GAMIFYING CHEMISTRY: ENHANCING STUDENTS' UNDERSTANDING OF ELECTRON CONFIGURATION AND LEWIS DOT STRUCTURES THROUGH *KAHOOT!*

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ABSTRACT. *This study explores the use of Kahoot!, an online game-based learning platform, as an instructional intervention to enhance students' understanding of electron configuration and Lewis dot structures, two of the most challenging topics in secondary-level chemistry. In light of students' persistent struggles with these abstract concepts, the researchers implemented Kahoot! as a gamified strategy to foster engagement, improve learning outcomes, and support meaningful participation. A one-group quasi-experimental design was employed, involving students from a public school in Nueva Vizcaya, Philippines. Students completed a researcher-developed test before and after the intervention, while a validated motivation scale was used to assess learner motivation. The findings revealed a significant improvement in students' conceptual understanding after the gamified intervention. Students demonstrated higher comprehension of the target topics following the use of Kahoot!, which indicates the effectiveness of game-based learning in supporting knowledge acquisition in science. Motivation levels were also high, with students reporting increased enjoyment, attention, and participation in class. Additionally, the results suggested a significant relationship between student motivation and academic performance, reinforcing the value of motivational strategies in enhancing learning. These results highlight the potential of Kahoot! as an effective instructional tool in science education. The study supports the integration of gamified approaches to create engaging, inclusive, and student-centered learning environments. Teachers are encouraged to explore digital game-based platforms to not only improve content mastery but also support the emotional and motivational needs of learners.*

Keywords: *Kahoot!, online gamification, pre-test, post-test, science, secondary, students*

1. Introduction

The integration of technology in education has transformed traditional teaching methods, particularly through the use of gamified platforms like *Kahoot!*. In science education, where abstract concepts such as electron configuration and Lewis dot structure often pose challenges to student understanding, interactive tools offer promising solutions. Gamification not only enhances engagement but also supports meaningful learning by promoting active participation. This study explores the effectiveness of using *Kahoot!* as a gamified learning intervention to improve students' comprehension of electron configuration and Lewis dot structure.

Numerous studies have shown that game-based learning, whether digital or traditional, can positively impact student motivation and engagement in the classroom. In their critical review, Wu et al. highlighted that digital game-based learning (GBL) enhances learning outcomes in STEM subjects, especially in knowledge acquisition and retention [1]. Jorda and Omega also demonstrated how digital games supported students in understanding challenging topics like trigonometry [2].

Digital game-based learning (DGBL) has emerged as an effective tool for science education across various levels. Studies have shown that DGBL can significantly improve students' science learning outcomes, particularly for average- and high-achieving students [3]. DGBL platforms include gamified simulations, traditional digital games, mobile applications, and educational modifications of commercial games [4]. Role-playing and multiplayer designs are popular in science educational settings, with most games aimed at improving content knowledge, inquiry ability, and motivation [5]. Recent research indicates that both digital and non-digital game-based learning can enhance science learning performance and self-efficacy compared to traditional lecture-based instruction, with digital games showing a particular advantage in boosting self-efficacy [6].

Among game-based tools, *Kahoot!* has become a widely used platform that blends learning with interactive play. It is a digital student response system that encourages participation through competitive quizzes using available classroom technology. Wang, Zhu, and Sætre noted that *Kahoot!* Represents a newer generation of student engagement tools that use gamification to support motivation and comprehension [7]. Beyond knowledge checks, *Kahoot!* also builds metacognitive skills, empathy, and teamwork through collaborative play.

Digital game-based learning platforms like *Kahoot!* have gained popularity in education due to their potential to enhance student engagement and learning outcomes. *Kahoot!* has been shown to positively impact learning performance, classroom dynamics, and student attitudes [8]. Studies indicate that *Kahoot!* can improve engagement and learning when integrated into traditional lecture-based classrooms [9]. The platform's real-time feedback feature allows instructors to tailor their teaching based on student understanding, while anonymous surveys encourage broader classroom participation [10]. Digital games, in general, have been found to increase motivation and engagement among students when used effectively in instruction [11]. However, challenges such as technical issues, time pressure, and difficulty level adjustments have been reported by both students and teachers using *Kahoot!* [8].

With ongoing technological advancements, educators now have more tools to design learning environments that incorporate elements of play. This shift has given rise to game-based learning, defined by Zarzycka-Piskorz as the use of game elements in non-game contexts [12]. The experiential nature of games allows learners to participate more fully in the learning process. Game-based learning captures attention and promotes retention by leveraging the motivational power of play.

Whitton described game-based learning as learning through active play [13]. DeGrove et al. added that any digital game used in an educational context qualifies as game-based learning [14]. As more teachers explore these methods, the focus shifts toward improving student involvement, comprehension, and motivation—key areas where traditional methods often fall short [15].

