




## Role of gamification in chemistry learning classrooms: Enhancing student motivation through interactive learning approach

 Chengcheng Zhao<sup>1+</sup>

<sup>1</sup>Chengdu International Studies University, China.

<sup>1</sup>Email: [P145806@siswa.ukm.edu.my](mailto:P145806@siswa.ukm.edu.my)

 Khairul Azhar  
Jamaludin<sup>2</sup>

<sup>2</sup>Universiti Kebangsaan Malaysia, Lingkungan Ilmu, 43600 Bangi,  
Selangor, Malaysia.

<sup>2</sup>Email: [khairuljamaludin@ukm.edu.my](mailto:khairuljamaludin@ukm.edu.my)



(+ Corresponding author)

### ABSTRACT

#### Article History

Received: 13 August 2025

Revised: 2 February 2026

Accepted: 27 February 2026

Published: 7 April 2026

#### Keywords

Chemistry curriculum

Game-based learning

Gamification

Interactive learning

Motivation.

Gamification is a dynamic teaching method that incorporates gaming features into classroom settings to enhance motivation and engagement. The significance of the gamification approach, exemplified by tools such as ChemCaper, Quizlet, Kahoot, Socrative, and Gimkit, is examined in this research, with particular focus on its impact on students' motivation levels and learning outcomes. Using a semi-structured qualitative research methodology, 54 students from higher secondary schools participated in the study. Both traditional and gamified teaching methods were alternated weekly over a period of three months. Following this period, a questionnaire survey was conducted to assess the role of gamification in chemistry education. The results indicated that integrating gamified learning into conventional teaching significantly increased students' motivation to attend classes, fostered participation in group studies within a healthy competitive classroom environment, and enhanced self-confidence levels. The findings also demonstrated that gamified learning improved students' self-dependency, boosted critical thinking and problem-solving abilities, mental strength, engagement levels with their teachers, as well as overall academic performance in terms of scoring. The findings also reported that students preferred gamified tools for giving classroom examinations and preferred the gamified learning process for their studying. Among the gamified tools, ChemCaper is the most preferred tool by the students. Collectively, the results indicated that in chemistry learning, gamification greatly boosts learning outcomes. In conclusion, this outcome showed how gamification, as a learner-centered approach, could redefine chemistry education and provide insightful guidance for teachers striving to render science more intriguing and understandable.

**Contribution/Originality:** The article displays preliminary research and innovative work in measuring how gamification inspires students in chemistry classrooms by undertaking interactive learning techniques. The article depicts that the incorporation of gamification tools substantially boosts students' motivation levels, self-dependency, critical thinking, problem-solving abilities, and mental strength. ChemCaper is the most preferred gamified tool among students.

## 1. INTRODUCTION

Rapid technological development is constantly creating novel and creative strategies for meeting the expanding demands of students in the education process (Ryan & Deci, 2024). However, classic educational approaches have remained in practice today and have consistently become inadequate (Baeten, Struyven, & Dochy, 2013; Hellín et al., 2023). Since science education fosters critical 21<sup>st</sup> century abilities like flexibility and troubleshooting, and produces

students/individuals in science, it has been acknowledged as one of the most essential facets of modern schooling (Boudadi & Gutiérrez-Colón, 2020; Kumar, 2023). As there, therefore, exists a lot of curiosity in learning theories that are being utilized in tools and/or methods that support scientific thinking (Landers, Bauer, Callan, & Armstrong, 2015; Morris, Croker, Zimmerman, Gill, & Romig, 2013).

Chemistry learning, like other natural and physical sciences, serves an integral part in day-to-day life by providing students with opportunities to comprehend their surroundings (Baydas & Cicek, 2019; Bhattacharjee, 2015). Nonetheless, there are a number of issues related to educating and comprehending chemistry at all stages of education. For example, prior research has examined students' insufficient interaction between teachers and students, restricted spatial imagery, challenges in comprehending chemistry language, and inadequate problem-solving abilities (Childs & Sheehan, 2009; Erman, 2017; Kumar, 2023). This has led students from various fields to continually encourage scientific educational settings that would suitably address these challenges (Dorimana, Uworwabayeho, & Nizeyimana, 2021; North et al., 2021; Sholahudin & Yenti, 2022; Sibomana, Karegeya, & Sentongo, 2021).

Educators, individuals, and students from multiple disciplines, including science teaching, have recently been giving particular importance to game-based learning (GBL) as a recent trend in pedagogy (Dicheva, Dichev, Agre, & Angelova, 2015; Papadakis, Trampas, Barianos, Kalogiannakis, & Vidakis, 2020). The implementation of game designing principles, gaming-play mechanical work aesthetics, and conceptualizing games for non-gaming instances to inspire students are considered as GBL by Kapp (2012) and Kumar (2023). GBL's core concept is the idea that game components' motivating potential could be translated to an instructional context. Since gamification utilizes techniques that learners are already acquainted with and also draws curiosity, several scholars have identified its implementation in science teaching to be intriguing (Loganathan, Talib, Thoe, Aliyu, & Zawadski, 2019; Suh, Wagner, & Liu, 2018; Vidakis et al., 2020). GBL may additionally foster critical thinking that aligns with recognized scientific concepts, practices, and teaching methods in the field of education (Cahyana, Paristiowati, Savitri, & Hasyrin, 2017; Kalogiannakis, Papadakis, & Zourmpakis, 2021; Li & Chu, 2021). Although GBL is generally considered to be beneficial in boosting student participation, its implications on learning goals have frequently been contested, with participant-specific research results yielding conflicting inferences, casting doubt on its benefits (Hamari, Koivisto, & Sarsa, 2014; Kara, 2021). Therefore, their rising popularity and the inconsistent outcomes have further intensified their importance for investigating particular teaching methods for assessing the consequences (Chon, Sharif, & Saleh, 2024; Kumar, 2023).

The past several years have witnessed an immense quantity of research on the current state of the art in web-based gaming utilization in classroom teaching (Göksün & Gürsoy, 2019; Groening & Binnewies, 2019; Huang & Hew, 2018; Ismail et al., 2019; Kyewski & Krämer, 2018; Lopez & Tucker, 2019; Zhang & Fang, 2019). These gamified strategies can be utilized and applied in an array of ways, including role playing, leaderboards, point systems, and reward systems to enhance motivation and engagement among classroom students (Zeybek & Saygı, 2024). These resources have also been shown to be advantageous in settings pertaining to healthcare and schooling (van Gaalen et al., 2021; Zahedi et al., 2021). The usefulness of such technologies in fostering enthusiasm and involvement in significant application scenarios, such as computer programming or other technical disciplines, along with their capability to facilitate learning, are the main topics of this linked work (Hellín et al., 2023). One outstanding instance is research by Jusas, Barisas, and Jančiukas (2022) that looked at how web-based gaming affected students taking an instructional class on object-oriented computer programming. Gamification substantially boosted students' happiness with the course and improved motivation and participation, according to the study. According to a separate study by Marín, Frez, Cruz-Lemus, and Genero (2018), students who learned C programming on a gamified interface excelled compared to those who utilized a non-gamified processor in terms of grades. Fotaris, Mastoras, Leinfellner, and Rosunally (2016) reported that implementing a gaming-based method to impart programming led to more course material downloads, increased enrollment, and higher overall scores. Gamified educational programs are beneficial

for learning among students, according to Buckley and Doyle (2016), and their implications on student engagement vary based on whether the learner is inspired by extrinsic or intrinsic factors.

The majority of research studies on game-based education have focused primarily on either science or engineering disciplines (Cahyana et al., 2017; Ndiokubwayo, Uwamahoro, & Ndayambaje, 2020). Moreover, only a few have limited it to particular chemistry subject areas. Stated differently, there aren't many studies in chemistry classroom education through adopting game-based strategies that have tried to explore the various educational games utilized in chemistry classrooms and how they've improved students' motivation for acquiring knowledge or comprehension of chemistry ideas. Accordingly, this study explores how gamification influences academic performance in chemistry major students in terms of motivation, engagement, and learning behaviors. Considering this, the present study aims 1) to identify the types of gamification tools utilized by chemistry students in classroom learning, 2) to identify the ways by which the recognized game-based strategies support students' motivation and comprehension of chemistry ideas in secondary school, and finally 3) to find out the relationship among them and their role in pedagogy.

### *1.1. Existing Gamification Tools in Chemistry Education Classrooms*

Quizlet is a recognized online educational platform that utilizes exercises, tests, and electronic flashcards to help learners in their studies (Sailin et al., 2019). Users can either create customized research sets or browse millions of sets made by experts on a variety of issues. Quizlet enables efficient memorization and independent learning by utilizing features such as spaced repetition, practice exams, and interactive tasks. Instructors, pupils, and lifelong learners worldwide use it regularly (Kustiawan, 2024).

A platform called Kahoot! utilizes games to make education entertaining and vibrant. Known as "kahoots," and also called 'Quizizz,' it permits teachers, students, and entities to develop and engage in real-time quizzes, interviews, and debates (Guardia, Del Olmo, Roa, & Berlanga, 2019). Classrooms, job sites, and online educational settings utilize Kahoot! to strengthen understanding and promote involvement. Its vibrant images, music, and competitive style draw students of all ages (Ismail et al., 2019).

ChemDraw is a software program that chemists and learners utilize to create schematics, molecule structures, and equations. It facilitates users in developing chemistry equations, IUPAC designations, and molecular framework drawings and visualizations (Zhang, Muktar, Wijaya Ong, Lam, & Fung, 2021). ChemDraw is extensively utilized to accurately and concisely portray complicated chemical knowledge in investigations, classes, and publishing (Zhang et al., 2021).

Gimkit is a framework for dynamic, game-based education that utilizes gamified features and tests to make the classroom atmosphere more engaging and entertaining (Sharmin & Chow, 2024). In order to promote active learning through contests and cooperation, Gimkit, founded by Seattle high school student Josh Feinsilber, empowers students and educators to build and participate in live quiz games (Vasanthi, Bakyalakshmi, & Kalaivani, 2023).

CheMakers is a chemical and experimentation-focused interactive game for learning (Zhang et al., 2021). The attendees, who are frequently students, assume the responsibilities of "makers" in order to learn about chemical interactions, synthesize substances, and utilize scientific concepts in real-world tasks. The objective is to utilize educational and enjoyable exercises for fostering imaginative thinking, analytical thinking, and greater insight into chemistry (Zhang et al., 2021).

Alkhimia is an interactive game or theme that draws inspiration from the centuries-old practice of alchemy (Chee & Tan, 2012). Users solve problems, integrate elements, and evaluate mysterious ideas to modify or discover new insights. Alkhimia, which combines science, magic, and storytelling, focuses on symbolic reasoning and experimentation, challenging players to think both analytically and intuitively (Chee & Tan, 2012).

A board game is a tabletop sport in which participants maneuver tokens or components over a predetermined surface (the board) in accordance with an array of guidelines. Board gaming activities might be supportive or

attractive, and they often integrate tactics, randomness, and interactivity (Antunes, Pacheco, & Giovanela, 2012). Through planned game playing, they are intended to challenge, amuse, and occasionally instruct users.

ChemEscape is an instructional game that incorporates puzzle-solving with chemistry fundamentals (Clapson et al., 2020). Through employing their understanding of chemical processes, components, and laboratory procedures, gamers undertake an array of chemistry-based assignments and escape room-style riddles. In an intriguing and captivating setting, the game fosters knowledge through real-life problem-solving (Clapson, Gilbert, & Musgrove, 2020; Eilks, Prins, & Lazarowitz, 2013).

A 3D role-playing game (3D RPG) is a type of video gaming system that integrates character-centered narrative and advancement mechanisms within a three-dimensional environment. Users control a character or group, traverse complex 3D settings, fight, complete quests, and gain experience over time through decisions and knowledge (Chen, Wong, & Wang, 2014).

The Card Game and Bioplastic Synthesis Activity is an appealing teaching tool that integrates accurate scientific endeavors alongside enjoyable learning experiences (Clapson et al., 2020). The game involves acquiring and pairing cards that depict chemical parts and synthesizing strategies, educating participants about polymeric materials, substances, and durability. Next, there is a bioplastic synthesizing activity where participants utilize their acquired knowledge to produce real bioplastics using appropriate laboratory equipment (Clapson et al., 2020).

