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Gamifying Science Education: How Wordwall-Integrated Joyful Learning Enhances Cognitive Outcomes and ARCS Motivation in Elementary School

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Abstract

Teacher-centered instruction in elementary science often fails to engage students, limiting learning outcomes and motivation. Gamification tools like Wordwall offer promise, yet evidence for their integration within joyful learning—especially under Indonesia's Merdeka Curriculum—remains scarce. This quasi-experimental study evaluated the effectiveness of Wordwall-based joyful learning on sixth-graders' cognitive outcomes and motivation in Natural and Social Sciences (IPAS), while quantifying effect sizes. A nonequivalent control group design was used (experimental n = 30, control n = 30). The experimental group received four sessions of Wordwall games (Match Up, Maze Chase, Airplane); the control group had conventional instruction. Learning outcomes were measured with a 20-item test (KR-20 = 0.82); motivation with an ARCS questionnaire (Cronbach's 〈 = 0.85). Analysis included N-Gain, independent *t*-tests, and Cohen's d. The experimental group showed significantly higher improvement (N-Gain = 0.68 vs. control 0.35; Cohen's $d = 1.58$, 95% CI [0.98,2.18], $p < 0.001$). Motivation scores increased by 25.7 points (experimental) vs. 7.3 points (control); Cohen's d = 1.42, $p < 0.001$. The largest gains occurred in the Attention and Satisfaction subscales of the ARCS model. Wordwall-based joyful learning substantially enhances both cognitive outcomes and learning motivation in elementary IPAS education. These findings provide empirical support for gamified, student-centered approaches under the Merdeka Curriculum. Future research should explore long-term retention and cross-context replication.

Keywords: Wordwall; joyful learning; gamification; ARCS motivation; elementary science; learning outcomes

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INTRODUCTION

Contemporary dynamics in elementary education are currently confronting a disparity between curricular demands and realities in the field. A primary challenge frequently encountered is the low level of cognitive and affective engagement among students, particularly in the Natural and Social Sciences (IPAS) subject. This subject inherently necessitates a profound conceptual

understanding and meaningful learning experiences. However, empirical facts indicate that the praxis of IPAS instruction is often dominated by conventional, teacher-centered approaches. The implication of this one-way pedagogical method is a minimization of active student participation, which ultimately results in low material retention (Wicaksono, 2020).

Stagnation in teaching methods carries serious psychological implications. Recent literature corroborates that the dominance of lecturing methods tends to degrade student's intrinsic motivation, particularly in abstract subjects like IPAS (Bai & Huang, 2020). This phenomenon underscores the urgency of a paradigm shift toward an approach that is more interactive and humanistic. It is crucial to acknowledge that today's elementary students belong to Generation Alpha or digital natives, who possess distinct learning characteristics compared to previous generations. They tend to process visual information faster and prefer interactive, feedback-rich environments over static textual learning. Consequently, the conventional lecturing method creates a disconnect between the student's natural learning preferences and the instructional delivery, leading to cognitive boredom and passivity.

Furthermore, the current educational landscape in Indonesia, under the Merdeka Curriculum (Kurikulum Merdeka), places a strong emphasis on the development of critical thinking and student autonomy (Profil Pelajar Pancasila) (Kemendikbudristek, 2022). However, achieving these competencies is challenging when the learning process is hindered by low engagement. Preliminary observations indicate that the passive nature of conventional instruction fails to cultivate the Critical Reasoning and Independence dimensions required by the national curriculum. Students are rarely given the opportunity to explore concepts independently or receive immediate feedback on their understanding, which are crucial components for fostering deep learning and 21st-century skills.

A pedagogical solution relevant to bridging this gap is the implementation of the joyful learning approach. This approach is designed to engineer a learning atmosphere that is positive, enjoyable, and free from pressure, thereby triggering total student engagement. From the perspective of educational psychology, the effectiveness of Joyful learning aligns with the ARCS Model (Attention, Relevance, Confidence, Satisfaction). Beyond ARCS, this study also draws upon the Cognitive Load Theory, which suggests that learning is maximized when extraneous cognitive load is minimized. Conventional instruction often imposes high extraneous load through text-heavy explanations of abstract IPAS concepts. In contrast, game-based learning instruments like Wordwall utilize dual-coding (visual and verbal) to reduce this load, facilitating easier information processing and retention (Mayer, 2014; Sweller et al., 2011).

