JPF | Volume 13 | Number 2 | 2025 | 243 - 259

p - ISSN: 2302-8939
e - ISSN: 2527-4015

Jurnal Pendidikan Fisika

https://journal.unismuh.ac.id/index.php/jpf

DOI: 10.26618/jpf.v13i2.17915

Analysis of the Impact of Contextual Teaching and Learning Integrated with Quizizz on High School Students' Learning Outcomes

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Received: January 15, 2025; Accepted: March 30, 2025; Published: April 30, 2025

Abstract – *Physics education often faces persistent challenges in enhancing students' engagement and conceptual understanding, especially when abstract topics are taught through traditional, teacher-centered approaches. This study addresses these issues by investigating the impact of integrating the Contextual Teaching and Learning (CTL) model with the gamified digital platform Quizizz on student learning outcomes in high school physics. Employing a true experimental pretest-posttest control group design, the study involved 54 Grade XII students at SMA Negeri 1 Malunda, divided into an experimental group (CTL with Quizizz) and a control group (direct instruction). Data were collected using a validated multiple-choice test (validity = 90.81%, reliability = 0.82) and analyzed through descriptive and inferential statistics, including N-Gain and t-tests. The results showed a significant improvement in the experimental group's average posttest scores (from 41.39 to 59.57), with an N-Gain of 0.30 (moderate), compared to the control group's minimal increase (from 49.96 to 49.31), with an N-Gain of 0.07 (low). Statistical tests confirmed a significant difference between the groups (p < 0.05). This study demonstrates that combining CTL and Quizizz not only supports conceptual learning through real-world contexts but also increases motivation and active participation through interactive gamification. The novelty of this research lies in the effective integration of CTL with digital gamified tools to enhance physics instruction. The findings contribute to the advancement of physics education by providing empirical evidence for adopting CTL-Quizizz as a powerful instructional strategy to enhance conceptual understanding and academic achievement in secondary education.*

Keywords: *contextual teaching and learning; gamification; learning outcomes; physics education; quizizz*

I. INTRODUCTION

In the contemporary educational landscape, the pursuit of effective pedagogical strategies and tools to enhance student learning outcomes remains a critical concern for educators and researchers. Recent studies have highlighted enduring challenges in science education, including declining student engagement, disparities in access to digital resources, and inconsistent academic performance (Setiawan & Supardi, 2024; Maulana & Raniansyah, 2023; Muliati et al., 2023).

These issues underscore the urgent need for innovative and inclusive instructional approaches. Traditional teaching methods, predominantly lecture-based instruction, and rote memorization, often fail to actively engage students or foster deep conceptual understanding, particularly in physics education, where abstract concepts such as force, energy, and motion require visualization and hands-on application (Setiawan & Supardi, 2024). These limitations necessitate instructional models that support diverse learning styles and promote active participation (Farhin et al., 2023). Contextual Teaching and Learning (CTL) has emerged as a promising pedagogical framework that bridges abstract academic content with real-world applications, thereby fostering deeper comprehension and engagement. In physics education, CTL enables students to explore scientific principles through everyday experiences and contexts, making abstract concepts more tangible (Hariyono, 2023; Maulana & Raniansyah, 2023; Muliati et al., 2023).

Integrating educational technology, specifically gamification platforms such as Quizizz, has been shown to enhance student motivation and learning outcomes further (Paľová & Vejačka, 2022). Quizizz allows for dynamic formative assessment through features such as real-time feedback, automated scoring, and progress tracking, making learning more interactive and student-centered (Kabilan et al., 2023; Koć-Januchta et al., 2022). Gamification elements, such as points, badges, and leaderboards, can transform conventional assessments into engaging experiences that foster healthy competition and a sense of accomplishment (Tenório et al., 2018).

