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The effect of Wordwall gamification on students' motivation and critical thinking in ratio material

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Abstract. This study aims to examine the effect of Wordwall gamification on the learning motivation and critical thinking skills of sixth-grade elementary school students in ratio material. A quantitative quasi-experimental design with nonequivalent control group was used. The sample consisted of 50 students selected through purposive sampling, divided into experimental and control groups. Data were collected using a motivation questionnaire and HOTS-based critical thinking test, then analyzed using MANOVA. Results indicate that Wordwall significantly improves both learning motivation and critical thinking skills, both partially and simultaneously. Wordwall media showed a significant positive effect on both variables. For learning motivation, the significance value was $p < 0.05$ with an effect size of 84.9%. For critical thinking skills, the significance value was also $p < 0.05$ with an effect size of 64.7%. Pillai's Trace value = 0.864; $F(2,47) = 149.672$; $p < 0.001$. This means the combination of dependent variables differs significantly across classes. This finding suggests that Wordwall can serve as an effective, engaging, and practical alternative media to enhance mathematics learning quality in elementary schools.

Introduction

The education sector plays a strategic role in improving the quality of human resources through the implementation of the Independent Curriculum, which emphasizes flexibility, learning autonomy, and the strengthening of students' critical and creative thinking competencies (Kause et al., 2025). Internationally, this approach aligns with modern educational frameworks that prioritize active learning and technology integration to enhance student engagement and cognitive development (Koivisto & Hamari, 2019; Plass et al., 2015). To achieve these goals, the integration of technology in the classroom is strongly encouraged to make the teaching and learning process interactive, dynamic, contextual, and fully student-centered (Alimuddin et al., 2023; Fitriyah & Wardani, 2022). However, the reality on the ground shows that the use of technology in mathematics instruction at the elementary school level has not been optimal. Learning processes are still largely dominated by conventional, teacher-centered approaches, which tend to create a rigid classroom atmosphere and fail to maximize students' motivation to learn and critical thinking skills (Fauzi et al., 2022).

Mathematics is a fundamental subject for developing students' logical, systematic, and critical thinking abilities from an early age (Wati et al., 2025). Despite its importance, mathematics is often

perceived as intimidating and difficult due to the abstract nature of its subject matter. For elementary students, concrete and visual representations are essential to bridge this abstraction gap (Iyamuremye & Burns, 2025). This situation requires external stimulation through the provision of conducive, challenging, and innovative learning media to encourage and sustain students' motivation to learn (Sardiman, 2018; Uno, 2023). Without such stimulation, low motivation to learn ultimately becomes a major barrier, weakening students' critical thinking skills and their ability to understand mathematical concepts in depth (Nitbani, 2022; Widana et al., 2024). Therefore, there is a need for innovative learning media based on educational games or game-based learning, which can create an interactive and enjoyable atmosphere while stimulating students' active participation and higher-order problem-solving abilities through visual challenges (Agustina et al., 2025).

One highly relevant digital platform that has proven effective in visualizing abstract mathematical material in concrete terms is Wordwall (Walidah et al., 2022). The use of Wordwall can significantly boost students' motivation and learning performance through its interactive template features and the provision of instant feedback during the learning activities (Anriani et al., 2025; Nafian et al., 2024). The importance of testing this medium is based on the results of initial observations conducted in Grade VI at SDN 3 Randulawang regarding the topic of ratio, which revealed low levels of students' affective and cognitive abilities. Approximately 66% of the students showed learning motivation below the minimum standard, with an average questionnaire score of 58 out of an ideal score of 70. This low affective condition was directly proportional to cognitive mastery, with only 33% of students achieving scores above the Minimum Completeness Criteria (KKM).

Several previous studies have confirmed the effectiveness of using Wordwall as a learning medium in elementary schools. To map the position of this research and clarify its novelty, a comparison with relevant studies is presented in Table 1 below.