Learning abstract concepts in science, such as electron configuration and Lewis dot structures, presents real challenges for many students. Kristiana et al. reported that over 65% of high school students struggled with electron configuration and Lewis structures [16]. These difficulties are not just conceptual; they can limit a student's ability to understand chemical bonding and properties [17]. Elszeghy and Pasonen-Seppänen emphasized that gamified tools like *Kahoot!* can help address these gaps by promoting focus, reasoning, and retention [18]. In turn, this encourages collaborative learning and immediate feedback—both crucial in mastering complex ideas [19].

Curnow emphasized the foundational importance of Lewis structures in understanding the chemistry of p-block elements, tracing their significance back to early work by Lewis and Pauling [20]. However, drawing Lewis structures remains difficult for beginners. Cui and Harshman acknowledged that while improved methods exist in the literature, many are too complex or applicable only to a narrow range of molecules. They proposed a simplified rationale-based approach to address this issue [21].

Gamification presents many opportunities for learners and educators. According to Yürük, it fosters motivation, improves academic performance, encourages participation, and creates an inclusive and relaxed classroom environment [22]. For teachers, gamified lessons can enhance teaching effectiveness by aligning with students' needs, interests, and learning preferences.

In support of Sustainable Development Goal 4, which promotes quality education and lifelong learning for all, the use of digital tools like *Kahoot!* aligns with global educational priorities. Gamified learning in science fosters deeper understanding, motivation, and inclusion—key elements of student success and sustainable educational development [23].

The purpose of this study is to examine how *Kahoot!* can support students' understanding of electron configuration and Lewis dot structures. Specifically, it investigates whether the integration of *Kahoot!* into science instruction has a significant effect on student comprehension before and after an intervention. By doing so, this research aims to show how game-based tools can be integrated into classroom practice to improve learning outcomes. The central thesis is that using *Kahoot!* as an online gamification tool significantly enhances student understanding of electron configuration and Lewis dot structure, offering a practical and engaging alternative to traditional teaching approaches. This study hopes to encourage educators and pre-service teachers to consider *Kahoot!* as an effective strategy for making science instruction more meaningful and engaging.

2. METHODOLOGY

2.1 Research Design

This study employs a quantitative method using a one-group quasi-experimental design to determine the effectiveness of *Kahoot!* as an online gamification tool in improving students' understanding of electron configuration and Lewis dot structure. The researchers used a 50-item test-type questionnaire to measure learning gains and determine whether students' conceptual understanding improved after the intervention. The study involved a pre-test and post-test design, with *Kahoot!* Integrated into the instruction phase.

2.2 Population and Sample of the Study

The study involved 22 senior high school students enrolled in a chemistry subject from a public secondary school located in the northeastern part of Nueva Vizcaya, Philippines. The participants were selected through purposive sampling, focusing on students who were actively enrolled in the chemistry course during the academic term.

2.3 Instrumentation

The study utilized two main instruments: The achievement Test and the Motivation Scale for Kahoot Learning. A researcher-made 50-item test-type questionnaire was used to assess the students' understanding of electron configuration and Lewis dot structure. The same set of test items was used for both the pre-test and post-test to ensure consistency in measuring learning gains. The items were based on curriculum standards and validated through consultations with chemistry educators and a review of related literature. The test was pilot-tested on a similar class but not part of the study. From a 60-item test, it was reduced to 50 after item analysis.

On the other hand, the Motivation Scale for Kahoot Learning was used to assess student motivation related to the use of *Kahoot!*, the researchers adapted the 20-item, unidimensional Motivation Scale for Kahoot Learning from Jarrah *et al.* [24]. This scale measures students' levels of engagement, enjoyment, and perceived effectiveness of gamified instruction, and was modified for applicability in a chemistry classroom setting. The instrument includes 5-point Likert-scale items and was validated for content and reliability before administration.

3. RESULTS AND DISCUSSION

The students participate in the pre-test and post-test to determine if there is an improvement before and after the intervention like the *Kahoot!* as an online gamification.

Table 1 presents the students' level of understanding of electron configuration and Lewis dot structure before and after the use of gamification through *Kahoot!*. As shown in the table, students initially demonstrated generally low levels of understanding (M = 18.2, SD = 5.87). Over half of the students (54.5%) were categorized as having low understanding, while (31.8%) were in the average range. A small proportion (13.6%) showed very low understanding, and none of the students reached the High or Very High categories in the pretest.