Gamification also supports the development of a growth mindset by encouraging persistence, resilience, and a focus on effort rather than innate ability. Elements such as immediate feedback and rewards for progress help maintain student motivation and reduce anxiety related to failure (Li et al., 2023). Prior research has demonstrated that gamified platforms provide scaffolding through attainable goals and positive reinforcement, thereby enhancing learning engagement (Surendeleg et al., 2014; Huang & Hew, 2018). Specifically, Quizizz incorporates these features through real-time scoring, achievement badges, and leaderboards, promoting sustained participation and incremental improvement (Jaramillo-Mediavilla et al., 2024). Furthermore, adaptive technologies embedded in gamified tools offer personalized learning paths tailored to individual progress and needs (Alramammnh et al., 2024; Kaya & Erçağ, 2023). Importantly, such tools also have positive effects on students with learning disabilities by providing inclusive and motivating learning environments (Alramammnh et al., 2024; Brunvand & Hill, 2018; Furdu et al., 2017).

Preliminary observations at SMA Negeri 1 Malunda during the 2024/2025 academic year revealed persistent instructional challenges in Class XII physics instruction. Initial assessments indicated low engagement and poor academic performance, with the experimental group scoring an average of only 41.39 on the pretest and achieving a learning outcome rate of just 36.60%. Despite widespread access to smartphones and internet connectivity, traditional instructional methods have not effectively utilized these resources to enhance learning. These findings are consistent with broader concerns regarding the limitations of conventional pedagogical approaches in physics education.

Recent studies have explored individual solutions to these challenges. The CTL model has shown potential in contextualizing abstract physics content to make it more accessible and relevant (Maulana & Raniansyah, 2023; Muliati et al., 2023). Similarly, gamified learning environments have been shown to increase student motivation and interaction (Ananda et al., 2023; Pham, 2023). However, the successful implementation of gamification requires thoughtful instructional design to ensure that motivational elements complement rather than distract from learning objectives (Puritat, 2019). The convergence of CTL and gamification strategies offers a promising approach to fostering conceptual understanding, engagement, and academic achievement. By anchoring abstract content in real-life scenarios and harnessing the motivational benefits of gamified learning, educators can create enriched and dynamic classroom environments (Alramammnh et al., 2024; Purba et al., 2024). Nevertheless, while the benefits of CTL and gamification have been well-documented individually, limited research has investigated the synergistic effects of their integration, particularly in the context of high school physics education.

This study aims to evaluate the impact of combining the CTL model with the gamified learning platform Quizizz on students' academic outcomes in physics, specifically in the topic of fluid statics. By comparing this integrated instructional strategy with conventional teaching methods, the research seeks to determine whether CTL-Quizizz can enhance conceptual understanding, engagement, and overall learning achievement. The findings are expected to inform evidence-based practices for developing more interactive, inclusive, and effective learning environments in physics education.

II. METHODS

This study employed a true experimental research design, specifically the pretest-posttest control group design, to enable a rigorous comparison of learning outcomes between students who receive a CTL and Quizizz-based intervention and those who do not. This design was selected due to its ability to maintain high internal validity, allowing for accurate measurement of the intervention's impact on students' conceptual understanding and engagement. In this design, two groups, the experimental and control groups, are randomly selected. Both groups are administered a pretest to assess their initial level of understanding, followed by a posttest after the treatment phase. The experimental group is taught using the CTL model supported by the Quizizz platform, whereas the control group receives instruction via traditional direct teaching methods.

