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Realistic mathematics education and wordwall to enhance students' mathematics learning motivation

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Abstract

Background: Mathematics learning motivation among junior high school students remains low due to procedural, decontextualized instruction that fails to connect mathematical concepts to students' real-life experiences, as observed in several junior high schools in Central Indonesia.
Purpose: This study examines the effects of Realistic Mathematics Education assisted by Wordwall, Realistic Mathematics Education without Wordwall, and conventional instruction on students' motivation to learn mathematics. It further examines the potential contribution of context-based instructional design reinforced by digital media to motivational outcomes.
Methods: A quantitative quasi-experimental design was employed involving three intact classes: an experimental class implementing RME with Wordwall, an experimental class implementing RME without Wordwall, and a control class receiving instruction without RME reinforcement. Students' mathematics learning motivation was measured using a validated questionnaire, and the data were analyzed descriptively and inferentially using independent samples t-tests to compare motivation levels across groups.
Result: The findings indicate significant differences in mathematics learning motivation between the experimental and control groups. Both classes exposed to RME-based instruction demonstrated higher motivation than the control class, with the class using RME reinforced by Wordwall showing the highest levels of motivation, suggesting that the integration of digital game-based media further enhances student engagement.
Conclusion: The findings indicate that context-based RME reinforced with Wordwall was associated with higher mathematics learning motivation than conventional instruction among the junior high school students examined, suggesting a potential contribution of instructional design quality to students' motivational engagement.

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INTRODUCTION

Learning motivation is widely recognized as an important factor associated with students' cognitive engagement, perseverance, and quality of understanding (Khozaei et al., 2022; Rubio et al., 2022). Students with high motivation tend to be more active, persistent in facing difficulties, and willing to explore various problem-solving strategies (Rubio et al., 2022). Conversely, low motivation is often associated with avoidance attitudes toward mathematics and suboptimal learning performance (Gaspard et al., 2023; Radišić et al., 2026). Within mathematics education specifically, motivation has also been linked to students' engagement in higher-order thinking processes such as problem-solving and mathematical reasoning, although this relationship is best understood as one

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of several contributing factors rather than a singular determinant (Rubio et al., 2022). These findings suggest that strengthening students' motivation to learn mathematics remains a relevant concern for improving instructional quality, particularly in classroom contexts where mathematics is still taught through procedural and decontextualized approaches that offer limited opportunities for meaningful engagement.

However, in classroom practice, the TIMSS 2023 international report indicates that nearly half (46%) of eighth-grade students worldwide reported that they "do not like" learning mathematics, reflecting a persistent perception of mathematics as difficult, abstract, and disconnected from students' daily experiences This perception develops alongside the dominance of learning approaches that emphasize procedures, symbols, and routine problem-solving (Lahdenperä et al., 2022). In such situations, students often focus on the final answers without understanding the underlying conceptual meaning (Kafetzopoulos & Psycharis, 2022). As a result, mathematics learning activities are viewed as academic obligations rather than meaningful intellectual processes (Dreyfus, 2018; Sormunen et al., 2020). This condition is associated with low interest and motivation to learn mathematics. The motivation problem becomes even more critical when students are confronted with material that demands conceptual understanding and reasoning (Baten et al., 2026; Lu et al., 2026; Täht et al., 2024). Therefore, a learning approach is needed that can change the way students make meaning of mathematics.

Among the various factors contributing to this condition, the pedagogical approach employed is often considered one of the influencing elements, alongside other affective and contextual factors. Conventional teacher-centered learning approaches often limit opportunities for student exploration and active participation (Dawkins & Cook, 2017). Learning interactions in such settings tend to be one-way, with the teacher as the primary source of knowledge. In this context, students may act as recipients of information rather than meaning-makers (Moore et al., 2024). Such learning patterns provide little opportunity for students to connect mathematics to the reality they know (Walkington et al., 2024). When this connection is not established, students' intrinsic motivation may be less likely to develop, as they tend to engage with mathematics primarily to meet evaluative demands rather than to pursue conceptual understanding.

To overcome the limitations of conventional approaches, Realistic Mathematics Education (RME) was developed as an approach that places realistic contexts as the starting point for mathematics learning. RME views mathematics as a human activity that develops from efforts to understand and model real situations (Sevinc & Lesh, 2022). In RME learning, students are encouraged to explore contextual problems, develop informal strategies, and gradually move toward formal concepts (Fredriksen, 2021). In RME learning, students are encouraged to explore contextual problems, develop informal strategies, and gradually move toward formal concepts (Fredriksen, 2021). This process provides room for students to actively participate and experience the relevance of mathematics (Voigt et al., 2020). Accordingly, RME may be theoretically positioned as an instructional approach with the potential to foster the psychological conditions associated with intrinsic motivation, rather than a guaranteed pathway to motivational growth.