Table 1. Previous Research

Researcher & Year	Research Focus & Location	Media Used	Variables Measured	Findings & Research Gap
Walidah, Mudrikah, & Saputra (2022)	Effect of Wordwall on mathematics learning	Wordwall Educational Game	Motivation and learning outcomes	Results: Increases motivation and learning achievement. Limitations: Only measures learning outcomes; does not examine critical thinking skills.
Wahyuni, Nisa, Widanti, & Putri (2023)	Use of Wordwall in elementary learning	Wordwall	IPAS subject learning outcomes	Results: Makes learning more interesting and improves scores Limitations: Limited to one subject; does not test two variables at the same time.
Ainurrohmah, Siswono, & Wiryanto (2024)	Improving critical thinking skills	Improving critical thinking skills	Critical thinking	Results: Develops reasoning ability. Limitations: Media is combined with another method; not tested as a single independent treatment

Researcher & Year	Research Focus & Location	Media Used	Variables Measured	Findings & Research Gap
Stefania, Umaya, & Ndori (2025)	Understanding mathematical concepts	Wordwall	Concept mastery	Results: Helps visualize abstract material. Limitations: Conducted at junior high school level; no simultaneous analysis of motivation and thinking skills.

Based on the matrix of previous studies above, a clear research gap underscores the importance of this study. While earlier research by Walidah et al. (2022) and Wahyuni et al. (2023) only examined motivation or basic cognitive learning outcomes, the study by Ainurrohmah et al. (2024) still linked the use of Wordwall to the group-based Teams-Games-Tournament (TGT) model. The research by Stefania et al. (2025) was limited to the junior high school level. The novelty of the present study lies in testing the effect of Wordwall gamification both independently and simultaneously through multivariate analysis (MANOVA) on two key aspects at once: the affective domain (learning motivation) and higher-order cognitive skills (HOTS-based critical thinking skills) of sixth-grade elementary school students, specifically regarding the topic of ratio. This combined approach has not been implemented before, so this research not only fills a gap in the existing literature but also provides concrete methodological and practical solutions for transforming the abstract mathematical concept of ratio into a critical and competitive reasoning activity at the elementary school level.

While previous studies have shown the benefits of Wordwall, most focus only on learning outcomes or motivation separately, with limited research examining its simultaneous effect on both affective and cognitive aspects. This study aims to fill this gap by testing its influence on both variables together. Accordingly, the following hypotheses are proposed: (1) H_1: Wordwall gamification has a significant effect on students' learning motivation; (2) H_2: Wordwall gamification has a significant effect on students' critical thinking skills; and (3) H_3: Wordwall gamification has a significant simultaneous effect on both learning motivation and critical thinking skills.

Method

Research Design

This study employs a quantitative approach with a quasi-experimental method using the Nonequivalent Control Group Design. This design was selected because subjects were not randomly assigned; instead, existing classes were used to maintain the stability of students' learning environment (Sugiyono, 2008). In implementation, both the experimental class (learning using the Wordwall educational game) and the control class (conventional learning) were administered a pretest before receiving treatment, followed by a posttest using the same instrument to measure the impact of the intervention, as shown in Table 2.

Table 2. Nonequivalent Control Group Design

Group	Pre-test	Treatment	Post-Test
Experiment	O1	x	O2
Control	O1	-	O2

Explanation
O_1: Initial scores of motivation and critical thinking
X: Learning using Wordwall media
-: Conventional learning
O_2: Final scores after treatment

Population and Sampling Technique

The population of this study consists of all sixth-grade elementary school students in the Jati Cluster, Blora Regency. Sampling was carried out using the purposive sampling method Arikunto (2010), based on criteria including equivalent school accreditation, similar initial mathematics academic ability among students, and availability of technological facilities. In accordance with these criteria, a total of 50 students from two schools were selected: Grade VI students at SDN 3 Randulawang (26 students) formed the experimental group using the Wordwall educational game, while Grade VI students at SDN 1 Temuireng (24 students) served as the control group taught using conventional methods, as detailed in Table 3.

