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THE EFFECT OF KAHOOT! -BASED LEARNING ON STUDENTS' COMPUTATIONAL THINKING AND LANGUAGE LEARNING ATTITUDES

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Abstract

Computational thinking is considered an essential 21st-century skill, improving problem-solving and creative thinking skills. Therefore, there is increasing attention being paid to integrating CT into education. Furthermore, Oman Vision 2040 highlights the significance of advancing and cultivating a skilled workforce, prioritising competencies like computational thinking. Studies conducted on higher education students revealed a gap in CT skills among higher education students. As a result, this study aimed to address this gap by exploring CT development in higher education, emphasising the integration of innovative teaching approaches like game-based learning, which engaged students in activities aligned with CT principles. A quasi-experimental design was employed, utilising pre- and post-tests, interviews, and Computational Thinking and Language Learning Attitudes questionnaires to collect data from 24 Foundation Programme students at Sultan Qaboos University. It is worth mentioning that the intervention was informed by the TPACK framework for task design and reinforced by Brennan and Resnick's (2012) computational thinking dimensions, offering both pedagogical and learner-centred theoretical grounding. The results indicated a significant positive impact on both CT skills and language learning attitudes. Based on these findings, it is recommended that higher education curricula incorporate game-based learning to enhance CT skills and student engagement.

Keywords: Language Learning Attitudes, CT competencies, 21st century skills, Game-based learning, Higher Education students, critical thinking,

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Introduction

The rapid evolution of technology shapes education, requiring institutions to equip students with the necessary knowledge and skills to navigate future challenges. The World Economic Forum's Future of Jobs Report (2020) highlights problem-solving and technological skills as key competencies. Computational thinking (CT) is a crucial 21st-century skill, enhances students' abilities to tackle complex issues effectively. Wing (2006) emphasised CT's broad applicability beyond computer science. Despite its importance, research indicates a gap in CT competencies among higher education students, necessitating innovative instructional strategies game-based learning (GBL). GBL actively engages students in tasks that align with CT principles, making it a promising pedagogical approach (Adipat et al., 2021).

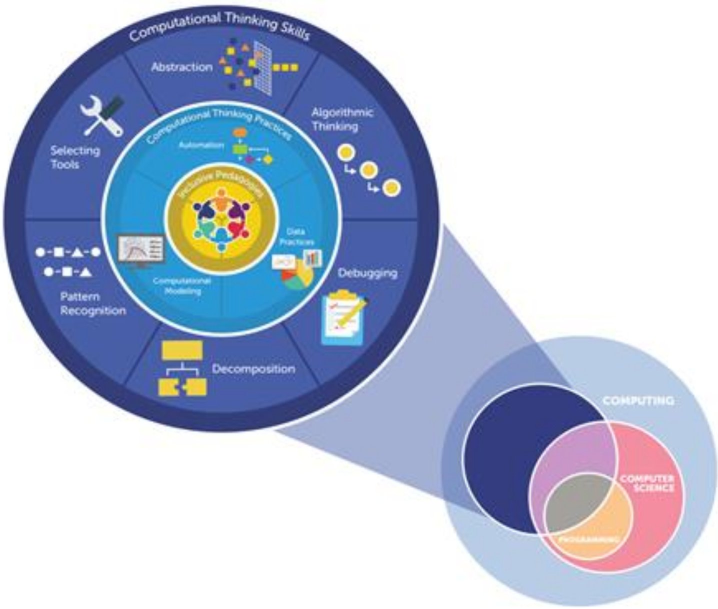
In 2019, the government introduced Oman Vision 2040, a strategic plan aimed at positioning the country among the world's developed nations. A core aspect of this vision is advancing education by empowering human capital, equipping national talent with competitive skills, updating school curricula to align with future needs, and supporting diverse learning pathways. Oman's educational philosophy is guided by principles that shape the learning process, including the Society of Knowledge and Technology principle, which underscores the importance of equipping students with the ability to engage with modern technology, develop higher-order thinking skills, and foster inquiry-based learning. The goal is to cultivate an environment that encourages observation, analysis, experimentation, and creativity (Oman Educational Council, 2017).

