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Research paper

Digital Gamification: Application of Kahoot in Teaching The Biology Subject

Sheilla Indiaka Mutiva [1] * Prof. Ronald Waweru Mwangi [2], Dr. Jael Sanyanda Wekesa [3]

[1] Author's Designation: Master's student, School of Computing and Information Technology, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya
[2] Co-Author's Designation: Professor, School of Computing and Information Technology, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya
[3] Co-Author's Designation: Doctor, School of Computing and Information Technology, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya
**Corresponding author E-mail: sheilamutiva@gmail.com*

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Abstract

Digital technology has increasingly transformed the landscape of science education, positioning gamification as a powerful pedagogical tool to enhance learner engagement and comprehension. This study investigates the application of digital gamification using 'Kahoot!' to enhance comprehension of biology subject content among secondary school students. The study seeks to determine the effectiveness of digital gamification in reinforcing students' understanding of cell organelles; examine learners' motivation during the gamified learning process; and evaluate the impact of a digital gamification intervention through pre- and post-intervention assessments. A quasi-experimental design was employed involving two groups: an experimental group using 'Kahoot!' -based digital quizzes and learning content, and a control group exposed to traditional teaching methods. The study targeted Form Two biology students, with gamified content aligned to the cell organelles topic in the Kenyan secondary school curriculum. Data was collected using comprehension tests. Quantitative analysis through t-test revealed statistically significant improvements in comprehension, motivation, and engagement levels among students in the experimental group compared to the control group. The findings demonstrate that digital gamification fosters deeper understanding, enhances motivation, and promotes active participation in biology lessons. The study recommends the integration of digital gamification tools like 'Kahoot!' into science instruction to foster a more interactive and learner-centered environment.

Keywords: *Achievement; Biology; Comprehension; 'Kahoot!'; motivation.*

1. Introduction

The Kenyan education system has progressively transitioned towards learner-centered pedagogies, emphasizing student engagement and enhanced performance in science subjects [1]and [2]. Traditional classroom instruction has been transformed through the implementation of competency-based learning and the increasing availability of digital technology [3] and [4]. Challenges persist, as some secondary school students continue to struggle with fully engaging in and comprehending complex scientific concepts [5 - 7]. This is especially true in the sciences, where abstract concepts like cell organelles present considerable challenges to comprehend among learners [8], [9] and (Rapanta et al. 2020).

Secondary educators and policymakers have effectively utilized creativity and technology to enhance meaningful learning and engage students in challenging learning areas [11 - 13]. 'Kahoot1', a digital platform that integrates gamification with live quizzes and instant reporting, exemplifies one of these strategies [14] and [15]. 'Kahoot!' contrasts with traditional direct lecturing methods by incorporating dynamic visual content, fostering a participatory and student-centered environment that enhances conceptual clarity and promotes active engagement in the learning process [16] and [17]. Figure 1 represents the input and output of the gamification Intervention.

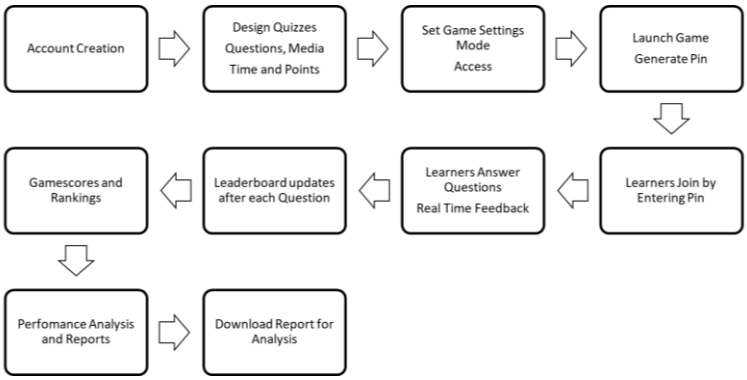


Fig. 1: Input and Output of the Gamification Intervention.

According to [18] gamified digital tools can enhance student engagement, motivation, and retention of concepts and knowledge across various educational learning areas. Findings by [19]assert that digital learning tools like 'Kahoot!' are effective in addressing learning gaps and enhancing learning instruction in the classroom. Empirical research examining the impact of 'Kahoot!' on secondary Biology education in Kenya is limited. This research investigates the effectiveness of 'Kahoot!', a digital gamification application, in enhancing Kenyan secondary school students' comprehension of cell organelles. The study evaluates the influence of 'Kahoot!' on student engagement with Biology content, grounded on the theoretical framework of engagement, including behavioral, emotional, and cognitive responses to learning materials. This specifically addresses the following research objectives:

i) To examine the effect of the 'Kahoot!' intervention on secondary school students' comprehension of cell organelles materials by pre- and post-intervention evaluations.

ii) To examine learners' motivation and engagement in using 'Kahoot!' in the acquisition of knowledge about cell organelles.

This research will explain the cognitive advantages and motivational responses associated with 'Kahoot!', offering practical implications for the application of instructional technology in science classroom lessons. The findings will influence both the practice of Biology teaching and the broader integration of gamification in facilitating STEM education in resource-constrained settings.

1.1. Gamifying learning

Point-award systems, badges, leaderboards, and challenges are introduced into educational environments to make the process of studying and learning more attractive and engaging for students, while also helping them to achieve their goals. The growing preference in E-learning domains can be, in most parts, due to the shortcomings of classroom methods that do not always succeed in keeping learners engaged and motivated. Game-based learning Tools and services focus on engagement and motivation[20] and [18]. It is proposed that game-generated platforms contribute to student motivation and satisfaction, ultimately promoting better learning effects. The contributions of [21] reveals that the use of progress bars along with any kind of reward might inspire the students as much as possible. Research by [18]Gamification stimulates self-directed learning of students. Gamified systems are thought to support learners in being responsible for their learning, leading to independence, self-motivation, and perseverance [22]. The study by [23] Maintain that achievements as well as tracking and immediate feedback, encourage students studying online to feel more focused and responsible.

A meta-analysis conducted by [24] also revealed the beneficial effects of gamification on cognitive, motivational, and behavioral measures. Research indicates that legitimate gamification that integrates game mechanics into learning content results in better learning performance than superficial game add-ons. Furthermore, well-designed gamification contributes to educational development as opposed to mere entertainment. A study by [25] caution the reader that it may not be easy to overgeneralize, as "not all that is gamified is gamifable". Their research suggests that gamified learning may be more effective for younger students, in specific domains of knowledge, and depending on the learners' level of digital proficiency. [20] also advocate for user-centered design and continuous assessment to make certain that gamification meets learners' needs.

