COGNITIVE SCIENCES AND HUMAN DEVELOPMENT

The role of Kahoot in enhancing motivation, engagement, and learning in chemistry among Form 4 students

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ABSTRACT

A growing body of research has examined gamification in education; however, evidence on its effectiveness in enhancing conceptual understanding in secondary chemistry classrooms, particularly in rural Malaysia, remains limited. This quasi-experimental study compared traditional instruction with Kahoot-based gamified learning among 141 students. Academic achievement was assessed through pre- and post-tests, learning motivation was measured using the Instructional Materials Motivation Survey, and semi-structured teacher interviews provided insights into classroom experiences. The results showed a significant increase in motivation among students in the Kahoot group ($p < .001$). Both the experimental and control groups demonstrated significant improvement in achievement from pre-test to post-test; however, the difference in post-test achievement between the groups was not statistically significant ($p = .39$). Teachers reported increased engagement, participation, and classroom interaction during gamified activities, although infrastructure limitations such as device access and internet connectivity remained challenges. These findings suggest that Kahoot-based gamification can effectively enhance motivation, engagement, and learning in resource-limited secondary chemistry classrooms, highlighting its practical and theoretical significance.

Keywords: Kahoot, motivation, achievement, engagement

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1 INTRODUCTION

The use of educational technologies has gradually changed how teaching and learning take place in schools, with greater emphasis now placed on interactive rather than purely teacher-centred approaches (Afzal et al., 2023; Taha et al., 2021). As part of this shift, gamification has received growing attention as an instructional approach. Gamification typically involves using selected game elements, such as points, competition, and feedback, within learning activities to encourage student engagement and motivation. When applied appropriately, these elements have been shown to support active participation and sustain students' interest in learning (Aljraiwi, 2019; Hamari et al., 2014).

In science education, the need for engaging teaching strategies is particularly clear. Chemistry lessons often require students to understand abstract concepts that are not directly observable, such as atomic theory, chemical bonding, and molecular structure. For many secondary school students, these topics are difficult to grasp and may lead to reduced motivation when instruction relies heavily on repetition or rote learning (Bahagian Pembangunan Kurikulum, 2018). Although gamified approaches have been introduced in various educational settings, their use in secondary STEM education, particularly in rural or developing contexts, remains relatively limited (Asniza et al., 2021; Moshinski et al., 2021).

In Malaysia, concerns about students' interest and achievement in chemistry have been highlighted through national trends and international assessments such as TIMSS (Yang et al., 2022). Atomic structure, which serves as a core foundation for learning chemistry, is often taught using traditional instructional methods that may not adequately support conceptual understanding or sustained engagement (Yang et al., 2022). This challenge has increased interest in instructional strategies that address both cognitive understanding and student motivation (Landers, 2014). Among available digital platforms, Kahoot has become popular for its simple interface, visual features, and ability to provide immediate feedback during classroom activities (Özdemir, 2025).

While numerous studies have investigated Kahoot in general learning contexts (e.g., Wang & Tahir, 2020) and in subjects such as language (e.g., Pham et al., 2025) and mathematics (e.g., Rahim & Mohammed, 2024), relatively few have explored its use in chemistry education, where abstract reasoning and visualisation are particularly important (Asniza et al., 2021). To address this gap, the present study examines the effectiveness of Kahoot-based learning on Form 4 students' academic achievement and motivation in atomic structure. The study focuses on three objectives: to examine changes in student performance following gamified and traditional instruction, to explore differences in learning motivation using validated measures (Denzin & Lincoln, 2017; Mohammed, 2024), and to understand teachers' experiences of implementing gamification in rural chemistry classrooms (Mohd Hussin, 2021). By employing a mixed-methods approach, this study offers both quantitative findings and qualitative insights relevant to instructional practice in the Malaysian educational context (Denzin & Lincoln, 2017; Ministry of Education Malaysia, 2023).