The ABSQR coding games serve as an adventure game that combines mobile games with Augmented Barcode Structured QR (ABSQR) coding (Harman & Yenikalaycı, 2020). Every ABSQR code includes embedded content that, when inspected, brings up particular gaming difficulties, obligations, or insights. In order to facilitate exploring and studying, the main gameplay mechanics involve examining, interpreting, and engaging with the content associated with every algorithm (Harman & Yenikalaycı, 2020).

Molebots is an interactive game that educates participants about molecules and chemical processes by merging robotics and chemistry (Gupta, 2019). In order to generate atoms, carry out responses, and resolve chemistry-based riddles, participants utilize "Molebots," which are robot-like figures interacting with different compounds and elements. In an enjoyable, participatory setting, the game fosters understanding through practical exploration of chemical structures (Gupta, 2019).

Activity cards are interactive resources that are utilized in training sessions, schooling, and gaming to help gamers or players traverse specific duties, problems, or learning goals (Duvarcı, 2010). Usually, every card has targets, specifications, and a summary of the assignment for fostering participation, creative thinking, or skill improvement (Höft & Bernholt, 2019).

Two appreciated interactive gaming formats are game cards and computer gaming (Rastegarpour & Marashi, 2012). Computerized or tangible stacks of cards are utilized in card gaming, which are frequently dependent on fortune, recollection, and strategy. Computer-based gaming are online adventures that are executed on electronic gadgets. They can be everything from straightforward puzzles to intricate simulations, and they frequently incorporate sounds, visuals, and real-time conversations (Rastegarpour & Marashi, 2012).

An educational game called Chemory Game was set up to assist players in remembering and retaining chemistry-related topics such as molecular makeup, chemical processes, and the periodic table (Daubenfeld & Zenker, 2015). The game enhances retention and understanding of chemistry concepts by having participants match cards or pictures that depict chemical substances, molecules, or processes (Daubenfeld & Zenker, 2015).

Also referred to as musical chairs, Chairs! is a quick-paced, entertaining game that is usually played in a social or party setting (Winter, Wentzel, & Ahluwalia, 2016). Participants compete to sit in unoccupied chairs whenever the music ends. It highlights attentiveness, rapid responses, and an element of luck. Chairs are pulled out as the contest progresses, thus making it more competitive until only one person remains (Winter et al., 2016).

A chemical nomenclature application is a piece of computer software or device that enables individuals to acquire, understand, and utilize the laws of chemical naming (Sousa Lima et al., 2019). Students, instructors, and experts can

utilize it to precisely identify substances and understand their composition by transforming chemistry formulas into IUPAC names and vice versa (Sousa Lima et al., 2019).

An escape room is a real or electronic puzzle exercise in which participants are "locked" in a customized room and have to work through an array of assignments and riddles within a particular period of time in order to get out (Dietrich, 2018). Participants coordinate to unravel indications, locate hidden belongings, and accomplish tricky puzzles in order to reveal the way out, which fosters creative thinking, problem-solving, and cooperation (Dietrich, 2018).

Element cycles, such as the water, nitrogen, and carbon cycles, are natural mechanisms that enable the flow of chemical substances through Earth's systems (Pippins, Anderson, Poindexter, Sultemeier, & Schultz, 2011). A crucial aspect of conserving ecological equilibrium and sustaining life on Earth, these processes explain the movement of ingredients between living things, the atmosphere, oceans, and soils (Pippins et al., 2011).

A game-based approach is a classroom or training strategy that utilizes game mechanics and parts to inspire students, engage them, and boost the learning process (Wilson & Samide, 2014). This technique renders studying more exciting and pleasurable by integrating competition, incentives, obstacles, and engagement, leading to greater dedication and advancement in skills (Wilson & Samide, 2014).

Ion Hunters is a classroom game in which participants seek for and recognize ions in a system or environment (Yenikalaycı, Çelikler, & Aksan, 2019). Various ion kinds, their characteristics, and their interactions in chemical processes are all imparted to the participants. Users are frequently asked to utilize their knowledge of chemistry to figure out ionic substance riddles, equilibrium formulas, and precisely recognize ions in the game's tasks (Yenikalaycı et al., 2019).

Pantomime MisCoAct is a unique and interactive game that blends collective problem-solving with pantomime, or performing without speaking (Belova & Zowada, 2020). Participants express thoughts, instances, or attitudes to others utilizing body language, gestures, and imagery. The game is an intriguing and captivating method for increasing cooperation and imagination since it encourages inventiveness, informal communication, and collaboration (Belova & Zowada, 2020).

Misha and Kosha Game-Based Learnings is a learning tool that imparts a variety of topics to youngsters through interactive gaming with two characters, Misha and Kosha (Partovi & Razavi, 2019). Learners may communicate with the material in an enjoyable and stimulating way, considering the game's utilization of storytelling, troubleshooting, and investigation. Games teach users language, science, arithmetic, and analytical thinking through the adventures of the characters (Partovi & Razavi, 2019).

By simulating numerous organic processes, the educational game ORG600 (Organic Processes Game) strives to educate participants about biological chemistry (Da Silva Júnior et al., 2021). Participants take part in tasks that require them to identify reacting agents, forecast products, and negotiate various reaction categories, such as addition, substitution, elimination, and rearrangement. Through a collaborative, simulation-based approach, the game promotes students in exercising and strengthening their understanding of organic chemistry fundamentals (Da Silva Júnior et al., 2021).

Playing the learning game Picture Chem assists participants in comprehending chemistry subjects utilizing visual aids (Kavak & Yamak, 2016). Participants link pictures of chemical reactions, frameworks, and lab apparatus to the identities, equations, or procedures of the respective substances. The game integrates ideas and phrases with graphics, which fosters visual comprehension and enables learners to grasp complex chemistry concepts (Kavak & Yamak, 2016).

Work-Integrated Learning (WIL) is a teaching strategy that integrates schooling with everyday life employment experiences (Ponikwer & Patel, 2021). It conveys students' opportunity to put their academic knowledge to use in real-world scenarios through co-ops, apprenticeships, and internships. WIL addresses the knowledge disparity

between academia and business while boosting employment potential, developing skills, and enhancing understanding of working life (Ponikwer & Patel, 2021).

## 2. REVIEW OF LITERATURE

Since the introduction in last decade, gamification approach was utilized to a wide range of disciplines, including education (Kalogiannakis et al., 2021). Kapp defines gamification as "the use of game design elements, gameplay mechanics, aesthetics, and game thinking for non-game applications to motivate students" (Kapp, 2012). A wide array of strategies, including leaderboards, incentives, and game elements, have been adopted to effectively employ gamification. In particular, the majority of these applications share certain identical features, despite the dearth of a standardized name for gaming (Hellín et al., 2023). Gaming is now focused on utilizing online venues or apps to involve students, employing digital devices such as desktops, notebooks, or cellphones (Klock, Ogawa, Gasparini, & Pimenta, 2018). These resources have been advantageous in diverse fields, including education and health students (van Gaalen et al., 2021).

In a comprehensive review of the literature, Khaldi, Bouzidi, and Nader (2023) addressed gamification in higher education e-learning. The majority of utilized game features for gamifying e-learning systems, they discovered, were leaderboards, badges, and points (PBL elements). For example, Jusas et al. (2022) investigated the implications of internet-based gaming on learners enrolled in programming courses. They pointed out that gamification significantly boosted student satisfaction following the course and improved enthusiasm and participation. Yet, an additional investigation by Marín et al. (2018) reported that students who taught C programming on a gaming interface outperformed students who utilized a non-gamified compiler. According to Fotaris et al. (2016), deploying a game-based strategy for teaching programming boosted students' attendance, course material downloads, and final scores. The outcomes of Buckley and Doyle (2016) indicate that game-based educational strategies enhance student comprehension and that gamification has various implications for student engagement.

Apart from that, certain research has centered on developing and evaluating gaming resources for massive open online courses (MOOCs), which present distinct advantages and challenges for engaging and motivating students. For example, De Freitas and Mira da Silva (2023) investigated the effects of gamification in MOOCs and reported that gamified MOOCs enhance engagement as well as retention. In another study, an online tool called GamiTool was developed by Ortega-Arranz et al. (2022) and utilized to assist educators in gamifying MOOCs. Evaluations conducted by MOOC experts and gaming designers highlighted an excellent degree of design versatility, accessibility, and acceptance of GamiTool.

This approach could be employed by academics to understand the implications of gamification in MOOC environments and by instructors to improve student engagement. The gamification approach is also widely used in the health sector. For instance, Wang et al. (2023) explored the effectiveness of gaming team competition as a mobile health (mHealth) approach on medical trainees through a cluster micro-randomized trial, which indicated that collective competition substantially enhanced regular physical activity, implying its potential as a mobile health intervention tool. To date, studies on utilizing gamification tools for studying chemistry are primarily review-based, with limited survey-based quantitative studies (Byusa, Kampire, & Mwesigye, 2022; Kumar, Lim, Sivarajah, & Kaur, 2023).

### 2.1. Study Gaps of the Present Investigation

The majority of research so far discussed above is centered on gamification's utilization in computer-aided educational systems, in general sciences, and mathematics, despite a rising number of works underlining its capability as an innovative teaching tool in education.

The scientific literature on studying chemistry is still dispersed and generally consists of customized exploratory analyses that only concentrate on apparent student participation. Besides, a significant amount of work currently

examines gaming from an engineering standpoint but fails to effectively confront the pedagogical principles that underlie the techniques in which gamified approaches in chemistry classrooms endorse inspiration, conceptual grasp, and long-term study outcomes.

### *2.2. Research Question*

How does gamification in chemistry curriculums influence academic performance by modulating student motivation and learning behaviors?

## **3. METHODOLOGY**

### *3.1. Theoretical Framework*

Semi-structured qualitative research approach has been chosen for this investigation to obtain their viewpoints, circumstances, and a better understanding of how gaming contributed to their education. Semi-structured qualitative interviews are conducted with 54 Chemistry major students to assess the effectiveness of gamification on learning behaviors. The Cognitive Load Theory is used in this study to evaluate the management of cognitive demands in educational game designs (Sweller, 2020).

Thereafter, the Self-Determination Theory is applied to assess intrinsic and extrinsic motivation in learning (Ryan & Deci, 2024). This methodology aligns with earlier research on gamification that utilized an array of strategies (Baydas & Cicek, 2019; Chang & Wei, 2016; Ding, Er, & Orey, 2018; Lo & Hew, 2020).

### *3.2. Participants*

Participants in this study were randomly selected. A total of 54 chemistry major students (aged between 16 and 18) from a higher secondary school in China participated in this study and submitted survey responses about their perceptions of academic involvement. The study spanned 3 months, and classroom learning included both gamified education and conventional education. At the end of the pedagogical intervention strategies, all students were asked to complete a survey, which focused on their viewpoints regarding involvement in gamified learning and academic endeavors.

ChemCaper, Quizlet, Kahoot, Socrative, and Gimkit are five different gamification activities utilized for gamified learning in the classroom. All students are familiar with these activities, including how to use them and what to do during gamified learning sessions, as well as traditional activities, to understand the pedagogical intervention strategies before participating in the intervention. Once a week, for a total of sixty minutes, an identical teacher instructed all students on the same topics.

In the first week, students engaged in traditional in-class tasks related to traditional learning, starting with traditional lessons during the initial phase and continuing through Q&A sessions. The following week, all students participated in gamified learning on the same topic, which either extended the previous unfinished lecture or covered identical material.

The lesson began with a brief speech introducing the gamified education practice, then proceeded to inquiry-driven learning exercises and discussions. These five gamified systems were preferred due to their intuitive and versatile e-quiz layouts.

After each session, whether traditional or gamified, assessments related to the topics covered in class were conducted using various methods, including paper-based tests and online gamified e-quizzes. Upon course completion, a questionnaire was distributed to collect data, as illustrated in Table 1.

**Table 1.** The questionnaire attributes for collecting data about the impact of integrating a gamification approach into the traditional learning process.

Questionnaire items	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Gamification enhances motivation to attend classes.	5	4	3	2	1
Gamification makes learning enjoyable and engaging.	5	4	3	2	1
Gamification enhances group study.	5	4	3	2	1
Gamification improved students' self-confidence.	5	4	3	2	1
Gamification improved competitiveness among students.	5	4	3	2	1
Gamification improved the learning environment during classes.	5	4	3	2	1
Gamification helps to learn new things during the course.	5	4	3	2	1
Gamification helps students to think independently.	5	4	3	2	1
Gamification improved critical thinking of students.	5	4	3	2	1
Gamification improved the problem-solving skills of the students.	5	4	3	2	1
Gamification improved teacher-student relationships.	5	4	3	2	1
Gamification improved the mental strength of students.	5	4	3	2	1
Gamification improved the academic achievement of students	5	4	3	2	1
Which assessment type is better?	Traditional	Gamified			
Which learning method is better?	Traditional	Gamified			
Which gamified tool is better for learning chemistry?	ChemCaper	Quizlet	Kahoot	Socrative	Gimkit

Both gamified education and conventional education were the teaching tool types that acted as the investigation's independent metrics. ChemCaper, Quizlet, Kahoot, Socrative, and Gimkit are five different gamification activities that were utilized for gamified learning. Traditional paper-based tests, gamified e-quizzes, online assessments, etc., were used to evaluate students' academic achievement.