Table 3. Distribution of Research Samples

No.	School / Group	Learning Treatment	Number of Students (N
1.	SDN 3 Randulawang (Experimental Class)	Wordwall Educational Game Media	26
2.	SDN 1 Temuireng (Control Class)	Conventional Method	24
Total Research Sample			50

Background and Timeline of the Study

This study was conducted over three months during the even semester of the 2025/2026 academic year. The first month was used for administrative preparation, permit application, instrument development, and validation; the second month included pre-test administration, four treatment sessions using Wordwall media, and post-test administration; while the third month was dedicated to data processing, statistical analysis, and report preparation.

Research Ethics and Permission

This study has obtained official research permission from the Education Office of Blora Regency and the principals of both participating schools. All activities were conducted in accordance with educational research ethics, ensuring the confidentiality of student data and the safety of all participants throughout the study

Research Implementation Procedure

The entire intervention was carried out consistently across four sessions, each lasting 2 × 35 minutes, for both groups. The experimental group received instruction using Wordwall media, while the control group learned the same material through conventional methods. To ensure consistency, the same teacher delivered lessons in both groups, and the same learning objectives, topics, and assessment standards were applied. This controlled procedure minimized external variables that could affect the results

Data Collection Techniques, Instruments, and Feasibility Testing

The researchers collected data using two main instruments: a learning motivation questionnaire and a critical thinking skills test. Before use, two expert lecturers in mathematics education validated both instruments, confirming their content validity. The researchers also conducted empirical testing with 30 students outside the research sample. The motivation scale, developed based on Keller's ARCS model, showed a reliability coefficient of Cronbach's Alpha = 0.87, while the critical

thinking test, based on Ennis's taxonomy, obtained a reliability coefficient of KR-20 = 0.82. Both values exceed the minimum standard of 0.60, confirming the instruments are valid and reliable for data collection. Table 4 below presents details on the distribution of indicators for these two instruments.

Table 4. Blueprint of Research Instruments

Dependent Variable	Theory/Dimension	Success Indicator	Instrument Format
Learning Motivation	ARCS Model (Keller)	Attention, Relevance, Confidence, Satisfaction	24-item Likert scale
Critical Thinking Skills	Ennis Taxonomy	Explanation, Analysis, Inference, Evaluation	15-item HOTS test

(Note: Detailed technical specifications of the Wordwall platform are not included here, as they are general features of the application and not specific to this study).

Data Analysis Techniques and Criteria

Quantitative data in the form of N-Gain scores were analyzed using parametric inferential statistics with IBM SPSS software in two stages. First, the analysis prerequisites were tested using the Shapiro-Wilk Normality Test and Levene's Test for Homogeneity. The Shapiro-Wilk test is supported by strong methodological arguments indicating that the Kolmogorov-Smirnov test is more appropriate and consistent for large sample sizes (N > 100). In contrast, for small to medium sample sizes, such as in this study, where the total number of participants (N) was only 50 students, the Shapiro-Wilk test has been statistically proven to be far more sensitive, accurate, and possesses greater statistical power in detecting the normality of data distribution (Razali & Wah, 2011). These prerequisite assumptions are considered satisfied if the p-value is greater than 0.05. Second, hypothesis testing was performed using Multivariate Analysis of Variance (MANOVA) (Ghozali, 2018). The simultaneous test refers to the Wilks' Lambda indicator presented in the Multivariate Tests table. In contrast, the partial test refers to the Tests of Between-Subjects Effects table to obtain the F-value and the measure of effect size (Partial Eta Squared) for each dependent variable. Decision-making criteria were based on the p-value, with the null hypothesis (H_0) rejected if $p < 0.05$.