2 METHODS

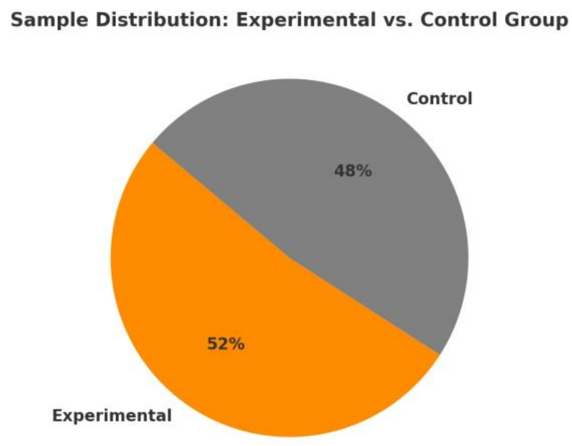
2.1 Design

This study adopted a mixed-methods, quasi-experimental design to examine the effectiveness of Kahoot-based gamification on students' motivation and academic achievement in learning Atomic Structure. Quantitative data were used to measure changes in achievement and motivation, while qualitative data provided deeper insights into teachers' experiences and perceptions of implementing Kahoot-based instruction in chemistry classrooms. The integration of both approaches enabled a comprehensive evaluation of both learning outcomes and instructional processes.

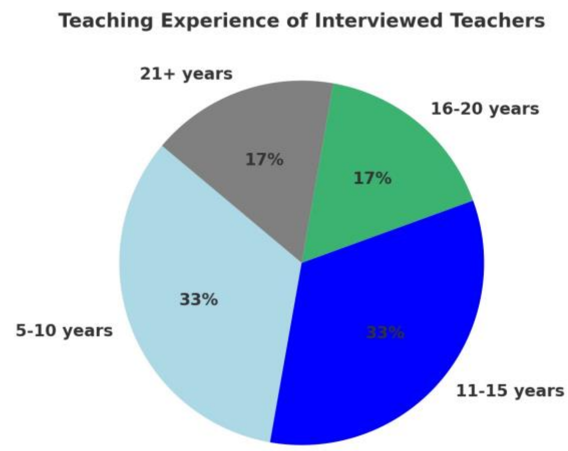
2.2 Participants

The participants comprised 141 Form 4 students from selected secondary schools in the West Coast and interior divisions of Sabah, Malaysia. A total of 141 Form 4 students from four secondary schools participated in the study. Schools were selected using convenience sampling based on administrative approval, accessibility, and the availability of digital infrastructure required to support the Kahoot intervention. Within the selected schools, purposive sampling was used to recruit Form 4 students enrolled in the STEM stream and studying Chemistry, ensuring alignment with the study objectives and the Atomic Structure topic. Students were then allocated to experimental and control groups: 52% (n = 73) to the experimental group, which received Kahoot-based gamified instruction, and 48% (n = 68) to the control group, which received conventional teacher-centred instruction. To minimise selection bias and ensure comparability between groups, both groups followed the same curriculum content, instructional duration, and assessment procedures, differing only in the instructional approach used during the intervention.

In addition, six chemistry teachers participated in semi-structured interviews to provide qualitative perspectives on instructional implementation, student engagement, and contextual challenges associated with Kahoot-based learning. Figure 1(a) illustrates the sample distribution: 52% of students were assigned to the experimental group, which engaged in Kahoot-based learning, while 48% were assigned to the control group, which followed traditional instruction. Additionally, teachers with varying years of experience in chemistry education were interviewed, as depicted in Figure 1(b): 33% had 5-10 years, 33% had 11-15 years, and smaller proportions had 16-20 years or more than 21 years of teaching experience.



(a)



(b)

Figure 1. Respondent distribution based on (a) control and experimental group of students' samples; (b) interviewees' teaching experience in chemistry.