In line with the acceleration of educational technology, the integration of game-based learning and gamification has become a primary catalyst in realizing *Joyful Learning*. Various recent meta-analyses demonstrate that gamification has a significant impact on improving motivation and learning outcomes across various educational levels (Bai & Huang, 2020; Sailer & Homner., 2020). Through game mechanisms, students are invited to learn through measurable challenges, healthy competition, and instant feedback (Pesare et al., 2016; Seaborn & Fels, 2015). Furthermore, gamification facilitates social and collaborative skills, creating challenges that trigger intrinsic motivation without cognitively burdening the student (Cooney & Darcy, 2020; Dugnol-Menéndez et al., 2021).

One popular and flexible game-based learning instrument for elementary schools is wordwall. This platform offers a variety of interactive formats such as quizzes, matching pairs, and anagrams that function effectively as media for concept reinforcement (Indrawati et al., 2025; Yanuarto & Setyaningsih, 2024). Consistent findings from prior research show that wordwall is effective in boosting learning outcomes and literacy across various disciplines (Annisa & Rudyanto, 2022; Arsini et al., 2022; Hidayah et al., 2023; Lestari & Rohmani, 2024). Beyond cognitive aspects, the use of this platform has also been proven to simultaneously stimulate student activity and learning interest (Aidah & Nurafni, 2022).

Although studies regarding Wordwall have been widely published, the majority of prior research tends to be partial; focusing either solely on the description of media usage or

measuring only a single learning outcome variable. There remains a paucity of literature, particularly quasi-experimental studies, that evaluates the effectiveness of Wordwall when specifically framed within a Joyful learning approach in IPAS instruction (Aeni et al. 2023; Lubis & Ponidi, 2025; Wedananta & Suprianti, 2024).

Based on preliminary observations at SDN Petukangan Utara 02, South Jakarta, indications of relevant issues were found, wherein teaching methods have not fully accommodated the engagement needs of sixth-grade students. Therefore, this study aims to fill this empirical gap by evaluating the effectiveness of Joyful learning based on Wordwall games in improving student learning outcomes and motivation. This research is expected to provide theoretical and practical contributions to the development of adaptive active learning strategies in the digital era.

METHODS

Research Design

This study employs a quasi-experimental approach utilizing a nonequivalent control group design. This design was selected to evaluate the causal relationship between the intervention and the dependent variables without disrupting the natural setting of the school, as full randomization of subjects was not feasible. Despite the use of intact classes, this design allows for an objective measurement of the treatment's impact on student learning outcomes and motivation (Creswell, 2023). The specific research configuration consists of two groups, as presented in Table 1.

Table 1. Research Design Configuration

Group	Pretest	Treatment	Posttest
Experimental	O_1	X	O_2
Control	O_3	–	O_4

Source : Creswell & Creswell (2023)

As shown in Table 1, the experimental group receives the intervention (X) between the pretest (O_1) and posttest (O_2), while the control group undergoes conventional instruction without the intervention. This design facilitates a comparative analysis of learning outcomes and motivation between the group receiving the Wordwall based intervention and the group undergoing conventional instruction (Hidayaty et al. 2022).

Population and Sample

The population comprises all sixth-grade students at SDN Petukangan Utara 02, South Jakarta, during the 2025/2026 academic year. The sample was determined using a purposive sampling technique, resulting in the selection of two classes : Class VI-A as the experimental group and Class VI-B as the control group, each consisting of 30 students. The experimental group received the Joyful learning treatment integrated with Wordwall, while the control group engaged in conventional learning characterized by expository methods and written exercises.

Research Variables

The independent variable in this study is the Wordwall based joyful learning model. The dependent variables are student learning outcomes and learning motivation in the Natural and Social Sciences (IPAS) subject. The theoretical framework posits that variations in learning outcomes and motivation are influenced by the implementation of the Wordwall based Joyful learning approach (Annisa & Rudyanto, 2022; Lestari & Rohmani, 2024).