Results and Discussion

Description of the Wordwall Educational Game Media Treatment

Before conducting the quantitative hypothesis testing, this section describes the characteristics of the learning intervention implemented in the experimental class at SDN 3 Randulawang. The learning process for the topic of ratio in the experimental class was fully integrated with game-based learning media using the specially designed Wordwall platform. The Wordwall media was systematically developed to include three main components: a Start Page displaying the quiz title "Ratio Adventure for Grade VI" along with an option to select an avatar character; a Gameplay Page presenting contextual mathematical word problems related to proportional reasoning, complete with a countdown timer and dynamic scoring features; and a Leaderboard and Feedback section that displays final scores and student rankings in real time, as shown in Image 1 below.

Image 1. Interface of the Interactive Wordwall Media for the Topic of Ratio for Grade VI

Image 1 shows the three main components of the quiz media: the start page displaying the adventure title and avatar selection (top-left), the leaderboard and instant-feedback section after completing the activity (bottom-left), and the countdown timer visualization while solving contextual ratio problems (right).

Descriptive Statistical Analysis

The following describes post-test performance scores for 50 respondents, comprising 26 students from the experimental class at SDN 3 Randulawang and 24 students from the control class at SDN 1 Temuireng (see Table 5).

Table 5. Descriptive Statistics of Post-test Data for Motivation and Critical Thinking

Descriptive Statistics						
Class Group		N	Minimum	Maximum	Mean	Std. Deviation
Experiment	Pre-Test Motivation Scale	26	51	71	61.38	5.742
	Pos-Test Motivation Scale	26	90	109	98.54	5.464
	Pre-Test Critical Thinking	26	0	7	4.35	1.719
	Post-Test CriticalThinking	26	7	15	11.96	1.907
	Valid N (listwise)	26				
Control	Pre-Test Motivation Scale	24	45	70	61.88	5.488
	Pos-Test Motivation Scale	24	47	71	60.29	6.189
	Pre-Test Critical Thinking	24	2	8	4.71	1.706
	Post-Test CriticalThinking	24	2	8	5.83	1.659

Descriptive Statistics					
Class Group	N	Minimum	Maximum	Mean	Std. Deviation
Valid N (listwise)	24				

As shown in Table 5, the experimental group using Wordwall achieved far greater post-test improvements, while scores in the control group remained nearly unchanged. Image 1 below presents this comparison visually.

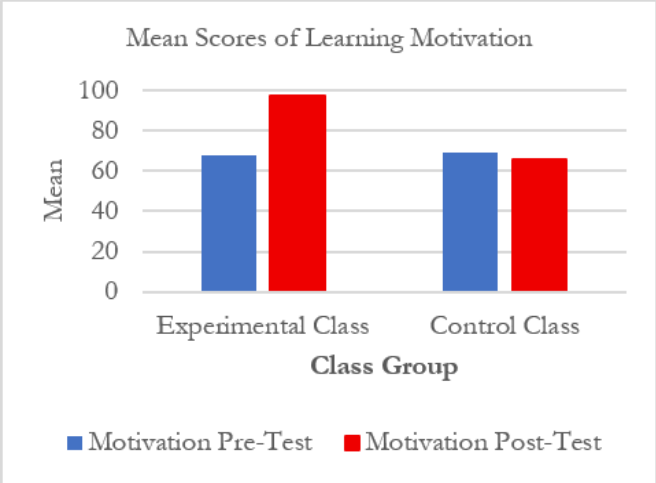

Image 2. Comparison of Students' Pre-test and Post-test Scores for Learning Motivation

Image 1 shows a clear increase in motivation scores for the experimental group, while the control group remained unchanged. Similarly, Image 2 illustrates that critical thinking scores also improved much more in the group using Wordwall compared to conventional learning