In line with these national priorities, computational thinking, encompassing problem-solving, critical thinking, and algorithmic reasoning, plays a crucial role in preparing Omani students for evolving technological demands. This study aimed to examine the impact of GBL on higher education students' CT skills and attitudes toward language learning.

Problem Statement

Universities in the United States and overseas are reevaluating their undergraduate computer science curriculum. They are altering their initial computer science course to encompass essential principles and concepts, not solely focused on programming. For example, according to Bryant et al. (2010), Carnegie Mellon has adjusted its undergraduate first-year courses to enhance CT for non-majors (as cited in Wing 2017). "If we are to equip every student in the next generation with the skill set to participate in our technological society, all educators, across disciplines and grade bands, need to provide opportunities for students to engage in computational skills and practices" (Mills et al., 2021). Additionally, some studies urge to improve the CT skills of students, as, based on these studies, the CT of the students does not meet the needs of 21st-century requirements because students have low CT competencies. According to Harangue & Kata (2020), the result of their study reveals that it is necessary to rethink education where developing CT would be of key significance. Also, they clarified that, based on their measurement, developing students' CT has to be a national educational aim. Furthermore, Mills et al., (2021) point of view is in line with Harangus & Katai, (2020) as they emphasized that integrating CT in classrooms cannot be done by the teachers only or the institution; however, it must be a collective work and decision from the education policymakers to provide an appropriate classroom environment. They have provided a framework that demonstrates the integration of CT in different curricula and not only focuses on programming, but their framework also has three main components or circles (Figure 1). The first circle highlights CT skills, the cognitive procedures essential to employing computational tools to solve problems. The second circle reveals the CT practices that integrate various computational skills to solve problems. In contrast, the innermost circle depicts the pedagogies that need to engage students in a CT environment (Mills et al., 2021).

Figure 1. Framework for computational thinking Integration (Mills et al., 2021)



In addition, Harangus & Katai, (2020) pointed out that to improve CT skills, different teaching styles have to be implemented as CT consists of complex concepts (Harangus & Katai, 2020). As a result, using GBL will create a more engaged and interactive class based on different research, as game-based learning has the potential to "engage the learner in different ways. They could provide effective engagement through characters, behavioural engagement by the use of gestures and movements" (Vásquez et al., 2017). Thus, implementing GBL might enhance the CT skills of higher education students and equip them with the skills required in the 21st century, specifically those that will meet Oman's 2040 vision.

Research Significance

This research holds significant potential as it addresses an important educational gap by concentrating on improving students' CT skills, a recognized challenge in modern education and workforce readiness. By highlighting the importance of CT and proposing game-based learning as a practical solution, the research is highly relevant to educational policy and practice, aiming to enhance the workforce qualifications of graduates and aligning with Oman Vision 2040's goals. This interdisciplinary study has broader implications, extending beyond Oman, and its findings could contribute to discussions on curriculum reform and instructional strategies, making it a valuable addition to the growing body of knowledge on CT education.

Oman Vision 2040 emphasizes the development of a skilled workforce that can thrive in a technology- driven, knowledge-based economy. So, this study directly supports these goals by proposing GBL as an innovative instructional strategy to promote CT skills in higher education. Curriculum reform is crucial in achieving this, as traditional methods often lack the needed engagement and interactive components to foster CT. The study provides practical insights for educational institutions to integrate GBL into curricula, therefore equipping students with the critical thinking and problem-solving skills required for the future workforce.

Additionally, in terms of instructional strategies, this research advocates for a shift from teacher-centered to learner-centred approaches, which in aligned with Oman Vision 2040's emphasis on adaptive learning strategies that cater to diverse student needs. Using GBL will allow educators to create a more interactive, dynamic and engaging learning environment, boosting both cognitive development and positive attitudes towards learning. This approach not only develops CT skills but also improves students' engagement and motivation in language learning, thereby contributing to curriculum modernization in line with the vision's goals. Moreover, the findings from this research can affect policy reforms in education by encouraging the adoption of digital tools like GBL in everyday teaching practices. Implementing these tools help bridge the gap between traditional rote learning and the need for 21st- century skills, thus ensuring that graduates are equipped to meet the demands of an increasingly complex and technology-driven global economy. Although the focus of this study is on Oman, the implications of its findings are broader. The integration of CT through GBL is a global educational challenge, and the insights provided here can contribute to the international conversation on curriculum reform and instructional innovation.

