

The Effect of Kahoot and Wordwall-Based Learning Media on Fourth-Grade Students' Conceptual Understanding of Whole Numbers

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Article History

Received : 25 April 2026;

Revised : 10 May 2026;

Accepted : 16 May 2026.

Keywords

Kahoot;

Wordwall;

Conceptual Understanding;

Whole Numbers;

Game-Based Learning.



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Abstract

Conceptual understanding is essential in elementary mathematics because it enables students to interpret numerical relationships and apply concepts in problem-solving situations. This study aimed to examine the differential effect of Kahoot and Wordwall Quiz-based learning media on fourth-grade students' conceptual understanding of whole numbers. A quantitative approach with a quasi-experimental non-equivalent pretest-posttest design was employed. The participants were 36 fourth-grade students divided into two intact classes, with one class learning through Wordwall Quiz and the other through Kahoot. Data were collected using 15 multiple-choice items and analyzed using descriptive statistics, normalized gain (N-Gain), paired sample t-tests, and paired-samples Cohen's d. The findings showed that both groups improved, but the improvement patterns differed. The Kahoot group showed a statistically significant increase, $t(17) = 5.41$, $p < 0.001$, $d = 1.28$, with an N-Gain of 0.21. Meanwhile, the Wordwall Quiz group showed a positive but non-significant increase, $t(17) = 2.02$, $p = 0.059$, $d = 0.48$, with an N-Gain of 0.14. The novelty of this study lies in comparing two quiz-based digital media with different interaction designs in elementary mathematics. The findings imply that digital quiz media should be integrated with conceptual explanation, reasoning discussion, and contextual problem-solving activities.

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How to Cite : Ananda, T. Y., Faizah, S., & Pristiani, R. (2026). The Effect of Kahoot and Wordwall-Based Learning Media on Fourth-Grade Students' Conceptual Understanding of Whole Numbers. *Didactica : Jurnal Kajian Pendidikan Dan Pembelajaran*, 6(1), 12-21.
<https://doi.org/10.56393/didactica.v6i1.4296>



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Introduction

Mathematics learning in elementary school plays a crucial role in developing students' logical, critical, and systematic thinking skills from an early age. Beyond its function as a computational tool, mathematics also serves as a foundation for reasoning and problem-solving abilities that are essential in everyday life (Li et al., 2024). In the context of 21st-century education, numeracy literacy has become a key competency that determines students' readiness to face increasingly complex learning and real-life challenges. However, international assessments consistently indicate that Indonesian students' mathematical performance remains relatively low, as reflected in PISA 2018 and TIMSS 2019 results (Mullis et al., 2020; OECD, 2019). These findings highlight the urgent need to improve the quality of mathematics learning, particularly at the elementary level. At this stage, learning should not only emphasize procedural fluency but also strengthen conceptual understanding, because students need to connect mathematical ideas, interpret numerical relationships, and apply concepts meaningfully in problem-solving situations (Madrid et al., 2024).

One of the most fundamental topics in elementary mathematics is whole numbers, as this topic serves as the basis for understanding arithmetic operations and more advanced mathematical concepts such as fractions, measurement, and algebraic thinking. Mastery of whole number concepts is essential because it supports students' ability to understand place value, compare and order numbers, recognize numerical patterns, perform operations accurately, and interpret mathematical situations in daily life. However, classroom practices indicate that many elementary students still experience difficulties in understanding the meaning and application of whole numbers. Students frequently struggle to interpret place value, apply arithmetic operations accurately, and solve contextual problems that require reasoning rather than direct calculation. Preliminary classroom observations also revealed that several students tended to memorize arithmetic procedures without fully understanding the underlying mathematical concepts. These conditions indicate that students' conceptual understanding of whole numbers requires instructional support that encourages active engagement, reasoning, and meaningful interaction with mathematical ideas.