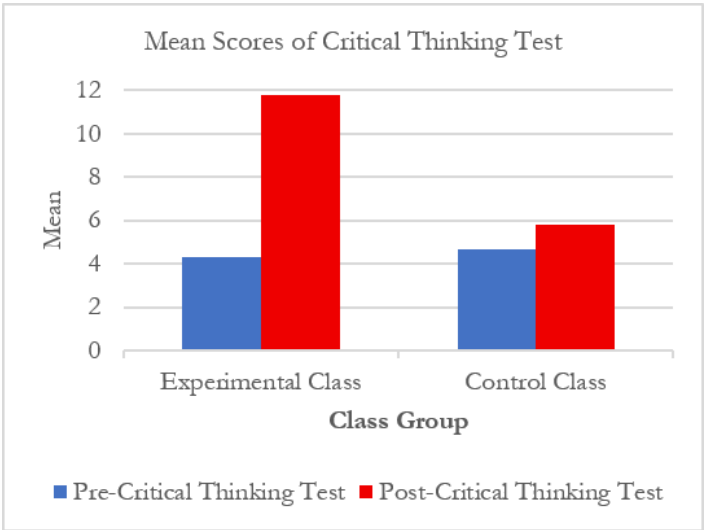

Image 3. Comparison of Students' Pre-test and Post-test Scores for Critical Thinking Skills

Image 2 confirms that critical thinking scores also improved substantially in the experimental group, while the control group showed only a small increase. Overall, the results show that Wordwall gamification effectively enhances both students' learning motivation and critical thinking skills.

Prerequisite Tests for Data Analysis

Normality was tested using the Shapiro–Wilk method, while homogeneity of variance was examined using Levene's test. All variables showed significance values greater than 0.05, indicating that the data were normally distributed and had homogeneous variance. Thus, the assumptions for parametric analysis were satisfied, and MANOVA could be applied. Table 6 presents the full results.

Table 6. Summary of Statistical Assumption Tests

Variable	Group Class	n	Normality Test (Shapiro-Wilk)		Homogeneity Test (Levene's Test)	
			Statistik (W)	Sig. (p)	Levene (F)	Sig. (p)
Learning Motivation	Experimental	26	0.970	0.633	0.195	0.661
N-Gain	Control	24	0.959	0.412		
Critical Thinking Skills	Experimental	26	0.977	0.793	0.018	0.894
N-Gain	Control	24	0.946	0.219		

Partial Hypothesis Testing

Partial hypothesis testing examined the effect of Wordwall media on each dependent variable separately. Table 7 presents the results.

Table 7. Results of Partial Testing for the Effect of Inter-Variable Factors

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	N-Gain Motivation Scale	18727.102[a]	1	18727.102	270.328	0.000
	N-Gain Critical Thinking	525.721[b]	1	525.721	87.993	0.000
Intercept	N-Gain Motivation Scale	15790.462	1	15790.462	227.938	0.000
	N-Gain Critical Thinking	953.401	1	953.401	159.577	0.000
Class	N-Gain Motivation Scale	18727.102	1	18727.102	270.328	0.000
	N-Gain Critical Thinking	525.721	1	525.721	87.993	0.000
Error	N-Gain Motivation Scale	3325.218	48	69.275		
	N-Gain Critical Thinking	286.779	48	5.975		
Total	N-Gain Motivation Scale	39276.000	50			
	N-Gain Critical Thinking	1825.000	50			
Corrected Total	N-Gain Motivation Scale	22052.320	49			
	N-Gain Critical Thinking	812.500	49			

a. R Squared = 0.849 (Adjusted R Squared = 0.846)
b. R Squared = 0.647 (Adjusted R Squared = 0.640)

Based on the results in Table 7, Wordwall media showed a significant positive effect on both variables. For learning motivation, the significance value was $p < 0.05$ with an effect size of 84.9%. For critical thinking skills, the significance value was also $p < 0.05$ with an effect size of 64.7%. This means the null hypothesis is rejected, confirming that Wordwall significantly improves both learning motivation and critical thinking skills.

Simultaneous Hypothesis Testing (MANOVA Test)

This test examined the combined effect of Wordwall media on both learning motivation and critical thinking skills. The results are presented in Table 8.

