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Effectiveness of Wordwall as a Gamification-Based Learning Medium in Enhancing Student Motivation and Learning Activities

Muh. Al Amin[1)*], Nurwahid Syam[2)], Juniarti Iryani[2)]

[1)]*Digital Business, Bina Adinata Institute of Technology and Business, Bulukumba, 92561, Indonesia*
[2]*Computer Systems, Bina Adinata Institute of Technology and Business, Bulukumba, 92561, Indonesia*

**Corresponding author: daeng.ngawing@gmail.com*

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Abstract *– Low learning motivation and limited student engagement remain persistent challenges in elementary science education, particularly in abstract topics such as light and sound. Conventional instructional approaches often fail to involve students, resulting in suboptimal learning experiences. In response to this issue, gamification-based digital learning media have emerged as a promising alternative to enhance student motivation and learning activities. This study aims to examine the effectiveness of Wordwall, a gamification-based learning medium, in increasing motivation and engagement in science learning among elementary school students. A mixed-methods approach with a sequential explanatory design was employed. Quantitatively, a true-experimental pretest–posttest control-group design was used with two Grade V classes at an elementary school in South Sulawesi, Indonesia, involving 50 students, equally divided into experimental and control groups. The experimental group received instruction using Wordwall, while the control group was taught using conventional methods. Data were collected using a learning motivation questionnaire and an observation sheet for learning activities. Qualitatively, phenomenological interviews were conducted with teachers and students to explore their learning experiences. The quantitative results showed that students in the experimental group experienced a significantly higher increase in learning motivation (21.37%) and learning activities (22.19%) compared to the control group (8.49% and 11.81%, respectively), with statistically significant differences confirmed by t-tests and ANOVA ($p < 0.05$). Qualitative findings supported these results, indicating that Wordwall created a more interactive, enjoyable, and engaging learning environment that encouraged active participation and sustained attention. The novelty of this study lies in integrating a true-experimental design with a qualitative phenomenological analysis to comprehensively examine the motivational and behavioral aspects of learning in elementary science education. In conclusion, Wordwall is an effective gamification-based learning medium for enhancing students' motivation and engagement in science learning, and this study provides empirical evidence for the development of gamification-based instructional models in physics education at the elementary level.*

Keywords: *gamification; learning activities; motivation; physics education; wordwall*

I. INTRODUCTION

Engaging and interactive learning is a crucial factor in improving educational quality, particularly at the primary school level (Caracuel-Cáliz et al., 2025). Nevertheless, learning practices in many elementary schools remain dominated by conventional instructional approaches that offer limited stimulation for students. Such approaches often result in low learning motivation and minimal student engagement during classroom activities (Santrock, 2020). Insufficient motivation has been shown to reduce students' active involvement in learning, which ultimately leads to suboptimal learning outcomes (Napitupulu et al., 2024). Consequently, there is a pressing need to develop and implement instructional innovations that are more responsive to the characteristics and learning preferences of today's digital-native students.

Amid persistent challenges in sustaining students' engagement and motivation in contemporary classrooms, gamification has emerged as a strategically relevant instructional innovation. Gamification, defined as the systematic integration of game elements into non-game contexts such as education (Saleem et al., 2022), extends beyond mere classroom entertainment. Grounded in motivational and engagement theories, gamification has been empirically associated with increased intrinsic and extrinsic motivation (Fiskawarni et al., 2025), which in turn enhances students' interest, persistence, and active involvement in learning activities (Hermayesi & Fitriani, 2024; Kurniati et al., 2025). Furthermore, accumulating evidence suggests that well-designed gamified learning environments can promote sustained participation, strengthen memory retention through meaningful reinforcement mechanisms, and facilitate deeper conceptual understanding of subject matter (Sari et al., 2024)

Among various gamification-based learning tools, Wordwall has emerged as a practical and accessible platform that can be readily integrated into classroom instruction (Dahalan et al., 2024). Wordwall enables teachers to design interactive game-based activities, such as quizzes, matching exercises, and crossword puzzles, which can be adapted to different learning objectives and student needs (Sari et al., 2024). Previous research has demonstrated that the use of Wordwall can effectively increase students' learning motivation and improve their mastery of instructional content (Widhiatama & Brameswari, 2024). These findings suggest that Wordwall holds considerable potential as a solution to address low student motivation and limited learning activity in elementary school classrooms.