Instruments

Data collection relied on three primary instruments: an IPAS learning outcome test, an observation sheet for learning activities, and a learning motivation questionnaire. First, the Learning Outcome Test consists of 20 multiple-choice items developed based on the cognitive levels C1–C4 of the Merdeka Curriculum. The test underwent content validity testing by three subject matter experts and was declared valid. The validation process involved a rigorous

iterative review. The experts evaluated the instruments based on three main criteria: content suitability with the Merdeka Curriculum learning objectives (ATP), linguistic clarity for sixth-grade cognitive levels, and the accuracy of the answer keys. Initially, the draft consisted of 25 items. However, after the expert review, 5 items were removed due to ambiguity and overlapping answer choices, resulting in the final 20 items used for the research. This rigorous screening ensured that the instrument truly measured the cognitive constructs intended, specifically focusing on Higher Order Thinking Skills (HOTS) such as analyzing (C4) historical events rather than merely recalling dates. Subsequently, an empirical try-out was conducted on non-sample students, where reliability analysis using the KR-20 formula yielded a coefficient of 0.82, categorized as very high reliability (Creswell, 2023). Second, the Observation Sheet was utilized to assess student engagement during the Wordwall activities, focusing on indicators of attention, active participation, and cooperation. Third, the Motivation Questionnaire, adapted from the ARCS model (Attention, Relevance, Confidence, Satisfaction), employs a 5-point Likert scale. Reliability testing for this instrument using Cronbach's Alpha resulted in a coefficient of 0.85 (> 0.70), indicating strong internal consistency (Fraenkel et al.,2019).

Research Procedures

The research procedure was executed in three distinct phases. ncluded the analysis of IPAS learningthe development of teaching modules, and the validation of test instruments by content experts.

The implementation phase spanned four meetings. In the experimental group, the learning process began with a conceptual trigger, followed by the core activity where students engaged with Wordwall games individually and in groups using school tablets. The intervention utilized specific Wordwall game modes tailored to the characteristics of the learning material. For the topic of 'The Events Leading to Independence,' the 'Match Up' mode was employed, requiring students to drag and drop historical figures (e.g., Soekarno, Hatta) to their respective roles. This mechanism was chosen to strengthen associative memory regarding historical actors. Subsequently, the 'Maze Chase' mode was used to test students' understanding of the chronology of events (e.g., Rengasdengklok Incident to the Proclamation). In this mode, students had to guide a character to the correct answer zone while avoiding enemies, adding an element of adrenaline and speed that forced quick cognitive retrieval. Finally, the 'Airplane' mode was used as a post-learning refresher, where students steered a plane into clouds containing correct statements about the values of independence struggles. The games were designed to reinforce specific IPAS topics (e.g., Indonesia's Independence History). Competitive elements were introduced via the Wordwall such as leaderboard feature to stimulate healthy competition. Conversely, the control group followed the conventional workflow such as teacher explanation, question and answer session.

Data Analysis Technique

Data analysis was performed using both descriptive and inferential statistics via SPSS version 26 software. Descriptive analysis provided the mean, standard deviation, and categorization of scores for learning outcomes and motivation. Inferential analysis included the Paired Sample t-test to examine differences between pretest and posttest scores within a single group, and the Independent Sample t-test to compare the improvement in learning outcomes between the experimental and control groups. Furthermore, the effectiveness of the intervention was analyzed using the Normalized Gain (N-Gain) calculation, interpreted with categories of high (> 0.70), moderate (0.30–0.70), and low (< 0.30) effectiveness (Bai & Huang, 2020).

RESULTS AND DISCUSSION

Results

Prerequisite Analysis

Before conducting hypothesis testing, prerequisite analyses comprising normality and homogeneity tests were performed. The normality test using the Shapiro-Wilk method indicated that the pretest and posttest data for both the experimental and control groups were normally distributed, with a significance value (Sig.) > 0.05. Furthermore, the homogeneity test using Levene's Test yielded a significance value of 0.214 (> 0.05), indicating that the variances of both groups were homogeneous. Since both prerequisites were met, parametric statistical analysis using the t-test was deemed appropriate.