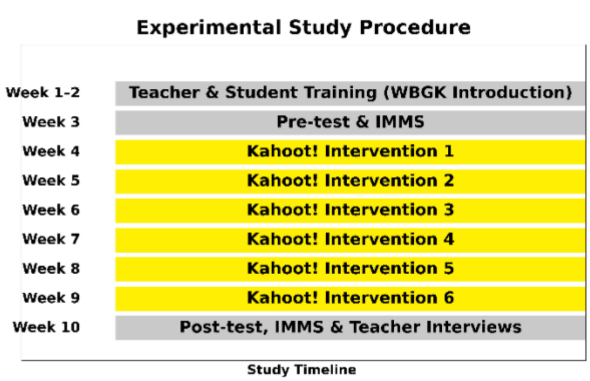
2.3 Intervention Procedure

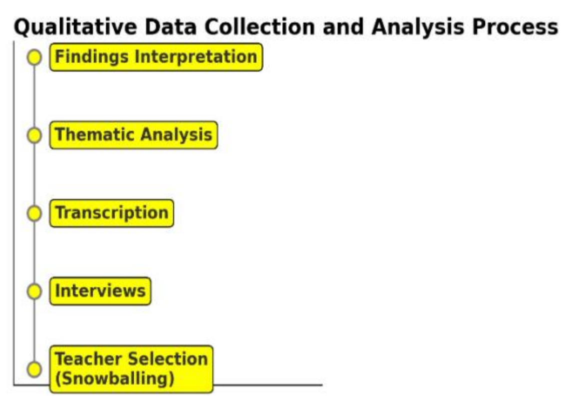
Ethical approval for this study was obtained through the Educational Research Application System of the Ministry of Education Malaysia. The Sabah State Education Department and the participating schools also granted permission to conduct the research. As the study involved secondary school students, written consent was obtained from parents or guardians before students participated. Participation was voluntary, and all collected data were anonymised to ensure participants' confidentiality and privacy.

The intervention lasted approximately 10 weeks. Kahoot-based activities were implemented across Weeks 4–7 and 9–10, comprising six sessions overall, following teacher training in Weeks 1–2 and baseline (Week 3) and post-intervention assessments (Week 10), as shown in Figure 2(a). During the initial phase, students in both groups completed a pre-test on Atomic Structure and a motivation questionnaire to establish baseline equivalence. The experimental group then participated in structured Kahoot-based learning activities embedded in regular chemistry lessons, while the control group followed conventional instructional approaches covering the same curriculum content. Kahoot-based activities incorporated interactive quizzes, immediate feedback, timed questions, and point-based scoring to encourage active participation and engagement.

The Kahoot-based intervention was implemented through structured in-class and out-of-class activities embedded within regular chemistry lessons. Teachers ensured that devices were properly managed during each session with approval from the school administration. As a result, students were allowed to bring their own devices during the intervention sessions. During classroom sessions, students accessed Kahoot quizzes using QR codes provided in the printed learning manual. The teacher conducted sessions in *Host Live* mode, allowing students to participate in real-time quizzes designed to reinforce key concepts of atomic structure. Students responded to multiple-choice questions individually through their mobile devices and received immediate feedback on their performance. The platform's competitive features, including point-based scoring and timed responses, were used to sustain engagement and encourage active participation. In addition to in-class sessions, students were encouraged to engage in independent revision through Kahoot's *Play Solo* mode. Teachers provided direct links or QR codes so students could revisit quiz content outside classroom hours, supporting self-paced reinforcement of concepts. Following each session, teachers conducted short debriefing discussions to clarify misconceptions, review commonly missed questions, and consolidate conceptual understanding. This structured combination of interactive participation, feedback, and guided reflection aimed to strengthen both cognitive understanding and learning motivation. At the end of the intervention, both groups completed a post-test and a post-intervention motivation survey, and semi-structured interviews with teachers were conducted to capture reflections on student engagement, instructional effectiveness, and implementation challenges.