1.2. Application of 'Kahoot!' in learning

Technology has its part to play in a transforming educational scene, by determining the delivery systems which are now possible for the dissemination of knowledge and the retrieval of information.' Kahoot! is, in a nutshell, a game-based learning platform that uses elements of fun, competition and interactivity in the context of the educational spaces [26]. This makes it the utility power of 'Kahoot!' to revitalize science education, particularly in terms of captivating and hooking students onto their content. [27].

In the class, gamification partly plays to the advantage of Kahoot! by the logic itself of framing motivating environments through award points, limited times, and the display of the player's performance on leaderboards [28]. This is an at-ease, yet enticing entry point for something often seen as abstract or difficult mostly in science education [29]. [30] found that science learning is characterized by memorization of terms, comprehension of concepts, and application of principles, all of which can be game-based in platforms like 'Kahoot!'. An example of this is the immediate feedback aspect of the 'Kahoot!'; the feedback allows the learner to realize what their misconception is and fix it while the activity is still being carried out, meaning it is more formative than punitive [31]. Even from the elevated academic perspective, 'Kahoot!' brings the learning experience down to a very human level of play and fun in the otherwise sanitized world of science education. This is very useful for students who feel that the subject's learning content is difficult. When students are laughing, cheering, and connecting through a shared digital experience, science is no longer a lonesome chore; it becomes a shared adventure.

Another interesting point is the popularity of 'Kahoot!' as a teaching tool in design. Just using 'Kahoot!' does not necessarily translate better learning results. The questions, how they align with the learning targets, and how the activity connects to other teaching and learning strategies all play a part in the overall effectiveness. In applying these technologies, teachers should be thoughtful in how and when such tools are used, to support instead of substitute for authentic inquiry and discussion [32].

'Kahoot!' has exciting potential for making science learning more engaging for students and providing opportunities for collaborative reinforcement of scientific knowledge in a playful, human-centered way [33]. As we examine on how to better communicate complex scientific ideas, 'Kahoot!' makes clear, learning can and perhaps ought to be fun as well as a serious classroom environment. Additional studies reveal how these platforms can be most effectively utilized in various fields of science and for various students.

1.3. Application of Quizizz in learning

Digital assessment systems in education have advanced quite a lot, notably with learner-centered perspectives. Quizizz is a website that allows teachers to create online quizzes for their students in a fun and engaging way. The interactive environment in this platform has made persuasive instructional activities and learning circumstances versatile, such as those of emergency remote learning [34].
Quizizz has been associated with a significant increase in learner engagement and exam preparedness in science subjects. This is particularly the case in elementary school settings where elementary students engage in scientific inquiry. This type of digital interaction seems to be related to brain activity changes that may be associated with higher-level thinking patterns [35]. The preliminary results emphasize the importance of the inclusion of "interactive" platforms for an integrated learning approach. However, the directionality of this relationship requires further situational evidence.
Incorporating gaming aspects in the learning journey has provided structure for enhanced cognitive interaction with the learning materials. Gamification of Quizizz depends on repeated participation, score-based competition, and visual feedback effects on the learner's feeling and emotional processing level of the mind; in influencing learner emotions and attitudes [36]. Learners can engage with knowledge items in a non-linear, adaptive style in a User Interface and a secondary task itself, which may enhance retention. However, longitudinal dynamics are poorly understood.
The implementation of Quizizz in middle-level educational programs has been seen as an innovative approach to improving understanding in curriculum-specific courses like Science 10. The platform is used both as an assessment tool and as an educational scaffolding device. The resulting dynamic appears to facilitate formative assessment while encouraging peer engagement via real-time feedback [37]. Nevertheless, although the platform's flexibility seems promising, it is dependent on pedagogical alignment and contextual affordances.

1.4. Application of gimkit in learning

The application of Gimkit in educational settings is widely acknowledged for its ability to enhance learner interaction, improve academic performance, and maintain engagement across several subjects. An expanding body of academic research has examined the many aspects of this gamified learning tool, focusing on its psychological, pedagogical, and technical effects in primary and secondary educational environments. [38]evaluated the effect of Gimkit on students' test achievement scores and retention in high school-level Biology. The quasi-experimental design of the study showed that students in Gimkit-enrolled classes achieved significantly improved learning outcomes and better memory retention compared to those in conventional instruction. The interactive characteristics of the platform (real-time feedback mechanisms, rewards, and self-directed participation) were regarded as pivotal factors in transforming the environment into one that encourages and fosters higher levels of cognitive engagement and knowledge recall.
Another study by [39] examined the use of Gimkit under the STEAM model and used it as a digital game-based multimedia tool to improve the ability of problem solving in writing of explanatory texts for primary school students. The study highlighted that students developed a more refined cognitive reflection and learning capabilities through a combination of gamification activity and critical thinking. The implementation of STEAM, especially the interdisciplinary application of learning, has helped to free Gimkit from memory-based instruction into higher-level thinking skills.
Furthermore [40] also examined the relationship between Gimkit teaching and students' academic performance in some subjects. Their results emphasized the function of the platform, because of its adaptive elements (variety of questions, progress tracking, competitive cooperation) and their impact on learning gains. Findings indicated that the introduction of the digital interface led to increased activism among students and greater engagement in learning activities, which implied the transformation of the traditional student-teacher relationship to learner-centered environments.

1.5. Application of cospaces edu in learning

Immersive digital simulation technology has given rise to a new form of pedagogy, enabling new forms of representation and narratives that allow students to interact better with complex knowledge domains, through platforms like CoSpaces Edu. It offers immersive interactive virtual environments to explore complex topics. The platform has been well known for its extensive engagement in the science and computational learning domains.
A quasi-experimental study by [41]proved the pedagogical impact of CoSpaces Edu in science. Their results showed that students who were instructed with the software had significantly superior conceptual retention and interest compared to those who were taught traditionally. Improved academic achievement was accredited to the fact that the virtual environments allowed interactive, student-centred participation. The open-ended and constrained ability of the tool to mimic natural phenomena in user-constructed and flexible digital environments afforded students the ability to manipulate, observe, speculate and generate questions within a framework not all too different from the process of natural inquiry, albeit in a virtual setting.
Also [17]made an empirical investigation with primary school children, which emphasized the platform's role in the cultivation of computational thinking (CT). The study found that CoSpaces Edu supported students' design of Virtual Reality stories and programmatic spaces, which in turn significantly enhanced their algorithmic thinking, abstraction, and problem-solving skills. The 3D space internal to the building allowed students to mentally manipulate abstract CT ideas through 3D interactive digital models, thus enhancing the internalization of procedural thinking.