Learning Outcomes Results

Descriptive analysis was conducted to compare the cognitive learning outcomes of the experimental group Wordwall based joyful learning and the control group (conventional learning) before (pretest) and after (posttest) the treatment.

Table 2. Mean and Standard Deviation of Learning Outcomes

Group	N	Pretest Score	Posttest Score
Experimental	30	59.7 ± 3.10	86.4 ± 4.25
Control	30	59.7 ± 3.05	73.9 ± 3.80

Source : Primary Data Processed, 2025

Table 2 shows that in the initial condition (pretest), the mean scores of both groups were identical (59.7), suggesting that the initial academic ability of both classes was homogeneous. However, in the posttest, the experimental group experienced a higher score increase significantly higher score increase compared to the control group. The experimental group's score rose drastically to 86.4, whereas the control group only reached 73.9. This *indicating* statistical disparity indicates a positive influence of the Wordwall based Wordwall based joyful learning on student learning outcomes.

Effectiveness Analysis (N-Gain)

The effectiveness of the improvement in learning outcomes was further analyzed using the Normalized Gain (N-Gain) score to determine the category of improvement.

Table 3. N-Gain Score Calculation Results

Group	N-Gain Mean	Category
Experimental	0.68	Moderate
Control	0.35	Moderate

Source : Primary Data Processed, 2025

Based on Table 3, the experimental group obtained an N-Gain value of 0.68, which is at the upper limit of the moderate category and approaching the high category. Meanwhile, the control group obtained an N-Gain value of 0.35, which is at the lower limit of the moderate category. This demonstrates that the improvement in learning outcomes in the experimental group was more optimal far more optimal compared to the control group. This difference underscores that the use of Wordwall functions not merely as a variation in learning media, but contributes tangibly to learning effectiveness (Bai & Huang, 2020).

Hypothesis Testing (Independent Sample t-test)

To test the significance of the difference in learning outcome improvement between the two groups, an Independent Sample t-test was conducted on the N-Gain scores.

Table 4. Independent Sample t-test Results (N-Gain Score)

Data	t	df	Sig. (2-tailed)	Decision	Conclusion
N-Gain Score	6.12	58	.000	Reject H_0	Significant Difference

Source : Primary Data Processed, 2025

The Independent Sample t-test results showed a significance value of $p = 0.000$ ($p < 0.05$). This indicates a significant difference in the improvement of learning outcomes between the experimental and control groups. Therefore, the null hypothesis (H0) is rejected and the alternative hypothesis (H_a) is accepted. Given the higher average N-Gain in the experimental group (0.68), it can be concluded that the implementation of Wordwall based joyful learning is significantly effective in improving student learning outcomes in the IPAS subject.

Motivation Measurement Results

Student learning motivation was measured using a questionnaire based on the ARCS model (Attention, Relevance, Confidence, Satisfaction). The analysis compared the motivation scores of students in the experimental and control groups before and after the treatment.

Table 5. Comparison of Mean Student Motivation Scores

Group	Pretest Score	Posttest Score	Gain	Sig. (2-tailed)
Experimental	62.5	88.2	25.7	.000
Control	63.1	70.4	7.3	.021

Source: Primary Data Processed, 2025

Based on Table 5, the experimental group demonstrated a much higher increase in learning motivation compared to the control group. The average motivation score in the experimental group increased by 25.7 points, whereas the control group only experienced an increase of 7.3 points. This sharp contrast highlights the psychological impact of the gamified approach. The t-test results yielded a significance value of 0.000 ($p < 0.05$) for the experimental group, indicating that the increase in student motivation following the application of Wordwall based joyful learning is statistically significant.

Discussion

Based on the research results, the experimental group that received Wordwall based joyful learning demonstrated a significantly higher improvement in learning outcomes compared to the control group. This is reflected in the experimental group's posttest mean score of 86.4, whereas the control group only reached 73.9. This disparity in achievement indicates that students in the experimental group were able to attain a more optimal level of mastery in IPAS materials after participating in Wordwall based learning. This statistical gap is not merely a numerical difference but represents a substantial pedagogical shift. The experimental group's ability to surpass the mastery threshold suggests that the intervention successfully bridged the gap between abstract historical concepts and the students' cognitive grasp, a feat that proved challenging for the conventional method.

