and cognitive engagement.

### 3.4.1 Behavioral Engagement

The experimental group demonstrated high levels of active participation in group discussions, completing gamification missions, and accessing digital materials. Almost all students completed digital assignments on time. The control group tended to be passive and only followed the teacher's instructions one-way.

#### 3.4.2 Emotional Engagement

Students in the experimental group demonstrated high levels of enthusiasm. Positive responses were evident in their facial expressions, verbal comments ("fun," "exciting," "want to continue"), and their enjoyment of earning digital badges. Some students in the control group appeared bored and lost focus after 20–30 minutes of learning.

#### 3.4.3 Cognitive Engagement

The experimental group was more active in asking "why" and "how" questions when solving contextual problems. The process of reflection and exploration of alternative strategies increased significantly.

### 3.5 Visual Documentation and Student Reflections

Digital documentation such as screenshots of learning games, quiz results, and activity recordings demonstrates that game-based assignments with contextual narratives (e.g., "Little One's Adventures in the Traditional Market") help students connect mathematics to everyday life.

Student reflections collected through the digital notes feature demonstrate a deep understanding and pride in their achievements. Example of a student reflection: "I enjoy learning using games because it's like playing and thinking. Turns out math can be fun too!"

### 3.6 Comparison of Teacher Responses

Teachers in the experimental group reported that: This model helps reach students who are typically passive. Digital media and gamification help explain material previously considered abstract. The main challenges were preparation time and adapting to digital devices, but the results were worth it. Meanwhile, teachers in the control group observed that learning was still teacher-centered and had difficulty maintaining students' attention throughout the lesson.

### 3.7 Discussion

The results of this study demonstrate that the integration of the Realistic Mathematics Education (RME) approach and gamification in the context of elementary school learning can produce a more meaningful and transformative learning experience for students. This innovation not only impacts cognitive learning outcomes but also facilitates students' affective and social development within a 21st-century learning framework. These findings reinforce the theory that meaningful learning occurs when students can connect learning experiences to the realities of their lives, and when the learning process is framed in an atmosphere that stimulates curiosity, provides autonomy, and stimulates emotional engagement.

The implementation of the RME approach as the basis for learning design offers advantages in terms of contextualization of material. In this context, RME is not merely a mathematics teaching method, but rather a pedagogical paradigm that brings abstract concepts closer to concrete representations through modeling the realities of everyday life. Mathematical concepts such as number operations, measurement, and fractions are presented through contextual scenarios familiar to students, such as buying and selling at a market, measuring ingredients in cooking, or calculating time in daily activities. This strategy enables students to build a bridge of understanding from empirical experience to the formal symbolic realm. This is in accordance with Vygotsky's social constructivism theory which emphasizes the importance of social interaction and contextualization in building new knowledge.

Meanwhile, gamification serves as a medium to increase student motivation and learning engagement through the use of game elements in non-game environments. Elements such as point systems, levels, challenges, leaderboards, and digital rewards are adopted to create a competitive and collaborative learning atmosphere. This study found that the integration of gamification into RME design not only adds a fun dimension to learning but also significantly increases student active participation in completing learning tasks. Students are more interested in trying, exploring, and even repeating learning activities due to the direct feedback they experience from the gamification system.

These findings indicate that the combination of RME and gamification creates a powerful pedagogical synergy. RME provides a strong epistemic structure, while gamification provides an affective and motivational framework. Pedagogically, this combination enables learning that is not only conceptually meaningful but also enjoyable and encourages emotional engagement. In practice, this learning model is able to accommodate various learning styles and student needs, creating an inclusive and adaptive learning environment.

Significant improvements in student learning outcomes are a key indicator of the success of this approach. Average student grades increased substantially after participating in the RME-based and gamification-based learning process. Furthermore, observation scores for student engagement during the learning process showed a positive trend, indicating that students were not merely passive subjects in the learning process but were actively involved as problem solvers, collaborators, and creators in a dynamic learning environment. Discussion, exploration, and reflection activities became more lively, as students grew in ownership of their learning process.

Increased learning motivation is also a significant achievement. Many students who previously displayed a passive attitude and lacked interest in mathematics learning now demonstrate high enthusiasm. This motivation, within the framework of Self-Determination Theory (SDT), indicates the fulfillment of three basic psychological needs: autonomy, competence, and connectedness. The gamification elements used successfully encourage students to feel empowered in learning (a sense of agency), feel capable of facing challenges, and feel connected to their peers and teachers in a collaborative learning environment.