Qualitative data collection followed a structured approach, as shown in Figure 2(b). Teacher selection was conducted through snowball sampling, focusing on educators with experience in both traditional and gamified teaching. Semi-structured interviews explored their views on student engagement, learning outcomes, and challenges. Interview transcripts were analysed thematically, identifying key themes such as motivation, classroom interaction, and technology constraints. This mixed-methods approach combined quantitative and qualitative data to provide a comprehensive evaluation of gamification in chemistry education. The pre-test and post-test results measured student achievement, while teacher interviews provided deeper insights into its practical application.





(a) (b)

Figure 2. Data analysis process based on (a) quantitative data; (b) qualitative data.

2.4 Instruments

Students' academic achievement was measured using a researcher-developed Atomic Structure test as pre- and post-tests. Subject-matter experts reviewed the test to ensure content validity and alignment with the Form 4 Chemistry syllabus. Motivation was measured using the five-point Likert scale Instructional Materials Motivation Survey (IMMS), covering attention, relevance, confidence, and satisfaction. The Instructional Materials Motivation Survey (IMMS) demonstrated acceptable internal consistency during pilot testing involving 67 Form 4 students from four secondary schools in Kota Belud, Sabah. After refinement and removal of low-correlating items, Cronbach's alpha values were as follows: attention ($\alpha = .81$), relevance ($\alpha = .74$), confidence ($\alpha = .71$), and Satisfaction ($\alpha = .77$). These values exceed the recommended threshold of $\alpha \geq .70$ for acceptable reliability (Leavy, 2017), indicating that the instrument was suitable for measuring students' motivational constructs in the main study. Qualitative data were collected through semi-structured interviews with chemistry teachers, focusing on instructional practices, student responses, perceived benefits, and challenges related to Kahoot-based gamification.

3 RESULTS

Quantitative data were analysed using descriptive and inferential statistical techniques. Paired-sample t-tests were conducted to examine within-group differences between pre-test and post-test scores. In contrast, independent-sample t-tests were used to compare post-intervention outcomes between the experimental and control groups. Qualitative interview data were transcribed verbatim and analysed thematically using an inductive coding approach. Emerging themes were identified to represent teachers' perceptions of engagement, instructional change, and contextual limitations. Quantitative and qualitative findings were integrated during interpretation to enhance the credibility of the results through triangulation.

3.1 Effects of Kahoot-Based Gamification on Academic Achievement

After the intervention, the experimental group showed a significant increase, with post-test scores rising to a median of over 70, while the control group also improved by reaching around 60. The spread of post-test scores in the experimental group indicates a stronger learning effect, suggesting that Kahoot-based learning had a positive impact on academic performance. Statistical analysis confirmed these findings. A paired-samples t-test indicated a significant improvement in achievement within the experimental group from pre-test (M = 51.95, SD = 15.56) to post-test (M = 66.47, SD = 15.67), $t(72) = -7.65$, $p < .001$. However, an independent-samples t-test showed no statistically significant difference in post-test achievement between the experimental and control groups, $t(139) = -0.862$, $p = .39$. Similarly, the comparison of gain scores between groups was not statistically significant, $t(139) = -1.173$, $p = .243$. These results indicate that both instructional approaches were effective in improving achievement. Although the between-group difference was not statistically significant, the Kahoot group demonstrated a greater increase in scores, supporting previous research indicating that gamification enhances engagement and enjoyment in chemistry learning (Othman, Husin, et al., 2024). Figure 3 illustrates the differences in pre-test and post-test achievement scores between the experimental and control groups, showing the impact of Kahoot on student achievement. Before the intervention, both groups had similar median scores, 55 for the control group and 53 for the experimental group, indicating comparable initial knowledge levels.