Table 1: Students' Level of Understanding of Electron Configuration and Lewis Dot Structure before the use of gamification through *Kahoot!*

Score Range	Qualitative Interpretation	Pretest		Posttest	
		f	%	f	%
0-10	Very Low	3	13.6	0	0
11-20	Low	12	54.5	0	0
21-30	Average	7	31.8	0	0
31-40	High	0	0	7	31.8
41-50	Very High	0	0	15	68.2
Overall Score		M=18.2, SD=5.87		M=42.0, SD=5.79	

Following the gamified intervention, students' performance showed substantial improvement. The post-test scores increased dramatically (M = 42.0, SD = 5.79), placing the overall performance within the Very High category. Most students (68.2%) scored in the Very High range, while the remaining (31.8%) were categorized as High. Notably, no students scored below (31) points in the post-test, indicating a complete shift away from the lower performance. This shift suggests that the gamified approach using *Kahoot!* may have significantly enhanced students' conceptual understanding. The marked increase in scores supports the effectiveness of interactive, game-based learning strategies in fostering engagement and improving mastery of science content.

Studies have shown that most students find the topic of Lewis structures challenging. For instance, Kristiana et al. on their large-scale study of high school students found high rates of difficulty in understanding Lewis structures: 65.59% struggled with electron configuration, 67.33% with identifying valence electrons and Lewis symbols, and 69.37% with constructing Lewis structures. Struggles with electron configuration and Lewis dot structures can hinder students' ability to predict chemical properties and understand more advanced topics in chemistry [17].

Kahoot!, an interactive game-based learning platform, has shown promising results in enhancing science education across various levels. Studies indicate that *Kahoot!* improves student motivation, engagement, and academic performance in science and mathematics [25, 26]. It serves as an effective formative assessment tool, particularly in remote teaching settings for undergraduate Physical Sciences teacher education [26]. In elementary schools, *Kahoot!* has been utilized to make science learning more interactive and enjoyable, employing a play-based learning approach [27]. The platform's effectiveness extends to high school computer science education, where it has been found to reinforce concepts in an engaging and motivating manner [28]. Overall, *Kahoot!*'s integration into science education aligns with the development of 21st-century competencies and skills, promoting pedagogic innovation and meaningful learning experiences across different educational contexts [26, 27].

Table 2 presents the students' motivation levels following the integration of *Kahoot!* in Chemistry instruction.

Table 2. Post-Intervention Level of Motivation of Students

Items	Mean	SD
1. Using *Kahoot!* in Chemistry class brings me joy.	4.77	0.43
2. *Kahoot!* motivates me to participate in Chemistry class actively.	4.68	0.43
3. *Kahoot!* provides ample time for me to answer questions.	4.41	0.43
4. Collaborating with my peers through *Kahoot!* helps me overcome the fear of giving wrong answers.	4.27	0.44
5. *Kahoot!* captures my attention during Chemistry class.	4.55	0.42
6. I find Chemistry lessons on *Kahoot!* to be engaging.	4.45	0.42
7. *Kahoot!* encourages me to prepare for lessons in advance to compete and strive for the top spot.	4.00	0.43
8. I enjoy competing with my classmates to solve *Kahoot!* questions in Chemistry.	3.73	0.44
9. I frequently join *Kahoot!* competitions during Chemistry class.	4.18	0.41
10. *Kahoot!* helps me remember Chemistry lesson content for a longer duration.	4.45	0.42
11. I prefer learning Chemistry through *Kahoot!*.	4.36	0.37
12. Anticipating *Kahoot!* Activities make me look forward to Chemistry class.	4.59	0.39
13. I feel enthusiastic about using *Kahoot!* to excel in Chemistry.	4.59	0.40
14. *Kahoot!* reduces my shyness when participating and answering questions.	4.36	0.32
15. I enjoy watching educational videos provided by *Kahoot!*.	4.55	0.33
16. The visuals on *Kahoot!* caught my eye.	4.55	0.35
17. *Kahoot!* allows me to discuss answers with my peers before making a choice.	4.50	0.37
18. The music on *Kahoot!* Adds excitement to my learning experience.	4.59	0.40
19. *Kahoot!* boosts my motivation to learn.	4.64	0.43
20. I do not get bored when using *Kahoot!* in Chemistry class.	4.68	0.47
OVERALL Mean	**4.45**	**0.44**

It can be seen that the overall mean score was high *(M = 4.45, SD = 0.44)*, indicating that students were generally highly motivated using *Kahoot!* as a gamified learning tool. The highest-rated aspects of *Kahoot!*! were its ability to bring enjoyment, sustain interest, and encourage active participation. These findings suggest that the tool effectively promoted a positive emotional climate in the classroom. Additionally, students reported increased motivation to learn and greater anticipation for future lessons, showing the tool's potential to enhance long-term engagement.