Kahoot is a public classroom evaluation and review tool, functioning to determine students' comprehension while simultaneously offering an enjoyable evaluation (Sharmin & Chow, 2024; Vasanthi et al., 2023). Individuals are capable of designing multiple quizzes by setting up a free profile on the platform. When generating a questionnaire, participants must select whether it is private or public, assign it an identity, and upload a photograph. For accessing the quiz, participants are provided with a 6-digit code, but neither usernames nor passwords are required. The system features ideas, songs, scoreboards, memes, models, and other features for rendering studying enjoyable and captivating. In the current investigation, each query had a 30-second loading period (Vasanthi et al., 2023).

Socrative is a free internet-based assessment application that allows teachers to assign participants testing exercises in class, as well as comprehend and record their progress, produce reports, and watch their responses instantaneously (Zainuddin, Shujahat, Haruna, & Chu, 2020). It becomes easier for teachers and students to measure their development and learning whenever they have access to cutting-edge evaluation instruments. Additionally, it facilitates educators in constructing multiple-choice questions, true/false, or short-answer tests that can be retained and utilized afterward (Zainuddin et al., 2020). In real-time, participants reply to the assignment on their gadgets once their educator displays it to the class. Unlike Quizizz and iSpring Learn LMS, it lacks a Player Leaderboard, but it includes a "SpaceRace" game where participants can advance their rocket by providing the correct responses (Zainuddin et al., 2020).

Quizlet is a powerful digital education software that assists teachers and students undertake, contribute, and explore dynamic teaching tools and configurable flashcards (Sailin et al., 2019; Zainuddin et al., 2020). Andrew Sutherland launched Quizlet in 2005, and it currently has over 60 million users in nearly 130 nations. Computerized flashcards, practice tests, matching games, and real-time quizzes are some of its primary features, all of which aim to enhance comprehension and memorization across various disciplines (Nguyen & Van Le, 2023; Zainuddin et al., 2020).

Quizlet is an adaptable tool for students around the world because it is accessible in a variety of languages and also offers both free and premium membership options (Kustiawan, 2024; Zainuddin et al., 2020).

ChemCaper is a modern academic role-playing game (RPG) developed to assist students (aged 10-14) in making chemistry studying enjoyable and engaging. It was created by ACE EdVenture Studio, is centered on the IGCSE Year 7 Chemistry curriculum, and aims to transform science learning by blending fundamental chemistry concepts into a stimulating gaming environment. The activity features a distinctive "Chempendium" that connects in-game content to real chemistry occurrences, enabling a "learning by doing" approach. ChemCaper is a single-player game promoting exploration and problem-solving and is compatible with multiple devices, including Windows, Mac, iOS, and Android. The game's immersive experience is enhanced by music composed by Norihiko Hibino, who is well-known for the Metal Gear Solid series.

Gimkit is a framework for dynamic, game-based education that utilizes gamified features and tests to make the classroom atmosphere more engaging and entertaining (Sharmin & Chow, 2024; Vasanthi et al., 2023). In order to promote active learning through contests and collaboration, Gimkit, founded by Josh Feinsilber, empowers students and educators to create and participate in live quiz games. Students use their personal devices to complete Gimkit questions at their own pace, earning in-game money for correct answers. The ability to purchase power-ups and other upgrades with this digital currency adds a strategic element to learning (Sharmin & Chow, 2024; Vasanthi et al., 2023). Teachers are capable of customizing their courses to various styles of learning owing to the platform's multiple gaming modes, which feature live gaming and homework tasks. Gimkit also offers robust data analytics, enabling teachers to accurately monitor individual as well as team performance. Gimkit is available in both free and Pro editions, with the Pro edition providing additional options and types of games. Gimkit can be installed on a variety of devices, including PCs, tablets, and smartphones (Sharmin & Chow, 2024; Vasanthi et al., 2023). Gimkit transformed conventional education into an enjoyable and dynamic experience by fusing learning with gaming elements, boosting student engagement and strengthening memory retention.

### 3.3. Data Analysis

Data were first verified for normality (Shapiro-Wilk test). Descriptive statistics (frequency and percentage) were utilized for analyzing the quantitative information gathered through the survey data and to compile the responses from all students. All statistical analyses were performed using Microsoft Excel 2019.

## 4. RESULTS

The survey findings pertaining to the influence of the gamification learning application on students' inspiration in chemistry learning have been displayed. Exploring diverse motivational elements and their effects on students' learning experiences in chemistry classroom owing to intervention of gamification tool was the primary objective of the survey. The questionnaire's responses have been displayed in Figures 1–12 and Table 1, which convey an overall perspective of the intrinsic motivational levels ascribed to the integration of gamification framework in the chemistry classroom learning.

According to Figure 1, the interactive gamified learning application displayed advantageous effects on students' excitement for attending classes. Approximately 66.67% of surveyed participants stated that they strongly agreed or agreed with this statement. Only a small proportion (14.81%) opposed or declined completely that the gamification tool is not influential in stimulating their presence in the classroom (Figure 1). The outcomes, which are illustrated in Figure 2, revealed that the gamification system boosted students' inspiration for studying in an enjoyable and/or attentive manner. The majority of participants (87.04%) strongly agreed or agreed with this assertion, demonstrating the gamification approach's critical role in boosting students' academic performance and commitment (Figure 2). The outcomes illustrated in Figure 3 revealed that the gamification system boosted students' inspiration for group studying. Approximately 92.59% of students strongly agreed or agreed with this assertion, demonstrating wide

adoption of the gamification approach by students during classroom learning (Figure 3). As seen in Figure 4, students' self-esteem has improved substantially. Considering the questionnaire's findings, approximately 71.69% of surveyed students acknowledged or strongly acknowledged that the gamified learning approach boosted their degree of trustworthiness, implying that the approach's built-in strategy was an important driver in this finding (Figure 4).

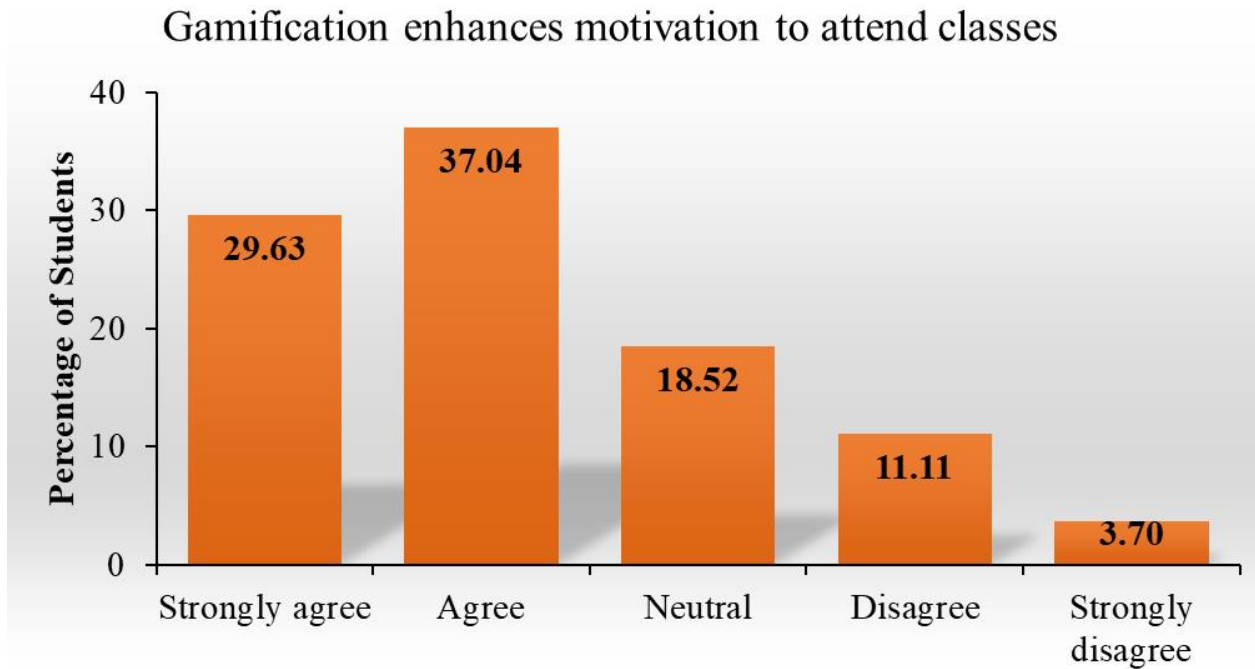


Figure 1. Gamification impact on class attendance of students.

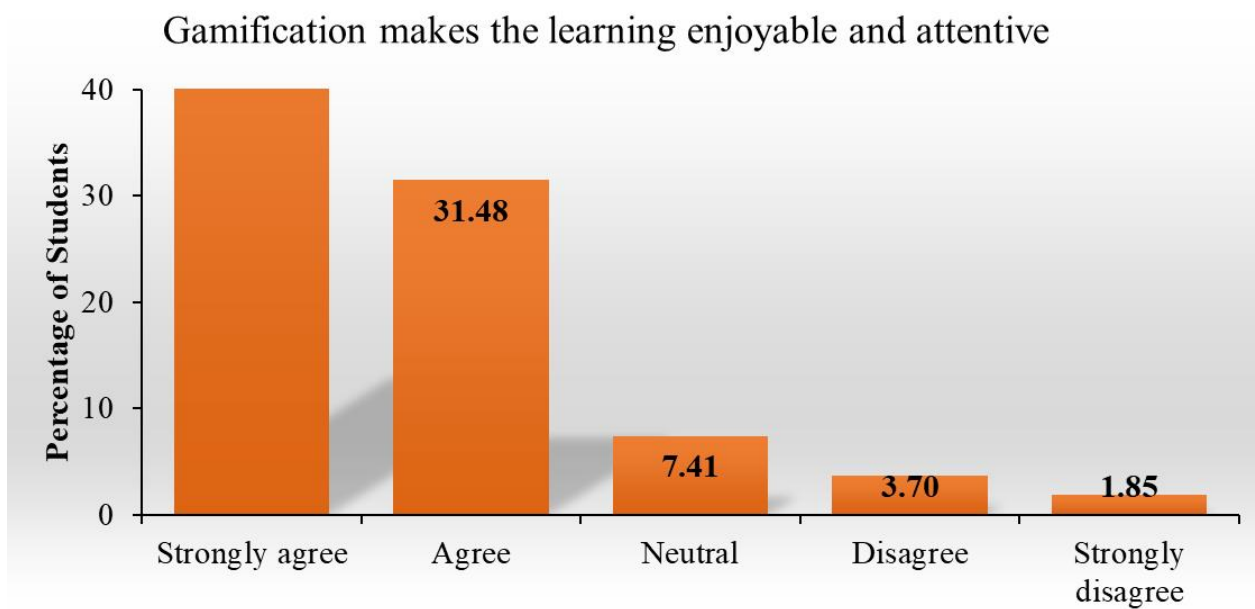


Figure 2. Gamification impact on class enjoyability and attentiveness by the students.