Table 8. Results of the Simultaneous Multivariate Analysis (MANOVA)

Multivariate Tests[a]

Effect		**Value**	**F**	**Hypothesis df**	**Error df**	**Sig.**
Intercept	Pillai's Trace	0.869	156.521[b]	2.000	47.000	0.000

Multivariate Tests[a]						
Effect		**Value**	**F**	**Hypothesis df**	**Error df**	**Sig.**
	Wilks' Lambda	0.131	156.521b	2.000	47.000	0.000
	Hotelling's Trace	6.660	156.521b	2.000	47.000	0.000
	Roy's Largest Root	6.660	156.521b	2.000	47.000	0.000
Class	Pillai's Trace	0.864	149.672b	2.000	47.000	0.000
	Wilks' Lambda	0.136	149.672b	2.000	47.000	0.000
	Hotelling's Trace	6.369	149.672b	2.000	47.000	0.000
	Roy's Largest Root	6.369	149.672b	2.000	47.000	0.000

a. Design: Intercept + Class
b. Exact statistic

Based on the results in Table 8, the MANOVA test showed a significance value of $p < 0.05$. This means the null hypothesis is rejected, confirming that Wordwall media has a significant simultaneous effect on both students' learning motivation and critical thinking skills.

Discussion

The Impact of Wordwall Media on Students' Learning Motivation

The results show that Wordwall media significantly improves students' learning motivation. Its gamification features such as interactive displays, time-based challenges, and leaderboards create a more enjoyable learning atmosphere, which suits the developmental stage of elementary students. This finding is consistent with Zulfah (2023), who confirms that Wordwall effectively increases students' interest and enthusiasm for learning, making mathematics lessons more engaging and encouraging active participation.

Theoretically, this improvement aligns with Self-Determination Theory: Wordwall shifts students from passive to active learners by fulfilling the needs for autonomy, competence, and relatedness (Ryan & Deci, 2017). Digital game based learning is proven to make learning activities more enjoyable and reduce boredom, which directly boosts students' intrinsic motivation (Sailer & Homner, 2020; Sudarmika, 2021; Widana et al., 2019). It creates a low-pressure, engaging environment suitable for abstract mathematics material. This is supported by Arimbawa (2021), who notes that game-based learning boosts curiosity and reduces fatigue in elementary students. Nisa & Susanto (2022) and Kurniawati & Tresnawati (2025) also confirm that Wordwall's interactive features effectively raise motivation in mathematics. Furthermore, Walidah et al. (2022) and Rahmawati et al. (2024) explain that instant feedback and positive reinforcement help sustain student engagement and confidence throughout the learning process.

The Impact of Wordwall Media on Students' Critical Thinking Skills

Beyond motivation, Wordwall media also significantly improves students' critical thinking skills. Ratio material requires strong reasoning to understand comparisons and relationships between quantities, and Wordwall facilitates this by presenting concepts through interactive and contextual visualizations, making abstract ideas easier to grasp. This improvement aligns with Piaget's Theory of Cognitive Development. At age 11-12, students are transitioning from concrete to formal operational thinking and still need visual support to process abstract logic (Slavin, 2019). Wordwall acts as a cognitive bridge that helps students organize information more clearly. Interactive media with visual and game like features effectively supports the development of reasoning and problem

solving skills, especially for elementary students (Hwang & Wu, 2012; Wouters et al., 2013; I Made Elia Cahaya et al., 2024).

Furthermore, this improvement in critical cognitive ability is made possible by Wordwall's feature of providing instant feedback. When students select a correct or incorrect answer, the system immediately delivers visual confirmation in real time. According to Cognitive Load Theory, this instant feedback reduces extraneous cognitive load and maximizes germane cognitive load, thereby supporting the construction of mental frameworks (Sweller et al., 2019). When an answer is incorrect, the system immediately directs students' attention to identify and evaluate where their reasoning went wrong without long delays, allowing them to quickly formulate new problem-solving strategies and practice self-regulation in subsequent quiz items. The platform's instant feedback also plays an important role. According to Cognitive Load Theory, immediate responses reduce unnecessary mental effort and help students build correct understanding more effectively (Sweller et al., 2019). When answers are incorrect, students can quickly identify mistakes and adjust their reasoning, supporting self-regulated learning.