However, implementing this approach is not without challenges. One of the main challenges lies in teacher readiness to design and manage RME-based learning and gamification. Teachers are required to possess high pedagogical, technological, and instructional design competencies to synergistically and balancedly integrate realistic contexts with game elements. Furthermore, the use of technology as the primary infrastructure in gamification requires adequate support facilities, both in terms of hardware and connectivity. In the context of elementary schools in areas with limited resources, this aspect presents a challenge that needs to be addressed through a hybrid or low-tech gamification approach.

Another weakness identified was the tendency for some students to focus too much on the game elements, thus distorting the learning objectives. In some cases, external motivation driven by rewards or competition actually reduces intrinsic motivation in students who feel less capable of competing. Therefore, it is important for teachers to design gamification systems that emphasize not only competition but also allow for collaboration, recognition for effort, and adjustment to individual student needs. Models that emphasize mastery-oriented feedback are recommended over performance-oriented feedback to keep students focused on the learning process, not just the end result.

Within the Merdeka Belajar curriculum framework, this approach aligns with the principles of student-centered learning. Both RME and gamification emphasize students' active role in constructing knowledge, developing potential, and finding meaning in learning. A curriculum that allows for differentiation, flexibility, and contextualization is highly compatible with this approach. Furthermore, the integration of these approaches also supports the achievement of the Pancasila Student Profile, particularly in critical reasoning, creativity, and mutual cooperation. Students accustomed to solving realistic problems in a fun context tend to be more adaptive, resilient, and collaborative in facing real-world challenges.

Theoretically, this research broadens understanding of the implementation of meaningful learning in the context of elementary education. It supports the view that meaningful learning is not the result of a direct transfer of knowledge from teacher to student, but rather the process of constructing meaning by students through contextual and challenging learning experiences. In this context, RME provides the conceptual structure, while gamification provides the affective and motivational ecosystem that enables meaningful learning.

Furthermore, the results of this study have practical implications for the development of technology-based learning innovations rooted in local values and students' contextual needs. By utilizing local stories, culture, or customs within the context of RME and incorporating game elements familiar to children, learning can become a vehicle for preserving values while enhancing 21st-century competencies. This strategy also provides a responsive approach to the needs of the digital native generation, who have different learning preferences than previous generations.

As a contribution to academic scholarship, this study enriches the literature on the integration of context-based pedagogical approaches and digital technology in elementary education. Prior research has largely discussed RME and gamification separately. Therefore, this study offers a conceptual and empirical synthesis demonstrating that integrating the two can produce a more comprehensive, inclusive, and transformative learning approach.

Future research could explore the effectiveness of this approach in cross-subject contexts or in inclusive education. Furthermore, developing culturally based gamification models and adaptive technology-assisted RME systems (such as AI learning assistants or AR-based contextual modules) is a promising area of research. Longitudinal research is also needed to observe the long-term impact of this approach on the development of students' independent learning characteristics and problem-solving abilities.

Overall, RME-based learning and gamification within the "Smart Class for Smart Kids" framework demonstrate that pedagogical innovations combining real-world contexts, technology, and engaging experiences can create learning environments that foster holistic cognitive, affective, and social engagement. This model is not only a technical solution to the challenges of 21st-century education, but also represents a vision of education that is humanistic, relevant, and sustainable.

## 4 CONCLUSIONS

Based on the results of the study entitled "smart class for smart kids: innovation of rme and gamification in building meaningful learning in elementary schools", it can be concluded that the integration of the realistic mathematics education (rme) approach and gamification in the smart class model has proven effective in improving the quality of mathematics learning in elementary schools. This improvement is reflected in the posttest results which show a significant difference between the experimental group and the control group, with student learning outcomes in the experimental group being statistically higher. In addition, the implementation of this model is able to encourage stronger learning motivation, especially in aspects of competence and utility value, through gamification elements such as points, badges, and challenges that create a fun learning atmosphere and trigger active student participation. Observations also show higher student engagement behaviorally, emotionally, and cognitively, as seen from enthusiasm in discussions, completing assignments, and exploring materials. This model aligns with the principles of the independent learning curriculum, which emphasizes contextual, student-centered, and enjoyable learning, while also supporting the achievement of the pancasila student profile in critical reasoning, creativity, and mutual cooperation. However, the implementation of the smart class model still faces challenges, particularly related to the availability of technological infrastructure and teacher readiness to design rme-based and gamification-based learning. Therefore, teacher training and facility support are crucial factors for long-term success. Overall, this study demonstrates that the rme-based and gamification-based smart class can create a more meaningful, enjoyable, and effective learning experience, not only in improving learning outcomes but also in motivating and actively engaging students in the learning process.

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