



## The Effect of Wordwall on Bilingual Mathematics Learning Motivation in Elementary School

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**Abstract:** This study examined changes in elementary students' motivation after the implementation of Wordwall in bilingual mathematics learning. This study used a quantitative pre-experimental one-group pretest-posttest design. The participants were 28 fourth-grade students at MI Bilingual Roudlotul Jannah Sidoarjo, Indonesia. Data were collected using a learning motivation questionnaire based on Keller's ARCS model, which includes Attention, Relevance, Confidence, and Satisfaction. The instrument was validated using Pearson's Product-Moment correlation and tested for reliability using Cronbach's Alpha. The data were analyzed using descriptive statistics, N-Gain analysis, the Shapiro-Wilk normality test, a paired sample t-test, and Cohen's effect size. The findings showed that students' mean motivation score increased from 63.18 in the pretest to 87.79 in the posttest. The N-Gain score was 0.6794, indicating moderate improvement. The paired-samples t-test showed a significant difference between the pretest and posttest scores, and Cohen's *d* indicated a very large effect size. These findings suggest that Wordwall can serve as a promising interactive digital learning medium for supporting students' motivation in bilingual mathematics learning. However, because this study used a pre-experimental design without a control group, the results should be interpreted as evidence of motivational improvement within the observed classroom rather than as definitive causal proof of Wordwall's effectiveness.

**Keywords:** Wordwall; Learning Motivation; Bilingual Mathematics Learning; Elementary Education; Digital Learning Media

**Abstrak:** Penelitian ini mengkaji perubahan motivasi siswa sekolah dasar setelah penerapan Wordwall dalam pembelajaran matematika bilingual. Penelitian ini menggunakan pendekatan kuantitatif dengan desain pra-eksperimen one-group pretest-posttest. Partisipan penelitian adalah 28 siswa kelas IV MI Bilingual Roudlotul Jannah Sidoarjo, Indonesia. Data dikumpulkan menggunakan angket motivasi belajar berdasarkan model ARCS Keller, yang mencakup Attention, Relevance, Confidence, dan Satisfaction. Instrumen divalidasi menggunakan korelasi Pearson Product Moment dan diuji reliabilitasnya menggunakan Cronbach's Alpha. Data dianalisis menggunakan statistik deskriptif, analisis N-Gain, uji normalitas Shapiro-Wilk, paired sample t-test, dan effect size Cohen's *d*. Hasil penelitian menunjukkan bahwa skor rata-rata motivasi siswa meningkat dari 63,18 pada pretest menjadi 87,79 pada

*posttest. Skor N-Gain sebesar 0,6794 menunjukkan tingkat peningkatan sedang. Hasil paired sample t-test menunjukkan adanya perbedaan signifikan antara skor pretest dan posttest, sedangkan Cohen's dz menunjukkan besaran peningkatan yang sangat besar. Temuan ini menunjukkan bahwa Wordwall dapat menjadi media pembelajaran digital interaktif yang menjanjikan untuk mendukung motivasi siswa dalam pembelajaran matematika bilingual. Namun, karena penelitian ini menggunakan desain pra-eksperimen tanpa kelompok kontrol, hasil penelitian perlu ditafsirkan sebagai bukti peningkatan motivasi dalam kelas yang diamati, bukan sebagai bukti kausal yang definitif atas efektivitas Wordwall.*

**Kata kunci:** *Wordwall; Motivasi Belajar; Pembelajaran Matematika Bilingual; Pendidikan Dasar; Media Pembelajaran Digital.*

## **Introduction**

Learning motivation is an important factor in elementary education because it influences students' attention, persistence, participation, and willingness to engage in classroom activities (Chang, 2021; Fakhriyah & Assegaf Baalwi, 2025). In mathematics learning, motivation becomes particularly important because students often perceive mathematics as abstract, difficult, and less connected to their daily experiences. Low motivation may reduce students' participation and make them less confident in solving mathematical problems. Previous studies have shown that students' motivation is closely related to engagement, achievement, and persistence in mathematics learning (Ryan & Deci, 2020; Schukajlow et al., 2023). Therefore, teachers need learning strategies and media that can make mathematics more engaging, meaningful, and accessible for young learners.