1.6. Engagement theory

The engagement theory promotes authentic, student-centered, interactive learning involving collaborative technology resources in meaningful tasks. It suggests that students learn most when they are engaged in learning that is collaborative, project-based, and meaningful, thereby encouraging continued interest, effort, and motivation (Kearsley & Shneiderman, 1998). The game-based student response system, 'Kahoot!', illustrates how the mechanics in the program can be applied with engagement theory when using game-based platforms like leaderboards, real-time feedback, time-based challenges, and interactive play. A study by [42], Kahoot enriches the dynamics of the classroom by providing competition with leaderboards and instant feedback, which leads to more engagement and attention. The feature of leaderboard, in turn, practically facilitates the cognitive aspect of the theory, "relate" when students engage in cooperatively driven surroundings. "Such competitive edge fosters a highly social, participatory environment in which every learner wants to be a part of the action, particularly in large cohorts where it's hard to get students to contribute. [43] Additionally, make the claim that 'Kahoot!' adds value to students' motivation and enjoyment, lending credence to the theory's "create" aspect, which encourages learners to actively participate in

meaningful activities for learning. In a study carried out with engineering students, they found that 'Kahoot!' promoted motivation and learning, because it included rewards, and progression, and as a result, the theory proposed that sustained meaning and enjoyable engagement is achieved through task ownership and reinforces this. [44] Also supports the material donation aspect of the engagement theory, in that learners are using their learning within a real-time context that supports other learners. Game-based learning through 'Kahoot!' enabled students to be more involved in their learning, focusing and interacting more. Utilizing gamification features like timers and scoring led to an enhanced cognitive engagement by introducing urgency and a sense of accomplishment, consequently leading to a more intensive focus on the learning material.

2. Method

The study used a 'Kahoot!' learning platform as a method of delivering Biology learning content to two learners. The Kahoot! game was named 'cell organelles and their functions'. The study was about the biology topic of cell organelles and their functions, which was the independent variable. Learners' motivational questionnaires, pre-test, and post-test Biology assessment test were administered to learners in the 'Kahoot!' gamified learning content, which was the dependent variable, and it was used to measure the level of achievement and motivation. The pre-test and post-test were designed on Kahoot! platform. The reason why the learning content was designed was to assist learners in improving their understanding of the cell organelles subtopic. The design of 'Kahoot!' learning content was done based on the Kenyan Biology syllabus and followed the curriculum designed by the Kenya Institute of Curriculum Development.

2.1. Participants

A quasi-experimental study was conducted for three weeks in two secondary schools during this phase. Both schools displaying similar characteristics were found at the beginning of the study, which is essential for reducing bias in the quasi-experimental approach. Learners were of age between 13-14 years old; the researcher was permitted to conduct the study by the relevant body. The permission to conduct the study was also given by the school principals. This study mitigated selection bias by selecting two groups with comparable characteristics in terms of age, subjects, class size, pre-test outcomes, and learning environment. After identifying similar features between the schools, random assignment was utilized to select one school as the experimental group and another as the control group. In a quasi-experimental research framework, pre-existing groups must be employed according to specific criteria, such as participant availability, research aims, and established methods [45]. Students in the experimental group were instructed via 'Kahoot!' gamified learning content, while those in the control group were taught through traditional teaching techniques.
Figure 2 illustrates the design of the current research.

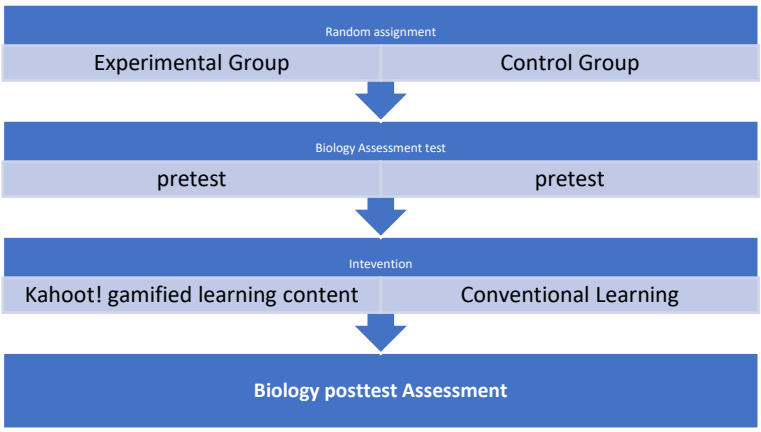


Fig. 2: Design of the Current Research.

The learners in this study used two different methods of delivering instructions as presented in Table 1. Students of Form Two West used the 'Kahoot!' gamified platform while those in Form Two East used the conventional method of teaching.

Table 1: Intervention in Each Group

Item	Form Two West (Experimental Group)	Form Two East (Control group)
Number of learners	45	44
Type of intervention	Kahoot! gamified content	Traditional Learning Content

The 'Kahoot!' gamified learning content was used by the experimental group online. The gamified learning content presented questions that had clear goals and instant feedback, and the degree of feedback provided on the platform.

2.2. Development of learning content on the 'Kahoot!' platform

'Kahoot!' (https://kahoot.com/) is a website forum offering free interactive games designed for educational purposes, where educators can create customized MCQ (Multiple Choice Question) that transform into engaging activities for learners. Learners can participate using computers. According to [46], Bloom's Taxonomy can effectively guide the design of formative assessments in real-time online learning by ensuring that questions target not only basic recall (knowledge) but also higher-order cognitive skills such as application, analysis, and evaluation. When used with 'Kahoot!', educators can structure quiz questions that align with different levels of Bloom's hierarchy—for example, asking students to recall biological terms (remembering), explain a cellular process (understanding), or compare functions of organelles (analyzing). Users have the flexibility to craft their quizzes or utilize quizzes shared by others within the 'Kahoot!' community, tailoring content to suit their classroom requirements. When creating assessments, users can personalize the duration allotted for answering

each question and the number of response options provided. 'Kahoot!' games, which were designed by the researcher, were given to the experimental group.

The study started by administering the pre-test Biology assessment to learners. The pre-test was important because it enabled the learners to remember the content about cell organelles and their functions [47]. In this research study, teachers were involved in the delivery of the learning content. The five teachers who were engaged in administering the learning content to learners in the experimental group were also tested on the level of their knowledge about the use of the 'Kahoot!' platform during the teaching and the learning process. Figure 3 shows the steps followed by learners on the 'Kahoot!' platform to be awarded scores.

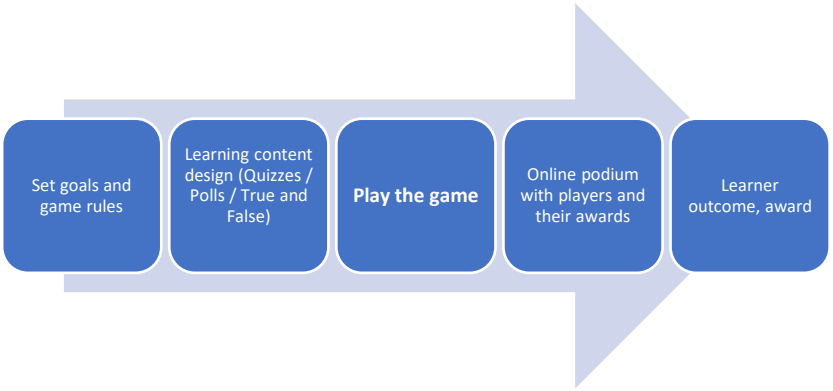


Fig. 3: Steps Followed by Learners on the 'Kahoot!' Platform to Be Awarded Scores.