Research Justification

This research focuses on a critical and widely recognized educational gap regarding CT skills. As technology advances and affects aspects of modern life, the acquisition of CT skills has become increasingly imperative for students to succeed in the 21st century. Furthermore, improving CT skills in higher education can significantly impact students' employability and workforce competency, which is important for individual success and the broader economic development of Oman, aligning harmoniously with the ambitious goals and strategies outlined in Oman Vision 2040. The research also delves into innovative teaching methods, particularly the incorporation of GBL which offers an engaging approach to pedagogy. The exploration of such innovative strategies contributes to the evolving body of knowledge on effective educational practices in the digital age. Moreover, by aligning this study with Oman Vision 2040, which outlines the significance of equipping students with the skills needed to meet the challenges of the 21st century, the research becomes integral to the country's development goals.

Research Objectives

This research addresses two main objectives:

Objective 1: To assess the impact of game-based learning on students' computational thinking skills by measuring their performance and proficiency in computational thinking concepts.

Objective 2: To assess the influence of game-based learning on students' attitudes towards language learning, focusing on factors like motivation, engagement, and perceived enjoyment.

Additionally, the study explores how students perceive the Kahoot! -based learning process and how it supports both computational thinking and language learning development

Research Questions

This research aims to answer the following questions:

1. To what extent does game-based learning affect students'

computational thinking?
2. To what extent does game-based learning affect students' attitudes towards language learning?
3. What are students' perceptions of Kahoot! -based learning processes in developing computational thinking and language learning skills?

Theoretical Framework

This study draws upon Constructivism, Behaviorism and the TPACK model to explore GBL's effectiveness. Constructivism advocated by theorists like Piaget and Vygotsky, underlines that learners construct knowledge through interaction, making GBL ideal for fostering CT skills. Behaviorism, initiated by psychologists such as Skinner, highlights reinforcement mechanism such as rewards, which are inherent in GBL. The TPACK model integrates technology, pedagogy, and content knowledge to guide effective technology use in education.

Constructivism Theory

Constructivism means that knowledge is constructed in the learner's mind and that learners build on their knowledge by searching for information, trying to find meaning in what they are learning, and reflecting and receiving knowledge (Vygotsky, 1978). Von Glasersfeld (2001) has viewed constructivism as looking for 'fit' rather than 'match' with reality. In other words, looking for information that matches reality leads to having individuals with the same minds as copies and replicas of each other; however, concentrating on having information that fits reality creates different shapes of knowledge due to the variety in individuals' minds and background, so each constructs knowledge based on their way of interacting with reality. According to Piaget (1952), who is widely regarded as the first constructivist, knowledge is constructed through life experience and the different stages of an individual's life during which they attempt to structure, organize and restructure their experiences based on the evolving patterns of thought (Bodner, 1986). In addition, the key elements of constructivism are, that the main goal of education is to allow learners to gain and create new knowledge, learning is the approach of constructing meaning, with emphasis on active learning and discovery, and learners construct knowledge based on their own experience and schemes of thoughts and teacher role is as a facilitator of resources to ensure that knowledge and learning is taking place (Lodi, 2020). In the context of GBL, this theory is particularly relevant because it emphasizes active engagement and problem-solving. For example, in this study, students participated in games where they had to answer questions about which CT skills are involved, thereby actively constructing their CT skills. This aligns with Piaget's concept of cognitive development and Vygotsky's social constructivism, where learning occurs through interaction and collaboration (Vygotsky, 1978). Based on these aspects of constructivism, a matrix has been developed to show how constructivism aligns with CT and GBL. Moreover, constructivism highlights that the classroom environment has to be student-centred learning; similarly, for students to be CT competent they have to have hands-on experience. In this research, the role of the teacher was to guide the students, which gave more space for students to construct knowledge based on their interaction with the games. Collaboration is also a key aspect that is associated with constructivism and CT. GBL is ground to achieve this because this learning approach matches the aspects of CT and constructivism theory. It provides a collaborative and interactive environment in which students have the comfort and the base to work together and share their knowledge to overcome challenges. It also allows learners to reflect on their learning by having the feature of immediate feedback and the different types of evaluation that encourage students to identify areas for improvement and improve metacognitive awareness, which is in line with Applefield et al., (2000) who highlighted that students build on knowledge based on active construction process rather than passive reception of information. Recent studies, such as Zainuddin et al., (2020), have shown that GBL environments foster deeper engagement and understanding, further supporting the application of constructivist principles in this context.