At UPT Inpres Tete Batu Elementary School, low student motivation remains a persistent challenge, particularly in subjects perceived as difficult and less engaging. This issue is especially evident in the Natural and Social Sciences subject, where teachers often struggle to capture students' attention and sustain their active participation throughout the learning process.

Preliminary observations indicate that students tend to be passive when instruction relies on conventional methods, such as lecture-based teaching, and consequently display limited learning activities. This condition underscores the need to implement more interactive and innovative learning models to foster student engagement and motivation.

Although several studies have reported that the integration of technology into learning environments positively influences student motivation and learning outcomes (Suyuti et al., 2023), research specifically examining the effectiveness of Wordwall at the elementary school level remains limited. Existing studies largely focus on general technology use or emphasize cognitive learning outcomes, leaving a gap in empirical evidence on Wordwall's role in enhancing students' motivation and learning activities. Therefore, further investigation is needed to clarify the effectiveness of Wordwall as a gamification-based learning medium in elementary education. The urgency of this research lies in the growing importance of digital technology in addressing issues of low motivation and limited learning activity among elementary school students. As a gamification platform, Wordwall facilitates interactive and game-based learning experiences that can make learning more engaging and meaningful (Nenohai et al., 2022). In addition, this study extends previous research by employing a true-experimental design (Sugiyono, 2015) combined with a phenomenological qualitative approach, thereby providing a more comprehensive and in-depth understanding of both learning outcomes and learning experiences.

Furthermore, this research aligns with national education policies, which emphasizes student-centered learning and the strategic use of technology to enhance learning effectiveness (Amalia & Asbari, 2023). Accordingly, the findings of this study are expected to serve as a reference for teachers and schools in adopting effective digital learning media to improve the quality of instruction in elementary schools, using light and sound materials as the instructional context. These topics are often perceived as abstract and challenging by elementary school students, as they require scientific reasoning and conceptual understanding that are difficult to achieve through conventional teaching methods. Teachers also face challenges in presenting such materials in an engaging and comprehensible manner due to limitations in interactive learning media (Koç & Kanadlı, 2025). Therefore, light and sound materials were selected because they demand a visual, interactive, and contextual learning approach, making them suitable for examining the effectiveness of Wordwall-based gamification.

Despite the growing body of literature on technology-enhanced and gamification-based learning, several research gaps remain. Studies on Wordwall at the elementary school level are still predominantly based on quasi-experimental designs and focus mainly on cognitive outcomes. Research that integrates a true-experimental design with a qualitative approach to examine

students' learning motivation and learning activities comprehensively remains scarce. Moreover, empirical studies specifically investigating the use of Wordwall in elementary science learning, particularly in light and sound materials, are limited. This study seeks to address these gaps by systematically examining the effectiveness of Wordwall as a gamification-based learning medium in improving elementary school students' motivation and learning activities.

Based on these research gaps, the present study aims to examine in depth the effectiveness of Wordwall implementation in elementary school learning. Specifically, this study investigates how the use of Wordwall influences various dimensions of students' learning motivation and analyzes its impact on learning activities encompassing mental, emotional, physical, and social aspects. In addition, this study seeks to determine whether there are significant differences in learning motivation and learning activities between students taught using Wordwall-based instruction and those taught using conventional learning methods.

II. METHODS

This study employed a mixed-methods approach that integrates quantitative and qualitative methods to obtain a comprehensive understanding of the effectiveness of Wordwall as a gamification-based learning medium (Samal et al., 2024). The quantitative component was used to objectively measure changes in students' learning motivation and learning activities, while the qualitative component was designed to explore in depth the experiences and perceptions of teachers and students during the learning process. The adoption of this research design was motivated by the need not only to statistically test differences in learning outcomes, but also to capture the instructional processes and classroom dynamics underlying those outcomes (Iryani & Syam, 2024).