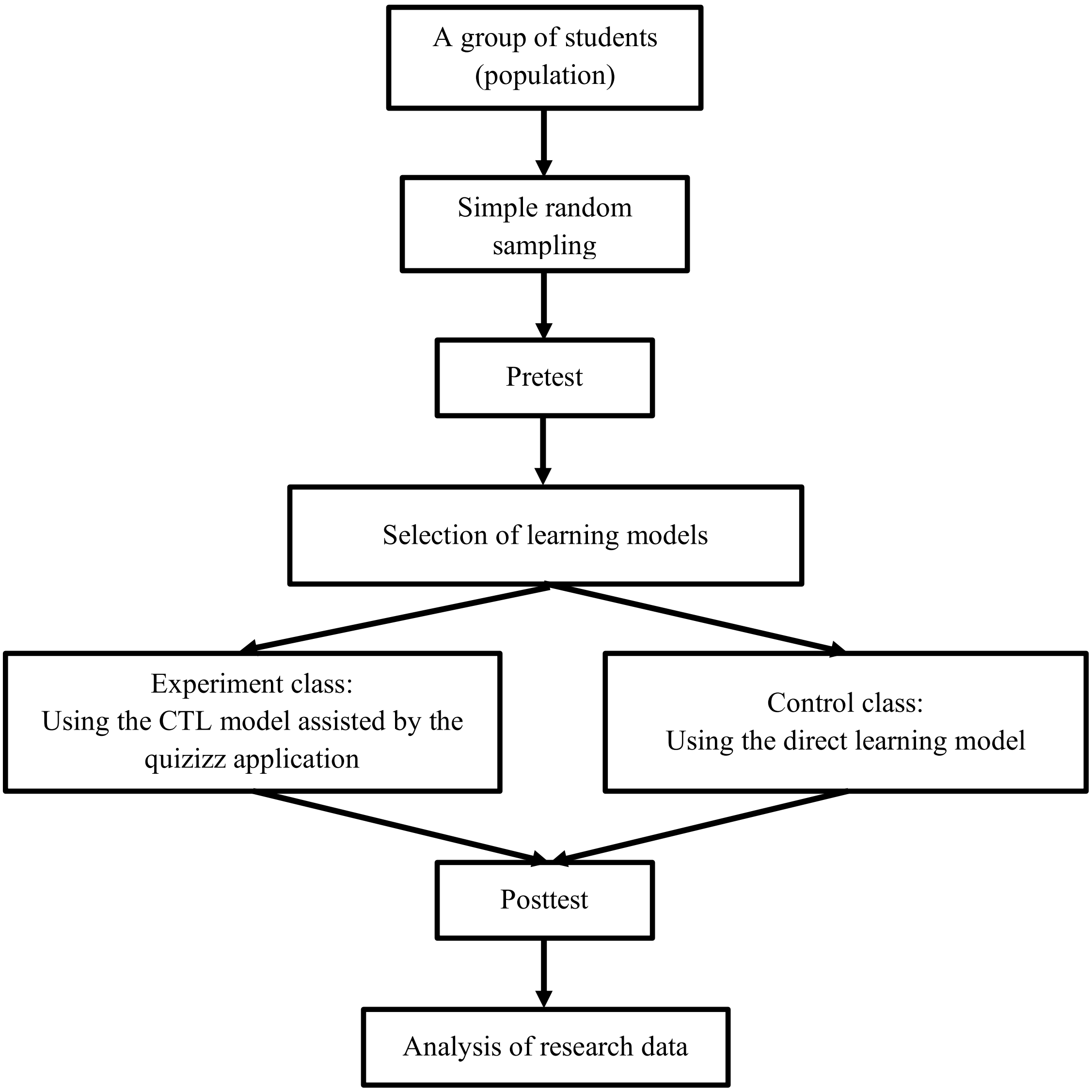

Figure 1. Flowchart of the research procedure using a pretest-posttest control group design

The research was conducted at SMA Negeri 1 Malunda, focusing on Class XII students during the odd semester of the 2024/2025 academic year. The study was conducted in alignment with the school's regular physics class schedule. The population consisted of all students in class XII at SMA Negeri 1 Malunda, comprising the following three classes: XII Venus (28 students), XII Saturnus (26 students), and XII Merkurius (30 students). In total, the study involved 84 students aged 16–18 years with diverse academic backgrounds, as reflected in their previous semester grades. All participants had regular access to smartphones and internet connectivity, ensuring the feasibility of implementing digital learning tools like Quizizz. Participants were selected through simple random sampling, with Class XII Venus designated as the experimental group and Class XII Saturnus as the control group. To ensure baseline equivalence, students' prior physics scores were analyzed before group assignments. This precaution was taken to minimize bias and increase the internal validity of the experiment.

The primary instrument used in this study was a learning outcomes test comprising 15 multiple-choice questions. The test items were developed in alignment with the national physics curriculum and underwent content validation by a panel of subject matter experts. Based on expert evaluations, the instrument achieved a content validity score of 90.81%, classified as very valid. The reliability of the test was assessed using the Kuder-Richardson Formula 20 (KR-20). The resulting reliability coefficient was 0.82, indicating a high level of internal consistency.