This process matches the findings of Sasmita & Harjono (2021), who note that visual and contextual presentation strongly influences students' ability to solve mathematical problems. Sulistyaningsih et al. (2023) also confirm that Wordwall's dynamic features enhance analytical skills and help students practice consistent problem-solving, which supports the transition from concrete to abstract thinking in mathematics.

Analysis of Simultaneous Effect (Correlation between Affective and Cognitive Domains)

The results of the multivariate test (MANOVA), which showed a very strong simultaneous effect ($F = 149.672$; $p = 0.000$), confirm the existence of a positive reciprocal relationship between learning motivation (affective) and critical thinking skills (cognitive) within students' mathematics learning environment. According to Thorndike's Law of Effect, responses followed by feelings of pleasure or satisfaction tend to be repeated and The MANOVA results confirm a strong positive relationship between students' learning motivation and critical thinking skills. This aligns with Thorndike's Law of Effect, which states that learning experiences that feel enjoyable and satisfying will be repeated and strengthened. When Wordwall media increases students' motivation, they become more focused and persistent, so challenging problems are seen as engaging tasks rather than difficulties.

This integrated effect is supported by Nursyahira et al. (2024), who found that game-based media improves both emotional engagement and reasoning ability at the same time. Hermansah & Jakaria (2025) add that digital learning media connects higher motivation with better cognitive outcomes in mathematics. As noted by Sabitha & Hasanudin (2024), Wordwall acts as an effective tool that reduces learning anxiety while encouraging active participation and problem-solving. Research shows that well-designed digital learning tools can simultaneously improve both students' interest and their ability to think logically (de Sousa Borges et al., 2014; Sailer & Homner, 2020). This also shows how such media supports the goals of the Independent Curriculum, which aims to develop active, critical, and independent learners.

Comprehensively, this combined effect reinforces the principle of modern instruction that the development of higher-order cognitive processes in elementary school students cannot be separated from the comfort of their learning environment. This integrated phenomenon aligns with the findings of Nursyahira et al. (2024), who confirm that game-based multimedia stimulation is simultaneously effective in boosting students' emotional engagement and motivation while sharpening their logical reasoning and critical analysis abilities. This is further supported by a study by Hermansah & Jakaria (2025), which shows that transforming the classroom through digital

learning media effectively aligns improvements in intrinsic motivation with sustained cognitive achievement in mathematics at the elementary school level. Within this dynamic digital learning ecosystem, the use of innovative platforms such as Wordwall acts as a dual accelerator that not only reduces learning-related anxiety but also challenges and facilitates active student participation, enabling them to achieve optimal problem-solving competence (Sabitha & Hasanudin, 2024). Accordingly, the successful demonstration of this simultaneous effect in the present study proves that digitalizing the classroom through appropriate media can serve as a practical bridge for implementing the Independent Curriculum, which aims to foster a generation of learners who are active, critical, creative, and independent.

Conclusion

Based on the results and discussion, it can be concluded that the use of Wordwall media has a significant positive effect, both partially and simultaneously, on students' learning motivation and critical thinking skills in learning ratio material. This media makes learning more interactive, interesting, and easier to understand, so it helps students achieve better learning outcomes compared to conventional methods. Referring to these findings, several recommendations are proposed. First, teachers can use Wordwall as an alternative learning media, especially for mathematics topics that are abstract and require reasoning. Second, schools are expected to support the availability of digital facilities and internet access so that this media can be applied optimally. Third, further researchers can develop similar media for other materials or subjects, and conduct studies with longer implementation time to obtain more comprehensive results.

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