Along with the growing utilization of technology in learning, interactive digital media have begun to be used to strengthen student engagement and motivation (Clark-Wilson et al., 2020; Kärki et al., 2022; Swidan et al., 2022). One medium that has been empirically reported to increase student motivation and engagement across various subjects, including mathematics-related instructional contexts, is Wordwal, , which provides interactive game-based learning activities with immediate feedback. Wordwall enables students to interact actively through quizzes, challenges, and simple yet responsive visual activities. In mathematics learning, these characteristics potentially increase students' attention, interest, and engagement during the learning process. Specifically, the game-based competitive elements and instant response features of Wordwall are theorized to support motivational mechanisms identified in self-determination theory namely, students' sense of competence through immediate performance feedback and autonomy through self-paced interactive engagement both of which are associated with the development of intrinsic motivation. The integration of Wordwall into RME learning can strengthen the exploration of realistic contexts through more engaging and participatory activities. Thus, Wordwall functions as a support for the learning environment that facilitates learning motivation, not merely as a technical aid.

However, this theoretical account has not yet been comprehensively tested through empirical studies that jointly consider RME, interactive digital media, and students' motivation to learn mathematics. Recent quasi-experimental research has reported that Wordwall-based gamification can significantly enhance students' motivation toward learning mathematics at primary and lower-secondary levels, both when used as a stand-alone medium and when embedded in cooperative or gamified models (Armiati et al., 2022; Sevinc & Lesh, 2018; Voigt et al., 2020). Taken together, these findings indicate that although both RME and Wordwall have shown promise in improving mathematics-related outcomes, prior research has not isolated the incremental effect of Wordwall within an explicitly RME-based instructional design, nor has it compared RME-with-Wordwall, RME-without-Wordwall, and conventional instruction within a single study. In addition, most existing Wordwall studies employ two-group or pre-experimental designs, focus on achievement as the primary outcome, and treat motivation as a secondary or non-focal variable, which limits conclusions about how different instructional configurations shape students' motivation to learn mathematics. Against this backdrop, the present quasi-experimental study specifically tests whether Wordwall-assisted RME, RME without Wordwall, and conventional instruction differentially affect junior high school students' motivation to learn mathematics, thereby addressing the absence of studies that simultaneously compare these three instructional conditions within a theoretically grounded RME–Wordwall framework

This study aims to compare students' mathematics learning motivation across three instructional conditions: Realistic Mathematics Education (RME) assisted by Wordwall, RME without Wordwall, and conventional instruction. Specifically, the study examines whether students exposed to these three instructional approaches demonstrate different levels of mathematics learning motivation and whether the integration of Wordwall provides an additional motivational contribution beyond RME alone. By positioning students' mathematics learning motivation as the primary outcome, this study seeks to provide empirical evidence regarding the potential role of context-based mathematics instruction and interactive digital media in supporting students' motivational engagement in mathematics learning.

LITERATURE REVIEW

Although RME has been widely implemented, recent meta-analyses and systematic literature reviews indicate that the majority of empirical RME studies have examined outcomes such as conceptual understanding, problem-solving, and other cognitive indicators, with relatively fewer studies explicitly targeting motivational constructs. Such findings show that context-based learning helps students build mathematical meaning more deeply (Fredriksen, 2021; Putranto & Marsigit, 2018; Sevinc & Lesh, 2018; Voigt et al., 2020). At the same time, the affective domain has typically appeared as a secondary or ancillary outcome in only a subset of studies, suggesting that motivational effects of RME remain less systematically documented than cognitive effects. This pattern points to a research gap regarding how RME-based instructional designs relate to students' mathematics learning motivation. Within contemporary motivational frameworks such as self-determination theory and expectancy–value theory, motivation is conceptualized as a mediating process linking students' learning experiences to their subsequent engagement and achievement. Accordingly, examining mathematics learning motivation in RME settings responds both to the documented emphasis on cognitive outcomes and to theoretical accounts that position motivation as an important mediator between instructional experiences and learning outcomes

Theoretically, motivation to learn mathematics is formed through the interaction between students, tasks, and the learning environment (Beswick et al., 2023; Khozaei et al., 2022; Middleton et al., 2023). From the perspective of contemporary motivation theories such as self-determination theory and expectancy–value theory, these interactions shape students' perceived competence and task value, which are key determinants of their autonomous motivation to engage in mathematics learning. When students are confronted with meaningful problems relevant to their lives, their curiosity and learning engagement tend to increase. RME provides these conditions using realistic contexts and reflective discussions. The integration of interactive media such as Wordwall can be theoretically expected to complement this process by providing immediate feedback and opportunities for self-paced practice that may support students' perceived competence and sustained engagement. Within this framework, RME supported by interactive digital media is better conceptualized as an instructional design with a theoretically grounded potential to influence students' motivation to learn mathematics, rather than as a mechanism whose motivational effects have been established empirically in this study.