### Gamification enhances group study

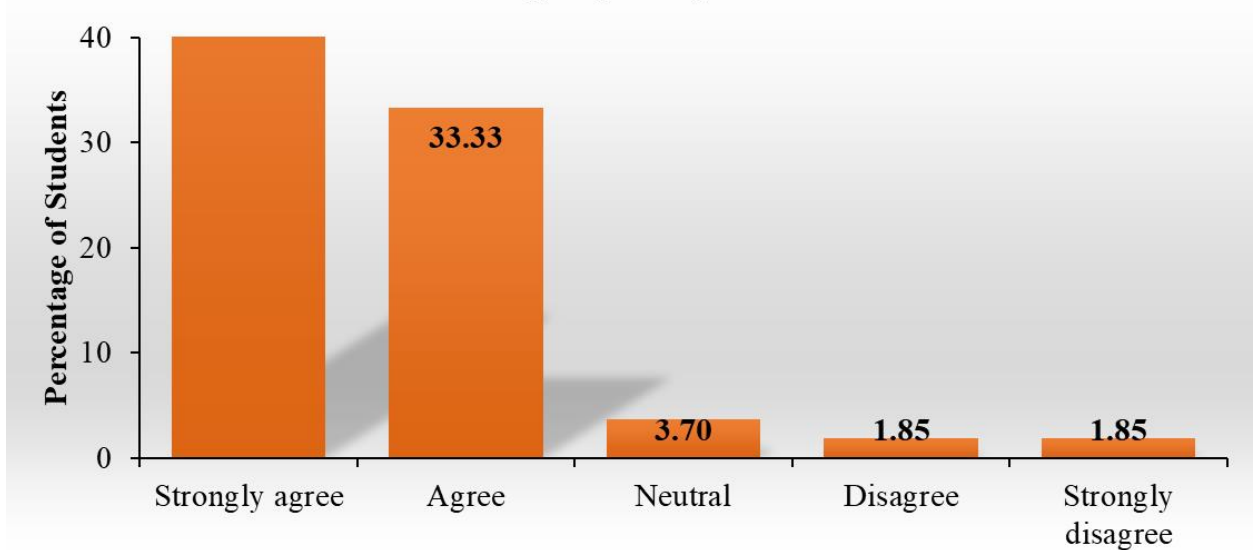


Figure 3. Gamification impact on group study of the students.

### Gamification improved self-confidence of students

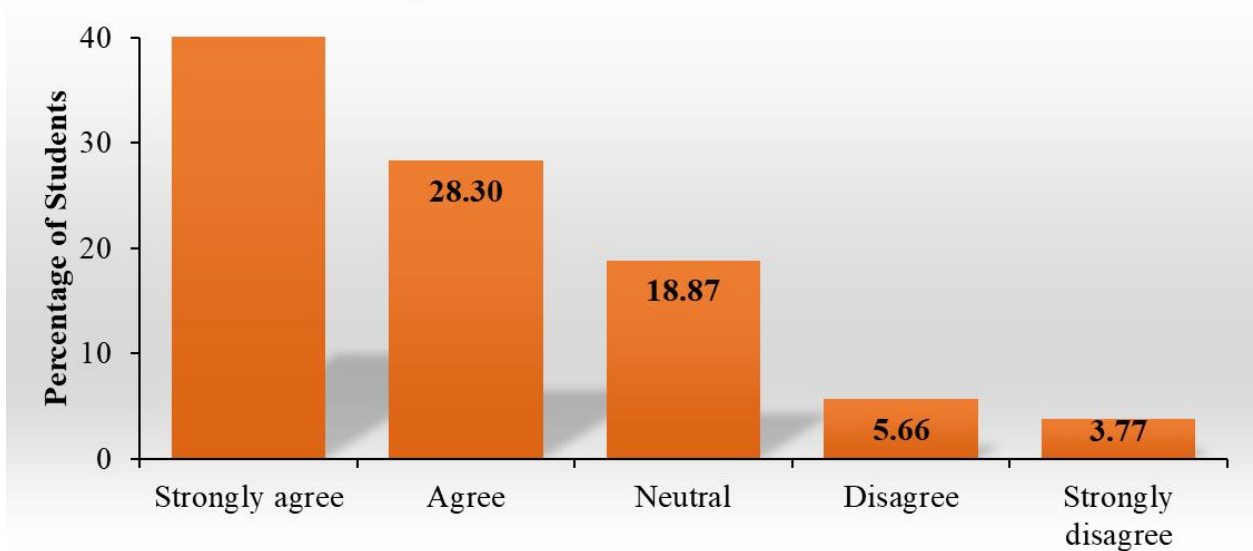


Figure 4. Gamification impact on self-confidence of the students.

Figure 5 displays how the approach improved competitiveness among students in a peaceful classroom atmosphere as a booster for student inspiration. A large percentage of attendees (58.18%) acknowledged strongly or agreed that the gamified approach's implications strengthened their competitiveness. Additionally, a sizable fraction of those surveyed (36.36%) voiced no viewpoint; fewer students (5.45%) were either strongly opposed or disagreed (Figure 5). As seen in Figure 6, the gamification system substantially boosted the academic environment in the classroom, and students' inspiration for acquiring new ideas or concepts improved significantly. Considering the questionnaire's findings, approximately 88.69% of surveyed students acknowledged or strongly acknowledged that the gamified learning approach substantially boosted both the classroom's academic environment and the acquisition of new ideas, implying that this approach might play a critical role in developing student motivation as well as overall academic performance (Figure 6). According to Figure 7, the interactive gamified learning application had an advantageous effect on students' independent thinking capabilities. Approximately 68.52% of surveyed participants stated that they strongly agreed or agreed with this statement. Only a small proportion (14.81%) opposed or

completely disagreed that the gamification tool is not influential in fostering independent thinking (Figure 7). The outcomes, illustrated in Figure 8, revealed that the gamification system boosted students' critical thinking and problem-solving skills during classroom teaching. The majority of participants (61.11% for critical thinking and 68.52% for problem-solving skills) strongly agreed or agreed with this assertion, demonstrating the gamification approach's critical role in enhancing students' academic performance and engagement (Figure 8). Only a small proportion (18.52% for critical thinking and 9.26% for problem-solving skills) opposed or completely disagreed that the gamification tool has no direct role in boosting students' critical thinking and problem-solving skills (Figure 8).

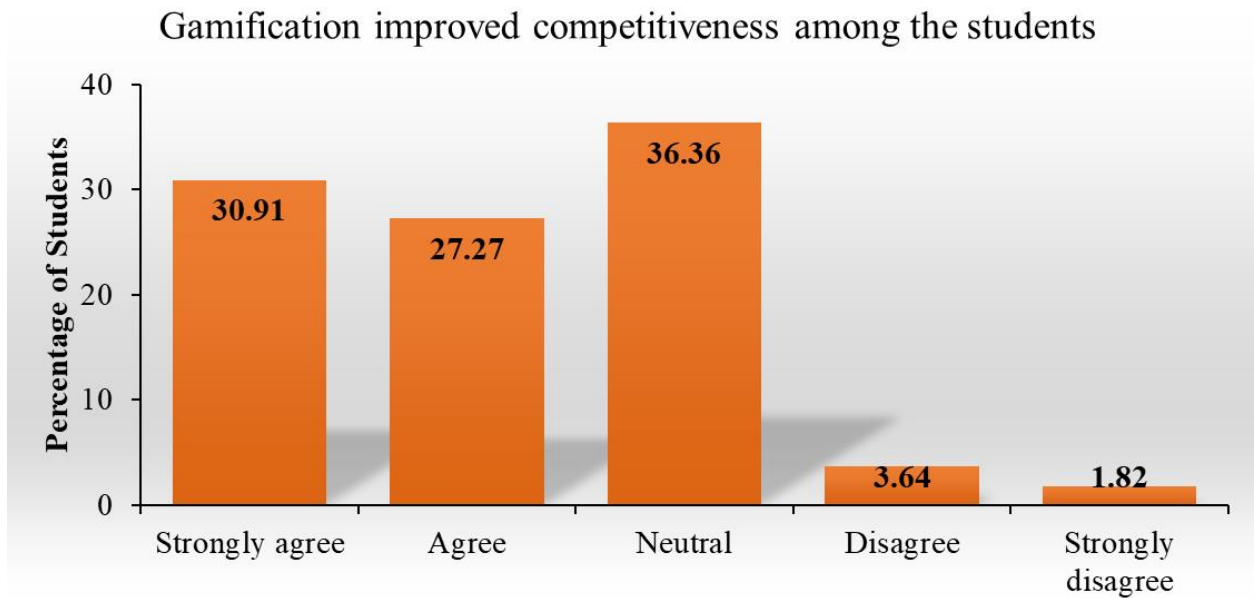


Figure 5. Gamification impact on competitiveness of the students.

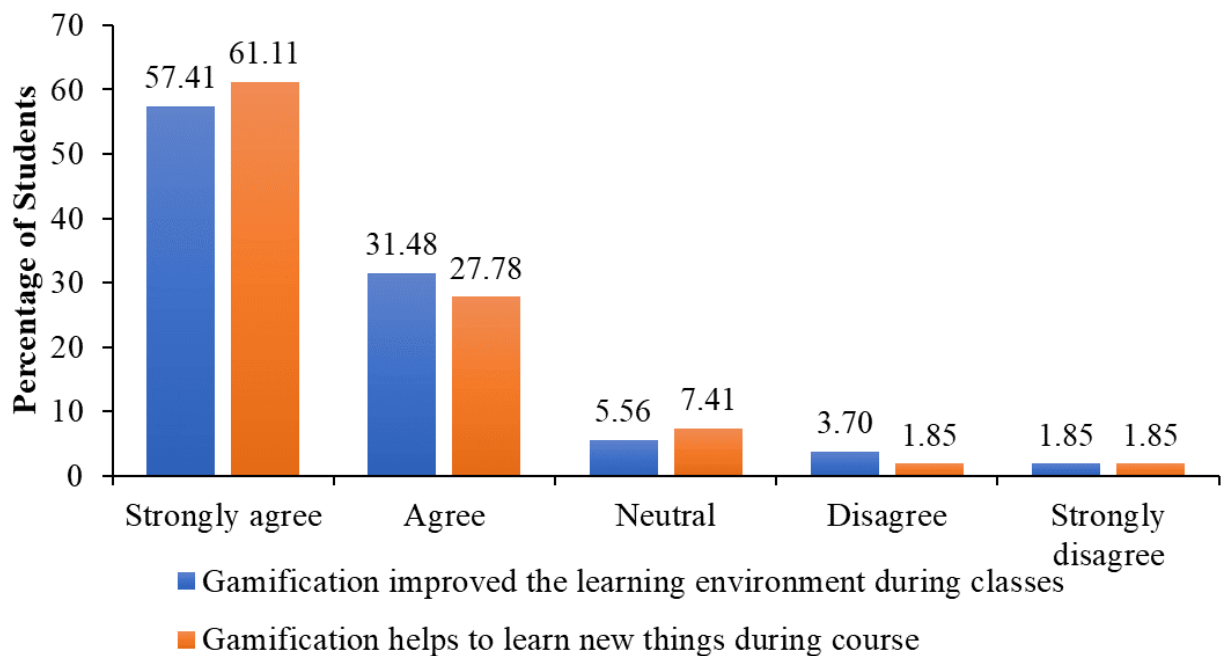


Figure 6. Gamification impact on improving the class atmosphere and learning new ideas.

### Gamification helps students to think independently

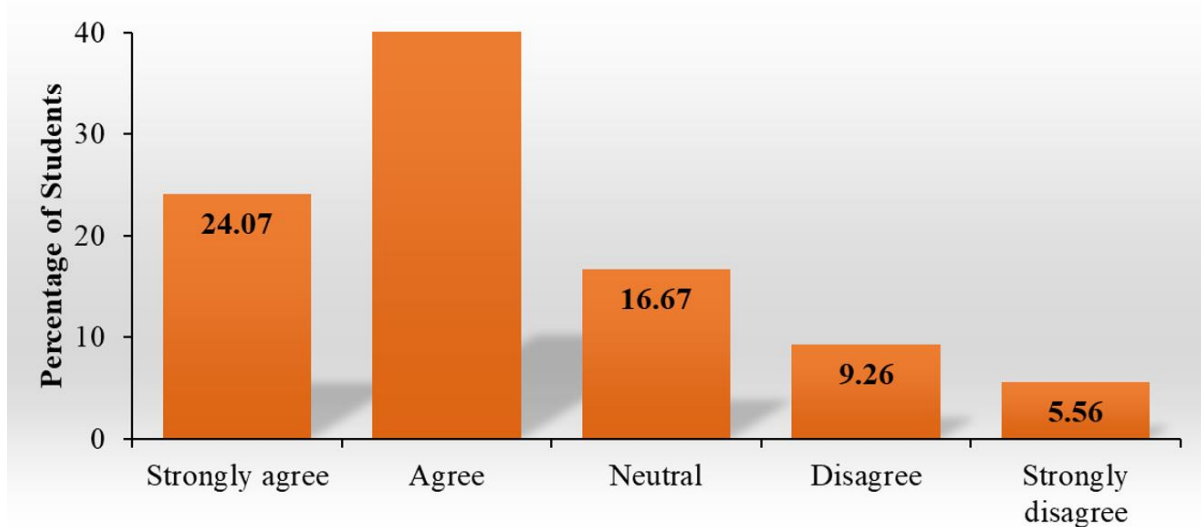


Figure 7. Gamification impact on independent thinking of the students.