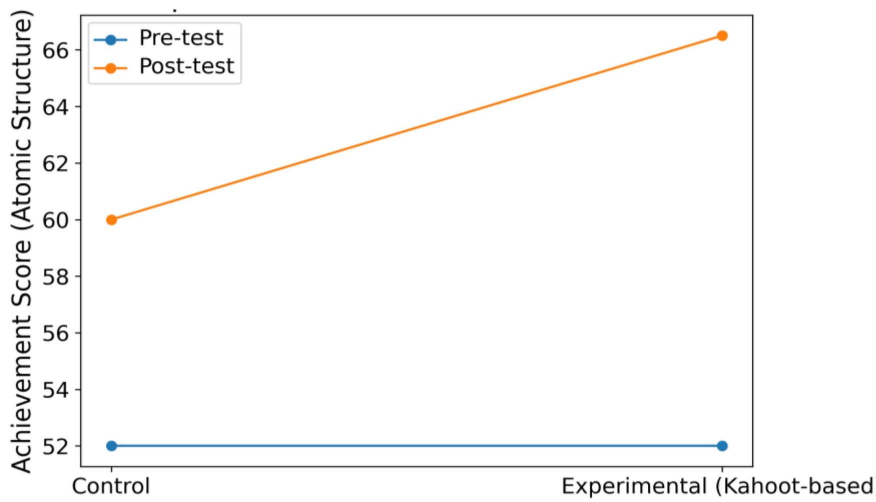


Figure 3. Pre-test and post-test difference between groups on achievement.

Prior studies support these findings, emphasising that game-based learning enhances student engagement, retention, and comprehension of complex concepts (Gan & Sun, 2021; Nadeem et al., 2023). The interactive nature of Kahoot, with real-time feedback, competition, and rewards, likely contributed to increased achievement scores (Suryapranata et al., 2023).

3.2 Effects of Kahoot-Based Gamification on Learning Motivation

To examine whether Kahoot-based gamification influenced students' learning motivation, motivation scores obtained from the Instructional Materials Motivation Survey (IMMS) were analysed using paired-sample t-tests to assess within-group changes and independent-samples t-tests to compare differences between the experimental and control groups. The results indicated that the experimental group demonstrated a noticeable increase in motivation following the intervention, with post-intervention scores higher than pre-intervention levels. A paired-samples t-test indicated that the experimental group experienced a significant increase in motivation from pre-test ($M = 129.44$, $SD = 17.13$) to post-test ($M = 136.67$, $SD = 16.17$), $t(72) = 4.26$, $p < .001$, with a moderate effect size (Cohen's $d = 0.50$). Furthermore, an independent-samples t-test revealed a statistically significant difference in motivation between the experimental and control groups after the intervention ($p < .05$). These findings suggest that Kahoot-based gamification was effective in enhancing students' learning motivation, particularly by increasing attention, engagement, and participation during classroom activities. Figure 4 shows the difference in pre-test and post-test motivation levels between the control and experimental groups.