Table 1. Research Matrix of the implementation of constructivism in this Research

Aspect	Constructivism Theory	Computational Thinking	Game-Based Learning
Active Learning	Emphasizes active engagement of learners	Encourages learners to actively analyze	Provides interactive environments where

Aspect	Constructivism Theory	Computational Thinking	Game-Based Learning
	in constructing knowledge through exploration, collaboration, and reflection.	problems, break them down into smaller parts, and develop solutions through iterative processes.	learners engage actively with content, make decisions, and explore consequences, fostering hands-on learning experiences.
Collaboration and Social Learning	Values collaborative learning environments where learners share and construct knowledge together.	Promotes collaborative problem-solving and communication skills essential for computational thinking, encouraging learners to work together to tackle challenges.	Facilitates social interaction among learners through multiplayer games, cooperative activities, and online communities, fostering peer learning and knowledge sharing.
Reflection and Metacognition	Emphasizes the importance of reflection and metacognitive strategies in enhancing learning outcomes, encouraging learners to monitor their understanding and adapt their approaches accordingly.	Promotes metacognitive skills such as planning, monitoring, and evaluating problem-solving processes, enabling learners to reflect on their CT strategies and refine their approaches.	Incorporates feedback mechanisms, debriefing sessions, and reflective activities within game environments to encourage learners to assess their performance, identify areas for improvement, and develop metacognitive awareness.
Contextualized Learning Environments	Advocates for learning experiences that are situated within meaningful contexts relevant to learners' interests, experiences, and real-world applications.	Encourages learners to apply CT skills within authentic contexts, such as solving real-world problems, designing projects, or creating digital artifacts.	Provides immersive and interactive virtual environments that simulate real-world scenarios, enabling learners to apply CT skills in context-rich settings and make connections between abstract concepts and concrete applications.
Scaffolding and Support	Promotes the use of scaffolding strategies and instructional support to guide	Offers scaffolding tools, resources, and instructional support to help learners	Incorporates scaffolding mechanisms, tutorials, hints, and adaptive feedback systems

Aspect	Constructivism Theory	Computational Thinking	Game-Based Learning
	learners through challenging tasks and provide the necessary support for skill development.	develop CT skills, such as algorithmic thinking, pattern recognition, and problem decomposition.	within game designs to support learners' cognitive

Behaviourism

Behaviourism was originally a psychological theory founded by J.B Watson, but it gained popularity and was considered significant in education during the 1950s. The key principle of this theory relies on comprehending individuals' behaviors through stimuli-responses interactions and the relation between them (Moore, 1999). In other words, behaviourism studies how individuals react to different situations, events or actions, and these reactions are observable actions or behaviors. E.L. Thorndike brought up the concept of that learning process involves the occurrence of relationship between a behaviour and its consequences (Islam, 2015), which is now called the behaviourist theory of stimulus-response learning. This theory was developed by Skinner in the operant conditioning model which emphasized that a learning process exists when there are reinforcements and rewards to individuals' actions (Clark, 2018). It is worth mentioning that there are two types of behaviourism, methodological behaviourism and radical behaviourism. Methodological behaviourism excludes any other factors than external and observable behaviors; however, radical behaviourism includes analysis of internal mental process along with external behaviours. In this research in which the context is GBL, radical behaviourism is considered, and it is implemented in a way that learners receive reinforcement (e.ge., points, rewards.. etc) for their performance (response) which in return affects their learning attitudes. Games often incentivize certain behaviours by offering in-game rewards such as currency, power-ups, and points. Conversely, undesirable behaviour may result in a penalty, such as losing in-game currency, items, or even the player's life. It's worth noting that games frequently use this reward and punishment system to encourage players to engage in specific behaviours and discourage others.