2.3. Procedure and data collection

The students were initially instructed on how to use computers to play the 'KAHOOT!'. To address potential anxiety and reduce the effects of over-competition, students were first given structured guidance on how to use 'Kahoot!', including instructions on navigating the platform and strategies for focusing on learning rather than competition. The class was introduced to the topic of cell organelles and their functions through gamification on the 'KAHOOT!' platform. Contrasting with their familiar lecture format, this technology-driven approach proved more engaging and interactive for students. The three games (https://create.kahoot.it/share/game-one/dd0b1ed0-f0aa-410d-a5ea-ff9a7ec2ddd6), (https://create.kahoot.it/share/game-two/bc44e3bc-f92c-4d57-b462-37dc00dc5961), and (https://create.kahoot.it/share/game-3/99827cee-ea79-4b49-b194-9952c3418f7d) were embedded on the 'KAHOOT!' platform. It equipped learners with the knowledge necessary to participate in the 'KAHOOT!' game post-test biology assessment created by a researcher in collaboration with biology teachers. Students accessed the game through the student portal, https://kahoot.it/, where they enter an access code and choose a unique, informal name to maintain anonymity during gameplay. This anonymous approach allows students to participate to their fullest potential without revealing their identities. Upon entering the game, 'KAHOOT!' presents the question-answer interface on their computers. After a 20-second time limit, the 'KAHOOT! Podium displays the game results, showcasing the leaderboard with the names of top-performing students and the correct answer to each question. After the interactive lesson and game, the learners in the experimental group responded to a learner's motivational questionnaire, which was on the 'KAHOOT!' platform. The student's motivational questionnaire was used to assess the learner's interest when engaging with the 'KAHOOT!' platform during the study. They were then allowed to use their computers to access a custom-made 'KAHOOT!' game (https://create.kahoot.it/share/pretest-biology-assessment/a04f2f61-046c-4149-9d67-2c786dc0c99f) for a pre-test Biology assessment. By entering the Game PIN into the 'KAHOOT!' portal, the students gained access to the game. Once all students were logged in, the game commenced. The students were presented with 11 questions, a mix of multiple-choice and true-or-false, with a 20-second time limit for each question. This time frame was based on the teacher's recommendation that students should be able to answer within this period. Each multiple-choice question had four answer options, while true-or-false questions had two. After the timer expired, the game revealed the correct answer and the number of students who selected each option. At the end of each round, 'KAHOOT!' displayed the round leader. All students had the opportunity to answer all 11 questions. Following the pre-test, students were given a KAHOOT! game pin to play three games in a self-paced manner. (https://create.kahoot.it/share/game-one/dd0b1ed0-f0aa-410d-a5ea-ff9a7ec2ddd6), (https://create.kahoot.it/share/game-two/bc44e3bc-f92c-4d57-b462-37dc00dc5961) and (https://create.kahoot.it/share/game-3/99827cee-ea79-4b49-b194-9952c3418f7d). After the instructional material was presented, students used their computers to access another custom-made 'KAHOOT!' game (https://create.kahoot.it/share/posttest-biology-assessment/80f6990a-2ccc-440a-88a5-49e395f0911b) for a post-test Biology assessment. Again, they entered the Game PIN to log in, and the game began once all students were logged in. The format was identical to the pretest, with 11 questions and a 20-second limit per question. Correct answers and the number of students selecting each option were displayed after the timer expired, and the leader of each round was shown as in the figures below. After completing the 'KAHOOT!' game, students were presented with a motivational questionnaire. Their responses helped researchers determine how well the students understood cell organelles and their functions after using 'KAHOOT!', as well as their overall interest and motivation in learning with 'KAHOOT!' The questionnaire had eight Likert-scale questions, rated from 1 (strongly disagree) to 5 (strongly agree) (https://create.kahoot.it/share/motivational-questionnaire/884fc764-f4a1-4aeb-898b-6831b12aaa29). On the other hand, the control group was issued a photocopied Biology assessment pre-test, which consisted of 11 questions. The same teacher who did the presentation to the experimental group taught the control group about cell organelles and their functions using the conventional method. The learners in this group were then given a post-test Biology assessment. The group did not respond to the learner's motivational questionnaire. Designing and using learning content for the learners in the conventional classroom was easy with minimum pressure because the teachers had experience using it.

2.4. Validity and reliability of research instruments

The verification of the validity of the relevance of the 'Kahoot!' gamified learning content and the pre-test was obtained after carrying out a pilot study in a secondary school with learners of the same characteristics as those in the main study. Experts, consisting of experienced teachers in the biology subject and lecturers in the university and the Kenya Institute of Curriculum Development, were involved in the assessment of the biology learning content before they were used in the research study. Similarly, based on the feedback from experts,

improvements were made to both the gamified learning content and the pre-testing. As a result, the 'Kahoot!' gamified learning content was achieved at 87.98%. Based on the achievement level, 76 is considered to have reached a high level of achievement and the determination of good validity content. The assessment tests in pre- and post-tests were different but similar in terms of cognitive level. The pre- and post-test assessment question items used were obtained from the biology textbook of the Kenya Literature Bureau.

3. Results

3.1. Effectiveness of 'Kahoot!' intervention in teaching and learning

The results of the pre-test process scores for the control group and experimental group is presented in the tables.

Table 2: Pre-Test Mean Scores for Control Group and Experimental Group

Test	N	Mean (M)	Standard Deviation (SD)	t-value	Significance (p)
Control Group	44	9.69	3.183	1.456	0.000
Experimental Group	45	9.68	3.309	1.342	0.00

The null hypothesis was not rejected, as no significant differences were observed in the pre-test scores of the control group (M= 1.64, SD= 3.183) and the experimental group (M= 1.68, SD= 3.309), with a t value exceeding 0.05. Consequently, there was no significant difference in learner achievement following the pre-test Biology assessment. The random selection for the group indicated the initial performance levels of the learners regarding cell organelles and their functions.