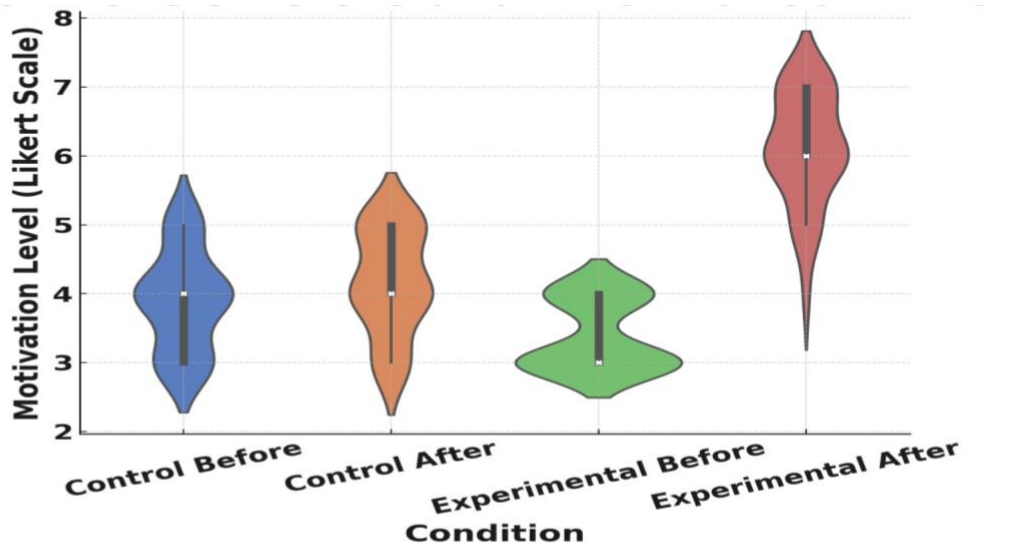


Figure 4. Pre-test and post-test differences in motivation between groups.

3.3 Teachers' Perceptions of Kahoot-Based Gamification

Teachers reported clear changes in classroom interaction after introducing Kahoot-based activities into chemistry lessons. Several teachers explained that they relied less on lecture-style teaching and adopted more interactive approaches, leading students to be more willing to answer questions and participate in classroom activities. Digital tools such as Kahoot and Quizizz were seen as useful for supporting student engagement and helping to reinforce chemistry concepts during lessons (Sailer & Homner, 2020). One teacher reported that students seemed more focused and responsive during gamified sessions than during traditional lessons, suggesting that interactive activities helped sustain students' attention and involvement (Hamari et al., 2014).

Despite these positive experiences, teachers also pointed out several challenges when implementing gamification in rural schools. Limited internet access and a lack of digital devices were commonly mentioned, especially in schools with fewer technological resources (Zhang et al., 2021). These limitations made it difficult to ensure that all students could participate equally in gamified activities and reduced the frequency with which such tools could be used in lessons (Afzal et al., 2023). Because of these constraints, teachers generally viewed gamification as a support to existing teaching methods rather than a replacement for traditional instruction (Othman, Osman, et al., 2024). Some teachers overcome the limitations by incorporating gamified lessons at the end of their lessons or during the revision period before examinations. Teachers also observed that gamified activities increased engagement and motivation among students who were previously less active in class. Students who were usually quiet or hesitant to speak appeared more confident when responding through the digital platform. Similar observations have been reported in studies on adaptive gamification in K–12 classrooms, which found improvements in students' cognitive, emotional, and behavioural engagement (Cheong et al., 2014; Gaurina et al., 2025). These experiences suggest that gamification may foster a more inclusive classroom by offering students multiple ways to participate (Sotos-Martínez et al., 2023). In addition, teachers noted that students were better able to remember chemistry concepts that had been practised through gamified activities.

During follow-up lessons, students showed improved recall, especially when interactive quizzes were used to review previously taught content. This observation is consistent with studies showing that game-based approaches can support longer-term retention when used appropriately in chemistry instruction (Hu et al., 2022; Lutfi & Hidayah, 2021). At the same time, teachers stressed the importance of combining gamified activities with clear explanations and guided practice to ensure that students developed an accurate understanding of chemistry concepts (Landers, 2014; Othman, Husin, et al., 2024). Overall, teachers viewed gamification as an effective tool for reinforcing learning when carefully integrated into the broader instructional approach.

4 DISCUSSION

This study examined the effectiveness of Kahoot-based gamification in supporting students' academic achievement and learning motivation in the topic of Atomic Structure within secondary chemistry education. Using a quasi-experimental mixed-methods design, the findings provide insight into how students and teachers experienced gamified instruction in semi-urban and rural school contexts in Sabah. The quantitative findings indicate that students in the experimental group showed greater improvement in academic achievement than those in the control group. Although both groups showed progress from pre-test to post-test, the increase was more pronounced among students who participated in Kahoot-based activities. This suggests that the use of gamified quizzes and immediate feedback supported students' engagement with atomic structure concepts during lessons. Similar outcomes have been reported in previous studies, which suggest that game-based digital platforms can enhance learning by encouraging repeated interaction and providing timely feedback (Landers, 2014; Purba et al., 2019). At the same time, the results also show that achievement gains were not uniform across all students. This indicates that while gamification can support learning, it does not automatically lead to strong academic outcomes for every learner (Landers, 2014).