This is particularly important in the GBL context, where rewards and punishments are used to shape student engagement and attitudes.

Table 2. Research Matrix of the implementation of Behaviourism in the research

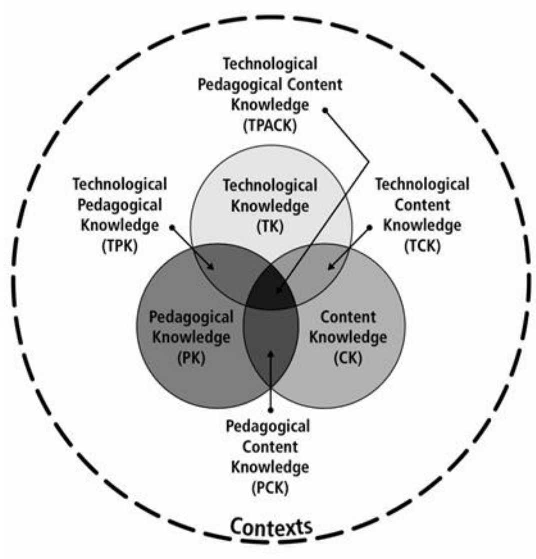
Aspect	Behaviorism	Computational Thinking	Language Learning Attitudes	Game-Based Learning
Learning Principles	Emphasis on stimulus-response	Focus on problem-solving, algorithms	Positive reinforcement, repetition	Engages through challenges, rewards
Approach to Learning	Passive learning, conditioning	Active problem-solving, logical thinking	Positive attitudes towards language learning	Interactive learning environment
Feedback Mechanisms	Rewards, punishment	Feedback loops, debugging	Encouragement, correction	Immediate feedback, progress tracking
Motivation	Extrinsic motivation	Intrinsic motivation	Intrinsic motivation, interest	Intrinsic motivation, achievement
Language Acquisition	Repetition, drills	Analytical thinking, pattern recognition	Practice, exposure to language	Contextual language use, immersion
Cognitive Development	Associative learning, memorization	Critical thinking, abstraction	Critical thinking, problem-solving	Decision-making, strategy development
Pedagogical Strategies	Drill and practice	Problem-based learning, algorithm development	Immersion, communicative activities	Simulations, role-playing
Adaptability	Limited adaptability	Flexible problem-solving approaches	Openness to new language experiences	Adaptive challenges, personalized learning

The connection between behaviourism, CT, language learning attitudes, and GBL creates an interactive framework that helps to develop effective and engaging educational experiences (Krath et al., 2021). Behaviourism highlights stimulus-response associations and repetitive learning techniques, while CT concentrates on problem-solving and algorithmic reasoning. Positive reinforcement and intrinsic motivation towards language acquisition are the primary focus of language learning attitudes. In this research, GBL combines these principles by providing an interactive environment that encourages active participation, immediate feedback, and intrinsic motivation through challenges and rewards. By combining the feedback mechanisms of behaviourism, the problem-solving approaches of CT, and the motivational factors of language learning attitudes, GBL provides a versatile platform for promoting cognitive development, language acquisition, and adaptive learning strategies (Krath et al., 2021). This holistic approach enhances learners' engagement and motivation, cultivates critical thinking skills, and fosters a positive attitude towards language learning, ultimately facilitating effective and enjoyable learning experiences.

TPACK Model

TPACK refers to Technology Pedagogy Content and Knowledge. This model is developed based on the PCK framework, which focuses on pedagogy, content and knowledge, but due to the development in today's world and the integration of technology, TPACK has been introduced to assist teachers in comprehending educational technologies and PCK, so in this model, PCK interacts with each other and with Technology to deliver effective learning (Koehler et al., 2013). Teachers have three main areas of knowledge: content, pedagogy, and technology. These areas of knowledge interact with each other and are represented as PCK (pedagogical content knowledge), TCK (technological content knowledge), TPK (technological pedagogical knowledge), and TPACK (technology, pedagogy, and content knowledge). All these areas of knowledge are equally important to the model, and this is represented in the framework (Figure 2 adopted from Koehler et al., 2013).