The challenge becomes even more complex in bilingual mathematics learning, where students must simultaneously develop mathematical understanding and process mathematical vocabulary and classroom instructions across multiple languages. This dual demand may increase students' cognitive load and reduce their confidence when the learning media they use do not adequately support them. Previous research has emphasized that language plays an important role in mathematics learning because students need to interpret mathematical vocabulary, symbols, representations, and classroom discourse simultaneously (Barwell, 2020). For elementary students, bilingual mathematics learning therefore requires instructional support that connects visual representations, language use, mathematical meaning, and active participation.

The development of digital learning media provides opportunities to address these challenges. Interactive digital media can help teachers create learning activities that are more visual, participatory, and responsive to students' learning needs (Emilia et al., 2024). In mathematics classrooms, digital game-based learning and gamification have received increasing attention because they can integrate learning content with game elements such as challenge, feedback, scores, competition, and achievement. Recent studies show that

gamification and digital game-based learning can support students' motivation, engagement, and academic performance when game elements are integrated meaningfully into instructional activities (Jaramillo-Mediavilla et al., 2024; Lampropoulos & Sidiropoulos, 2024; Zheng et al., 2024). In primary mathematics learning, game-based approaches are also considered useful because they can make abstract concepts more concrete and enjoyable for students (Russo et al., 2024; Widiasari et al., 2024).

One digital platform that supports interactive learning is Wordwall. Wordwall enables teachers to create a variety of learning activities, including quizzes, matching tasks, word games, and interactive exercises (Zulfah, 2023). These features allow teachers to present learning materials in a more engaging format and provide students with immediate responses during the learning process (Oktiani, 2017). In mathematics learning, Wordwall can reinforce conceptual understanding, vocabulary recognition, and students' active involvement through game-like activities. Previous studies have shown that Wordwall can improve students' interest, engagement, and motivation in learning (Fadhilah & Nurmalasari, 2025; Permana & Kasriman, 2022; Saputri & Hadiyanti, 2025; Yulianto et al., 2024). However, most existing studies have examined Wordwall in general classroom contexts or monolingual learning environments.

To better understand students' motivation, this study uses Keller's ARCS motivational model as its theoretical framework. The ARCS model consists of four dimensions: Attention, Relevance, Confidence, and Satisfaction (Keller, 2010; Sari & Afrini Rahmi, 2023). This model is relevant for analyzing the use of Wordwall because interactive digital media may attract students' attention, connect learning activities to students' needs, increase confidence through practice and feedback, and create satisfaction through enjoyable learning experiences (Zahroh & Sutriyani, 2025; Wahyudi et al., 2025). In addition, the visual and interactive features of Wordwall align with multimedia learning principles, which emphasize the role of well-designed verbal and visual information in supporting learning (Mayer, 2020).

Although scholars have widely discussed digital game-based learning, empirical evidence on Wordwall in bilingual mathematics instruction at the elementary Islamic school level remains limited. Previous studies have mainly examined general learning motivation, students' interest, or mathematics achievement in non-bilingual contexts. However, few studies have explored how Wordwall supports students' motivation when they learn mathematical concepts and bilingual terminology simultaneously. This gap is important because bilingual mathematics learning requires media that can support both conceptual understanding and motivational engagement.

Therefore, this study aims to examine changes in students' motivation after the implementation of Wordwall in bilingual mathematics learning at MI Bilingual Roudlotul Jannah Sidoarjo, Indonesia. Specifically, this study

investigates whether students' motivation differs before and after using Wordwall and to what extent it improves after the intervention. By integrating Wordwall into bilingual mathematics learning and interpreting students' motivation through the ARCS framework, this study contributes to the literature on technology-enhanced learning, digital game-based learning, and motivation in elementary mathematics education.