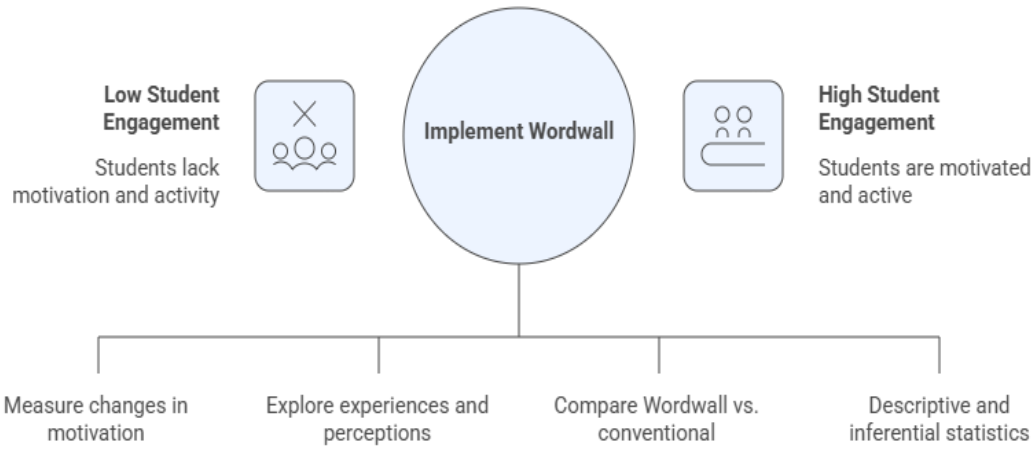

Figure 1. Implementing learning improvement with wordwalls

The research was conducted at UPT Inpres Tete Batu Elementary School, Pallangga District, Gowa Regency, South Sulawesi Province, during the 2024/2025 academic year. The study focused on the implementation of Wordwall media in Natural and Social Sciences (IPAS) learning, with particular emphasis on science topics related to light and sound taught in Grade V. The population of this study consisted of all students enrolled at UPT Inpres Tete Batu Elementary School in the 2024/2025 academic year.

Sample selection was conducted using purposive sampling, in which participants were selected based on criteria relevant to the research objectives (Sahir, 2021). From two Grade V classes with relatively similar characteristics in terms of class size, academic ability, and availability of learning facilities, one class was assigned as the experimental group and received instruction using Wordwall-based gamification, while the other class served as the control group and was taught using conventional instructional methods in the form of varied lectures. Each group consisted of 25 students.

This study involved two main types of variables, namely independent and dependent variables (Haifa et al., 2025). The independent variable was the use of Wordwall as a gamification-based learning medium. Wordwall is an interactive digital game-based platform designed to enhance student engagement through enjoyable learning activities, immediate feedback, and healthy competition. The dependent variables were students' learning motivation and learning activities, reflecting their behavioral and psychological responses to the implementation of Wordwall in IPAS learning.

The quantitative component of the study employed a true-experimental design with a pretest–posttest control group. In this design, both the experimental and control groups were administered a pretest to determine baseline levels of learning motivation and learning activities. Subsequently, the experimental group received instruction using Wordwall media, whereas the control group continued to receive conventional instruction. After the intervention period, both groups were given a posttest to measure changes in learning motivation and learning activities attributable to the treatment (Iryani & Syam, 2024). The qualitative component was conducted through semi-structured, phenomenology-based interviews with teachers and students to explore their experiences, perceptions, and interpretations of using Wordwall in the learning process (Kvale & Brinkmann, 2009; Bancong, 2025).

Data were collected using multiple research instruments. Students' learning motivation was measured using a Likert-scale questionnaire consisting of 25 statements representing five motivation indicators, administered at both the pretest and posttest stages (Suyatna et al., 2020). This instrument was validated by experts using the Gregory formula and yielded a validity

coefficient of 1.0, indicating very high validity. Students' learning activities were assessed using an observation sheet based on an activity rubric encompassing mental, emotional, physical, and social aspects, consisting of 12 statement items. This observation instrument was also validated by experts and achieved a validity coefficient of 0.98, which falls within the very valid category (Mirnawati et al., 2022). In addition, qualitative data were collected through in-depth interviews with teachers and students, as well as through photographs of learning activities.