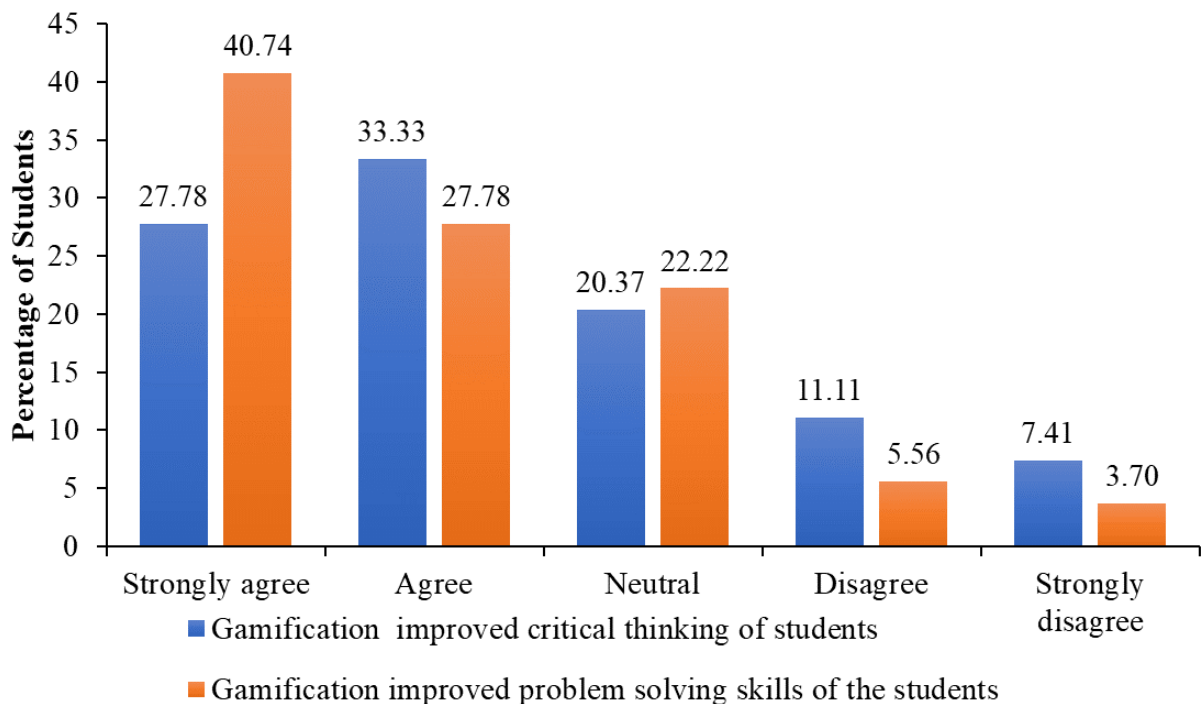


Figure 8. Gamification impact on critical thinking potentiality and problem-solving skill of the students.

Students also admitted that gamified learning approach also improved the teacher-student relationship substantially (Figure 9). Approximately 70.37% surveyed students stated that they strongly agreed or agreed with this statement, only a small proportion (14.81%) opposed or declined completely that gamification tool is not influential developing teacher-student relationship (Figure 9). Figure 10 displays how integration of gamified learning approach efficiently raised students' mental strength. A large percentage of students (72.22%) strongly acknowledged or acknowledged that gamified learning approach strengthened mental strength. Additionally, a sizable fraction of those surveyed (18.52%) voiced no viewpoint, a minority (3.70%) were strongly opposed and 5.56% students disagree (Figure 10), which implying that gamified learning approach don't have influential role in improving the mental strength. The outcomes, which are illustrated in Figure 11, revealed that gamification system

boosted the student's academic achievement during classroom teaching. Majority of participants (75.93%) strongly agreed or agreed with this assertion, demonstrating gamification approach's critical role in boosting students' overall academic performance (Figure 11). Only a small proportion (9.26%) opposed or declined completely that gamification tool not have any direct role for boosting the student's overall academic performance (Figure 11).

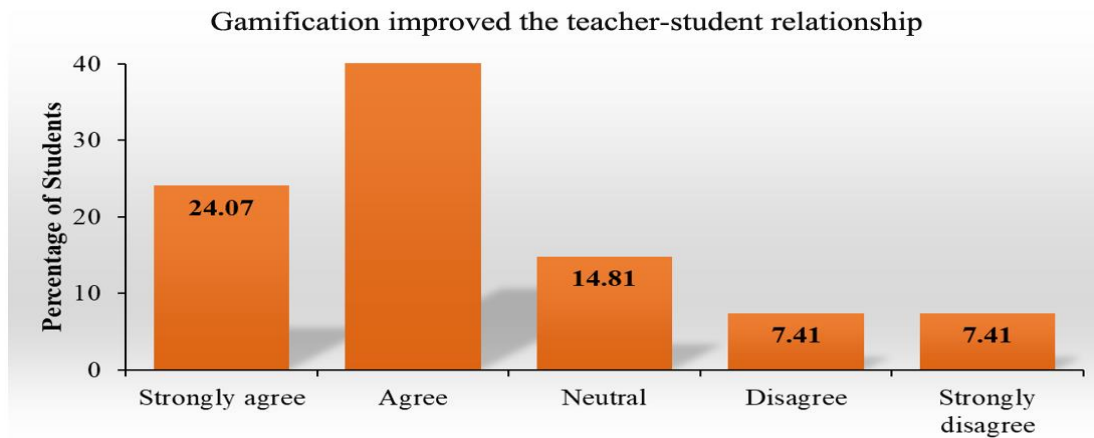


Figure 9. The impact of gamification on the teacher-student relationship.

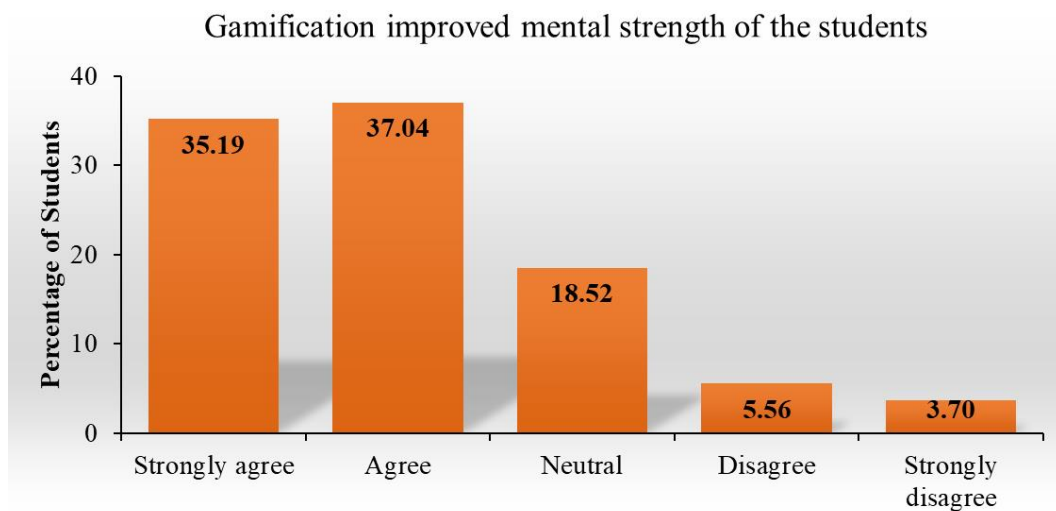


Figure 10. Gamification impact on mental strength of the students.

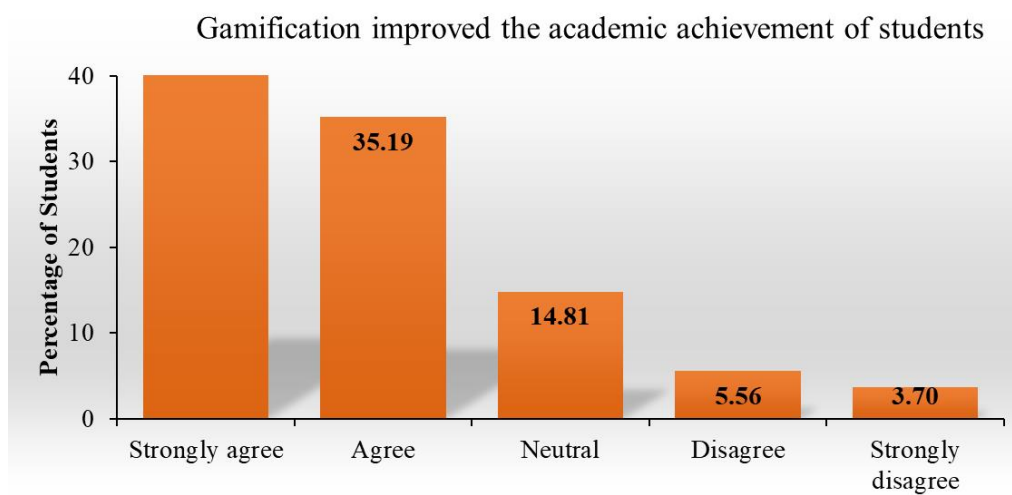
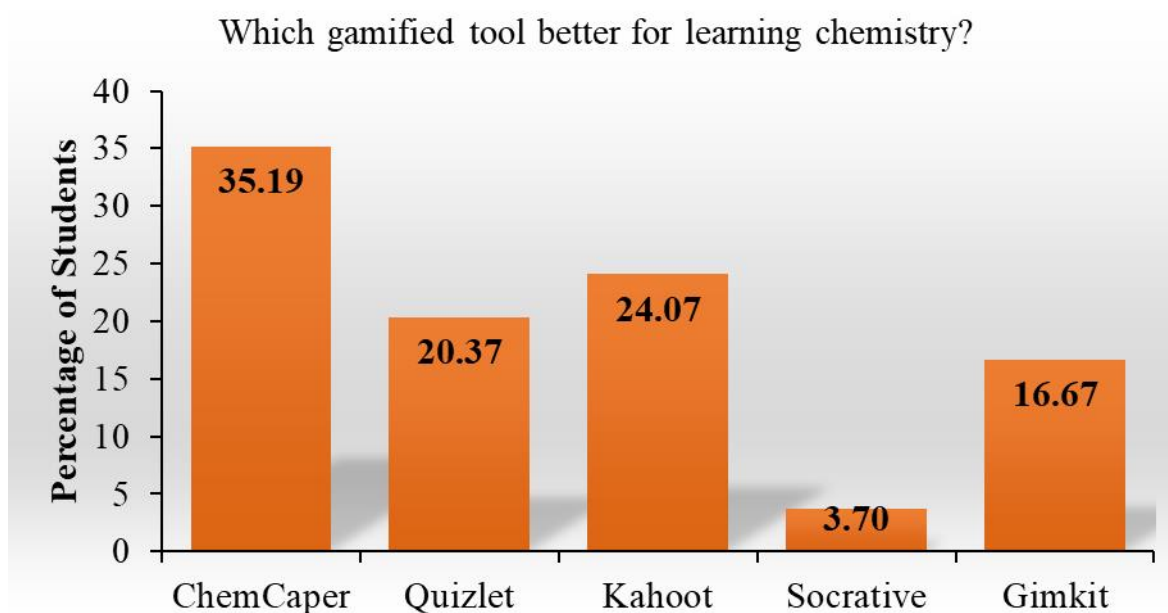


Figure 11. The impact of gamification on the overall academic performance of students.

Students admitted that the gamified learning approach is more enjoyable than traditional assessment (Table 2). Approximately 87.04% of surveyed students stated that they strongly believe that the gamified assessment approach is more motivational than traditional assessment types, while only 12.96% of students opposed this, indicating that gamified assessment is neither as influential nor as enjoyable (Table 2). A significant proportion of students (83.33%) also claimed that the gamified learning methodology is more preferred than traditional teaching methods (16.67%) (Table 2). For teachers and parents aiming to foster enthusiasm for chemistry among younger learners, ChemCaper emerged as a more preferred tool since it carefully integrates instructive information with entertaining gameplay (Figure 12). The findings depicted that ChemCaper is the most preferred (35.19%), followed by Kahoot (24.07%), Quizlet (20.37%), Gimkit (16.67%), and Socrative (3.70%) (Figure 12).