### **Method**

This study used a quantitative approach with a pre-experimental one-group pretest-posttest design. This design allowed the researchers to compare students' motivation before and after the Wordwall intervention (Saputri & Hadiyanti, 2025). However, because the study did not include a control group, the researchers interpret the findings cautiously. Therefore, this study presents Wordwall as associated with increased students' motivation rather than as definitively effective. The researchers conducted the study at MI Bilingual Roudlotul Jannah Sidoarjo with fourth-grade students. The population consisted of 52 students, and the researchers selected 28 participants through purposive sampling.

This study examined two variables: Wordwall use as the independent variable and students' learning motivation as the dependent variable. The researchers collected data using a learning motivation questionnaire based on Keller's ARCS model (2010). The questionnaire contained 15 items on a 4-point Likert scale, ranging from 1 = strongly disagree to 4 = strongly agree. The items covered all ARCS components.

Before the main survey, the researchers tested the instrument's validity and reliability through a pilot study involving 25 students. They examined item validity using Pearson's Product-Moment correlation. The results showed that all items met the validity criteria, with correlation coefficients ranging from 0.42 to 0.78, which exceeded the *r*-table value of 0.396 (Arikunto, 2020). The reliability test using Cronbach's Alpha produced a coefficient of 0.87, indicating high internal consistency ( $\geq 0.70$ ) (Hair et al., 2019).

The teacher used Wordwall in four bilingual mathematics lessons on plane geometry. The learning process began with a pretest to measure students' initial motivation. The teacher then explained mathematical concepts and integrated Wordwall as an interactive learning tool. The activities included quizzes, matching tasks, and educational games with time limits, scores, and competitive elements. Students worked individually and in groups, while the teacher guided reflection and peer feedback. After the intervention, the researchers administered the posttest using the same questionnaire.

The researchers analyzed the data using descriptive statistics, including mean and standard deviation. They also conducted an N-Gain analysis, the Shapiro-Wilk normality test, and a paired-samples *t*-test. The study used a significance

level of  $\alpha = 0.05$ . The researchers calculated the N-Gain score using the following formula:

$$\text{N-Gain} = \frac{(\text{Posttest Score} - \text{Pretest Score})}{(\text{Maximum Score} - \text{Pretest Score})}$$

To complement the significance test, the researchers calculated Cohen's  $d_z$  because the study involved paired measurements from the same participants. They used Cohen's  $d$  to determine the magnitude of the difference in students' motivation before and after the intervention, using the formula  $d_z = t / \sqrt{N}$ . The researchers interpreted the effect size as the magnitude of the pretest-posttest improvement, rather than as definitive causal evidence, because the study used a pre-experimental design without a control group.

The researchers addressed ethical considerations by obtaining permission from the school principal and informed consent from students and their parents. They ensured voluntary participation, maintained data confidentiality, and used the collected data only for research purposes.

## Result

The study's findings, including students' pre- and post-intervention scores on motivation, are presented in this section. Data for the study were collected from 28 fourth-grade students using descriptive and inferential statistical methods.

### 1. Descriptive Statistics of Students' Learning Motivation

The descriptive analysis compared students' motivation scores before and after the implementation of Wordwall in bilingual mathematics learning. Table 1 reports the pretest and posttest results.

**Table 1. Descriptive Statistics of Students' Learning Motivation**

Test	N	Minimum	Maximum	Mean	Standard Deviation
Pretest	28	50	78	63.18	6.976
Posttest	28	80	100	87.79	6.724

Table 1 shows that students' mean motivation score increased from 63.18 in the pretest to 87.79 in the posttest. This indicates that students demonstrated higher motivation after participating in bilingual mathematics learning supported by Table 1 shows that students' mean motivation score increased from 63.18 in the pretest to 87.79 in the posttest. The findings indicate that students demonstrated higher motivation after participating in bilingual mathematics learning supported by Wordwall. The standard deviation also decreased slightly from 6.976 to 6.724, suggesting that students' motivation scores became more homogeneous after the intervention.