METHOD

Research Design

This study employed a quantitative quasi-experimental design, specifically a pretest–posttest non-equivalent control group design. The research was conducted in Central Part of Indonesia. Schools were first selected purposively based on the availability of parallel classes with comparable curricula and students' academic backgrounds. Within the selected school, three intact classes at the same grade level were then assigned to the three instructional conditions (Wordwall-assisted RME, RME without Wordwall, and conventional instruction) using a simple random procedure (lottery) at the class level. The research implementation took place at the end of the semester, including preparation stages, treatment delivery, and final data collection. The learning material was adjusted to the applicable curriculum and taught by the same teacher across the three classes to maintain consistency in instruction. The learning environment was conditioned similarly to minimize the influence of external variables. All learning activities were conducted face-to-face, thereby representing regular mathematics learning conditions at the junior high school level.

Participant

The target population of this study comprised seventh-grade students in public junior high schools in the central region of Indonesia. The accessible population consisted of all seventh-grade students at one public junior high school that met the criteria of having parallel classes with comparable curricula and students' academic backgrounds. From this accessible population, a cluster sample of three intact seventh-grade classes (totaling 66 students) was selected. The three classes were then assigned at the class level to the Wordwall-assisted RME condition (Experimental Group 1), the RME-without-Wordwall condition (Experimental Group 2), and the conventional-instruction condition (Control Group) using a simple random procedure (lottery). Each class consisted of 22 students, so the total number of participants included in the analysis was 66 students. Experimental Group 1 received Realistic Mathematics Education (RME) supported by Wordwall, Experimental Group 2 received RME without Wordwall, and the Control Group received conventional teacher-centered instruction without RME or Wordwall. All participants completed the mathematics learning motivation questionnaire at both the pretest and posttest stages, and no cases were excluded from the analysis.

Table 1. Participants' Demographic Characteristics

Group	Number of students	Male	Female
Experimental 1	22	11	11
Experimental 2	22	10	12
Control	22	11	11
Total	66	32	34

Instruments

The research instruments included a questionnaire to examine students' motivation in learning mathematics, teacher activity observation sheets, student activity observation sheets, and a teaching module. The questionnaire consisted of 17 statements developed based on six indicators of learning motivation. Each indicator was represented by both positive and negative statements, which students responded to using a five-point Likert scale. The content validity of all instruments was evaluated through expert judgment by three validators who had expertise in mathematics education and educational measurement (one senior mathematics education lecturer, one educational psychologist, and one assessment specialist). Each expert rated the relevance of the items using a 5-point scale, and Aiken's V index was computed for each instrument. Following commonly used criteria, values above 0.80 were interpreted as indicating high to very high content validity (Aiken, 1985; Retnawati, 2016). As shown in Table 2, all instruments obtained Aiken's V values between 0.80 and 0.94, which fall within this range.

Instrument reliability was assessed using Cronbach's alpha coefficient. The motivation questionnaire yielded an alpha of 0.67, which can be interpreted as acceptable internal consistency for a newly developed scale in early-stage research, while the other instruments showed good to excellent reliability ($\alpha = 0.78 - 0.92$). This interpretation follows commonly cited reference values in which $\alpha \geq 0.70$ is considered acceptable and values in the $0.60 - 0.70$ range are viewed as borderline but usable for exploratory purposes. The validity and reliability results are summarized in Table 1, and the indicators of the motivation questionnaire are presented in Table 3.

Table 2. Validity and Reliability of the Instruments

Instrument	Aiken's V	Category of Validity	Alpha Cronbach	Category of Reliability
Motivation Questionnaire	0.94	Extremely Valid	0.67	High
Teacher observation sheets	0.80	Valid	0.88	Extremely high
Student observation sheets	0.94	Extremely Valid	0.78	High
Teaching Module	0.88	Extremely Valid	0.92	Extremely high

Table 3. Indicators and Statement Items of the Mathematics Learning Motivation Questionnaire

No	Indicator	Description of Indicator
1	Desire to succeed	Students' internal drive to understand the material and complete math assignments responsibly
2	Drive and need for learning	Students' interest and curiosity in learning mathematics
3	Future hopes and aspirations	Students' beliefs in the benefits of mathematics for their goals and future
4	Reward for learning	Student responses to recognition and achievement of mathematics learning outcomes
5	Interesting learning activities	Students' perceived interest in mathematics learning activities (e.g., contextual tasks, discussions, and use of learning media), independent of any specific tool or treatment condition.
6	Conducive learning environment	Comfort and support of the learning environment in mathematics learning

Procedures

This study employed a quasi-experimental pretest–posttest non-equivalent control group design involving three intact classes: Wordwall-assisted RME (Experimental Group 1), RME without Wordwall (Experimental Group 2), and conventional instruction (Control Group). At the initial stage, all participants in the three classes completed a pretest measuring their motivation to learn mathematics. During the intervention phase, Experimental Group 1 received Realistic Mathematics Education (RME) learning supported by Wordwall, Experimental Group 2 received RME learning without Wordwall, and the Control Group followed conventional teacher-centered instruction without RME or Wordwall over four sessions. The learning process in all classes was monitored using teacher and student activity observation sheets to document adherence to the planned instructional procedures. After all treatments were completed, all participants completed a posttest on mathematics learning motivation. All learning procedures (topic, time allocation, and assessment schedule) were implemented consistently across the three classes, and the same teacher taught all classes to minimize differences in teaching style and enhance treatment fidelity. Although the intervention spanned only four sessions, this duration was chosen to align with the school's scheduling constraints; accordingly, the observed motivational effects should be interpreted as short-term changes rather than long-term stability in students' motivation.