**Table 2.** Summarizes the findings of assessment type and learning type.

Which assessment type is better?	Traditional assessment	Gamified assessment
	12.96	87.04
Which learning method is better?	Traditional assessment	Gamified assessment
	16.67	83.33



**Figure 12.** Gamification tools utilized by the students.

The survey's findings convey fascinating details pertaining to how the gamification environment influences students' inspiration in learning chemistry. Although a large proportion of attendees acknowledged excitement and satisfaction with the application, it is necessary to comprehend that certain attendees couldn't find it as enjoyable or as inspirational. These outcomes imply that, in order to accommodate all motivating requirements of students, more studies and upgrades of the gamification aspects are necessary.

## 5. DISCUSSION

The results of this investigation demonstrate that incorporating a gamification approach assists in involving students in studying. Because it offers awards for students, the results also imply that competitiveness is an integral part of gamification adoption. Following lectures, tests inspired participants to team up in the classroom, resulting in boosted performance and results, according to this research.

According to the questionnaire findings, the interest and motivation to attend the classes were enhanced due to the incorporation of a gamification system, which addresses the first inquiry, "gamification enhances motivation to

attend classes." Approximately 66.67% of surveyed participants stated that they strongly agreed or agreed with this statement. Only a small proportion (14.81%) opposed or completely declined that the gamification tool is not influential in stimulating their presence in the classroom. This result signifies that students have been effectively motivated to be involved in classroom learning by the gamification approach incorporated into traditional teaching and learning. The obtained results in the present study are in line with several findings that have indicated that the gamification approach substantially improved and motivated students to attend teaching classes (Campillo-Ferrer, Miralles-Martínez, & Sánchez-Ibáñez, 2020; Hellín et al., 2023; Ndlovu & Mhlongo, 2020).

Regarding "gamification makes learning enjoyable and attentive," the majority of participants (87.04%) strongly agreed or agreed that the gamification system boosted students' motivation for studying in an enjoyable and/or attentive manner. This implies that the gamification approach plays a crucial role in enhancing students' academic performance and commitment. Additionally, approximately 92.59% of students strongly agreed or agreed that the gamification system increased their motivation for group studying, demonstrating widespread adoption of the gamification approach during classroom learning. These findings align with several studies indicating that the gamification approach significantly improves students' motivation for studying in an enjoyable and attentive manner, as well as motivating students for group study. For example, Zainuddin et al. (2020) reported that incorporating the gamification approach into traditional learning makes the teaching process more enjoyable, encourages group discussions, and helps students become more attentive in the classroom, ultimately improving students' overall academic performance.

Regarding "gamification improved self-confidence of students," approximately 71.69% of surveyed students acknowledged or strongly acknowledged that the gamified learning approach boosted their trustworthiness, implying that the approach's built-in strategy was an important driver in this finding. Furthermore, a large percentage of the attendees (58.18%) acknowledged strongly or agreed that the implications of the gamified approach strengthened their competitiveness. These findings are consistent with previous studies, depicting the influential impact of the gamified approach on improving students' self-confidence through a competitive learning atmosphere within the classroom. For example, Amo, Liao, Kishore, and Rao (2020) and Hellín et al. (2023) pointed out that the integration of gamified learning in classroom teaching improved competitiveness among students, enhanced student engagement and self-dependency, which ultimately improved students' motivational levels. Similarly, Landers, Bauer, and Callan (2017) reported that gamified tools' leaderboard plays a crucial role in improving students' motivation levels, self-confidence, as well as their academic performance.

The study investigated the role of gamification in improving the classroom environment. The results depicted that gamification systems substantially boosted the classroom's academic environment as well as students' motivation for acquiring new ideas and concepts, implying that this approach might play a critical role in developing student motivation as well as overall academic performance. Similar to our findings, Zainuddin et al. (2020) reported that the incorporation of gamification approaches in traditional learning processes significantly improved the classroom's learning environment, participation in group discussions, and increased students' attentiveness in the classroom, which ultimately aids students in generating new ideas and concepts. Furthermore, the majority of surveyed participants (68.52%) stated that they strongly agreed or agreed that interactive gamified learning applications displayed advantageous effects on students' independent thinking capabilities. Only a small proportion (14.81%) opposed or completely disagreed that gamification tools are not influential in fostering independent thinking. These findings indicate that an enjoyable and insightful learning atmosphere in the classroom actually boosts students' independent thinking potential through enhanced self-confidence (Hellín et al., 2023; Zainuddin et al., 2020).

Regarding "gamification improved critical thinking of students" and "gamification improved problem-solving skills of the students," the majority of participants (61.11% and 68.52% for critical thinking and problem-solving skills, respectively) strongly agreed or agreed with the gamification approach's critical role in boosting students' academic performance and commitment. Only a small proportion (18.52% and 9.26% for critical thinking and

problem-solving skills, respectively) opposed or declined completely that gamification tools do not have any direct role in boosting students' critical thinking and/or problem-solving skills. These outcomes align with earlier investigations (Huang & Hew, 2018; Tsay, Kofinas, & Luo, 2018), indicating that gamified education enhances students' critical thinking and problem-solving skills in various classroom settings. For example, gaming-based education in flipped classroom settings improves students' critical thinking and problem-solving abilities through behavioral and mental engagement, according to Lo and Hew (2020) and Huang, Hew, and Lo (2019). Four forms of educational engagement emotional, behavioral, cognitive, and agentic are positively impacted by gamified education (Reeve & Tseng, 2011).

The study also investigated the role of gamification in improving teacher-student relationships as well as students' mental strength and academic performance. The findings indicated that 70.37% of surveyed students stated that they strongly agreed or agreed that gamification improves teacher-student relationships, while only a small proportion (14.81%) opposed or declined completely that gamification tools are not influential in developing teacher-student relationships. Additionally, a large proportion of students (72.22%) strongly acknowledged or acknowledged that gamified learning approaches strengthened mental strength. Furthermore, the majority of participants (75.93%) strongly agreed or agreed that gamification systems boosted students' academic achievement during classroom teaching, demonstrating the critical role of gamification in enhancing students' overall academic performance. Only a small proportion (9.26%) opposed or declined completely that gamification tools have no direct role in boosting students' overall academic performance. These findings collectively depict that incorporating gamification approaches into traditional learning systems improved teacher-student relationships as well as boosted students' mental strength and academic performance through active engagement in classroom teaching. Incorporating gamification into educational programs might improve students' scores, as per (Jurgelaitis, Čeponienė, Čeponis, & Drungilas, 2019), which investigated student performance. Pre-class and post-class assignments were also completed on time by students enrolled in gamified exercises, according to Huang et al. (2019). Moreover, multiple research investigations have shown that, following game-based educational contexts, student participation and educational achievement are positively correlated, as demonstrated by (Çakıroğlu, Başıbüyük, Guler, Atabay, & Memiş, 2017; Chang & Wei, 2016; De Lope, Arcos, Medina-Medina, Paderewski, & Gutiérrez-Vela, 2017; Göksün & Gürsoy, 2019; Groening & Binnewies, 2019; Kyewski & Krämer, 2018). For example, Çakıroğlu et al. (2017) states that the utilization of game-based gadgets boosts students' educational achievement. De Lope et al. (2017) also claim that maintaining high levels of motivation and engagement requires students to actively participate and complete gamified learning activities. The study by Sánchez-Martín, Cañada-Cañada, and Dávila-Acedo (2017) supports this, as it found a relationship between academic scores, encouragement, and game engagement. According to Campillo-Ferrer et al. (2020), introducing Kahoot! quizzes promoted students' comprehension of specific ideas, increased their engagement levels, and encouraged students to acquire knowledge in a more lively and interactive environment.

Regarding the question “which assessment type is better?” and “which learning method is better?” the majority of participants (87.04% and 83.33% for assessment type and learning method, respectively) strongly agreed or agreed that the gamification approach is better for understanding the subject matter. They also opined that the gamified learning approach is more appropriate for acquiring chemistry knowledge in a more enjoyable fashion. Furthermore, this advanced approach is more crucial in boosting students' classroom attendance, participation in group discussions, involvement in classroom teaching, and creating a healthier classroom environment, which ultimately improves their academic performance and motivation. The present findings are in line with Zainuddin et al. (2020), who reported that the gamified learning approach is more influential than traditional teaching methods in improving students' academic performance and motivation.

The last question, “which gamified tool is better for learning chemistry?” the questionnaire outcomes depicted an insight into the capabilities of internet-based gamified applications that significantly impact students' motivation levels in classroom chemistry teaching. The findings indicated that ChemCaper is the most preferred (35.19%),

followed by Kahoot (24.07%), Quizlet (20.37%), Gimkit (16.67%), and Socrative (3.70%). This suggests that ChemCaper effectively helps students acquire chemistry knowledge in a more enjoyable and engaging manner compared to other gamified tools, as well as assisting students in outperforming their peers in the classroom. ChemCaper emerged as the top contender because it helps make chemistry studying enjoyable and engaging by blending fundamental chemistry concepts into a stimulating gaming environment. Additionally, the platform is user-friendly and accessible on multiple devices, including Windows, Mac, iOS, and Android, with the gaming experience enhanced by music. Furthermore, this may be attributed to the gamified system's recording of points, scores, and badges on the scoreboard. Kahoot and Quizlet are the other two dominant gamification applications used by students after ChemCaper. Their functionalities are quite similar, allowing teachers, students, and other entities to participate in real-time quizzes, interviews, debates, and more, aiming to improve comprehension and memorization across various disciplines. However, Quizlet differs from Kahoot in that users can customize questions and integrate them with configurable flashcards. Gimkit is another gamification application preferred by 16.67% of students. This app is also user-friendly for both teachers and students, allowing teachers to customize courses to accommodate multiple learning styles through various gaming modes, including live quizzes, gaming, and home assignments. Additionally, it can be installed on a variety of devices, such as PCs, tablets, and smartphones, transforming traditional education into an enjoyable and dynamic experience by combining conventional learning with gaming elements to boost student achievement and motivation.

## 6. LIMITATIONS OF THE STUDY

This investigation encompasses several shortcomings. Firstly, neither the shortcomings nor the constraints of each gamified venue were addressed in the questionnaire assessment. Secondly, the representative sample appeared inadequate, which restricts the reliability of outcomes because all study participants are from a single institution, and the majority of participants were teenagers. As a result, extrapolating the findings to all students is not rational. Prospective studies might therefore utilize larger samples employing various college-aged populations. Similarly, in terms of the focus group interviews, more individuals should be considered, as well as providing students with an opportunity to convey their thoughts on the subjects. Third, we recognize the possibility of prejudices in the gamification application used for data collection. We therefore strongly advocate that future studies on mental involvement or interpersonal learning utilize more sophisticated and objective methodologies, including the use of specialized artificial intelligence-based equipment such as learning analytics and different indices. Fourth, the usability of five different gamification apps was not assessed in the present study for gathering critical information. Additionally, programming complications were encountered in the apps to acquire outcomes. Therefore, we recommend that heuristic analysis, usefulness, and playfulness analyses be conducted in future research, and that research be extended to additional disciplines such as physics and mathematics.

## 7. CONCLUSION

In summary, the incorporation of gamified applications in the traditional learning process has tremendously boosted students' motivation and participation in classroom study. Utilizing the app's in-built features serves as an excellent approach to make classes more enjoyable and intriguing. The current research also proved that blending traditional knowledge with gamified learning through integrating app's in-built features like challenges, rewards, points, memes, and incentives into the questions improves the learning process, making it easier and more satisfying for students. The study also depicted that the incorporation of gamification applications in the traditional learning system increases students' thinking capabilities as well as problem-solving skills. Hence, utilizing this gamification application across various colleges for obtaining a variety of experiences and opinions is an additional important aspect to be given emphasis for prospective studies. Further, we strongly encourage that additional research be carried out on the execution of such creative gamified applications with various LMS platforms to make the learning process

more attractive and enjoyable for students. Moreover, the platform's usefulness spanning an array of curricular contexts and disciplines must be investigated in different educational disciplines also to make gamified learning a leading teaching tool in the twenty-first century.

**Funding:** This study received no specific financial support.

**Institutional Review Board Statement:** The Ethical Committee of the Chengdu International Studies University, China has granted approval for this study on 16 September 2024 (CISU-2024-916).

**Transparency:** The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.

**Competing Interests:** The authors declare that they have no competing interests.

**Authors' Contributions:** Both authors contributed equally to the conception and design of the study. Both authors have read and agreed to the published version of the manuscript.