Previous studies suggest that this issue is partly influenced by teacher-centered instructional practices that limit student interaction and reduce opportunities for active knowledge construction (Hidayat et al., 2023; Suryani et al., 2023). As a consequence, students become passive learners who rely heavily on procedural explanations instead of conceptual reasoning. Therefore, more interactive and student-centered instructional approaches are needed to support the development of conceptual understanding in elementary mathematics learning. Learning media used in this context should not only attract students' attention, but also facilitate participation, feedback, repeated practice, and conceptual reflection. The implementation of interactive and student-centered digital learning is also aligned with the principles of the Merdeka Curriculum, which emphasizes active learning, conceptual understanding, and the integration of technology in classroom instruction (Ministry of Education, Culture, Research, and Technology, 2022).

The rapid integration of digital technology into education has created new opportunities to design more engaging and meaningful learning experiences. One instructional approach that has gained significant attention is game-based learning, which integrates game elements into

classroom activities to increase student motivation, participation, and engagement. Game-based learning environments commonly incorporate features such as challenge, competition, rewards, feedback, and repeated attempts. These elements can support learning when they are connected to clear instructional objectives and meaningful cognitive activities. Sailer and Homner (2020) explained that gamification can positively affect cognitive, motivational, and behavioral learning outcomes, although its effectiveness depends on how game elements are designed and implemented. Thus, digital game-based learning should be aligned with students' cognitive processes, especially in mathematics learning where conceptual understanding requires students to process abstract ideas and identify relationships among concepts.

Among various game-based learning platforms, Kahoot and Wordwall are widely used in elementary education due to their accessibility and interactive instructional features. Kahoot is a quiz-based platform that emphasizes synchronous participation, time-limited responses, competition, scoreboards, and immediate feedback. These features can stimulate student engagement, strengthen attention, and help students recognize errors directly during classroom instruction (Wang & Tahir, 2020; Aljaloud et al., 2024). In whole number learning, immediate feedback may help students correct misconceptions related to number meaning, place value, and arithmetic operations. However, the fast-paced nature of Kahoot needs to be managed carefully so that speed does not dominate conceptual reasoning.

Wordwall also provides interactive learning features, including quiz-based activities for practice and concept reinforcement. In this study, the quiz feature of Wordwall was selected to maintain task comparability with Kahoot, so both groups engaged in quiz-based digital learning activities. Nevertheless, both platforms still differ in interaction design: Kahoot emphasizes real-time participation, time pressure, immediate feedback, and competitive scoreboards, whereas Wordwall Quiz provides a more flexible quiz-based activity that depends more on teacher guidance and task design. From the perspective of cognitive load theory, these differences may influence how students focus their attention on mathematical relationships and process whole number concepts (Sweller et al., 2019). Therefore, this study compares two quiz-based digital media with different interaction designs, rather than comparing all features available in Wordwall.

Previous studies have reported that Kahoot improves motivation, engagement, and learning outcomes through interactive gamification features and real-time classroom interaction (Licorish et al., 2018; Wang & Tahir, 2020; Aljaloud et al., 2024). Similarly, Wordwall has been shown to support meaningful and interactive learning experiences that encourage student participation (Rahayu & Wibowo, 2023; Yuliana et al., 2022). However, most previous studies primarily focus on general learning outcomes or motivation rather than specifically examining conceptual understanding as a core aspect of mathematical learning. In addition, existing research tends to investigate Kahoot and Wordwall separately without examining their influence within the same instructional context. More specifically, limited empirical evidence is available regarding how two quiz-based digital media with different interaction designs affect elementary students' conceptual understanding of whole numbers. This gap is important because conceptual understanding enables students to interpret number meaning, understand relationships among numbers, and apply mathematical knowledge flexibly in contextual problem-solving situations.