Data Analysis

Data analysis in this study was conducted using descriptive and inferential statistics to obtain a comprehensive overview of the learning process and outcomes. Descriptive statistics were used to analyze the implementation of learning and the profile of students' mathematics learning motivation. Observation data of teacher and student activities were analyzed by calculating the percentage of implementation for each session, which were then classified into categories of very poor, poor, fair, good, and very good based on pre-established interpretative criteria. This analysis aimed to ensure that Realistic Mathematics Education (RME) was implemented consistently across all classes. Additionally, descriptive analysis was used to describe students' mathematics learning motivation scores during the pretest and posttest stages. These results provided an initial overview of the changes in motivation after the learning intervention.

Data from the mathematics learning motivation questionnaire were analyzed based on scoring on a five-point Likert scale, with reverse scoring applied to negative statements. Each student's total motivation score was calculated by summing all item scores and then converted into a percentage. The percentages were classified into categories of very low, low, moderate, high, and very high motivation. This analysis was conducted to depict the level of students' mathematics learning motivation before and after treatment. Furthermore, the comparison of mean motivation scores between groups served as the basis for inferential analysis. Thus, descriptive analysis functioned as the foundation for interpreting the results of subsequent statistical tests.

Prior to hypothesis testing, the data were first subjected to prerequisite statistical tests, including normality and homogeneity tests. The normality test was conducted to ensure that the mathematics learning motivation data in each group was normally distributed. This test was carried out using IBM SPSS Statistics software at a significance level of 0.05. The data were considered normally distributed if the significance value was greater than 0.05. Subsequently, the homogeneity test was performed to determine the equality of variances among the groups. Data were considered homogeneous if the significance value of the homogeneity test was greater than 0.05.

Once the prerequisites were met, hypothesis testing was conducted using an independent samples t-test. This test was used to compare the mathematics learning motivation scores between the experimental group and the control group at the posttest stage. In this study, the two experimental classes were combined into a single experimental group because they received the same treatment, while one class served as the control group. The testing was conducted at a 0.05

significance level. The decision was based on the significance value (Sig. 2-tailed) resulting from the statistical test; if the significance value was less than or equal to 0.05.

RESULTS AND DISCUSSION

Results

Descriptive Data on Students' Learning Motivation

Descriptive statistical analysis was conducted to provide an initial overview of students' profiles regarding their motivation in learning mathematics across the three research groups, before and after the intervention. This analysis focused on comparing the means and distributions of pretest and posttest scores to identify patterns of change in learning motivation within each group. The presentation of descriptive statistics was intended to summarize the initial status of motivation in each group and to illustrate general tendencies of change following the intervention, rather than to infer baseline equivalence or treatment effects. Thus, the results of the descriptive analysis formed an important foundation for hypothesis testing in subsequent inferential analyses.

Data in Table 4 show that the three groups had nearly identical mean pretest scores, with very small differences and relatively comparable standard deviations. These descriptive findings suggest that, at the pretest stage, students in the three groups had broadly similar levels of mathematics learning motivation; formal tests of pre-intervention differences and baseline-adjusted treatment effects are reported in the inferential analysis section. Accordingly, any conclusions about the impact of the different instructional conditions on posttest motivation are based on the results of the inferential models rather than on descriptive similarity alone.

Following the intervention, all groups experienced increases in learning motivation scores; however, the magnitude of improvement showed differing patterns. Experimental Group 1, which applied Realistic Mathematics Education assisted by Wordwall, achieved the highest mean posttest score, followed by Experimental Group 2, which applied RME without Wordwall, and lastly the control group. These rankings are descriptive and serve only to indicate the relative ordering of group means; statistical comparisons among all three groups are presented in the subsequent inferential analysis to determine whether these descriptive differences are meaningful. Standard deviations at pretest and posttest are reported in Table 4 to characterize score dispersion, but no claims are made about individual improvement solely on the basis of changes in standard deviation.

Table 4. Descriptive Statistics of Students' Motivation Scores

Group	N	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Experimental 1 (RME with Wordwall)	22	68,45	7,38	84,12	5,96
Experimental 2 (RME without Wordwall)	22	67,98	7,51	80,60	6,34
Control	22	67,84	7,62	74,19	6,95

The posttest mean scores differed descriptively across the three instructional groups. At this stage, these differences should be interpreted only as patterns in the observed data and not as evidence of intervention effects. Experimental Group 1, which received Realistic Mathematics Education (RME) assisted by Wordwall, had a higher posttest mean score than Experimental Group 2, which received RME without Wordwall. However, whether this observed difference represents a statistically meaningful difference between Wordwall-assisted RME and RME without Wordwall is examined through the direct pairwise comparison reported in the subsequent inferential analysis.