**Disclosure of AI Use:** The author used OpenAI's ChatGPT (GPT-4) to edit and refine the wording of the Introduction and Literature Review. All outputs were thoroughly reviewed and verified by the author.

## REFERENCES

- Amo, L., Liao, R., Kishore, R., & Rao, H. R. (2020). Effects of structural and trait competitiveness stimulated by points and leaderboards on user engagement and performance growth: A natural experiment with gamification in an informal learning environment. *European Journal of Information Systems*, 29(6), 704-730. <https://doi.org/10.1080/0960085X.2020.1808540>
- Antunes, M., Pacheco, M. A. R., & Giovanela, M. (2012). Design and implementation of an educational game for teaching chemistry in higher education. *Journal of Chemical Education*, 89(4), 517-521. <https://doi.org/10.1021/ed2003077>
- Baeten, M., Struyven, K., & Dochy, F. (2013). Student-centred teaching methods: Can they optimise students' approaches to learning in professional higher education? *Studies in Educational Evaluation*, 39(1), 14-22. <https://doi.org/10.1016/j.stueduc.2012.11.001>
- Baydas, O., & Cicek, M. (2019). The examination of the gamification process in undergraduate education: A scale development study. *Technology, Pedagogy and Education*, 28(3), 269-285. <https://doi.org/10.1080/1475939X.2019.1580609>
- Belova, N., & Zowada, C. (2020). Innovating higher education via game-based learning on misconceptions. *Education Sciences*, 10(9), 221. <https://doi.org/10.3390/educsci10090221>
- Bhattacharjee, J. (2015). Constructivist approach to learning—an effective approach of teaching learning. *International Research Journal of Interdisciplinary & Multidisciplinary Studies*, 1(6), 65-74.
- Boudadi, N. A., & Gutiérrez-Colón, M. (2020). Effect of gamification on students' motivation and learning achievement in second language acquisition within higher education: A literature review 2011-2019. *The EuroCALL Review*, 28(1), 57-69. <https://doi.org/10.4995/eurocall.2020.12974>
- Buckley, P., & Doyle, E. (2016). Gamification and student motivation. *Interactive Learning Environments*, 24(6), 1162-1175. <https://doi.org/10.1080/10494820.2014.964263>
- Byusa, E., Kampire, E., & Mwesigye, A. R. (2022). Game-based learning approach on students' motivation and understanding of chemistry concepts: A systematic review of literature. *Heliyon*, 8(5), e09541. <https://doi.org/10.1016/j.heliyon.2022.e09541>
- Cahyana, U., Paristiwati, M., Savitri, D. A., & Hasyrin, S. N. (2017). Developing and application of mobile game based learning (M-GBL) for high school students performance in chemistry. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(10), 7037-7047. <https://doi.org/10.12973/ejmste/78728>
- Çakıroğlu, U., Başbuğ, B., Güler, M., Atabay, M., & Memiş, B. Y. (2017). Gamifying an ICT course: Influences on engagement and academic performance. *Computers in Human Behavior*, 69, 98-107. <https://doi.org/10.1016/j.chb.2016.12.018>
- Campillo-Ferrer, J.-M., Miralles-Martínez, P., & Sánchez-Ibáñez, R. (2020). Gamification in higher education: Impact on student motivation and the acquisition of social and civic key competencies. *Sustainability*, 12(12), 4822. <https://doi.org/10.3390/su12124822>

- Chang, J.-W., & Wei, H.-Y. (2016). Exploring engaging gamification mechanics in massive online open courses. *Journal of Educational Technology & Society*, 19(2), 177-203.
- Chee, Y. S., & Tan, K. C. D. (2012). Becoming chemists through game-based inquiry learning: The case of legends of Alkhimia. *Electronic Journal of e-Learning*, 10(2), 185-198.
- Chen, M.-P., Wong, Y.-T., & Wang, L.-C. (2014). Effects of type of exploratory strategy and prior knowledge on middle school students' learning of chemical formulas from a 3D role-playing game. *Educational Technology Research and Development*, 62(2), 163-185. <https://doi.org/10.1007/s11423-013-9324-3>
- Childs, P. E., & Sheehan, M. (2009). What's difficult about chemistry? An Irish perspective. *Chemistry Education Research and Practice*, 10(3), 204-218. <https://doi.org/10.1039/B914499B>
- Chon, V. B. F. A., Sharif, S. B., & Saleh, N. B. M. (2024). Gamification for enhancing students' learning motivation: A systematic review. *Journal of Cognitive Sciences and Human Development*, 10(2), 19-41. <https://doi.org/10.33736/jcshd.7231.2024>
- Clapson, M. L., Gilbert, B., Mozol, V. J., Schechtel, S., Tran, J., & White, S. (2020). ChemEscape: Educational battle box puzzle activities for engaging outreach and active learning in general chemistry. *Journal of Chemical Education*, 97(1), 125-131. <https://doi.org/10.1021/acs.jchemed.9b00612>
- Clapson, M. L., Gilbert, B. C. T., & Musgrove, A. (2020). Race to the reactor and other chemistry games: Game-based and experiential learning experiences in materials and polymer chemistry. *Journal of Chemical Education*, 97(12), 4391-4399. <https://doi.org/10.1021/acs.jchemed.0c01135>
- Da Silva Júnior, J. N., Lima, M. A. S., Pimenta, A. T. A., Nunes, F. M., Monteiro, Á. C., De Sousa, U. S., . . . Winum, J.-Y. (2021). Design, implementation and evaluation of a game-based application for aiding chemical engineering and chemistry students to review the organic reactions. *Education for Chemical Engineers*, 34, 106-114. <https://doi.org/10.1016/j.ece.2020.11.007>
- Daubenfeld, T., & Zenker, D. (2015). A game-based approach to an entire physical chemistry course. *Journal of Chemical Education*, 92(2), 269-277. <https://doi.org/10.1021/ed5001697>
- De Freitas, J. M., & Mira da Silva, M. (2023). Systematic literature review about gamification in MOOCs. *Open Learning: The Journal of Open, Distance and e-Learning*, 38(1), 73-95. <https://doi.org/10.1080/02680513.2020.1798221>
- De Lope, R. P., Arcos, J. R. L., Medina-Medina, N., Paderewski, P., & Gutiérrez-Vela, F. L. (2017). Design methodology for educational games based on graphical notations: Designing Urano. *Entertainment Computing*, 18, 1-14. <https://doi.org/10.1016/j.entcom.2016.08.005>
- Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (2015). Gamification in education: A systematic mapping study. *Journal of Educational Technology & Society*, 18(3), 75-88.
- Dietrich, N. (2018). Escape classroom: The Leblanc process—An educational “escape game”. *Journal of Chemical Education*, 95(6), 996-999. <https://doi.org/10.1021/acs.jchemed.7b00690>
- Ding, L., Er, E., & Orey, M. (2018). An exploratory study of student engagement in gamified online discussions. *Computers & Education*, 120, 213-226. <https://doi.org/10.1016/j.compedu.2018.02.007>
- Dorimana, A., Uworwabayeho, A., & Nizeyimana, G. (2021). Examining mathematical problem-solving beliefs among Rwandan secondary school teachers. *International Journal of Learning, Teaching and Educational Research*, 20(7), 227-240. <https://doi.org/10.26803/ijlter.20.7.13>
- Duvarcı, D. (2010). Activity-based chemistry teaching: A case of “elements and compounds”. *Procedia-Social and Behavioral Sciences*, 2(2), 2506-2509. <https://doi.org/10.1016/j.sbspro.2010.03.362>
- Eilks, I., Prins, G. T., & Lazarowitz, R. (2013). How to organise the chemistry classroom in a student-active mode. In Eilks, I., Hofstein, A. (Eds.), *Teaching Chemistry—A Studybook*. In (pp. 183-212.). Netherlands: Sense Publishers.
- Erman, E. (2017). Factors contributing to students' misconceptions in learning covalent bonds. *Journal of Research in Science Teaching*, 54(4), 520-537. <https://doi.org/10.1002/tea.21375>
- Fotaris, P., Mastoras, T., Leinfellner, R., & Rosunally, Y. (2016). Climbing up the leaderboard: An empirical study of applying gamification techniques to a computer programming class. *Electronic Journal of e-Learning*, 14(2), 94-110.

- Gökstün, D. O., & Gürsoy, G. (2019). Comparing success and engagement in gamified learning experiences via Kahoot and Quizizz. *Computers & Education*, 135, 15-29. <https://doi.org/10.1016/j.compedu.2019.02.015>
- Groening, C., & Binnewies, C. (2019). "Achievement unlocked!"-The impact of digital achievements as a gamification element on motivation and performance. *Computers in Human Behavior*, 97, 151-166. <https://doi.org/10.1016/j.chb.2019.02.026>
- Guardia, J. J., Del Olmo, J. L., Roa, I., & Berlanga, V. (2019). Innovation in the teaching-learning process: The case of Kahoot! *On the Horizon*, 27(1), 35-45. <https://doi.org/10.1108/OTH-11-2018-0035>
- Gupta, T. (2019). Game-based learning in chemistry: A game for chemical nomenclature. In Technology integration in chemistry education and research. In (pp. 65-79). Washington, D.C: American Chemical Society.
- Hamari, J., Koivisto, J., & Sarsa, H. (2014). *Does gamification work? - A literature review of empirical studies on gamification*. Paper presented at the Proceedings of the Annual Hawaii International Conference on System Sciences.
- Harman, G., & Yenikalayci, N. (2020). ABSQR code game: Reinforcing the names, formulas, types and reactions of acids, bases and salts. *Journal of Materials Education*, 42(1-2), 1-13.
- Hellín, C. J., Calles-Esteban, F., Valledor, A., Gómez, J., Otón-Tortosa, S., & Tayebi, A. (2023). Enhancing student motivation and engagement through a gamified learning environment. *Sustainability*, 15(19), 14119. <https://doi.org/10.3390/su151914119>
- Höft, L., & Bernholt, S. (2019). Longitudinal couplings between interest and conceptual understanding in secondary school chemistry: An activity-based perspective. *International Journal of Science Education*, 41(5), 607-627. <https://doi.org/10.1080/09500693.2019.1571650>
- Huang, B., & Hew, K. F. (2018). Implementing a theory-driven gamification model in higher education flipped courses: Effects on out-of-class activity completion and quality of artifacts. *Computers & Education*, 125, 254-272. <https://doi.org/10.1016/j.compedu.2018.06.018>
- Huang, B., Hew, K. F., & Lo, C. K. (2019). Investigating the effects of gamification-enhanced flipped learning on undergraduate students' behavioral and cognitive engagement. *Interactive Learning Environments*, 27(8), 1106-1126. <https://doi.org/10.1080/10494820.2018.1495653>
- Ismail, M. A.-A., Ahmad, A., Mohammad, J. A.-M., Fakri, N. M. R. M., Nor, M. Z. M., & Pa, M. N. M. (2019). Using Kahoot! as a formative assessment tool in medical education: A phenomenological study. *BMC Medical Education*, 19(1), 230. <https://doi.org/10.1186/s12909-019-1658-z>
- Jurgelaitis, M., Čeponienė, L., Čeponis, J., & Drungilas, V. (2019). Implementing gamification in a university-level UML modeling course: A case study. *Computer Applications in Engineering Education*, 27(2), 332-343. <https://doi.org/10.1002/cae.22077>
- Jusas, V., Barisas, D., & Jančiukas, M. (2022). Game elements towards more sustainable learning in object-oriented programming course. *Sustainability*, 14(4), 2325. <https://doi.org/10.3390/su14042325>
- Kalogiannakis, M., Papadakis, S., & Zourmpakis, A.-I. (2021). Gamification in science education. A systematic review of the literature. *Education Sciences*, 11(1), 22. <https://doi.org/10.3390/educsci11010022>
- Kapp, K. M. (2012). *The gamification of learning and instruction: Game-Based methods and strategies for training and education*. San Francisco, CA: John Wiley & Sons.
- Kara, N. (2021). A systematic review of the use of serious games in science education. *Contemporary Educational Technology*, 13(2), ep295. <https://doi.org/10.30935/cedtech/9608>
- Kavak, N., & Yamak, H. (2016). Picture chem: Playing a game to identify laboratory equipment items and describe their use. *Journal of Chemical Education*, 93(7), 1253-1255. <https://doi.org/10.1021/acs.jchemed.5b00857>
- Khalidi, A., Bouzidi, R., & Nader, F. (2023). Gamification of e-learning in higher education: A systematic literature review. *Smart Learning Environments*, 10(1), 10. <https://doi.org/10.1186/s40561-023-00227-z>
- Klock, A. C. T., Ogawa, A. N., Gasparini, I., & Pimenta, M. S. (2018). *Does gamification matter? A systematic mapping about the evaluation of gamification in educational environments*. Paper presented at the Proceedings of the 33rd Annual ACM Symposium on Applied Computing.