Table 3: Experimental Group Pre-Test and Post-Test Scores

Test	N	Mean (M)	Standard Deviation (SD)	t-value	Significance (p)
Pre-test	45	9.68	3.309		0.000
Post-test	45	11.84	3.102	3.041	

Table 3 indicates the pre-test and post-test performance for the subgroup of 45 learners that were being studied. The pre-test mean score was 9.68, with a standard deviation of 3.309; the post-test mean score improved to 11.84, with a standard deviation of 3.102. This represents enhanced performance after the intervention. A paired sample t-test was performed to ascertain the statistical significance of the observed difference. The generated t-value was 3.041, with an associated p-value of 0.000. The p-value is below the conventional significance threshold of 0.05, indicating statistical significance. This indicates that the improvement in scores from the pre-test to the post-test was not attributable to random chance but rather signifies that the intervention had a significant and beneficial effect on the participants' performance. Students possess prior knowledge of the structure and functions of cellular organelles.

Table 4: Control Group Pre-Test and Post-Test Scores

Test	N	Mean (M)	Standard Deviation (SD)	t-value	Significance (p)
Pre-test	44	9.69	3.183	2.573	0.0017
Post-test	44	9.97	2.463		

Table 4 illustrates the pre-test and post-test scores for the control group, including 44 learners. The mean result on the pre-test was 9.69, with a standard deviation of 3.183, but the post-test mean score improved to 9.97, with a standard deviation of 2.463. A paired sample t-test was performed to see whether the small difference in scores was statistically significant. The calculated t-value was 2.573, having a corresponding p-value of 0.0017. The p-value, being less than 0.05, indicates a statistically significant difference, implying a little yet notable improvement in performance despite the absence of the experimental intervention. The degree of enhancement is minimal, suggesting that the transformation might result from existing learning effects, familiarity with testing, or other uncontrolled factors rather than a targeted intervention.

Table 5: Post-Test Scores Comparison of 'Kahoot!' Gamified and Traditional Learning Content

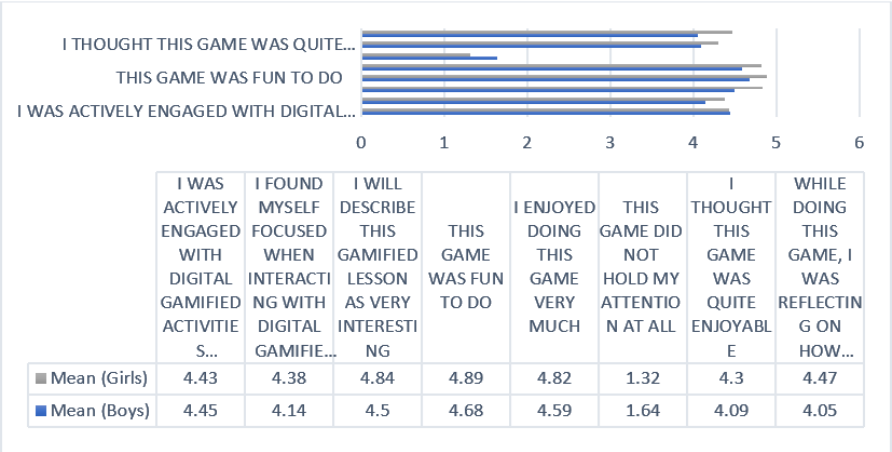
Group	N	Mean (M)	Standard Deviation (SD)	t-value	Significance (p)
Control Group	44	9.97	3.183	-2.18	0.016
Experimental Group	45	11.84	3.102		

Table 5 establishes a comparison of post-test results between the control group, which utilized ordinary learning materials, and the experimental group, which employed 'Kahoot!' gamified learning content. The control group (N = 44) revealed a mean score of 9.97 and a standard deviation of 3.183, whereas the experimental group (N = 45) earned an outstanding mean score of 11.84 with a standard deviation of 3.102. An independent sample t-test was performed to see if the mean score difference between the two groups was statistically significant. The computed t-value was -2.18, with a corresponding p-value of 0.016. The p-value, situated inside the standard threshold of 0.05, indicates that the difference is statistically significant. The study indicates that students utilizing 'Kahoot!' gamified learning materials had markedly superior results on the post-test compared to those subjected to conventional learning techniques. Consequently, the implementation of gamification via 'Kahoot!' seems to have positively influenced students' academic achievement.

3.2. Motivation for using digital gamification during the process of learning

The study on the motivation of using digital gamification during the learning process highlights significant gender differences in student engagement and attentiveness. Both boys and girls reported high levels of engagement with the gamified activities, with boys rating their engagement slightly higher than girls (Mean = 4.45 vs. 4.43), which indicates that gamification is generally effective at capturing the attention of both genders. However, girls reported being slightly more focused when interacting with the content, with a mean score of 4.38 compared to 4.14 for boys, suggesting that girls may be more attuned to the material in gamified environments. Additionally, girls described the gamified lessons as more interesting than boys did (Mean = 4.84 vs. 4.50), which aligns with the idea that girls may develop a stronger emotional connection to the interactive and dynamic nature of gamified content. Both genders found the game enjoyable, but girls rated it slightly higher in terms of fun and overall enjoyment (Mean = 4.89 vs. 4.68 for fun, mean = 4.82 vs. 4.59 for overall enjoyment),

supporting the notion that gamification enhances the learning experience by making it more engaging and enjoyable for students. Furthermore, girls were more attentive during the gamified activities, as reflected in the reversed scores for lack of attention (Mean = 1.32 for girls, 1.64 for boys), indicating a greater level of focus among female participants in digital gamified settings. Finally, girls reported reflecting on how much they enjoyed the game more frequently than boys (Mean = 4.47 vs. 4.05), which suggests that girls may be more intrinsically motivated when interacting with gamified learning materials. The findings in Figure 4 present the results of the learner's motivational questionnaire.



	I WAS ACTIVELY ENGAGED WITH DIGITAL GAMIFIED ACTIVITIES...	I FOUND MYSELF FOCUSED WHEN INTERACTING WITH DIGITAL GAMIFIE...	I WILL DESCRIBE THIS GAMIFIED LESSON AS VERY INTERESTING	THIS GAME WAS FUN TO DO	I ENJOYED DOING THIS GAME VERY MUCH	THIS GAME DID NOT HOLD MY ATTENTION AT ALL	I THOUGHT THIS GAME WAS QUITE ENJOYABLE	WHILE DOING THIS GAME, I WAS REFLECTING ON HOW...
Mean (Girls)	4.43	4.38	4.84	4.89	4.82	1.32	4.3	4.47
Mean (Boys)	4.45	4.14	4.5	4.68	4.59	1.64	4.09	4.05

Fig. 4: Motivational Questionnaire for the Learners in the Experimental Group.

4. Discussion

There was no significant difference on pre-test between the experimental and control groups. This was supported as there was virtually no difference in the mean scores between experimental (M = 9.68) and control (M = 9.69) groups, and it was not significant ($p > 0.05$). This result validates the initial similarity between the two groups and the strength of random assignment in experimental research [48].