Figure 2. *TPACK Framewor*



Content Knowledge (CK)

CK refers to the teachers' understanding of subject matter across different levels (Koehler et al., 2013). For example, the content of the English subject of grade 2 differs significantly from the foundation-level content. Teachers must comprehend the critical differences to ensure accurate knowledge delivery and prevent misconceptions.

Pedagogical Knowledge (PK)

PK involves teaching methods, classroom management, lesson planning, and student assessment. It encompasses understanding how students learn, applying appropriate teaching techniques, and adapting strategies based on students' needs (Koehler et al., 2013). The more PK- competent teachers are, the better they can facilitate learning and assess students' progress.

Pedagogical Content Knowledge (PCK)

PCK, introduced by Shulman (1980s), refers to the ability to deliver content effectively using diverse instructional methods. It includes interpreting subject matter, using multiple representations, and tailoring instructions to students' learning styles (Koehler et al., 2013). A deep understanding of content and pedagogy allows teachers to select the most suitable approaches for different learners.

Technology Knowledge (TK)

TK involves understanding and effectively utilizing technology in daily and educational settings. It extends beyond basic digital literacy, requiring awareness of evolving technologies like AI and their applications (NRC, 1999 as cited in Koehler et al., 2013). A strong grasp of TK enables teachers to integrate technology efficiently to enhance learning

Technological Content Knowledge (TCK)

Development in technology offers a new understanding of the content due to the wide range of resources (big data) and the change that this development brings to the subject matter (content). New ways of perceiving the world have been made possible through technological advancements. Examples include perceiving the heart as a pump or the brain as a machine for processing information. These technologies have offered perspectives for understanding various phenomena. All of these affect the understanding of the content because now it requires thinking deeply about the technologies associated with this subject matter and how technology influenced this subject or vice versa (Koehler, et al., 2013). Teachers are required to comprehend which technologies are appropriate for addressing subject-matter learning in their context.

Technological Pedagogical Knowledge (TPK)

TPK concentrates on the integration of technology in teaching. Teachers must determine which tools are available, practical and suitable for their context. Many technologies, like Microsoft Office or social media platforms, were not designed for education but can be adaptable for learning purposes. Teachers must reject functional fixedness and cultivate the ability to perceive beyond the most common uses of technologies, modifying them for customized pedagogical purposes (Taopan et al., 2020). Therefore, TPK demands a proactive, inventive, and open-minded approach to technology use, not for its own sake, but to enhance student learning and comprehension.

Technological Pedagogical Content Knowledge (TPACK)

According to Koehler, Mishra and Cain (2013), TPACK goes beyond the individual components, technology, pedagogy and content and highlights the integration of all three forms of knowledge. It acknowledges that effective teaching with technology requires understanding how content, pedagogy, and technology interact, intersect and influence one another. Each teacher has a different classroom environment with different students' abilities, perspectives and concepts, so based on TPACK, each teacher has to have the competence and the flexibility to decide on the technological tools, learning approach, methods used …etc. TPACK also demonstrates that having a fixed structure of teaching using the same method for all the students does not work well and will not result in creating an effective learning environment because what works with group A might not work with group B. However, they are at the same level, studying the same subject receiving the same method of learning and using the same technological tools. It is all because of the different components of TPACK. Once the teacher deeply understands the way they work together, they will be able to create a positive and effective learning environment.