### 2. N-Gain Analysis

The N-Gain analysis examined the improvement in students' motivation after the Wordwall intervention. Table 2 presents the results.

**Table 2. N-Gain Result of Students' Learning Motivation**

Variable	N	Minimum	Maximum	Mean N-Gain	Category
Students' Learning Motivation	28	0.35	1.00	0.6794	Moderate

The mean N-Gain score was 0.6794, which falls into the moderate category. This result indicates that using Wordwall was associated with a moderate improvement in students' motivation during bilingual mathematics learning. Although the increase was substantial in terms of score difference, the N-Gain classification suggests that the improvement remained within the moderate range.

### 3. Normality Test

The researchers used the Shapiro-Wilk test to assess data normality before conducting the paired-samples t-test. Table 3 presents the results.

**Table 3. Shapiro-Wilk Normality Test Result**

Variable	Shapiro-Wilk Sig.	Interpretation
Pretest	0.463	Normal
Posttest	0.036	Not normal

The Shapiro-Wilk test indicated that the pretest scores followed a normal distribution ( $p$ -value = 0.463), exceeding the 0.05 threshold. However, the posttest scores did not follow a normal distribution because the  $p$ -value was 0.036, which was below 0.05. Therefore, the researchers interpreted the paired-samples t-test results cautiously. Future analysis should also examine the normality of the difference scores to strengthen the statistical justification.

### 4. Paired Sample T-Test

To examine differences in students' motivation before and after using Wordwall, the researchers performed a paired-samples t-test. Table 4 presents the results.

**Table 4. Paired Sample T-Test Result**

Comparison	Mean Difference	t-value	df	Sig. (2-tailed)
Pretest-Posttest	-24.607	-22.036	27	0.000

Table 4 indicates a statistically significant difference between pretest and posttest motivation scores ( $p < 0.05$ ). Students reported higher motivation levels after the Wordwall intervention, suggesting a positive association between Wordwall-supported bilingual mathematics instruction and learning motivation. However, the absence of a control group limits causal interpretation.

### 5. Effect Size

To complement the significance test, the researchers calculated Cohen's  $d_z$  to determine the magnitude of the difference between pretest and posttest scores. They selected Cohen's  $d_z$  because this study used a one-group pretest-posttest design involving the same participants. Table 5 presents the results.

**Table 5. Effect Size Result**

Comparison	N	t-value	Mean Difference	Effect Size Type	Effect Size	Interpretation
Pretest-Posttest	28	22.036	24.61	Cohen's $d_z$	4.16	Very large effect

Table 5 shows a Cohen's  $d_z$  value of 4.16, indicating a very large effect. This result suggests that students' motivation increased not only statistically significantly but also practically substantially after the Wordwall intervention. However, because this study used a pre-experimental one-group pretest-posttest design without a control

group, the researchers interpreted the effect size as the magnitude of pretest-posttest improvement rather than as definitive causal evidence of Wordwall's effectiveness.

## **6. Summary of Findings**

Overall, the findings show that students' motivation for bilingual mathematics learning increased after the Wordwall intervention. The descriptive statistics showed an increase in the mean score from 63.18 to 87.79. The N-Gain score of 0.6794 indicated a moderate level of improvement, while the paired-samples t-test showed a statistically significant difference between pretest and posttest scores. In addition, Cohen's *d* value of 4.16 indicated a very large practical effect. These findings suggest that Wordwall may serve as a promising interactive digital learning medium to support students' motivation in bilingual mathematics learning. Nevertheless, the researchers interpreted the findings cautiously because the study lacked a control group.

## **Discussion**

This study found that students' motivation in bilingual mathematics learning increased after the Wordwall intervention. The mean motivation score rose from 63.18 in the pretest to 87.79 in the posttest. The N-Gain score of 0.6794 indicated a moderate improvement. In addition, the paired-samples t-test showed a statistically significant difference between pretest and posttest scores, while Cohen's *d* indicated a very large effect size. These findings suggest that using Wordwall was associated with meaningful improvements in students' motivation. However, considering the pre-experimental design without a control group, the results should be interpreted as evidence of motivational improvement within the observed classroom rather than as definitive causal evidence of Wordwall's effectiveness.