Based on these considerations, this study examines the differential effect of Kahoot and Wordwall Quiz-based learning media on fourth-grade students' conceptual understanding of whole numbers using a quasi-experimental design. The novelty of this study lies in comparing two quiz-based digital learning media that share a similar task format but differ in their interaction design, feedback mechanisms, pacing, and classroom competition. This comparison is important because the effectiveness of digital game-based learning may depend not only on the use of technology, but also on how the media structure students' cognitive engagement during mathematics learning. In this study, conceptual understanding refers to students' ability to understand numerical meaning, perform arithmetic operations accurately, and apply whole number concepts in solving contextual problems. Accordingly, this study seeks to answer the following research question: "To what extent do Kahoot and Wordwall Quiz-based learning media differentially affect fourth-grade students' conceptual understanding of whole numbers?"

Method

This study employed a quantitative approach using a quasi-experimental design with a non-equivalent pretest-posttest format to examine the effect of Kahoot and Wordwall Quiz-based learning media on fourth-grade students' conceptual understanding of whole numbers. The study was conducted at SDN 02 Kenongorejo and involved 36 fourth-grade elementary school students aged 9–10 years. The participants consisted of two intact classes, namely class IV A and class IV B, with 18 students in each class, and saturated sampling was used because all members of the population were included as research participants. Class IV A was assigned as the Wordwall Quiz group, while class IV B was assigned as the Kahoot group. The instructional treatment was conducted in four meetings, with each meeting lasting approximately 30 minutes, and both groups received the same whole number material, learning objectives, and pretest-posttest instruments. The Wordwall group used the quiz feature in Wordwall to maintain task comparability with the Kahoot group, so both groups engaged in quiz-based digital learning activities but differed in platform characteristics, particularly interaction design, pacing, feedback display, and classroom competition. The instructional activities were delivered by the respective classroom teachers, while comparable learning procedures were applied to reduce instructional differences between the two groups. Data were collected using 15 multiple-choice items developed from the Phase B learning outcomes, covering reading and writing whole numbers up to 10,000, place value, number comparison and arrangement, arithmetic operations, and contextual problem-solving involving whole numbers at the cognitive levels of understanding (C₂) and application (C₃). Before implementation, the instrument was validated by an expert validator through content, construction, and language/cultural appropriateness aspects, and the validation result indicated that the instrument was feasible to use without revision. Data were analyzed using descriptive statistics, N-Gain, and paired sample t-test after normality and homogeneity tests were conducted, with the significance level set at 0.05.

Results and Discussion

Results

This study examined the effect of Kahoot and Wordwall Quiz-based learning media on fourth-grade students' conceptual understanding of whole numbers. The results were analyzed

using descriptive statistics, normalized gain (N-Gain), paired sample t-test, and paired-samples Cohen's d as an effect size measure. The analysis was not only focused on statistical significance, but also on the extent of learning improvement reflected in the N-Gain scores.

Table 1. Descriptive Statistics and N-Gain of Students' Conceptual Understanding

Class	Media	Pretest - Mean	Posttest - Mean	Gain	N-Gain	Category
IV A	Wordwall Quiz	53.33	60.00	6.67	0.14	Low
IV B	Kahoot	38.67	51.50	12.83	0.21	Low

Table 1 shows that both groups experienced an increase in mean scores after the instructional treatment. The Wordwall Quiz group increased from 53.33 in the pretest to 60.00 in the posttest, with a gain score of 6.67. Meanwhile, the Kahoot group increased from 38.67 to 51.50, with a gain score of 12.83. The Kahoot group showed a higher mean gain than the Wordwall Quiz group. However, the N-Gain values of both groups remained in the low category, indicating that the improvement in students' conceptual understanding was limited in both learning media conditions.

Table 2. Paired Sample t-test and Effect Size Results

Class	Media	t-value	df	Sig. (p)	Paired-samples Cohen's d	Interpretation
IV A	Wordwall Quiz	2.02	17	0.059	0.48	Not significant
IV B	Kahoot	5.41	17	< 0.001	1.28	Significant

The paired sample t-test results in Table 2 show different statistical outcomes between the two groups. In the Wordwall Quiz group, the difference between pretest and posttest scores was not statistically significant, $t(17) = 2.02$, $p = 0.059$. In contrast, the Kahoot group showed a statistically significant difference between pretest and posttest scores, $t(17) = 5.41$, $p < 0.001$. The paired-samples Cohen's d value indicated that the standardized change in the Kahoot group was larger than that in the Wordwall Quiz group. Nevertheless, the effect size was interpreted cautiously because the N-Gain results still indicated low practical improvement.