- Kumar, B. S. (2023). Game-based learning in chemistry education: An overview of the literature. *Research Journal of Educational Sciences*, 11(2), 16-27.
- Kumar, S., Lim, W. M., Sivarajah, U., & Kaur, J. (2023). Artificial intelligence and blockchain integration in business: Trends from a bibliometric-content analysis. *Information Systems Frontiers*, 25(2), 871-896. <https://doi.org/10.1007/s10796-022-10279-0>
- Kustiawan, B. (2024). Utilisation of Quizlet app as a student performance assessment tool by teachers. *International Journal of Language and Ubiquitous Learning*, 2(2), 141-155. <https://doi.org/10.70177/ijlul.v2i2.956>
- Kyewski, E., & Krämer, N. C. (2018). To gamify or not to gamify? An experimental field study of the influence of badges on motivation, activity, and performance in an online learning course. *Computers & Education*, 118, 25-37. <https://doi.org/10.1016/j.compedu.2017.11.006>
- Landers, R. N., Bauer, K. N., & Callan, R. C. (2017). Gamification of task performance with leaderboards: A goal setting experiment. *Computers in Human Behavior*, 71, 508-515. <https://doi.org/10.1016/j.chb.2015.08.008>
- Landers, R. N., Bauer, K. N., Callan, R. C., & Armstrong, M. B. (2015). Psychological theory and the gamification of learning. In *Gamification in education and business*. In (pp. 165-186). Cham: Springer International Publishing.
- Li, X., & Chu, S. K. W. (2021). Exploring the effects of gamification pedagogy on children's reading: A mixed-method study on academic performance, reading-related mentality and behaviors, and sustainability. *British Journal of Educational Technology*, 52(1), 160-178. <https://doi.org/10.1111/bjet.13057>
- Lo, C. K., & Hew, K. F. (2020). A comparison of flipped learning with gamification, traditional learning, and online independent study: The effects on students' mathematics achievement and cognitive engagement. *Interactive Learning Environments*, 28(4), 464-481. <https://doi.org/10.1080/10494820.2018.1541910>
- Loganathan, P., Talib, C., Thoe, N., Aliyu, F., & Zawadski, R. (2019). Implementing technology infused gamification in science classroom: A systematic review and suggestions for future research. *Learning Science and Mathematics*, 14, 60-73.
- Lopez, C. E., & Tucker, C. S. (2019). The effects of player type on performance: A gamification case study. *Computers in Human Behavior*, 91, 333-345. <https://doi.org/10.1016/j.chb.2018.10.005>
- Marín, B., Frez, J., Cruz-Lemus, J., & Genero, M. (2018). An empirical investigation on the benefits of gamification in programming courses. *ACM Transactions on Computing Education*, 19(1), 1-22. <https://doi.org/10.1145/3231709>
- Morris, B. J., Croker, S., Zimmerman, C., Gill, D., & Romig, C. (2013). Gaming science: The "Gamification" of scientific thinking. *Frontiers in Psychology*, 4, 607. <https://doi.org/10.3389/fpsyg.2013.00607>
- Ndihokubwayo, K., Uwamahoro, J., & Ndayambaje, I. (2020). Effectiveness of PhET simulations and YouTube videos to improve the learning of optics in Rwandan secondary schools. *African Journal of Research in Mathematics, Science and Technology Education*, 24(2), 253-265. <https://doi.org/10.1080/18117295.2020.1818042>
- Ndlovu, T. N., & Mhlongo, S. (2020). *An investigation into the effects of gamification on students' situational interest in a learning environment*. Paper presented at the 2020 IEEE Global Engineering Education Conference (EDUCON), IEEE.
- Nguyen, L. Q., & Van Le, H. (2023). The role of Quizlet learning tool in learners' lexical retention: A Quasi-experimental study. *International Journal of Emerging Technologies in Learning*, 18(3), 38-50. <https://doi.org/10.3991/ijet.v18i03.34919>
- North, B., Diab, M., Lamer, P., Zaraq, J., Philippe, S., Müller, J., & Fischer, H. (2021). *Developing a platform for using game-based learning in vocational education and training*. Paper presented at the 2021 IEEE Global Engineering Education Conference (EDUCON).
- Ortega-Arranz, A., Asensio-Pérez, J. I., Martínez-Monés, A., Bote-Lorenzo, M. L., Ortega-Arranz, H., & Kalz, M. (2022). GamITool: Supporting instructors in the gamification of MOOCs. *IEEE Access*, 10, 131965-131979. <https://doi.org/10.1109/access.2022.3228762>
- Papadakis, S., Trampas, A. M., Barianos, A. K., Kalogiannakis, M., & Vidakis, N. (2020). *Evaluating the learning process: The "Thimel Edu" educational game case study*. Paper presented at the Proceedings of the 12th International Conference on Computer Supported Education (CSEDU 2020). SCITEPRESS.

- Partovi, T., & Razavi, M. R. (2019). The effect of game-based learning on academic achievement motivation of elementary school students. *Learning and Motivation*, 68, 101592. <https://doi.org/10.1016/j.lmot.2019.101592>
- Pippins, T., Anderson, C. M., Poindexter, E. F., Sultemeier, S. W., & Schultz, L. D. (2011). Element cycles: An environmental chemistry board game. *Journal of Chemical Education*, 88(8), 1112-1115. <https://doi.org/10.1021/ed100576a>
- Ponikwer, F., & Patel, B. A. (2021). Work-integrated learning: A game-based learning activity that enhances student employability. *Journal of Chemical Education*, 98(3), 888-895. <https://doi.org/10.1021/acs.jchemed.0c00919>
- Rastegarpour, H., & Marashi, P. (2012). The effect of card games and computer games on learning of chemistry concepts. *Procedia-Social and Behavioral Sciences*, 31, 597-601. <https://doi.org/10.1016/j.sbspro.2011.12.111>
- Reeve, J., & Tseng, C.-M. (2011). Agency as a fourth aspect of students' engagement during learning activities. *Contemporary Educational Psychology*, 36(4), 257-267. <https://doi.org/10.1016/j.cedpsych.2011.05.002>
- Ryan, R. M., & Deci, E. L. (2024). Self-determination theory. In Encyclopedia of quality of life and well-being research. In (pp. 6229-6235). Cham Springer International Publishing.
- Sailin, S. N., Alias, N. F., Jusaini, B. A., Ishak, H., Yang, L., & Chong, G. S. (2019). Integrating Quizlet for improving students' understanding of the science subject. *Practitioner Research*, 1, 53-67. <https://doi.org/10.32890/pr2019.1.3>
- Sánchez-Martín, J., Cañada-Cañada, F., & Dávila-Acedo, M. A. (2017). Just a game? Gamifying a general science class at university: Collaborative and competitive work implications. *Thinking Skills and Creativity*, 26, 51-59. <https://doi.org/10.1016/j.tsc.2017.05.003>
- Sharmin, N., & Chow, A. K. (2024). Impacts of gamified homework in an online oral biology course. *Journal of Dental Education*, 88(Suppl. 3), 1971-1974. <https://doi.org/10.1002/jdd.13361>
- Sholahudin, U., & Yenti, Y. (2022). Possible gamification learning for optimizing student learning motivation? *EduLine: Journal of Education and Learning Innovation*, 2(3), 261-266. <https://doi.org/10.35877/454RI.eduline975>
- Sibomana, A., Karegeya, C., & Sentongo, J. (2021). Effect of cooperative learning on chemistry students' achievement in Rwandan day-upper secondary schools. *European Journal of Educational Research*, 10(4), 2079-2088. <https://doi.org/10.12973/eu-er.10.4.2079>
- Sousa Lima, M. A., Monteiro, Á. C., Melo Leite Junior, A. J., de Andrade Matos, I. S., Alexandre, F. S. O., Nobre, D. J., . . . da Silva Júnior, J. N. (2019). Game-based application for helping students review chemical nomenclature in a fun way. *Journal of Chemical Education*, 96(4), 801-805. <https://doi.org/10.1021/acs.jchemed.8b00540>
- Suh, A., Wagner, C., & Liu, L. (2018). Enhancing user engagement through gamification. *Journal of Computer Information Systems*, 58(3), 204-213. <https://doi.org/10.1080/08874417.2016.1229143>
- Sweller, J. (2020). Cognitive load theory and educational technology. *Educational Technology Research and Development*, 68(1), 1-16. <https://doi.org/10.1007/s11423-019-09701-3>
- Tsay, C. H.-H., Kofinas, A., & Luo, J. (2018). Enhancing student learning experience with technology-mediated gamification: An empirical study. *Computers & Education*, 121, 1-17. <https://doi.org/10.1016/j.compedu.2018.01.009>
- van Gaalen, A. E. J., Brouwer, J., Schönrock-Adema, J., Bouwkamp-Timmer, T., Jaarsma, A. D. C., & Georgiadis, J. R. (2021). Gamification of health professions education: A systematic review. *Advances in Health Sciences Education*, 26(2), 683-711. <https://doi.org/10.1007/s10459-020-10000-3>
- Vasanthi, V., Bakyalakshmi, V., & Kalaivani, S. (2023). A review on learning through game-based tools. *Journal of Propulsion Technology*, 44(6), 6051-6055.
- Vidakis, N., Barianos, A. K., Trampas, A. M., Papadakis, S., Kalogiannakis, M., & Vassilakis, K. (2020). *In-game raw data collection and visualization in the context of the "ThimelEdu" educational game*. Paper presented at the International Conference on Computer Supported Education, Springer.
- Wang, J., Fang, Y., Frank, E., Walton, M. A., Burmeister, M., Tewari, A., . . . Wu, Z. (2023). Effectiveness of gamified team competition as mHealth intervention for medical interns: A cluster micro-randomized trial. *npj Digital Medicine*, 6(1), 4. <https://doi.org/10.1038/s41746-022-00746-y>

- Wilson, A. M., & Samide, M. J. (2014). Games, games, games; Playing to engage with chemistry concepts. *The Chemical Educator*, 19(1), 167-170.
- Winter, J., Wentzel, M., & Ahluwalia, S. (2016). Chairs!: A mobile game for organic chemistry students to learn the ring flip of cyclohexane. *Journal of Chemical Education*, 93(9), 1657-1659. <https://doi.org/10.1021/acs.jchemed.5b00872>
- Yenikalaycı, N., Çelikler, D., & Aksan, Z. (2019). Ion Hunters: Playing a game to practice identifying anions and cations and writing their names and formulas. *Journal of Chemical Education*, 96(11), 2532-2534. <https://doi.org/10.1021/acs.jchemed.8b00732>
- Zahedi, L., Batten, J., Ross, M., Potvin, G., Damas, S., Clarke, P., & Davis, D. (2021). Gamification in education: A mixed-methods study of gender on computer science students' academic performance and identity development. *Journal of Computing in Higher Education*, 33(2), 441-474. <https://doi.org/10.1007/s12528-021-09271-5>
- Zainuddin, Z., Shujahat, M., Haruna, H., & Chu, S. K. W. (2020). The role of gamified e-quizzes on student learning and engagement: An interactive gamification solution for a formative assessment system. *Computers & Education*, 145, 103729. <https://doi.org/10.1016/j.compedu.2019.103729>
- Zeybek, N., & Saygı, E. (2024). Gamification in education: Why, where, when, and how?—A systematic review. *Games and Culture*, 19(2), 237-264. <https://doi.org/10.1177/15554120231158625>
- Zhang, H., & Fang, L. (2019). *Project-based learning for statistical literacy: A gamification approach*. Paper presented at the Digital turn in schools—research, policy, practice: Proceedings of ICEM 2018 Conference.
- Zhang, Z., Muktar, P., Wijaya Ong, C. I., Lam, Y., & Fung, F. M. (2021). CheMakers: Playing a collaborative board game to understand organic chemistry. *Journal of Chemical Education*, 98(2), 530-534. <https://doi.org/10.1021/acs.jchemed.0c01116>

*Views and opinions expressed in this article are the views and opinions of the author(s), International Journal of Education and Practice shall not be responsible or answerable for any loss, damage or liability etc. caused in relation to/arising out of the use of the content.*