This aligns with Hidayaty et al. (2022), who found that the use of Wordwall significantly enhances student interest and learning outcomes because it transforms abstract concepts into interactive visual experiences. This indicates that instruction packaged in an enjoyable manner assists students in understanding concepts more deeply compared to conventional instruction. This finding validates the effectiveness of visual-based learning for elementary students who typically struggle with text-heavy materials. As noted by Viola and Yudha, (2024) digital visualization acts as a cognitive bridge, converting abstract historical narratives into concrete imagery that is easier for young learners to process and internalize. Regarding the improvement effectiveness, the experimental group achieved a Normalized Gain (N-Gain) score of 0.68, which falls within the moderate to high effectiveness category. This result is consistent with the meta analysis by Bai & Huang, (2020) and empirical findings by Surwantini, (2016), both of which highlight the positive impact of game-based learning on student achievement.

The superiority of this learning approach can be explained through the immediate feedback loop embedded in Wordwall based activities. Immediate feedback in the form of points, visual cues, and sounds allows students to quickly evaluate their responses. Recent studies emphasize that this mechanism reduces the 'split-attention effect' often found in traditional worksheets. By integrating the feedback directly into the gameplay, Wordwall minimizes

extraneous cognitive load, allowing students to focus their working memory on understanding the content rather than searching for answers. This supports the findings of Renoat et al. (2025) who argue that optimizing cognitive load through interactive media is crucial for enhancing information retention in the post-pandemic education era.

Furthermore, from a motivational perspective, these instant rewards align with the Satisfaction component of Keller's ARCS model, which emphasizes the role of positive reinforcement in sustaining learner motivation (Keller, 2020) . A deeper analysis of the motivation data through the lens of ARCS reveals specific psychological dynamics triggered by the intervention.

First, regarding Attention, the multisensory nature of Wordwall combining vivid colors, animations, and sound effects successfully captured student's perceptual arousal. In the context of 'Generation Alpha', who are accustomed to high-stimulus digital environments, the static nature of textbooks often fails to compete for their attention. As highlighted by the dynamic interface of gamified platforms effectively combats the drowsiness and disengagement often observed during conventional lessons.

Second, in terms of relevance, the game content was contextualized with familiar historical narratives, making the material feel personally significant rather than distant. By gamifying local history, students perceive the subject matter not as ancient artifacts but as an immersive narrative in which they are active participants.

Third, the aspect of confidence was nurtured through the 'scaffolding' inherent in the game design; students could retry levels and see immediate corrections, which reduced the fear of failure and built a sense of competence. This iterative process allows for low-stakes testing. This aligns with the findings of Lubis & Ponidi, (2025) who state that digital scaffolding encourages students to persist in facing difficult academic challenges.

Finally, satisfaction was reinforced not only through the intrinsic joy of playing but also through extrinsic rewards such as earning badges and seeing their names on the class leaderboard**.** This gamified reward system satisfies the students' need for achievement and recognition, creating a positive emotional loop associated with learning.

The result of the Independent Sample t-test on N-Gain scores showed a significance value of 0.000 ($p < 0.05$). This finding indicates that the difference in learning outcome improvement between the experimental and control groups is statistically significant. Thus, the improvement in the experimental group can be attributed to the implementation of Wordwall based joyful learning, rather than chance or differences in initial student ability. This statistical robustness confirms that the intervention is replicable and possesses a high degree of generalizability for similar educational contexts.

Pedagogically, the improvement in the experimental group can be explained through the characteristics of joyful learning, which emphasizes active student engagement. Game activities in Wordwall encourage students to participate actively, so the learning process is not merely about transferring information, but constructing understanding. This aligns with (Prisuna, 2021) who states that the integration of digital applications creates a new learning culture that fosters student autonomy and active participation elements often absent in teacher-centered classrooms. This shift promotes what Lestari & Rohmani, (2024) describe as student-centered autonomy, where leveled challenges in Wordwall allow students to progress from lower to higher-order thinking skills independently, reducing dependency on teacher instruction.