Overall, the findings indicate that Kahoot produced a statistically significant improvement in students' conceptual understanding of whole numbers, whereas Wordwall Quiz showed a positive but non-significant increase. However, the low N-Gain values in both groups suggest that neither medium produced a high level of conceptual improvement within the duration of the intervention. Therefore, the results should be understood as evidence of limited improvement, rather than strong practical effectiveness of quiz-based digital learning media within a short intervention period.

Discussion

The findings of this study indicate that Kahoot and Wordwall Quiz-based learning media produced different patterns of improvement in fourth-grade students' conceptual understanding of whole numbers. The Kahoot group showed a statistically significant improvement from pretest to posttest, whereas the Wordwall group showed a positive but non-significant increase. However, the N-Gain values in both groups remained in the low category. This result suggests that although digital game-based media can support students' learning,

their effect on conceptual understanding was still limited within the implemented instructional duration. Therefore, the findings should be interpreted cautiously, particularly because statistical significance does not always indicate strong practical improvement.

The statistically significant improvement in the Kahoot group may be related to the platform's interaction design, particularly its synchronous participation, immediate feedback, time-limited questions, and competitive scoreboard. These features may encourage students to pay closer attention, respond actively, and recognize errors during the learning process. In whole number learning, immediate feedback can help students identify misconceptions related to place value, arithmetic operations, and the interpretation of contextual problems. This finding is consistent with Wang and Tahir (2020), who reported that Kahoot supports learning through classroom interaction, feedback, and student engagement. Similarly, Aljaloud et al. (2024) found that Kahoot can improve student participation and academic performance by increasing students' involvement during learning activities.

Nevertheless, the low N-Gain score in the Kahoot group indicates that the improvement was not substantial in practical terms. Although Kahoot may support attention and engagement, conceptual understanding in mathematics requires more than quick responses to quiz questions. Students need repeated opportunities to explain their reasoning, connect numerical ideas, and apply concepts in various problem-solving situations. This is in line with Kilpatrick et al. (2001), who emphasized that mathematical proficiency involves conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. Therefore, the significant result in the Kahoot group should not be interpreted as evidence that Kahoot alone can produce deep conceptual mastery. Rather, Kahoot appears to provide stronger support for short-term engagement and formative reinforcement when compared with Wordwall Quiz in the context of this study.

The non-significant result in the Wordwall group should also be interpreted carefully. In this study, Wordwall was implemented specifically through its Quiz feature to maintain task comparability with Kahoot. Therefore, the result does not represent the full potential of Wordwall as a platform with various interactive templates, but only reflects the use of Wordwall Quiz within the implemented instructional design. Although Wordwall Quiz provided structured practice, its interaction pattern may not have generated the same level of real-time classroom competition and immediate social feedback as Kahoot. As a result, students' cognitive engagement may not have been as strongly stimulated during the learning process. However, this does not mean that Wordwall is ineffective; rather, its effectiveness may depend on how the teacher designs the task, guides students' reasoning, and connects the activity with conceptual discussion.

The difference in initial pretest scores may also have influenced the pattern of improvement. The Wordwall group had a higher pretest mean than the Kahoot group, which may have reduced the available room for score improvement. This possible ceiling effect needs to be considered when interpreting the lower gain in the Wordwall group. In contrast, the Kahoot group started from a lower initial mean score, allowing more opportunity for visible improvement after the intervention. Therefore, the stronger gain in the Kahoot group may be influenced not only by the platform characteristics, but also by differences in students' initial

achievement levels. This condition supports the need for cautious interpretation in quasi-experimental studies using intact classes.