In the investigation as to whether the experimental group's performance would exhibit a statistically significant increase after the use of 'Kahoot!', the hypothesis was rejected and unfounded due to the significant post-test mean score (M = 11.84) compared to the pre-test mean score (M = 9.68), $t = 3.041$, $p = 0.000$. [18] noted that students using gamified environments showed greater understanding of concepts and higher levels of performance than their counterparts in traditional classrooms.

The scores of the control group from different points in time were compared. This hypothesis was not rejected as it was observed only a moderate improvement (from 9.69 to 9.97), even though it was statistically significant ($p = 0.0017$). This small gain could be due to natural cognitive development as students are exposed to test formats and incidental learning, which is congruent with the work of [49] who suggests that learning is reinforced from repeated exposure, regardless of whether instructive.

Testing the difference in post-test scores between researcher-made tests in the control and experimental groups showed significantly higher scores for the experimental group ($p = 0.016$). This higher dimension among students who interacted with 'Kahoot!' corresponds to [50] who stressed that gamification helps create a dynamic and engaging learning environment, while at the same time improving knowledge retention and learner attention. Likewise, studies of [33] indicated that the interactive nature of 'Kahoot!' increases class participation, and supports a better understanding of the topic.

These shared results confirm that gamification by use of the 'Kahoot!' platform can improve learners' academic performance. Its immediate feedback, peer competition, and multimedia contribute to the effectiveness of 'Kahoot!' in engaging students in active learning [19]. In addition, its format, which stresses the importance of not only speed but also precision, acts as an incentive for students to study and learn at a higher level, resulting in better results.

5. Implications of the study

This section explains the practical and theoretical significance of the study findings.

5.1. Practical implementation

This study underscores the practical benefits of integrating digital gamification into educational practices, particularly in teaching and learning science subjects such as Biology. The findings indicate that digital gamification, exemplified using 'Kahoot!' for teaching cell organelles, significantly enhances students' comprehension and retention of learning content. Learners in the experimental group, who engaged with the gamified content, showed marked improvements in their post-test performance and reported higher levels of motivation compared to those taught using conventional methods.

These results suggest that educators should consider incorporating digital gamification tools into their teaching strategies to foster a more engaging and effective learning environment. By doing so, they can potentially improve learning outcomes and stimulate students' interest in the subject matter. Furthermore, the study supports the notion that gamification can be a valuable alternative method for content delivery, complementing traditional instructional approaches.

However, the study also highlights the need for further research to identify the optimal implementation of digital gamification across diverse educational contexts and subjects. Understanding how different variables affect the efficacy of gamification will enable educators to tailor these interventions to maximize their impact on student learning.

The sample size (n=89) reflects the capacity of the rural school's infrastructure, specifically, the availability of only 45 functioning computers. This practical limitation has been acknowledged and noted as a constraint on generalizability. The researcher recommends replication in larger and more diverse contexts.

5.2. Theoretical Implications

The findings of the study add value to the Self-Determination Theory (SDT), which proposes that there are three fundamental psychological needs: autonomy, competence, and relatedness. According to this theory, fulfilling these needs enhances intrinsic motivation, engagement, and overall well-being [51]. For autonomy, the design of the digital gamification intervention allowed learners to have autonomy in their learning process. Also [52] noted the importance of designing instructional teaching materials that are relevant to a particular field of learning. By incorporating elements of choice, control, and personalization, learners felt a sense of right of possession over their gaining experience, enhancing their motivation to engage with the material on learning. On competence, the digital gamification intervention was designed to provide learners with opportunities to develop and demonstrate their understanding of the learning content. Feedback mechanisms within the gamified activities supported learners in assessing their progress and improving their skills, fostering a sense of competence and mastery. Furthermore, relatedness in digital gamification intervention promoted social interactions and collaboration among learners, facilitating a sense of connection and belongingness within the learning community. Features such as multiplayer games, leaderboard competitions, and collaborative challenges encouraged learners to engage with each other, share knowledge, and support one another in their learning journey.

6. Conclusion

This research found that the implementation of 'Kahoot!' as a gamified teaching tool had a significant effect in increasing the academic achievement of students in Biology. While the comparison group had a slight improvement, the intervention group gained significantly more at post-test, supporting the use of gamification methods to improve learning outcomes. These results are in line with the works [28] and [53]that indicate the inclusion of game-based learning systems can generate higher-level engagement, content retention, and academic performance.

This result mirrors a wider consensus in the literature on educational research to incorporate digital gamification tools that foster interaction, immediate feedback, and active learning. Therefore, educators and curriculum developers are encouraged to integrate game-like approaches into their teaching or learning activities to achieve higher student motivation, engagement, and academic success.

References

[1] J. Owuondo, "Disrupting Kenya's Education System: Advancing towards a Learner-Centered Paradigm from Traditional Time-Based Structures," International Journal of Research and Scientific Innovation, vol. X, no. XI, pp. 188–195, 2023, https://doi.org/10.51244/IJRSI.2023.1011016.

[2] S. N. Kerkhoff et al., "Learner-centered teaching in rural Kenya: a case study," Teacher Development, pp. 1–27, Mar. 2025, https://doi.org/10.1080/13664530.2025.2476471.

[3] E. Kučera and O. Haffner, "Competency-Based Hybrid Learning: A Modern Approach to Teaching Programming and Digital Technologies Subjects," IEEE Access, vol. 13, pp. 54892–54919, 2025, https://doi.org/10.1109/ACCESS.2025.3555333.

[4] S. Nsyengula, J. E. Haule, W. Mhagama, and J. Wang'uba Okello, "Enhancing Competency-Based Learning Through Flipped Classroom Approach," Journal of Classroom Action Research, vol. 3, no. 2, pp. 36–48, Aug. 2024, https://doi.org/10.52622/jcar.v3i2.248.

[5] M. J. P. Dantic and A. Fluraon, "PhET interactive simulation approach in teaching electricity and magnetism among science teacher education students," Journal of Science and Education (JSE)، vol. 2, no. 2, pp. 88–98, Mar. 2022, https://doi.org/10.56003/jse.v2i2.101.

[6] P. Kaneza, J. B. Nkurunziza, I. Twagilimana, T. Mapulanga, and A. Bwalya, "Analysis of conceptual understanding of solutions and titration among Rwandan secondary school students," Cogent Education, vol. 11, no. 1, Dec. 2024, https://doi.org/10.1080/2331186X.2024.2315834.

[7] H. Ateş, "Integrating augmented reality into intelligent tutoring systems to enhance science education outcomes," Educ Inf Technol (Dordr), vol. 30, no. 4, pp. 4435–4470, Mar. 2025, https://doi.org/10.1007/s10639-024-12970-y.

[8] G. M. Cooper and K. W. Adams, "Physical Principles Underlying Cell Structure and Function," in The Cell, Oxford University Press, 2022. https://doi.org/10.1093/hesc/9780197583746.003.0003.