Data analysis began with descriptive statistics, including the calculation of mean scores, standard deviations, and percentages of learning mastery. To assess the improvement in students' learning outcomes between the pretest and posttest, the N-Gain score was calculated using the formula (Sugiyono, 2019).

$$\mathrm{N-Gain} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{Ideal score} - \text{Pretest score}}$$

The N-Gain categorization is shown in Table 1.

Table 1. N-gain criteria

Interval value	Category
$g \geq 0.70$	High
$0.30 < g < 0.70$	Medium
$g \leq 0.30$	Low

(Saputra et al., 2017)

Inferential analyses were then conducted to ensure the validity of subsequent comparisons. The Chi-Square test confirmed that the data were normally distributed, while the F-test demonstrated homogeneity of variances between the groups. With these assumptions met, an independent samples t-test was used to determine whether the differences in learning outcomes between the experimental and control groups were statistically significant. A significance threshold of $p \leq 0.05$ was applied to test the hypothesis.

III. RESULTS AND DISCUSSION

This section presents the findings and analysis of implementing the CTL model integrated with Quizizz in physics instruction at SMA Negeri 1 Malunda. The analysis is based on statistical procedures conducted using SPSS Version 24, incorporating both descriptive and inferential methods to evaluate the effectiveness of the intervention. The study compares learning outcomes between two groups: the experimental group, which received CTL-based instruction supported by Quizizz, and the control group, which received conventional direct instruction. The results are organized into three primary subsections: descriptive analysis of pretest and posttest scores, analysis of learning outcome indicators, and hypothesis testing. These findings are further contextualized with current research on technology-enhanced learning and gamification in education, particularly the role of Quizizz in fostering student engagement and academic performance.

1. Descriptive analysis

a. Pretest and posttest of experimental class

In the experimental group, which consisted of 28 students taught using the CTL model integrated with Quizizz, there was a clear improvement in student performance. Table 2 presents the statistical summary of their pretest and posttest scores. The pretest mean score was 41.39, with a median of 40.00, standard deviation of 13.35, and score range between 20.00 to 67.00. These results indicate that students began the intervention with relatively low conceptual understanding, reflected by the average achievement percentage of 36.60%, categorized as low.

Table 2. Experimental class pretest and posttest score statistics

		Pretest	Posttest
N	Valid	28	
	Missing	0	
Mean		41.39	41.39
Median		40.00	40.00
Std. Deviation		13.35	13.35
Minimum		20.00	20.00
Maximum		67.00	67.00

After the intervention, the posttest mean increased to 59.57, the median to 60.00, with a standard deviation of 16.37, and scores ranging from 27.00 to 93.00. The corresponding average achievement percentage rose to 58.27%, which falls into the moderate category. This progression signifies a meaningful gain in understanding after using the CTL-Quizizz approach. The improvement is illustrated visually in Figure 2, which compares pretest and posttest scores and highlights the upward trend in student performance after the intervention.