Wordwall's interactive, game-based features can explain the improvement in students' motivation. In elementary mathematics learning, students often encounter difficulties because mathematical concepts are abstract and require sustained attention. Wordwall helps transform learning activities into more engaging experiences through quizzes, matching tasks, time-based challenges, scores, and immediate feedback. These features are consistent with the concept of gamification, which refers to the use of game design elements in non-game contexts to increase engagement and motivation (Deterding et al., 2011). Recent studies have also shown that gamification and digital game-based learning can support students' motivation, engagement, and learning outcomes when game elements are integrated meaningfully into instructional activities (Jaramillo-Mediavilla et al., 2024; Lampropoulos & Sidiropoulos, 2024; Zheng et al., 2024). In this study, Wordwall did not merely serve as a digital learning tool but also acted as a motivational support mechanism, encouraging students to participate more actively in bilingual mathematics learning.

From the perspective of Keller's ARCS motivational model, Wordwall supported students' motivation through four dimensions: Attention, Relevance, Confidence, and Satisfaction (Keller, 2010). In the Attention dimension, Wordwall engaged students through visual displays, game formats, competitions, and varied learning tasks. These elements helped maintain students' focus during mathematics learning. Such support is particularly important in bilingual mathematics instruction, as students need to process both mathematical content and language simultaneously. The visual and interactive features of Wordwall also align with multimedia learning theory, which emphasizes the role of well-designed verbal and visual information in supporting learning processes (Mayer, 2020). Moreover, recent evidence on digital game-based learning in mathematics classrooms suggests that students' engagement

depends not only on the digital tool itself but also on how teachers scaffold activities and connect games to mathematical learning goals (Nurastanti & Ratnaningrum, 2025; Sun et al., 2021).

Regarding the Relevance dimension, the teacher integrated Wordwall activities with the learning objectives and content of the plane geometry unit, allowing students to connect game-based tasks with the mathematics concepts studied in class. The use of bilingual Indonesian-English instructions also better aligned the learning activities with the classroom context. Students were able to encounter mathematical concepts and vocabulary more practically and interactively. This connection between digital media, subject matter, and bilingual classrooms needs to strengthen students' perception that the learning activities were meaningful and useful. Recent studies show that game-based learning provides greater benefits when teachers align game activities with instructional objectives rather than use them merely for entertainment (Jääskä et al., 2022; Russo et al., 2024). Therefore, the relevance of Wordwall in this study extended beyond its game-based features to its integration with bilingual mathematics content.

The Wordwall activities strengthened the Confidence dimension by providing repeated practice, immediate feedback, and opportunities for students to complete tasks both individually and collaboratively (Al-Husseini et al., 2021). In bilingual mathematics learning, students may face additional challenges because they need to understand mathematical concepts while also dealing with language demands. Wordwall provided a less threatening learning environment in which students could try, make mistakes, and receive feedback quickly. Feedback is an important element in learning because it helps students understand their current performance and identify areas for improvement (Hattie & Timperley, 2007). Recent studies also emphasize that digital learning environments can enhance motivation when they provide opportunities for active participation, feedback, and progressive task completion. In this context, Wordwall's immediate feedback helped students feel more capable of completing mathematical tasks.

The Satisfaction dimension appeared through students' positive learning experiences after completing Wordwall activities. Game elements such as scores, rankings, and task completion can create a sense of achievement. These experiences may encourage students to view mathematics learning as more enjoyable and less intimidating. Satisfaction is important because motivation is not only built through attention and confidence but also through students' perception that learning produces positive emotional and academic experiences (Keller, 2010). This interpretation is consistent with recent literature suggesting that gamified learning can improve students' motivation when it supports achievement, enjoyment, and meaningful participation rather than focusing only on competition (Lampropoulos & Sidiropoulos, 2024; Russo et al., 2024).