Similarly, the descriptive ordering of posttest means across the Wordwall-assisted RME, RME-without-Wordwall, and conventional-instruction groups does not by itself establish the relative effectiveness of the three instructional conditions. The potential contribution of Wordwall beyond

RME alone, as well as the differences between each RME condition and conventional instruction, is evaluated using the omnibus and post-hoc inferential tests. Because instructional-design quality and classroom support were not measured as separate variables in this study, no interpretation is made regarding their independent roles in students' motivation to learn mathematics. These descriptive findings provide an initial empirical basis for hypothesis testing through inferential analysis in the subsequent stages

Distribution of Mathematics Learning Motivation Categories

To clarify changes in the level of mathematics learning motivation, posttest scores were classified into motivation categories based on predetermined criteria. This grouping aims to observe the substantive shift in the quality of students' learning motivation, not just through average scores. The classification results show a noticeable difference in the distribution of motivation categories between the experimental groups and the control group. In the experimental groups, most students fall into the high and very high motivation categories. Conversely, the motivation distribution in the control group is still spread across moderate to low categories. The distribution of mathematics learning motivation categories at the posttest stage is presented in Table 5.

Table 5. Distribution of Mathematics Learning Motivation Categories (Posttest)

Category of Motivation Level	Experimental (%)	Control (%)
Very high	45.45	18.18
High	43.18	36.36
Moderate	11.37	36.36
Low–very low	0.00	9.10

The distribution of motivation categories shows that almost all students in the experimental groups fall into the high and very high motivation categories. Within the observed sample, no students in the experimental groups were classified in the low or very low motivation categories at the posttest stage. This result describes the distribution of posttest motivation scores across the predefined categories and should not, by itself, be interpreted as evidence that RME promoted motivation evenly among all students. Conversely, the control group still shows a considerable proportion of students in the moderate motivation category, with a small portion even in the low motivation category. This descriptive pattern indicates that the posttest category distribution in the control group differed from that of the two experimental groups; however, it does not establish the magnitude or statistical significance of differences between instructional conditions.

The observed differences in category distributions are reported as a descriptive complement to the continuous-score results presented in Table 5. Conclusions regarding differences in students' motivation to learn mathematics across Wordwall-assisted RME, RME without Wordwall, and conventional instruction are based on the subsequent omnibus and pairwise inferential analyses. Thus, the category frequencies are used to describe the distribution of students' observed motivation scores, rather than to claim a qualitative shift or comparative effectiveness of a particular instructional condition.

Descriptive Visualization of Changes in Learning Motivation

Visually, the difference in the increase of mathematics learning motivation can be described by comparing by comparing the mean pretest and posttest scores across the three research groups: Experimental Class 1, Experimental Class 2, and Control Class. Experimental Class 1, which implemented Realistic Mathematics Education (RME) with the support of Wordwall, showed the highest increase in mean scores from pretest to posttest. Experimental Class 2, which applied RME without Wordwall, also showed higher posttest mean scores than pretest mean scores; however, its observed mean-score increase was smaller than that of Experimental Class 1.. In contrast, the Control Class showed a more moderate increase in mean scores compared to the two experimental groups. These visual differences in raw pretest-to-posttest mean-score changes should be interpreted descriptively and do not, by themselves, establish that RME or Wordwall-assisted RME had a stronger effect on students' motivation to learn mathematics. The figure shows an observed pattern in which the two RME-based groups, particularly the Wordwall-assisted RME group, had larger mean-score increases than the conventional-instruction group. Whether these differences across the three instructional conditions are statistically significant is determined through the subsequent inferential analysis, including the omnibus comparison and direct pairwise comparisons. Accordingly, the visual display serves to complement, rather than substitute for, the statistical evidence regarding differences in mathematics learning motivation

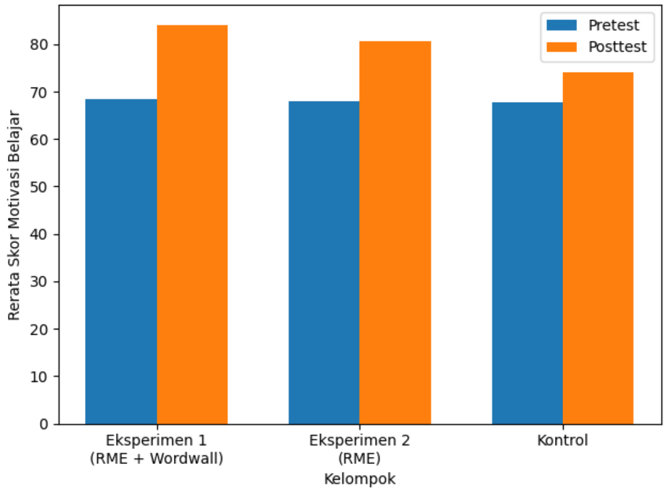

Figure 1. Learning Motivation Mean Scores

Prerequisite Analysis Testing

Before conducting hypothesis testing, the mathematics learning motivation data were first tested to meet the assumptions of parametric statistical analysis, namely the normality of data distribution and homogeneity of variances across groups. This prerequisite testing aims to ensure that the inferential analysis technique used is appropriate for the characteristics of the data. All tests were conducted using IBM SPSS Statistics software with a significance level of 0.05.