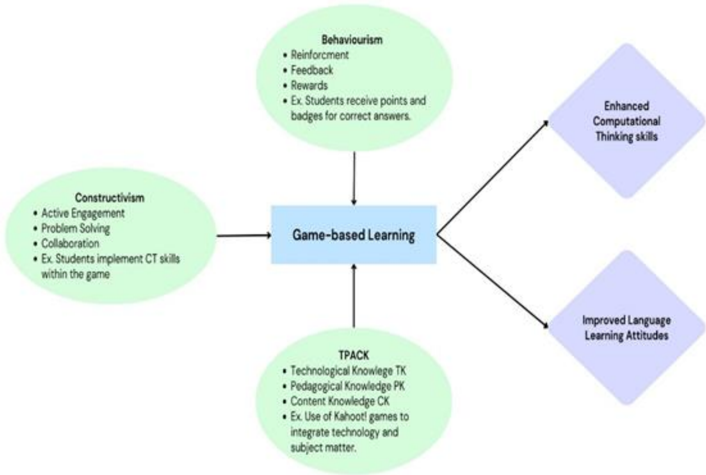
Implementation of TPACK in this Research

For this research, the Technological Pedagogical Content Knowledge (TPACK) framework was used to inform the development of instructional materials, specifically Kahoot! quizzes designed to assess the effect of game-based learning (GBL) on students' computational thinking (CT) and attitudes towards language learning. Although TPACK is mainly a teacher-focused framework, it served as a design model in this study to align content, pedagogy, and technology in the integration of Kahoot! activities. This alignment ensured that students engaged with structured learning experiences that support the development of both CT and language skills. To more directly address the student learning perspective, Brennan and Resnick's (2012) framework of computational thinking was also incorporated. This framework identifies three core dimensions of CT concepts (e.g., sequences, loops), practices (e.g., testing, debugging), and perspectives (e.g., expressing, connecting, questioning), which informed both task design and evaluation criteria. TPACK specifically influenced the selection and integration of technological tools like Kahoot!, ensuring their use was grounded in a solid understanding of content knowledge and effective pedagogical strategies. It guided the creation of quiz items that targeted CT and language learning objectives, while leveraging Kahoot!'s interactive features to promote active participation and assess students' attitudes toward GBL. As Taopan et al. (2020) argue, TPACK is rooted in constructivist principles, emphasising the need for learners to actively participate, reflect, collaborate, and be deeply engaged in the learning process. By aligning technology-enhanced tasks with pedagogical principles, TPACK supported the development of interactive learning tools that effectively integrated technological innovation, instructional design, and subject-specific content-highlighting its value in investigating the impact of GBL on CT and language learning attitudes.

Integration and Coherence

The theoretical framework section illustrates how these theories and the TPACK model collectively underpin this research. Constructivism guides the overall learning process, behaviourism supports motivation and engagement through reinforcement, and the TPACK model ensures the effective integration of technology. Together, these theories provide a robust foundation for understanding the impact of GBL on higher education students' CT and language learning attitudes. The diagram below (Figure 3) demonstrates the practical application of these theories in the context of GBL to improve CT and language learning attitudes.

Figure 3. Theoretical Framework Integration in Game-based Learning



Methodology

Institutional and ethical constraints have affected the research design as random assignment and a true-control group were not feasible; therefore, a quasi- experimental pre-post design without randomization was employed over eight sessions in a Reading and Vocabulary class. However, this design facilitates practical implementation within real classroom contexts but limits the ability to make strong causal claims. Participants (n=24) were Foundation Programme students at Sultan Qaboos University. The experimental group used Kahoot! Quizzes designed with CT principles, while the control group followed traditional instruction. Data collection methods included pre- and post-tests, questionnaire and interviews. The Mann- Whitney test was used for statistical analysis due to the small ample size.

Population & Sample

The target population of this study is students at the foundation level in higher education institutions in Oman. The sample consisted of 24 male and female students at Sultan Qaboos University, Foundation students of Spring 23/24 levels 5 and 6: FBES0506. Convenience sampling was used as the head of the Central Research and Conference Committee (SM) at the Centre for Preparatory Studies at Sultan Qaboos University sent a request to all foundation teachers to volunteer for this research if interested. Accordingly, the research was conducted in the available section (Table 3). In other words, this research included a relatively small sample size due to logistical and institutional constraints. A formal a priori power analysis was not conducted, but given the exploratory nature of this research, the findings are intended to yield initial insights rather than generalizable claims. As recommended by Field (2018), caution is exercised in interpreting the statistical results due to potential limitations in statistical power. The experimental and control groups had 12 students whose major is computer science, and the teacher of the experimental group pointed out that she hadn't used Kahoot! before with her students and she is new to this GBL platform. The experimental group had both male and female students; however, the male students form 63.6% of the sample, while the female students form 36.4% (figure 4).