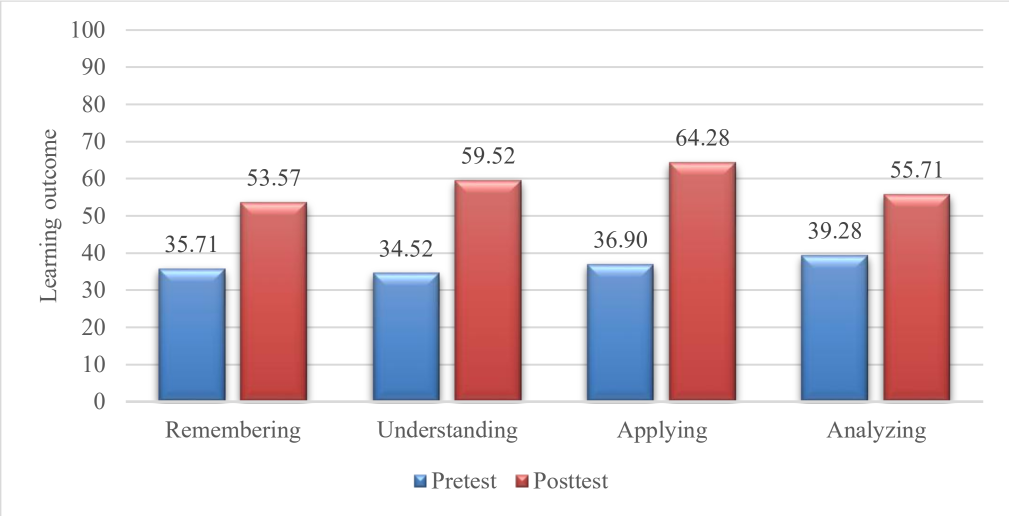

Figure 2. Comparison of pretest and posttest results in the experimental class

The improvement from an average score of 41.39 (low) to 59.57 (moderate) supports the efficacy of integrating CTL with technology-based formative assessments such as Quizizz. This aligns with findings from Ananda et al. (2023) and Manda et al. (2023), who reported that gamified tools significantly increase student motivation and academic performance. Pham (2023) and Ccoa et al. (2023) highlight that such features not only enhance learning outcomes but also reduce test anxiety and sustain student interest. In this study, engagement was evaluated through participation logs, the number of quiz attempts, and reflective student feedback. Students reported increased enjoyment and a deeper understanding during CTL-Quizizz sessions, attributing this to the instant feedback and competitive game elements.

As demonstrated in prior studies (Maraza-Quispe et al., 2024; Haryadi et al., 2023), timely corrective feedback plays a vital role in enhancing retention and conceptual mastery. Quizizz's capability to provide question-by-question feedback, including an immediate indication of correct or incorrect answers with brief explanations, greatly contrasts with the delayed feedback of conventional assessments. This immediacy enhances the learning loop, enabling students to self-correct and reinforce understanding in real-time. The graphical comparison in Figure 2 visually confirms a positive shift in posttest performance, strengthening the evidence that technology-assisted instruction, particularly with gamified platforms like Quizizz, can produce statistically and pedagogically significant improvements in student learning outcomes (Citra & Rosy, 2020).

b. Pretest and posttest of the control class

In contrast, the control group, consisting of 26 students who were taught using conventional direct instruction methods, showed minimal improvement. Table 3 displays the descriptive statistics for this group. The pretest mean was 49.96, with a median of 50.00 and standard deviation of 13.67. Posttest results indicate a slight decrease in mean to 49.31, a median of 47.00, and standard deviation of 15.83. The learning outcome percentages were 45.86% in the pretest and 49.51% in the posttest, both of which remained in the moderate category.

Table 3. Control class pretest and posttest score statistics

		Pretest	Posttest
N	Valid	26	
	Missing	0	
Mean		49.96	49.31
Median		50.00	47.00
Std. Deviation		13.67	15.83
Minimum		20.00	27.00
Maximum		73.00	87.00

This lack of meaningful improvement is depicted in Figure 3, which shows almost no difference between pretest and posttest scores. These results reinforce that traditional teaching methods are less effective in fostering conceptual mastery in abstract topics compared to technology-supported learning.