The normality test was used to assess whether the mathematics learning motivation data in each group were normally distributed. Meanwhile, the homogeneity test was conducted to determine the equality of variances among the research groups. The results of these prerequisite tests provided the basis for determining the feasibility of using parametric statistical tests in the subsequent analysis stages.

The normality test employed was the Shapiro–Wilk test because the sample size in each group was fewer than 50. This test was applied separately to the posttest mathematics learning motivation scores of all three instructional groups: Experimental Group 1 (Wordwall-assisted RME), Experimental Group 2 (RME without Wordwall), and the Control Group (conventional instruction).. The decision criterion was that the data were considered normally distributed if the significance value (Sig.) was greater than 0.05. The test results showed that the significance values for all groups were above the established significance threshold. Therefore, the mathematics learning motivation data in all groups met the normality assumption. The normality test results are summarized in Table 6.

Table 6. Normality Test Results of Posttest Scores in Mathematics Learning Motivation

Group	Shapiro–Wilk Statistics	Sig.	Decision
Experimental 1 (RME + Wordwall)	0.963	0.412	Normal
Experimental 2 (RME without Wordwall)	0.958	0.367	Normal

Control	0.969	0.521	Normal

After the normality assumption was met, a homogeneity of variance test was conducted using Levene's Test. This test aimed to ensure that the variances of mathematics learning motivation scores across groups are homogeneous. The decision criterion states that the data are considered to have homogeneous variances if the significance value is greater than 0.05. The test results showed that the significance value of Levene's test was above 0.05. Therefore, the variances of learning motivation data among the groups can be considered homogeneous. A summary of the homogeneity test results is presented in Table 7.

Table 7. Homogeneity Test Results of Posttest Scores for Learning Motivation

Statistical Testing	F	Sig.	Decision
Levene's Test	1.214	0.304	Homogeneous

Based on the results of the normality and homogeneity tests, the mathematics learning motivation data across the three research groups meet all assumptions of parametric statistics. The normal data distribution and homogeneous variances indicate that the data are suitable for analysis using parametric inferential tests. Therefore, a one-way analysis of variance (ANOVA) was conducted to compare posttest mathematics learning motivation scores across the three instructional conditions: Wordwall-assisted RME, RME without Wordwall, and conventional instruction. When the omnibus ANOVA indicated a statistically significant difference, Tukey's honestly significant difference (HSD) post-hoc test was used to identify the specific pairs of groups that differed. The results were reported with the F statistic, degrees of freedom, p-value, and an effect-size estimate (η^2), together with 95% confidence intervals where available. Meeting these assumptions supported the appropriateness of the planned ANOVA and post-hoc comparisons; however, the substantive conclusions regarding group differences were based on the inferential test results presented in the following section.

Hypothesis Testing Results

Hypothesis testing was conducted using an independent samples t-test on the posttest scores of mathematics learning motivation. This test aimed to identify differences in learning motivation among students after experiencing varied instructional conditions. The analysis results show a statistically significant difference between the groups compared, as presented in Table 8.

Table 8. Independent Samples t-Test Results for Mathematics Learning Motivation

Comparison of Groups	*t*	Sig. (2-tailed)
Experimental vs Control	4.21	0.000

The significance value (Sig. 2-tailed) obtained was less than 0.05, thus the null hypothesis was rejected. These results indicate that there is a significant difference in mathematics learning motivation between the experimental groups and the control group. The experimental groups consisted of two classes: Experimental Class 1, which implemented Realistic Mathematics Education (RME) with the support of the Wordwall media, and Experimental Class 2, which implemented RME without Wordwall support. The control group received learning without RME-based reinforcement. These findings suggest that RME-oriented learning, especially when reinforced with interactive digital media such as Wordwall, contributes to an increase in students' mathematics learning motivation compared to learning without such reinforcement.

The study results indicate that Realistic Mathematics Education (RME) learning significantly contributes to the increase in students' mathematics learning motivation. This increase is consistently reflected across several indicators, including the average motivation scores, shifts in motivation category distribution, and inferential test results showing meaningful differences between the treatment groups and the control group. Descriptively, the experimental groups exhibited higher average motivation scores compared to the control group. Moreover, the distribution of motivation categories showed a clear shift towards moderate and high motivation categories in the experimental groups, while the control group tended to remain in the low to moderate categories. This pattern suggests that RME-based learning not only raises mean scores but also expands the number of students with more positive learning motivation. Inferential test results reinforce these descriptive findings by demonstrating statistically significant differences between the experimental and control groups. These findings indicate that the increase in mathematics learning motivation was not due to chance but was related to the characteristics of the learning approach applied in this study.