The findings of this study are consistent with previous studies showing that Wordwall can improve students' interest, engagement, and motivation in learning (Fadhilah & Nirmalasari, 2025; Permana & Kasriman, 2022; Saputri & Hadiyanti, 2025; Yulianto et al., 2024). However, this study offers a more specific contribution by examining Wordwall in bilingual mathematics learning at the elementary Islamic school level. Most previous studies have discussed Wordwall in general classroom contexts or monolingual learning settings, while this study highlights its use in a bilingual mathematics classroom. This context is important because bilingual learning creates a dual demand: students must understand both mathematical concepts and language simultaneously. Therefore, the present study extends Wordwall's

discussion by showing how interactive digital media can support motivation in a more linguistically complex classroom setting.

Another contribution of this study lies in the use of the ARCS model as an analytical lens. Rather than merely reporting that students' motivation increased, this study explains how Wordwall may support motivation through attention, relevance, confidence, and satisfaction. This theoretical framing strengthens the interpretation of the findings by treating motivation as a multidimensional construct rather than a single general outcome. By connecting the statistical results with the ARCS framework, this study provides a clearer explanation of why Wordwall may be useful for supporting students' motivation in bilingual mathematics learning.

Despite these promising findings, this study has several limitations. It used a pre-experimental one-group pretest-posttest design without a control group and involved only 28 students from one elementary Islamic school. The researchers also implemented the intervention in only four instructional sessions. Therefore, the improvement in students' motivation cannot be attributed solely to Wordwall, and the findings cannot support broad generalization to all bilingual mathematics classrooms. Other factors, such as teacher guidance, classroom atmosphere, students' familiarity with the topic, repeated exposure to the questionnaire, and novelty effects, may also have influenced the results.

Other factors, such as teacher guidance, classroom atmosphere, students' familiarity with the topic, repeated exposure to the questionnaire, and novelty effects, may also have influenced the results. Future studies should use quasi-experimental or experimental designs with control groups, larger samples, longer intervention periods, and complementary qualitative data, such as classroom observations or student interviews, to provide stronger evidence of how Wordwall supports motivation in bilingual mathematics learning.

Overall, this study suggests that Wordwall is a promising interactive digital medium for supporting students' motivation in bilingual mathematics learning. Its game-based features, immediate feedback, and bilingual task structure support students' attention, relevance, confidence, and satisfaction. However, the findings should be positioned carefully as evidence of motivational improvement within a limited classroom context rather than as definitive proof of causal effectiveness. This cautious interpretation makes the study more methodologically sound while still highlighting its practical value for elementary mathematics teachers in bilingual learning environments.

## **Conclusion**

This study examined changes in students' motivation after the implementation of Wordwall in bilingual mathematics learning at the elementary Islamic school level. The findings showed that students' motivation improved after the intervention, as indicated by increases in pretest and posttest scores, a moderate N-Gain, a significant difference in the paired-samples t-test, and a very large effect size (Cohen's). These results suggest that Wordwall can serve as a promising interactive digital learning medium to support students' motivation in bilingual mathematics learning, particularly by creating more engaging, visually rich, and feedback-oriented learning activities.

The study also contributes to the literature by connecting Wordwall-based learning with Keller's ARCS motivational model. The use of Wordwall appeared to support students' Attention, Relevance, Confidence, and Satisfaction through game-based tasks, bilingual content, immediate feedback, and a more enjoyable learning

atmosphere. However, because the study used a pre-experimental one-group pretest-posttest design with a limited sample and no control group, the researchers interpreted the findings cautiously as evidence of motivational improvement within the observed classroom rather than as definitive causal proof of Wordwall's effectiveness. Future studies should involve larger samples, longer intervention periods, control groups, and complementary qualitative data to provide stronger evidence of how Wordwall supports motivation in bilingual mathematics learning.

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