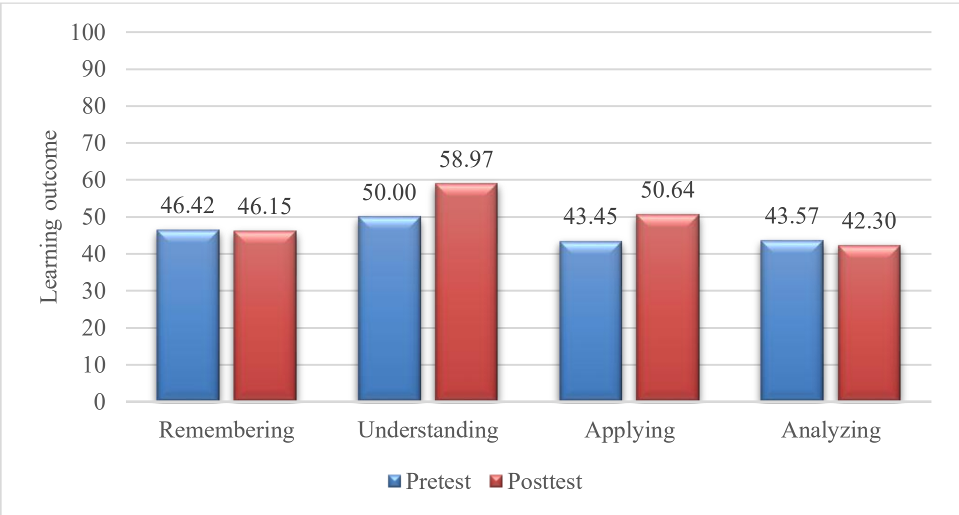

Figure 3. Comparison of pretest and posttest results in the control class

c. N-Gain

To further assess improvement, the normalized gain (N-Gain) was calculated and summarized in Table 4.

Table 4. N-gain test results

No.	Class	N-Gain	Category
1	Experiment	0.30	Medium
2	Control	0.07	Low

The experimental group achieved an N-Gain of 0.30, indicating moderate improvement, while the control group recorded a much lower N-Gain of 0.07, categorized as low. This disparity supports previous findings that technology-assisted learning methods, such as the integration of gamified tools, consistently yield higher N-Gain values than traditional methods (Fauzi et al., 2022; Suwiriyanti, 2024; Santoso & Husniyah, 2016). These results emphasize the potential of technology-enhanced instructional models to improve conceptual understanding and academic performance.

2. Inferential analysis

a. Normality test

The Shapiro-Wilk test was employed to assess the normality of the pretest and posttest score distributions for both the experimental and control groups. As shown in Table 5, all significance values (p-values) exceeded 0.05, indicating that the data were normally distributed and did not deviate significantly from a normal distribution.

Table 5. Results of the normality test

No.	Group	Sig	Conclusion
1	Pretest experimental class	0.157	Normal
2	Posttest experimental class	0.560	Normal
3	Pretest control class	0.403	Normal
4	Posttest control class	0.202	Normal

The results confirm that both pretest and posttest data sets meet the assumption of normality, thereby validating the use of parametric statistical methods, such as the t-test, for further analysis. Ensuring normality is crucial, as it enhances the accuracy and validity of inferences drawn from parametric procedures.

b. Homogeneity test

To ensure that the variance between the two groups was equivalent a key assumption for the t-test a Levene's Test for Equality of Variances was conducted. As shown in Table 6, the obtained significance value of 0.91 ($p > 0.05$) indicates that the variances in the posttest scores between the experimental and control groups are statistically homogeneous

Table 6. Results of the homogeneity test

Class	Levene Statistic	Sig	Description
Posttest experimental class	Based on Mean	0.91	Homogenous
Posttest control class			

The equality of variances between the experimental and control groups supports the assumption required for conducting the independent samples t-test. This ensures that comparisons between the groups are valid and unbiased, eliminating the potential for bias due to unequal variability and thereby strengthening the reliability of the findings.

c. Independent sample T-test)

An independent samples t-test was conducted to evaluate whether there was a significant difference in learning outcomes between the experimental group (taught using CTL integrated with Quizizz) and the control group (taught using conventional methods). As presented in Table 7, the p-value was less than 0.023, which is below the significance threshold of 0.05. This indicates that the difference in posttest scores between the two groups is statistically significant.

Table 7. Independent sample t-test results

Data	Sig. (2-tailed)	α	Description
Posttest experimental class and posttest control class	< 0.023	0.05	Significant difference

The t-test revealed a significant difference between the two groups ($p < 0.05$), indicating that the learning outcomes of students taught using the CTL model, integrated with Quizizz, were significantly higher than those of students taught through conventional methods. These results support previous studies that demonstrate the significant enhancement of student achievement through the integration of educational technology into active learning models (Rahmat, 2019; Rahmi et al., 2021; Sumilat, 2018). This finding confirms that the synergistic application of CTL and gamification tools, such as Quizizz, contributes meaningfully to improving students' conceptual understanding and performance. Specifically, the CTL model promotes hands-on, contextual learning experiences. At the same time, Quizizz provides immediate feedback, gamified motivation, and engagement-driven assessment, all of which are key drivers of effective learning in physics education.