Moreover, the increase in motivation observed in this study supports the theory of self-determined learning. This finding is consistent with (Dewanti & Putra, 2022) who reported that digital learning media effectively increases students' learning independence and motivation. In the conventional class, the pace is dictated strictly by the teacher. Conversely, Wordwall allows students to navigate challenges at their own speed, fulfilling their need for autonomy and fostering a sense of ownership over their learning journey.

It is also pertinent to discuss the comparative advantage of Wordwall relative to other gamification platforms often used in elementary education, such as Quizizz or Kahoot. While the

latter are predominantly focused on standard multiple-choice quiz formats, Wordwall offers a distinct pedagogical advantage through its 'interactivity switching' feature. This capability allows the same educational content to be transformed into various game mechanics such as *Maze Chase* for adrenaline-inducing speed tasks or *Match Up* for cognitive association without altering the core material. According to (Yanuarto & Setyaningsih, 2024), this high degree of learnability and interface flexibility is particularly suitable for elementary students who require diverse visual stimuli to maintain focus and prevent boredom (satiation) that typically occurs in repetitive quiz formats. Furthermore, unlike other platforms that rely heavily on synchronous internet connection, Wordwall provides printable options for offline activities. This versatility ensures that the learning engagement remains high even in constrained technical environments, supporting the holistic strengthening of digital literacy (Hamidah et al. 2023).

Conversely, the conventional learning applied in the control group tended to be one-way, which explains why their motivation and learning outcomes were relatively lower. This finding reinforces the arguments of Lestari & Rohmani, (2024) that the integration of interactive media like Wordwall is an urgent alternative to improve IPAS quality.It is also important to critically analyze the dynamics within the control group. Although there was a slight increase in learning outcomes (N-Gain 0.35), the observation data revealed a phenomenon of cognitive fatigue. Without the variation of visual stimuli provided by digital media, students in the control group struggled to maintain focus for prolonged periods. The reliance on verbal explanations and static text imposed a heavy load on their working memory. This observation aligns with recent research by Zunidar & Suwandi, (2025) which notes that information received passively without emotional hooks or visual reinforcement tends to decay rapidly in elementary students' memory. This finding reinforces the argument by Wicaksono, (2020) that in the post-pandemic era, returning to fully traditional methods without technological integration is no longer sufficient to meet the cognitive needs of elementary students.

Ultimately, aligned with the conclusion of Zunidar & Suwandi, (2025) media that successfully attracts student interest is directly proportional to academic success when students feel engaged in Wordwall games, psychological barriers are reduced, making the material easier to absorb. The transformation of the classroom from a rigid instructional space into a dynamic, playful environment proves that term “joy” is not merely an accessory to learning, but a fundamental prerequisite for deep cognitive immersion.

CONCLUSION

Based on the research results and discussion, it can be concluded that the implementation of Wordwall based joyful learning successfully enhances both learning outcomes and student motivation in the Natural and Social Sciences subject at the elementary school level. Instruction designed within an enjoyable and interactive atmosphere fosters active student engagement, thereby facilitating a more optimal understanding of learning concepts as evidenced by the significant improvement in the experimental group's post-test scores.

The improvement in learning outcomes (N-Gain = 0.68) observed in the experimental group correlates directly with the increase in learning motivation. The utilization of Wordwall media provides a challenging learning experience accompanied by immediate feedback, which positively impacts student attention and satisfaction, key components of the ARCS model, during the instructional process. Therefore, Wordwall based joyful learning serves as a viable and effective alternative pedagogical strategy to enhance the quality of IPAS instruction in elementary schools.

Furthermore, for practical implementation, educators are advised to ensure internet stability and device readiness before integrating this platform. Teachers should also strategically select game modes that align with the cognitive taxonomy of the lesson for instance, using 'Quiz' for diagnostic assessment and 'Game Show' for summative review. It is also crucial for teachers to act not just as technical facilitators, but as motivators who celebrate the students' achievements on the leaderboard to maintain the competitive yet collaborative atmosphere. It

is recommended that teachers systematically integrate interactive digital learning media to ensure that the learning process becomes more active, enjoyable, and meaningful.

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