[9] M. Kalogiannakis, S. Papadakis, and A.-I. Zourmpakis, "Gamification in Science Education. A Systematic Review of the Literature," Educ Sci (Basel), vol. 11, no. 1, p. 22, Jan. 2021, https://doi.org/10.3390/educsci11010022.

[10] C. Rapanta, L. Botturi, P. Goodyear, L. Guàrdia, and M. Koole, "Online University Teaching During and After the Covid-19 Crisis: Refocusing Teacher Presence and Learning Activity," Postdigital Science and Education, vol. 2, no. 3, pp. 923–945, Oct. 2020, https://doi.org/10.1007/s42438-020-00155-y.

[11] D. Henriksen et al., "Creativity and Technology in Education: An International Perspective," Technology, Knowledge and Learning, vol. 23, no. 3, pp. 409–424, Oct. 2018, https://doi.org/10.1007/s10758-018-9380-1.

[12] I. Shubina and A. Kulakli, "Pervasive Learning and Technology Usage for Creativity Development in Education," International Journal of Emerging Technologies in Learning (iJET), vol. 14, no. 01, p. 95, Jan. 2019, https://doi.org/10.3991/ijet.v14i01.9067.

[13] R. Christensen et al., "Supporting Learning Leaders for the Effective Integration of Technology into Schools," Technology, Knowledge and Learning, vol. 23, no. 3, pp. 457–472, Oct. 2018, https://doi.org/10.1007/s10758-018-9385-9.

[14] Y. Sikora, V. Chernykh, Y. Shaforost, S. Danylyuk, and I. Chemerys, "Leveraging gamification and game-based technologies for educational purposes," Multidisciplinary Reviews, vol. 7, p. 2024spe008, Jun. 2024, https://doi.org/10.31893/multirev.2024spe008.

[15] H. Fakieh Mansy Ali, M. Abd-El-Gawad Mousa, and E. Elsayed Rushdan, "Effect of Using Kahoot! As A Digital Game-Based Formative Assessment Tool in Enhancing Nursing Students' Knowledge and Learning Motivation," Egyptian Journal of Health Care, vol. 13, no. 4, pp. 1907–1921, Dec. 2022, https://doi.org/10.21608/ejhc.2022.338035.

[16] M. Pascu, "The contribution of students' learning styles to competences development through the use of Kahoot learning platform," Cogent Education, vol. 11, no. 1, May 2024, https://doi.org/10.1080/2331186X.2024.2352320.

[17] C. Ou, Designing Socially Dynamic Digital Learning. New York: Routledge, 2024. https://doi.org/10.4324/9781003368076.

[18] R. Smiderle, S. J. Rigo, L. B. Marques, and et al., "The impact of gamification on students' learning, engagement and behavior based on their personality traits," Smart Learn. Environ., 2020. https://doi.org/10.1186/s40561-019-0098-x.

[19] A. I. Wang and R. Tahir, "The effect of using Kahoot! for learning – A literature review," Comput Educ, vol. 149, p. 103818, May 2020, https://doi.org/10.1016/j.compedu.2020.103818.

[20] K. Palaniappan and N. Md Noor, "Gamification Strategy to Support Self-Directed Learning in an Online Learning Environment," International Journal of Emerging Technologies in Learning (iJET), vol. 17, no. 03, pp. 104–116, Feb. 2022, https://doi.org/10.3991/ijet.v17i03.27489.

[21] E. Ratinho and C. Martins, "The role of gamified learning strategies in student's motivation in high school and higher education: A systematic review," Heliyon, vol. 9, no. 8, p. e19033, Aug. 2023, https://doi.org/10.1016/j.heliyon.2023.e19033.

[22] J. Slamet, Y. Basthomi, F. M. Ivone, and E. Eliyanah, "Unlocking the Potential in a Gamification-Based MOOC: Assessing Autonomous Learning and Self-Directed Learning Behaviors," Teaching and Learning Inquiry, vol. 12, Jul. 2024, https://doi.org/10.20343/teachlearninqu.12.19.