The findings from this study demonstrate that applying the CTL model supported by Quizizz significantly enhances students' learning outcomes, particularly in the application of concepts (C3 level of Bloom's taxonomy). In the experimental group, the highest improvement was observed in the applying indicator, where students achieved 64.28%. This indicates the positive impact of incorporating real-world, hands-on experiences, such as experiments and group discussions, within the CTL framework. As noted by Hariyono (2023), learning through contextual and practical experiences fosters deeper understanding, as students are able to connect abstract concepts to their own lives.

The results align with several studies in the field of educational technology and physics education. For example, Ananda et al. (2023) found that Quizizz increased student engagement and participation, which supports our findings of heightened student motivation and involvement in the experimental group. Similarly, Pham (2023) and Ccoa et al. (2023) observed that the use of Quizizz reduced assessment anxiety and enhanced confidence, aligning with our results in terms of improving student's motivation and performance during assessments. More recent research, such as that by Maraza-Quispe et al. (2024), further corroborates these findings, demonstrating the positive effects of gamified tools on student achievement across various educational settings. The results of this study strongly support the effectiveness of combining CTL with digital tools, particularly Quizizz, in enhancing student learning outcomes. Our findings align with those of Alramammnh et al. (2024), who demonstrated that gamification addresses engagement challenges and fosters intrinsic motivation among students. Likewise, Jaramillo-Mediavilla et al. (2024) and Handayani & Abadi (2020) reported similar positive impacts of gamified learning tools on both motivation and academic performance, reinforcing our observation that the experimental group showed marked improvements in learning outcomes.

Quizizz, an interactive learning platform, proved to be particularly effective in promoting student engagement. By providing immediate feedback, real-time scoring, and gamification elements such as points, leaderboards, and challenges, Quizizz accelerates the learning process and keeps students motivated to participate in learning activities actively. These gamification features, which promote competition and rewards for effort, align with research indicating that technology-based applications can significantly enhance student motivation, making the learning process not only more engaging but also more enjoyable. This approach contrasts sharply with traditional methods that typically lack such interactive features.

In contrast, the control group, which received traditional instruction without technological support, did not show significant improvement in learning outcomes. This lack of progress can be attributed to the inherent limitations of conventional teaching methods, which often rely on one-way communication, where students receive information passively. Such methods can lead to decreased motivation, limited opportunities for critical thinking, and minimal student participation. Moreover, traditional instruction typically lacks the immediate feedback necessary to help students identify and correct misunderstandings in real-time, reducing the potential for deep learning. The CTL-Quizizz model, however, offered a more interactive learning experience that actively engaged students, encouraged collaborative learning, and provided instant feedback, all of which are essential for improving student achievement. This model facilitated active participation, enabling students to engage in group discussions, work on real-world problems, and apply their knowledge in practical contexts. Such activities not only enhanced conceptual understanding but also promoted critical thinking and deeper engagement with the material. The low learning outcomes observed in the control group, particularly in the analyzing indicator, highlight a key issue with traditional methods: they fail to engage students in active exploration and in-depth understanding of complex concepts. Lectures or direct explanations alone do not provide sufficient opportunities for students to apply and critically examine the material, which is essential for mastering higher-order cognitive skills.

The N-Gain results further validate the effectiveness of the CTL-Quizizz model. The experimental group achieved an N-Gain of 0.30, categorized as moderate, reflecting significant improvement in learning outcomes. In contrast, the control group had a much lower N-Gain of 0.07, which is classified as low. According to the classification by Saputra et al. (2017), N-Gain scores are categorized as low (≤ 0.3), moderate (0.3–0.7), and high (≥ 0.7), further clarifying the impact of the intervention. The significant improvement in the experimental group, particularly in concept application and understanding, underscores the importance of contextual and collaborative learning in enhancing cognitive abilities. These cognitive gains can be attributed to several aspects of the CTL model, including real-life problem-solving tasks and group discussions, which foster a deeper understanding of the material. The integration of Quizizz into this framework added another layer of engagement by providing interactive, gamified quizzes with immediate feedback. This not only reinforced key concepts but also sustained student engagement throughout the learning process, enabling continuous reflection and self-assessment. Overall, the findings from this study highlight the positive impact of combining contextual learning with digital tools, such as Quizizz, in enhancing physics education. The interactive nature of this combined approach creates a dynamic learning environment that engages students in a more meaningful way. The results suggest that educators should consider incorporating technology-enhanced strategies, such as gamification, into their teaching practices, particularly in complex subjects like physics, where engagement and active participation are crucial to student success.