Discussion

The observed differences in students' motivation to learn mathematics across the instructional conditions suggest that students' motivational responses may be associated with the learning experiences provided during mathematics instruction. However, because the study used intact classes in a quasi-experimental design and measured motivation as the primary outcome, the findings should be interpreted as baseline-adjusted differences in motivation across the instructional conditions rather than definitive evidence that a particular instructional feature caused changes in students' motivation. This interpretation is consistent with previous studies indicating that context-based mathematics instruction can be associated with stronger student engagement when mathematical tasks are perceived as relevant to students' everyday experiences (Ekowati et al., 2021; Fredriksen, 2021; Sevinc & Lesh, 2022). In this context, RME functions as a bridge between formal mathematical concepts and students' everyday experiences. The significance of this finding lies in the shift in how students make meaning of mathematics (Putranto & Marsigit, 2018; Voigt et al., 2020). Mathematics is no longer understood as a collection of abstract procedures but as an activity with purpose and meaning.

Previous literature shows that understanding learning goals plays an essential role in forming intrinsic motivation (Gaspard et al., 2023; Radišić et al., 2026; Rubio et al., 2022). This study's results reinforce this view by demonstrating that contextual meaning in RME promotes motivation stemming from students' cognitive and affective needs rather than external pressure. The findings of this study also indicate that mathematics learning motivation develops through students' active involvement in the knowledge construction process. RME provides space for students to explore, discuss, and reflect on mathematical ideas (Freeman et al., 2016; Kuper & Carlson, 2020; Rittle-Johnson, 2024). These instructional features offer a theoretically plausible account of the observed differences in students' motivation to learn mathematics; however, active knowledge construction, mathematical dialogue, and students' sense of ownership were not examined as mediating variables in this study.

The interpretation of the Wordwall component depends on the direct statistical comparison between the Wordwall-assisted RME and RME-without-Wordwall groups. If this comparison is statistically significant, it indicates that the Wordwall-assisted RME condition was associated with a higher adjusted posttest motivation score than RME without Wordwall. This result may be interpreted cautiously in relation to Wordwall's interactive response formats and immediate feedback, but the study did not measure students' engagement with the media, feedback use, or perceived competence. If the direct comparison is not statistically significant, the descriptively higher score in the Wordwall-assisted RME group should not be interpreted as evidence of an additional motivational effect of Wordwall beyond RME alone.

The observed differences should also be interpreted in light of competing explanations. Because the intervention was conducted over four sessions, the higher motivation scores in the Wordwall-assisted condition may partly reflect a novelty response to the digital medium. Differences in teacher attention, enthusiasm, pacing, or the fidelity of implementation across classes may also have influenced students' motivational responses, even though the same teacher taught all groups and common instructional procedures were used. Accordingly, the findings are limited to the short-term motivational outcomes observed under the specific implementation conditions of this study and do not isolate the independent mechanism through which Wordwall may have influenced motivation (Krawitz et al., 2026; Lu et al., 2026; Russo et al., 2025). Therefore, the contribution of digital media should be understood as part of a learning ecosystem, not as a singular factor.

From a pedagogical perspective, the findings suggest that teachers implementing RME may consider integrating interactive digital activities when these activities are aligned with contextual mathematical tasks and the planned learning objectives. RME provides a strong conceptual framework, while digital media supports its implementation in classroom practice (Putri et al., 2022). The combination of both creates a learning environment that is more responsive to students' needs, especially in maintaining interest and perseverance in learning mathematics. These results underscore that the quality of instructional design is more critical than just incorporating activities or exercises into the classroom. Another important implication relates to the role of the teacher. The teacher no longer serves solely as an information transmitter but as a designer of meaningful learning experiences (Jacobson, 2017; Middleton et al., 2023). This finding corresponds with literature emphasizing the importance of teachers' role in orchestrating context, interaction, and media use (Remillard et al., 2021; Swidan & Fried, 2021). Thus, the success of RME in enhancing motivation is more related to the quality of learning management than to the method itself.

Implications

Within the scope of this study, the findings indicate that students' motivation to learn mathematics differed across the three instructional conditions after adjustment for pretest motivation. The results do not provide direct evidence regarding broader 21st-century competencies, such as conceptual understanding, mathematical communication, or contextual problem-solving, because these outcomes were not measured (Csíkos & Szitányi, 2020). The observed motivational differences may nevertheless be relevant to future research examining whether motivation in context-based mathematics instruction is associated with students' engagement in higher-order mathematical activities. Such a relationship was not tested in the present study and should therefore be investigated using measures of both motivation and higher-order thinking. The specific contribution of this study is the comparison of junior high school students' motivation to learn mathematics across Wordwall-assisted Realistic Mathematics Education (RME), RME without Wordwall, and conventional instruction while accounting for pretest motivation. The findings provide evidence limited to the participating students, the mathematics topic taught, the four-session intervention period, and the specific classroom implementation conditions. The study does not demonstrate that instructional-design quality, teacher readiness, or any particular feature of RME or Wordwall independently determined students' motivation, because these variables were not measured as separate constructs. Accordingly, future research should examine these potential explanatory variables directly, use longer intervention periods, and assess whether observed differences in motivation persist beyond the initial implementation of interactive digital media.