Visual, auditory, and collaborative features were also well-received, contributing to an enriched and interactive learning environment. Furthermore, *Kahoot!* appeared to help reduce students' shyness and fear of giving incorrect answers.

While all items received favorable ratings, competitive elements received slightly lower scores, suggesting that not all students are equally driven by competition. Nonetheless, the overall findings affirm that *Kahoot!* significantly enhances student motivation and supports learner-centered, engaging instruction in Chemistry.

The findings of this study align with those of [29], who reported that gamification-based learning using *Kahoot!* significantly enhanced students' interest and academic performance, as evidenced by notable gains from pretest to posttest. Similarly, Campillo-Ferrer et al. [30] found *Kahoot!* to be an effective and creative instructional tool, demonstrating its ability to improve conceptual understanding, foster active participation, and boost student motivation through an engaging and interactive learning environment.

To determine whether the use of *Kahoot!* in teaching Chemistry had a significant effect on students' performance, a paired samples t-test was conducted to compare the students' scores pre-and post-intervention. The results are presented in Table 3.

Table 3. Comparison of Students' Chemistry Achievement Before and After the Intervention

Score	M	SD	t	df	p
Pretest	18.18	5.869	-24.703	21	.000
Posttest	41.95	5.786			

Table 3 shows the improvement in students' Chemistry performance following the implementation of *Kahoot!* as a gamified instructional strategy. The posttest scores were significantly higher compared to the pretest scores, $t(21)=-24.703$, $p<.001$, indicating that the intervention had a positive influence on students' understanding of electron configuration and Lewis dot structures.

This improvement supports the growing body of literature advocating for the integration of game-based learning tools in science education. The use of *Kahoot!* likely contributed to enhanced engagement, immediate feedback, and a more student-centred learning environment—factors that have been shown to boost comprehension and retention of complex scientific concepts [23, 29].

To further examine the relationship between students' motivation and their academic performance in Chemistry after the intervention, a Pearson product-moment correlation analysis was conducted. Table 4 presents the results of this analysis.

Table 4. Correlation Between Students' Chemistry Achievement and Motivation Post-Intervention

Variables	Mean	SD	r	p	**Strength** [32]
Achievement	41.95	5.79	.339	<.001	A distinct positive linear relationship
Motivation	4.4455	0.45			

The results reveal a moderate positive correlation between motivation and post-intervention Chemistry achievement ($r = .339$, $p < .001$). This indicates that students who reported higher levels of motivation also tend to perform better in their Chemistry tests.

The statistically significant relationship suggests that increased engagement and motivation—fostered through the use of gamified learning via *Kahoot!*—may contribute to improved academic outcomes. This aligns with previous findings emphasizing the role of motivation in facilitating deeper learning, particularly in subjects perceived as difficult or abstract, such as Chemistry [17, 23].

The results of this study support the idea that motivational strategies, especially those leveraging interactive technologies, can play a vital role in enhancing both the affective and cognitive dimensions of student learning. These findings underscore the value of incorporating engaging digital tools in science education to support both motivation and achievement.

4. CONCLUSIONS AND RECOMMENDATIONS

The results of this study demonstrate the positive effect of using *Kahoot!* as a gamified learning tool in Chemistry education. Students showed significant improvement in their understanding of electron configuration and Lewis dot structures, as reflected by the increase in students' post-test scores. This shift suggests that *Kahoot!* not only enhanced content mastery but also made learning more accessible and enjoyable for students.

Moreover, the high overall motivation score indicates that students found *Kahoot!* to be an engaging part of their Chemistry learning experience. The platform's playful and interactive features helped reduce anxiety, sustained attention, encouraged collaboration, and cultivated a more positive classroom atmosphere. Interestingly, students were particularly drawn to the fun, music, visuals, and peer interaction—elements that likely helped reduce the fear of making mistakes and boosted their willingness to participate. While competitiveness was less motivating for some, the overall learning environment created through *Kahoot!* was one where students felt both challenged and supported.

In light of these findings, it is recommended that educators consider integrating gamified learning platforms like *Kahoot!* into their instructional practices—particularly in science subjects that students often find abstract or difficult. Teachers can use *Kahoot!* not only for reviews and assessments but also as a tool to increase classroom interaction and student motivation. Additionally, school administrators and curriculum developers should provide opportunities for professional development that empower teachers to adopt innovative, student-centered teaching approaches. Finally, future research could explore how *Kahoot!* impacts long-term retention and performance across various science topics and learner groups. It would also be beneficial to examine how gamified strategies can be tailored to meet different learning styles and preferences, ensuring that every student can benefit from such approaches. By embracing tools that make learning more engaging and meaningful, educators can better support both the academic growth and emotional well-being of their students.

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