From the perspective of cognitive load theory, the effectiveness of digital game-based learning depends on whether the media helps students focus on relevant mathematical relationships or instead adds unnecessary distraction. Sweller et al. (2019) explained that instructional design should reduce extraneous cognitive load and support learners in processing essential information. In this study, Kahoot's immediate feedback and whole-class interaction may have helped direct students' attention to errors and correct answers. However, the fast-paced nature of quiz-based activities may also limit students' opportunity to deeply reflect on why an answer is correct or incorrect. Similarly, Wordwall Quiz may support practice and reinforcement, but it may be less effective for conceptual understanding if students only focus on completing quiz items without sufficient teacher-guided explanation and reflection.

The low N-Gain values in both groups also indicate that improving conceptual understanding of whole numbers requires more sustained instructional support. Whole number concepts involve place value, numerical relationships, operations, and contextual problem-solving, all of which develop gradually through repeated practice, discussion, and conceptual reflection. Sailer and Homner (2020) emphasized that gamification can support learning outcomes, but its effectiveness depends on the design and integration of game elements into meaningful learning activities. In this study, the intervention was conducted in four meetings, with each meeting lasting approximately 30 minutes. This relatively short duration may have limited students' opportunities to internalize whole number concepts deeply. Thus, the findings suggest that digital game-based media should be integrated with broader pedagogical strategies, not used as a stand-alone solution.

Several contextual factors should also be considered. The study involved a relatively small sample of 36 students from two intact classes, which limits the generalizability of the findings. In addition, the two classes were taught by different classroom teachers. Although both groups used the same learning material, learning objectives, and pretest–posttest instruments, teacher-related factors may have influenced classroom interaction and students' learning responses. These limitations do not invalidate the findings, but they indicate that the results should be understood as context-specific evidence rather than broad generalization. Future studies should involve larger samples, longer intervention periods, and more controlled instructional implementation to obtain stronger empirical evidence.

Overall, this study shows that Kahoot and Wordwall Quiz-based learning media can support students' conceptual understanding of whole numbers, but their impact remains limited when used in a short intervention. Kahoot showed a stronger statistical effect, possibly because of its real-time interaction, competitive features, and immediate feedback. Wordwall Quiz, on the other hand, may function more effectively as a practice and reinforcement tool when accompanied by teacher-guided discussion. Practically, teachers can use Kahoot for formative assessment and immediate feedback, while Wordwall Quiz can be used for structured practice and concept reinforcement. However, both media should be integrated with explicit conceptual explanation, discussion of students' reasoning, and contextual problem-solving activities to strengthen students' mathematical understanding.

Conclusion

This study concludes that the influence of quiz-based digital learning media on elementary students' conceptual understanding of whole numbers varies according to the interaction characteristics of each platform. Kahoot demonstrated a statistically significant improvement, whereas Wordwall Quiz showed a positive but non-significant increase. However, the low N-Gain values in both groups indicate that the improvement in conceptual understanding was limited, so the findings should not be interpreted as evidence that digital game-based media automatically produce strong conceptual mastery. Theoretically, this study shows that the effectiveness of digital game-based learning is related to the quality of cognitive interaction facilitated during instruction rather than merely the use of technology itself. Practically, Kahoot can be used for formative assessment, immediate feedback, and whole-class participation, while Wordwall Quiz can support structured practice and concept reinforcement. Both media should be combined with explicit conceptual explanation, discussion of students' reasoning, and contextual problem-solving activities to strengthen students' understanding of whole numbers. This study was limited by its small sample size, short intervention period, and the involvement of different classroom teachers; therefore, future studies should involve larger samples, longer interventions, more controlled teaching implementation, and exploration of other Wordwall features beyond the quiz format.

Acknowledgments

The authors express their sincere gratitude to the principal, teachers, and students of SDN Kenongorejo 02 for their cooperation and active participation in this study. Appreciation is also extended to academic supervisors and colleagues for their valuable guidance and constructive feedback throughout the research process. This research was conducted without specific funding from any public, commercial, or non-profit funding agency.

Authors' Note

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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