A key finding of this study relates to the statistically significant improvement in students' learning motivation following Kahoot-based instruction. Quantitative analysis revealed a significant increase in motivation scores within the experimental group between the pre- and post-intervention phases, as indicated by the paired-samples t-test. Furthermore, an independent-samples t-test showed that students exposed to Kahoot-based learning reported significantly higher levels of attention, engagement, and satisfaction than those in the control group who received traditional instruction. These findings are consistent with previous research showing that gamified learning environments can enhance motivation by introducing elements such as challenge, feedback, and participation (Landers, 2014; Zhao et al., 2022).

In chemistry education, where students often experience low confidence due to abstract content, this motivational support is particularly important (Salleh et al., 2023; Taber, 2020). Kahoot appeared to reduce students' anxiety about making mistakes, thereby encouraging broader classroom participation by presenting assessment activities in an interactive, low-pressure format (Castillo-Parra et al., 2022). However, the findings also suggest that increased motivation does not always translate into immediate academic gains for all students. This pattern may occur because motivational changes often precede measurable differences in achievement. Gamified activities can increase students' attention, participation, and willingness to engage with learning tasks; however, improvements in conceptual understanding and academic performance may require longer exposure to the instructional strategy. Previous research suggests that motivational engagement supports deeper cognitive processing over time, but its impact on academic outcomes may only become evident after sustained instructional implementation. This highlights the importance of balancing motivational elements such as points and competition with opportunities for meaningful understanding and reflection. When gamified activities are not carefully aligned with learning objectives, students may focus more on game mechanics than on conceptual understanding. Therefore, gamification should be viewed as a support for learning rather than a direct driver of achievement.

The qualitative findings provide further insight into how Kahoot-based gamification influenced classroom practices. Teachers reported noticeable improvements in student participation and responsiveness during gamified lessons. Immediate feedback from Kahoot enabled teachers to identify misconceptions and adjust their explanations during the lesson quickly. This observation aligns with research highlighting the importance of formative feedback in supporting learning, particularly in subjects that involve complex and abstract concepts such as chemistry (Azizoğlu et al., 2022). Despite these benefits, teachers also identified challenges related to limited access to digital devices, unstable internet connectivity, and time constraints, especially in rural schools. These issues reflect broader concerns regarding the digital divide in Malaysian education (Afzal et al., 2023; Zhang et al., 2021).

Overall, the present study shows that Kahoot-based gamification enhanced students' attention, participation, and engagement in chemistry lessons. Although both groups improved in academic achievement, differences were not statistically significant, suggesting that gamification primarily supports motivation and classroom interaction. Teachers reported increased confidence and participation, while noting challenges such as limited access to digital devices and an unstable internet connection, particularly in rural schools. These findings indicate that Kahoot is most effective as a complementary instructional tool, fostering interactive learning without replacing traditional teaching. Future research could examine long-term knowledge retention, its use across other chemistry topics, and strategies for integrating gamified approaches with broader pedagogical methods.

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AUTHOR CONTRIBUTIONS

The first author conceptualised the study, designed the methodology, conducted data collection and analysis, and drafted the manuscript. The second author provided overall supervision, contributed to the theoretical framework and research design, and critically reviewed the manuscript. The third author supported instrument development and quantitative analysis, ensuring methodological rigour. The fourth author offered subject-matter expertise in chemistry education and reviewed the instructional and disciplinary alignment. The fifth author provided contextual insights that informed the qualitative design, particularly regarding science and mathematics education practices in Sabah. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

ETHICAL STATEMENT

Permission to conduct this study was obtained from the Educational Planning and Research Division (EPRD), Ministry of Education Malaysia. All participants were informed about the purpose and procedures of the study, and informed consent was obtained prior to participation. Participation was voluntary, and the confidentiality and anonymity of all participants were assured throughout the research process.

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