Quantitative data analysis was conducted using descriptive statistics, including the calculation of means, standard deviations, and percentage increases in students' learning motivation and learning activities. Inferential statistical analysis was then applied to examine significant differences between the experimental and control groups using independent samples t-tests and analysis of variance (ANOVA). Qualitative data were analyzed using a phenomenological thematic analysis to identify recurring patterns, themes, and meanings emerging from the interview data (Lochmiller, 2021). To enhance procedural clarity, this research methodology was supported by a data-collection flowchart outlining the research process, including preparation, pretest administration, implementation of the instructional intervention, posttest data collection, and subsequent quantitative and qualitative data analysis.

III. RESULTS

1. Quantitative results

Data on students' learning motivation and learning activities were collected from both the experimental and control groups using questionnaires and observation sheets administered at the pretest and posttest stages. Learning motivation data were collected via a 25-item questionnaire distributed across five indicators, as presented in Table 1.

Table 1. Learning motivation indicators

No	Indicator	Item numbers
1	Students show consistent effort despite difficulties	1, 2, 3, 4, 5
2	Students have a goal in participating in learning	6, 7, 8, 9, 10
3	Students feel happy and interested in the learning materials	11, 12, 13, 14(–), 15
4	Students are encouraged to demonstrate learning achievement	16, 17, 18, 19, 20
5	Students find learning important and rewarding	21, 22, 23, 24, 25(–)

Table 1 shows that the learning motivation instrument comprises five indicators represented by both positive and negative statements. The percentage increase in students' learning motivation scores for both groups is presented in Table 2.

Table 2. Percentage of increased learning motivation

Groups	Pretest mean	Posttest mean	Absolute improvement	Percentage increase
Experiments	68.56	83.20	14.64	21.37%
Controls	68.28	74.08	5.80	8.49%

As shown in Table 2, there was a clear difference in the increase in learning motivation between the experimental and control groups. In the experimental group, the mean learning motivation score increased from 68.56 at the pretest to 83.20 at the posttest, resulting in an absolute improvement of 14.64 points, equivalent to a 21.37% increase. This substantial improvement indicates that the application of Wordwall media significantly enhanced students' learning motivation compared to their pre-intervention condition. In contrast, the control group showed a more modest increase in learning motivation. The mean pretest score of 68.28 increased to 74.08 at the posttest, yielding an absolute improvement of 5.80 points, or an 8.49% increase. Although learning motivation in the control group improved, the magnitude of this increase was considerably lower than that observed in the experimental group.

A comparison between the two groups reveals that the percentage increase in learning motivation in the experimental group was more than twice that of the control group (21.37% versus 8.49%). This finding suggests that Wordwall, as a gamification-based learning medium, is more effective at enhancing students' learning motivation than conventional instructional methods. Accordingly, the data presented in Table 2 reinforce the conclusion that Wordwall has a positive, meaningful impact on students' learning motivation.

Students' learning activities were measured using an observation instrument consisting of 12 statement items distributed across five indicators, as shown in Table 3.

Table 3. Learning activity indicators

No	Indicator	Item numbers
1	Students actively answer and discuss during learning activities	1, 2
2	Students actively think and solve problems on Wordwall	2, 3
3	Students interact with teachers and friends during Wordwall-based learning	4, 5, 6, 11, 12
4	Students actively use the device to access and play Wordwall	7, 8
5	Students show happy and enthusiastic expressions during learning activities	9, 10

Table 3 indicates that the learning activity instrument captures mental, emotional, physical, and social aspects of student engagement. The percentage increase in learning activity scores for both groups is presented in Table 4.