[23] Alexandru Capatina, David Juarez-Varon, Adrian Micu, and Angela Eliza Micu, "Leveling up in corporate training: Unveiling the power of gamification to enhance knowledge retention, knowledge sharing, and job performance," Journal of Innovation & Knowledge, vol. 9, no. 3, 2024. https://doi.org/10.1016/j.jik.2024.100530.
[24] M. Sailer and L. Homner, "The Gamification of Learning: a Meta-analysis," Educ Psychol Rev, vol. 32, no. 1, pp. 77–112, Mar. 2020, https://doi.org/10.1007/s10648-019-09498-w.
[25] C. Dichev, D. Dicheva, and K. Irwin, "Gamifying learning for learners," International Journal of Educational Technology in Higher Education, vol. 17, no. 1, p. 54, Dec. 2020, https://doi.org/10.1186/s41239-020-00231-0.
[26] M. Videnovik, T. Vold, L. Kiønig, A. Madevska Bogdanova, and V. Trajkovik, "Game-based learning in computer science education: a scoping literature review," Int J STEM Educ, vol. 10, no. 1, p. 54, Sep. 2023, https://doi.org/10.1186/s40594-023-00447-2.
[27] M. Z. Mat Husin and R. A. Azmuddin, "Learner Engagement in Using Kahoot! within a University English Proficiency Course," Educational Process International Journal, vol. 11, no. 2, 2022, https://doi.org/10.22521/edupij.2022.112.9.
[28] I. Cortés-Pérez, N. Zagalaz-Anula, M. del C. López-Ruiz, Á. Díaz-Fernández, E. Obrero-Gaitán, and M. C. Osuna-Pérez, "Study Based on Gamification of Tests through Kahoot!TM and Reward Game Cards as an Innovative Tool in Physiotherapy Students: A Preliminary Study," Healthcare, vol. 11, no. 4, p. 578, Feb. 2023, https://doi.org/10.3390/healthcare11040578.
[29] M. Kersting, J. Haglund, and R. Steier, "A Growing Body of Knowledge," Sci Educ (Dordr), vol. 30, no. 5, pp. 1183–1210, Oct. 2021, https://doi.org/10.1007/s11191-021-00232-z.
[30] C. Anane, "Impact of a game-based tool on student engagement in a foreign language course: a three-term analysis," Front Educ (Lausanne), vol. 9, Sep. 2024, https://doi.org/10.3389/feduc.2024.1430729.
[31] N. Kalleny, "Advantages of Kahoot! Game.based Formative Assessments along with Methods of Its Use and Application during the COVID-19 Pandemic in Various Live Learning Sessions," J Microsc Ultrastruct, vol. 8, no. 4, p. 175, 2020, https://doi.org/10.4103/JMAU.JMAU_61_20.
[32] S. Mhlongo, K. Mbatha, B. Ramatsetse, and R. Dlamini, "Challenges, opportunities, and prospects of adopting and using smart digital technologies in learning environments: An iterative review," Heliyon, vol. 9, no. 6, p. e16348, Jun. 2023, https://doi.org/10.1016/j.heliyon.2023.e16348.
[33] S. A. Licorish, H. E. Owen, B. Daniel, and J. L. George, "Students' perception of Kahoot!'s influence on teaching and learning," Res Pract Technol Enhanc Learn, vol. 13, no. 1, p. 9, Dec. 2018, https://doi.org/10.1186/s41039-018-0078-8.
[34] M. S. Darmawan, F. Daeni, and P. Listiaji, "The Use of Quizizz as an Online Assessment Application for Science Learning in The Pandemic Era," Unnes Science Education Journal, vol. 9, no. 3, pp. 144–150, Nov. 2020, https://doi.org/10.15294/usej.v9i3.41541.
[35] E. N. Rizki, H. Haryanto, and W. Kurniawati, "The Use of Quizizz Applications and Its Impact on Higher Order Thinking Skills of Elementary School Teacher Education Students in Elementary Science Learning," International Journal of Elementary Education, vol. 6, no. 2, pp. 282–289, Jun. 2022, https://doi.org/10.23887/ijee.v6i2.47686.
[36] N. MY, S. Hajar, and N. F. Arsyad, "Utilizing Quizizz for Game-Based Learning in Elementary Science Education," Journal of Education and Computer Applications, vol. 1, no. 1, pp. 12–19, Apr. 2024, https://doi.org/10.69693/jeca.v1i1.2.
[37] A. T. Capinding, "Utilization of 'Quizizz' a Game-based Assessment: An Instructional Strategy in Secondary Education Science 10," European Journal of Educational Research, vol. volume-11-2022, no. volume-11-issue-4-october-2022, pp. 1959–1967, Oct. 2022, https://doi.org/10.12973/eu-jer.11.4.1959.
[38] G. Avşar, C. Ozan, and E. Aydin, "The effect of reinforcement using the Gimkit game on learning the subject in nursing students," Nurse Educ Pract, vol. 68, p. 103595, Mar. 2023, https://doi.org/10.1016/j.nepr.2023.103595.
[39] S. Afandi, A. Laila, and B. A. Mukmin, "GICAME (Digital Educational Games): Interactive Multimedia Based on Gimkit with STEAM Approach to Improve the Problem Solving Ability of Writing Explanatory Texts for Grade V Students of SDN Pakel Subdistrict," 2025, pp. 279–293. https://doi.org/10.2991/978-2-38476-390-0_23.
[40] E. Andriana, Y. Ruhiyat, and L. Nulhakim, "THE INFLUENCE OF GIMKIT INNOVATIVE LEARNING MEDIA ON STUDENT LEARNING OUTCOME," Jurnal Profesi Keguruan, vol. 10, no. 1, Dec. 2024, https://doi.org/10.15294/jpk.v10i1.7633.
[41] H. Khattib and D. Alt, "A quasi-experimental study on the advantages of digital gamification using CoSpaces Edu application in science education," Educ Inf Technol (Dordr), vol. 29, no. 15, pp. 19963–19986, Oct. 2024, https://doi.org/10.1007/s10639-024-12635-w.
[42] O. Özdemir, "Kahoot! Game-based digital learning platform: A comprehensive meta-analysis," J Comput Assist Learn, vol. 41, no. 1, Feb. 2025, https://doi.org/10.1111/jcal.13084.
[43] T. A. Lashari, R. Fiayaz, S. A. Lashari, I. Khan, S. Sultana, and T. Afzal, "Kahoot: A game-based web tool to assess motivation, engagement fun, and learning outcomes among engineers," Computer Applications in Engineering Education, vol. 32, no. 2, Mar. 2024, https://doi.org/10.1002/cae.22684.
[44] R. Tandiono, "Gamifying online learning: An evaluation of Kahoot's effectiveness in promoting student engagement," Educ Inf Technol (Dordr), vol. 29, no. 18, pp. 24005–24022, Dec. 2024, https://doi.org/10.1007/s10639-024-12800-1.
[45] C. J. Miller, S. N. Smith, and M. Pugatch, "Experimental and quasi-experimental designs in implementation research," Psychiatry Res, vol. 283, p. 112452, Jan. 2020, https://doi.org/10.1016/j.psychres.2019.06.027.
[46] S.-J. Na, Y. G. Ji, and D. H. Lee, "Application of Bloom's taxonomy to formative assessment in real-time online classes in Korea," Korean J Med Educ, vol. 33, no. 3, pp. 191–201, Sep. 2021, https://doi.org/10.3946/kjme.2021.199.
[47] M. Janelli and A. A. Lipnevich, "Effects of pre-tests and feedback on performance outcomes and persistence in Massive Open Online Courses," Comput Educ, vol. 161, p. 104076, Feb. 2021, https://doi.org/10.1016/j.compedu.2020.104076.
[48] "Two-Group Random Assignment Pretest–Posttest Design," in The SAGE Encyclopedia of Communication Research Methods, 2455 Teller Road, Thousand Oaks California 91320 : SAGE Publications, Inc, 2017. https://doi.org/10.4135/9781483381411.n642.
[49] K. Zulkosky, D. Minchhoff, L. Dommel, A. Price, and B. M. Handzlik, "Effect of Repeating Simulation Scenarios on Student Knowledge, Performance, Satisfaction and Self-Confidence," Clin Simul Nurs, vol. 55, pp. 27–36, Jun. 2021, https://doi.org/10.1016/j.ecns.2021.03.004.
[50] A. Aibar-Almazán, Y. Castellote-Caballero, M. del C. Carcelén-Fraile, Y. Rivas-Campo, and A. M. González-Martín, "Gamification in the classroom: Kahoot! As a tool for university teaching innovation," Front Psychol, vol. 15, Mar. 2024, https://doi.org/10.3389/fpsyg.2024.1370084.
[51] R. L. White et al., "Self-determination theory in physical education: A systematic review of qualitative studies," Teach Teach Educ, vol. 99, p. 103247, Mar. 2021, https://doi.org/10.1016/j.tate.2020.103247.
[52] T. Z. Oo, T. Kadyirov, L. Kadyjrova, and K. Józsa, "Design-based learning in higher education: Its effects on students' motivation, creativity and design skills," Think Skills Creat, vol. 53, p. 101621, Sep. 2024, https://doi.org/10.1016/j.tsc.2024.101621.
[53] L. Jaramillo-Mediavilla, A. Basantes-Andrade, M. Cabezas-González, and S. Casillas-Martín, "Impact of Gamification on Motivation and Academic Performance: A Systematic Review," Educ Sci (Basel), vol. 14, no. 6, p. 639, Jun. 2024, https://doi.org/10.3390/educsci14060639.