Limitations and Suggestions for Future Research

This study has several limitations that should be considered when interpreting its findings. First, the study was conducted in only one public junior high school in Central Indonesia and involved a relatively small sample of 66 seventh-grade students distributed across three intact classes, which limits the generalizability of the findings to broader educational contexts. Second, the quasi-experimental design relied on intact classes rather than individual random assignment, meaning that unmeasured class-level characteristics may have contributed to the observed differences in students' mathematics learning motivation. Third, the intervention was implemented over only four instructional sessions; therefore, the findings primarily represent short-term motivational responses and cannot establish whether the observed differences would persist over a longer period. Fourth, although the study compared Wordwall-assisted RME, RME without Wordwall, and conventional instruction, it did not directly measure potential explanatory mechanisms such as perceived task relevance, autonomy, perceived competence, engagement with Wordwall, novelty effects, teacher attention, classroom interaction, or treatment fidelity. Consequently, the findings cannot determine which specific features of RME or Wordwall account for the observed differences in students' motivation. Future research should therefore replicate the three-condition design with larger samples drawn from multiple schools, grade levels, and educational settings to strengthen the external validity of the findings. Longer interventions accompanied by delayed follow-up measurements are also recommended to determine whether motivational differences remain stable after students become familiar with Wordwall and its novelty diminishes. Future studies should maintain separate Wordwall-assisted RME and RME-without-Wordwall conditions and employ baseline-adjusted analyses, effect sizes, and confidence intervals to provide more robust estimates of between-group differences. In addition, directly measuring potential mediating and implementation variables would help clarify how and under what classroom conditions Wordwall may provide an incremental motivational contribution beyond RME alone.

CONCLUSION

This study demonstrates that Realistic Mathematics Education (RME) significantly contributes to strengthening students' motivation to learn mathematics when implemented through a structured instructional design. Learning motivation does not merely arise as a response to learning activities but develops through experiences that enable students to perceive mathematics as a relevant and meaningful activity within real-life contexts. The findings affirm that context-based approaches play a crucial role in fostering students' intrinsic motivation, especially when they are actively engaged in exploring, discussing, and reflecting on mathematical ideas. The reinforcement of RME through interactive digital media further enriches students' learning experiences by providing visualizations, immediate feedback, and interactivity that support affective engagement throughout the learning process. Thus, mathematics learning motivation can be understood as the outcome of the interaction between pedagogical approaches and the quality of instructional design. The findings should be interpreted within several limitations. The study was conducted in one public junior high school in Central Indonesia and involved a small sample of 66 seventh-grade students distributed across three intact classes. In addition, the intervention was implemented over only four sessions. These conditions limit the generalizability of the findings to other schools, student populations, mathematics topics, and longer instructional periods. Because intact classes were used, unmeasured class-level characteristics may also have contributed to the observed differences, despite the adjustment for pretest motivation. Moreover, the study did not directly measure potential explanatory factors such as students' perceived relevance of mathematical tasks, autonomy, perceived competence, engagement with Wordwall, novelty responses to digital media, teacher attention, classroom interaction, or treatment fidelity. Therefore, the results should not be interpreted as demonstrating that any particular feature of RME, Wordwall, instructional design, or teacher learning management independently caused the observed differences in motivation.

Future research should replicate this three-condition comparison using larger samples from multiple schools and grade levels. Longitudinal pretest–posttest designs with delayed follow-up measurements are needed to determine whether motivational differences observed after a short intervention persist over time, particularly after the novelty of Wordwall has diminished. Further studies should maintain separate RME-with-Wordwall and RME-without-Wordwall conditions, apply baseline-adjusted analyses, report effect sizes and 95% confidence intervals, and directly measure potential explanatory variables. Such research would provide more precise evidence regarding the potential incremental contribution of Wordwall beyond RME alone.

AUTHOR CONTRIBUTIONS STATEMENT

Sirwanti conceived the study, developed the research design, coordinated the implementation of the study, conducted the data analysis, and drafted the manuscript. Naimah contributed to the development of the research instruments, data collection, interpretation of the findings, and manuscript preparation. Nurasrawati contributed to the implementation of the instructional treatments, data collection, and review of the manuscript. Nurmala contributed to the validation of the research instruments, interpretation of the results, and critical revision of the manuscript. Muhammad Ikram contributed to the research methodology, statistical analysis, interpretation of the findings, and final revision of the manuscript. All authors read and approved the final version of the manuscript.

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