Table 4. Percentage increase in learning activities

Groups	Pretest mean	Posttest mean	Absolute improvement	Percentage increase
Experiments	29.20	35.68	6.48	22.19%
Controls	29.80	33.32	3.52	11.81%

Based on Table 4, there was a notable difference in the improvement of learning activities between the experimental and control groups. In the experimental group, the mean learning activity score increased from 29.20 at the pretest to 35.68 at the posttest, resulting in an absolute improvement of 6.48 points, or a 22.19% increase. These results indicate that implementing Wordwall media effectively increased student involvement in learning activities. Meanwhile, the control group experienced an increase in learning activities from a pretest mean score of 29.80 to a posttest mean score of 33.32. This corresponds to an absolute improvement of 3.52 points or an 11.81% increase. Although learning activities in the control group improved, the extent of improvement was substantially lower than that observed in the experimental group. Compared with the control group, the experimental group showed a nearly double increase in learning activities (22.19% vs. 11.81%). This difference indicates that Wordwall, as a gamification-based learning medium, is more effective in enhancing students' learning activities than conventional teaching methods. Therefore, the data presented in Table 4 further support the finding that Wordwall not only improves learning motivation but also promotes more active student engagement in the learning process.

Following the descriptive analysis, inferential statistical analyses were conducted to examine differences in learning motivation and learning activities between the experimental and control groups. Independent-samples t-tests were used to compare mean scores at the pretest and posttest, while analysis of variance (ANOVA) was used to test the overall significance of differences between groups. These analyses aimed to determine whether the use of Wordwall as a gamification-based learning medium had a statistically significant effect on students' learning motivation and learning activities. The results of the independent samples t-tests, as shown in Table 5, indicate that there was no significant difference in learning motivation between the experimental and control groups before the intervention ($t = 0.17$, $df = 48$, $p = 0.865 > 0.05$). This finding suggests that both groups were comparable in terms of learning motivation at baseline.

Table 5. Independent samples test for learning motivation

Stages	t	df	Sig. (2-tailed)	Mean difference	Std. error difference
Pretest	0.17	48	0.865	0.28	1.62
Posttest	6.74	48	0.000	9.12	1.35

In contrast, the posttest results demonstrate a statistically significant difference in learning motivation between the two groups after the intervention. The t-test yielded t = 6.74 with df = 48 and p = 0.000 (< 0.05). The mean difference of 9.12, with a standard error of 1.35, indicates that students in the experimental group exhibited significantly higher learning motivation than those in the control group after Wordwall was implemented. These results provide strong statistical evidence that the intervention significantly increased students' learning motivation.

Table 6. Independent samples test for learning activities

Stages	t	df	Sig. (2-tailed)	Mean difference	Std. error difference
Pretest	-0,74	48	0,463	-0,60	0,81
Posttest	2,47	48	0,018	2,36	0,95

The pretest analysis for learning activities showed no statistically significant difference between the experimental and control groups (t = –0.74, df = 48, p = 0.463 > 0.05), indicating that both groups had comparable levels of learning activity before the intervention. However, the posttest results revealed a significant difference in learning activities after the intervention. The t-test yielded t = 2.47 with df = 48 and p = 0.018 (< 0.05). The mean difference of 2.36, with a standard error of 0.95, indicates that the experimental group demonstrated significantly greater learning activity than the control group. These findings confirm that the use of Wordwall had a positive, statistically significant impact on students' learning activities. Overall, the t-test results indicate that the intervention significantly improved students' learning motivation and learning activities, demonstrating the effectiveness of the learning method used in this study.

The ANOVA results, as shown in Table 7, indicate a statistically significant effect of the treatment on students' learning motivation. An F value of 22.80 with a significance level of 0.000 (p < 0.05) demonstrates that there were significant differences in learning motivation between the experimental and control groups. This finding confirms that using Wordwall as a gamification-based learning medium substantially enhances students' learning motivation.

Table 7. ANOVA test results for learning motivation

Source of variation	Sum of squares	df	Mean square	F	Sig.
Between groups	831.36	1	831.36	22.80	0.000
Within groups	1725.60	48	35.95		
Total	2556.96	49			

Similarly, the ANOVA results for learning activities reveal a significant effect of the treatment. The obtained F value of 6.12, with a significance level of 0.018 (p < 0.05), indicates

significant differences in learning activities between the experimental and control groups. These findings further support the conclusion that implementing Wordwall significantly improved students' learning activities.