The findings of this study have several significant implications for physics education. First, the successful integration of the CTL model with Quizizz underscores the potential of combining traditional pedagogical approaches with digital tools to create more effective learning environments. This suggests that physics educators should consider incorporating similar technology-enhanced learning strategies into their teaching practices. The results highlight that when combined, CTL and digital tools can offer a dynamic and engaging learning experience, especially in complex subjects like physics. Additionally, the significant improvement in concept application (64.28%) achieved by the experimental group reinforces the value of interactive, gamified learning experiences. These results suggest that gamification elements such as those integrated with Quizizz should be considered essential components in modern physics education. By incorporating game-based elements, such as points, leaderboards, and challenges, teachers can foster greater student engagement, motivation, and deeper learning in physics concepts that are traditionally perceived as difficult to grasp.

Moreover, the immediate feedback feature of Quizizz, when paired with the contextual learning approach of CTL, provides a more effective mechanism for monitoring and supporting student progress. This reinforces the importance of implementing real-time assessment tools in physics education, allowing educators to identify and address learning gaps promptly. The immediate feedback provided by Quizizz empowers students to adjust their understanding as they learn, which is critical in subjects like physics, where misconceptions can easily hinder progress. The success of the CTL-Quizizz integration in supporting diverse learning styles further emphasizes the need for flexible and varied instructional approaches in physics education. By adopting technology-enhanced teaching strategies, educators can better accommodate students' different learning preferences, creating a more inclusive and personalized learning environment. This also suggests that teachers should integrate both digital tools and active learning strategies into their classroom practices to support students with varying cognitive and engagement styles.

Finally, the positive outcomes observed in this study underscore the need for systematic teacher training programs that focus on integrating technology with pedagogical approaches, such as CTL. Educational institutions should invest in professional development opportunities to ensure that teachers are well-equipped to implement innovative, technology-supported learning models in their classrooms. Training teachers to effectively integrate these models will empower them to engage their students better and improve learning outcomes. Overall, this study demonstrates that using the CTL model supported by Quizizz media is an effective approach for improving physics learning outcomes. It is hoped that the implementation of this learning model can be expanded across various subjects and educational levels, creating more engaging and interactive learning environments. Moreover, teacher training on the use of technology in education is essential to fully optimize interactive learning media, such as Quizizz, thereby offering students more engaging, in-depth, and effective learning experiences.

IV. CONCLUSION AND SUGGESTION

The findings of this study confirm that the integration of the CTL model with the gamified platform Quizizz significantly improves students' physics learning outcomes, particularly in the domain of conceptual application. The experimental group, which received CTL-Quizizz instruction, demonstrated a notable increase in average scores from 41.39 to 59.57, achieving a moderate N-Gain score of 0.30. In contrast, the control group, which was taught using conventional methods, showed minimal improvement with a low N-Gain of 0.07. These results highlight the effectiveness of contextual, interactive, and gamified instruction in fostering student engagement, deepening understanding, and enhancing academic performance in abstract physics topics.

Despite these promising results, the study has several limitations. The sample was limited to a single school with relatively small participant numbers, which may restrict the generalizability of the findings. Furthermore, the study only measured cognitive outcomes and did not explore affective or psychomotor domains. Future research should involve larger, more diverse populations and consider long-term retention and motivation effects. Additionally, it is recommended to explore the integration of CTL and gamified platforms in other physics topics or broader science domains. This study contributes to the development of physics education by offering an innovative, empirically tested learning model that combines pedagogical strategies and digital tools to improve conceptual understanding and student engagement in science classrooms.

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