Table 8. ANOVA test results for learning activities

Source of variation	Sum of squares	df	Mean square	F	Sig.
Between groups	74.72	1	74.72	6.12	0.018
Within groups	585.28	48	12.19		
Total	660.00	49			

2. Qualitative results

In addition to quantitative analyses, this study incorporated qualitative data to strengthen and contextualize the statistical findings. In-depth interviews with teachers and students were conducted using a phenomenological approach to capture participants' lived experiences during the implementation of Wordwall-based learning. The interview data were analyzed using thematic analysis to identify recurring themes and patterns of meaning.

Table 9. Thematic analysis of qualitative data (phenomenological approach)

Theme	Interview quotes (teachers & students)	Interpretation
Higher enthusiasm and interest in learning	- Teacher: "Previously, children often got bored quickly if they only heard explanations, especially in difficult subjects such as science. But when I showed Wordwall, they immediately scrambled to move forward." - Student: "Learning to use Wordwall feels like playing a game. So it's not boring and doesn't make you dizzy if you learn difficult lessons like science."	Wordwall increases students' intrinsic motivation. According to Self-Determination Theory, fun learning not only increases students' engagement but also their motivation and desire to learn (Guay, 2022).
Focus and concentration in learning activities	- Teacher: "If there are usually students chatting, with Wordwall, they pay more attention because they want to participate in answering." - Student: "If the Wordwall question appears on the screen, I want to read and answer quickly. So I didn't have time to talk to my friends."	Wordwall's interactivity focuses students' attention. According to the ARCS Motivation Model, motivation and academic self-efficacy are key factors for student success (Bozkurt et al., 2025).

Collaborative and competitive activities	- Student: "If my group wins, I will be more motivated to learn better." - Teacher: "Children look compact when they use Wordwall. They encourage each other so that their group can get the highest score." - Student: "If I lose, I want to learn again so that tomorrow I can win."	Wordwall's gamification encourages collaboration and healthy competition. This aligns with the ARCS model, which found that social interactions among learners can increase their motivation to learn, as these interactions create a dynamic and collaborative environment (Mirzaei et al., 2024).
Technical barriers and adaptation process	- Teacher: "At first, there were children who were confused, but after two meetings, everyone got used to it." - Student: "At first I was afraid of hitting the wrong one, but over time it became easier, and I even liked it when there was another Wordwall." - Teacher: "There were obstacles at the beginning, but now they are the ones who ask me to create questions on Wordwall."	Technical barriers are temporary. Student adaptation shows that with consistency, learning technologies can be accepted and even anticipated with enthusiasm.

Overall, the qualitative findings corroborate the quantitative results by demonstrating that Wordwall not only produces statistically significant improvements in learning motivation and learning activities but also generates meaningful learning experiences from the perspectives of teachers and students. The integration of quantitative and qualitative evidence consistently indicates that Wordwall, as a gamification-based learning medium, effectively enhances motivation and learning activities among elementary school students.

IV. DISCUSSION

The findings of this study demonstrate that the use of Wordwall as a gamification-based learning medium has a significant positive effect on both learning motivation and learning activities of elementary school students. These results not only confirm Wordwall's empirical effectiveness but also strengthen the theoretical understanding of how gamification enhances student engagement and active participation in learning processes (Ratinho & Martins, 2023). From the perspective of Self-Determination Theory (SDT), the observed increase in students' learning motivation can be explained by the fulfillment of three fundamental psychological needs: autonomy, competence, and relatedness (Wang et al., 2019). Wordwall facilitates autonomy by

allowing students to actively engage with learning materials through game-based challenges, answer choices, and real-time feedback, thereby giving them a sense of control over their learning. The immediate scoring and feedback mechanisms embedded in Wordwall enhance students' perceived competence, as learners can recognize successes and identify mistakes promptly. Furthermore, the dimension of relatedness is fostered through collaborative activities and healthy competition, which promote social interaction and a sense of belonging among students. In this regard, the findings of this study extend the application of SDT to the context of gamification-based digital learning at the elementary school level.

In addition to SDT, the results of this study are closely aligned with the ARCS motivation model (Afjar et al., 2020). Wordwall effectively captures students' attention through visually appealing interfaces and engaging game mechanics. Relevance is achieved when IPAS content, particularly abstract topics such as light and sound, is presented in contextually relevant game formats closely related to students' everyday experiences. Students' confidence increases as they gradually succeed in completing challenges, while satisfaction emerges from accumulated scores, positive feedback, and enjoyable learning experiences. The integration of these ARCS components helps explain why Wordwall not only enhances learning motivation but also promotes more active learning behaviors across mental, emotional, physical, and social dimensions.

The findings of this study are consistent with previous research demonstrating the effectiveness of gamification in educational contexts. Irnawati et al. (2024) reported that gamification-based learning significantly improves students' motivation in subjects perceived as challenging, such as mathematics. Similarly, Suyuti et al. (2023) found that the integration of digital technology in learning contributes to improved student engagement and learning outcomes. Moreover, Alburo et al. (2025) showed that gamification in science education enhances student engagement, encourages critical thinking, and promotes collaborative learning, leading to more positive attitudes toward science learning.

Specifically related to Wordwall, Widhiatama and Brameswari (2024) demonstrated that integrating Wordwall into literature learning significantly increases students' engagement and motivation, as well as their interest in reading and interpretation activities. Compared to these studies, the present research offers stronger empirical support by employing a true-experimental design and enriching quantitative findings with a phenomenological qualitative approach. This methodological integration provides a more comprehensive understanding not only of the outcomes but also of the learning experiences underlying the observed improvements.

The primary theoretical contribution of this study lies in strengthening a gamification-based learning framework that integrates SDT and ARCS models within the context of elementary

science education. The findings suggest that the effectiveness of gamification extends beyond the mere incorporation of game elements; rather, it lies in its capacity to satisfy students' psychological needs while establishing a sustainable motivational structure. In this sense, Wordwall should be viewed not merely as a supplementary learning tool but as an integral component of a gamification-based instructional model designed to enhance motivation and learning activities. The conceptual implications of these findings point to the need for a paradigm shift in the use of digital media in education, from functioning solely as content-delivery tools to serving as learning designs grounded in motivational theory. Within this framework, Wordwall acts as a pedagogical bridge that connects motivational theories to classroom practice. This perspective aligns closely with the objectives of the Merdeka Learning policy, which emphasizes student-centered learning, effective use of technology, and the creation of meaningful learning experiences (Haq & Wakidi, 2024).

V. CONCLUSION AND SUGGESTION

The findings of this study demonstrate that Wordwall, when implemented as a gamification-based learning medium, is effective in increasing both learning motivation and learning activities of elementary school students in IPAS learning, particularly in science topics on light and sound. Quantitative results show that students who learned using Wordwall experienced significantly higher gains in motivation and learning activities compared to those taught using conventional methods. These improvements were evident across multiple dimensions, including mental, emotional, physical, and social engagement. The qualitative findings further corroborate these results by revealing that Wordwall creates a more interactive, enjoyable, and engaging learning environment, thereby supporting active student participation and sustained learning motivation.

Despite these positive findings, this study has several limitations. First, the research was conducted in a single elementary school with a relatively small sample size, which may limit the generalizability of the results. Second, the intervention focused on a specific science topic (light and sound), and its implementation was relatively short. Future research is therefore recommended to involve larger and more diverse samples, extend the duration of implementation, and examine the effectiveness of Wordwall across different science topics and educational levels. Further studies may also explore the long-term impact of gamification on conceptual understanding and higher-order thinking skills. Nevertheless, this study makes a meaningful contribution to the field of physics education by providing empirical evidence that gamification-based digital media, such as Wordwall, can effectively enhance student motivation and learning

in elementary science. The integration of a true-experimental design with qualitative insights strengthens the pedagogical relevance of this research. It supports the use of gamification as a theoretically grounded and practical approach in physics education.

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