Figure 4. Female & Male Participation

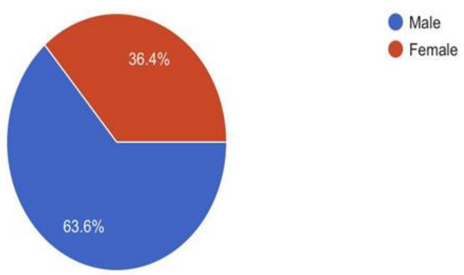


Table 3. Demographic Information on the Participants

Characteristics	Frequency	Valid Percentage
Gender		
Male	16	66.7
Female	8	33.3
Age		
18-20	-	-
University		
Sultan Qaboos University	-	-

Foundation Level Level 5	-	-
Section		
70 (Experiment Group)	12	50
80 (Control Group)	12	50

Instrument

This research is a mixed method research, so quantitative and qualitative methods were followed to collect the data.

Pre-test and Post-test

A pre-test was conducted to measure students' equivalence, and then at the end of the experiment, a post-test was administered to measure CT skills and attitudes toward language learning. The tests were content-based and were designed by the foundation department staff at CPS following the guidelines and regulations set by the institution and have undergone thorough review by the examiner (Table 4).

Table 4. Test Specification

Parts	Type of Questions	Marks
Part 1	MCQs	5 marks
Part 2	Fill in the blanks.	5 marks
Part 3	Match definitions.	5 marks
Part 4	MCQs	5 marks

CT Questionnaire

Besides conducting the pre-test, a CT skills questionnaire was done prior to the experiment for both groups in order to measure their CT skills before and after the intervention. It is worth mentioning that this questionnaire is done in order to control the extraneous variables and to reduce their influence on the research result and as a tool to answer the first question, which concerns the impact of GBL on students' CT skills. The questionnaire involves two parts; the first part is about demographic information, including the gender and the section number. The second part includes 22

Likert items that focus on the following CT skills: Abbreviations Decomposition, Pattern Recognition, Abstraction, Algorithmic Thinking, Generalization, Testing and debugging and Visualization (Table 5).

Table 5. CT Skills

Item	CT Skill
Items: 1,3, 6, 7, 11,12	Abstraction
Items:2, 5,	Visualization
Items: 4, 11, 18, 20	Algorithm thinking
Items:6, 9, 12, 13	Generalization
Items: 8, 9, 14,16, 17, 21 ,22	Testing & Debugging
Items: 9, 11,	Pattern Recognition
Items: 10, 11, 15, 19	Decomposition

Validity: The questionnaire was adopted from Rottenhofer et al., (2022). They have used this questionnaire in their research to measure the level of CT in Austrian Secondary Schools.

Reliability: The reliability of this questionnaire was calculated using Cronbach's coefficient and the coefficient was (α= 0.74) to the questionnaire items which considered acceptable according to Fraenkel and Wallen (1996) (as cited in Mohamad et al., 2015)

Language Learning Attitude Questionnaires

Another questionnaire was conducted at the beginning of the intervention and at the end, but this one aims to answer the second research question, which focuses on studying the impact of GBL on students' language learning attitudes. The questionnaire was conducted online using Goole Forms in order to make it easier for the students to get access. The first part of the questionnaire is intended to gather the demographic information of the students, including their gender and section number, to enable comparison of their responses. The second part of the questionnaire consists of Likert questions, which concentrated on a number of language learning attitudes: interest and enjoyment, motivation, language anxiety, collaboration and social interaction. The teachers of both sections were informed to ask the students to complete the questionnaire in class in order to ensure that they comprehend all the items.

Validity: The questionnaire was adopted from Rottenhofer et al., (2022). They used this questionnaire in their research to measure the level of CT in Austrian Secondary Schools.

Reliability: The reliability of this questionnaire was calculated using Cronbach's coefficient and the coefficient was (α= 0.70)

Interviews

Along with the above-mentioned instruments, interviews have been conducted with some of the participants to analyze the effectiveness of GBL on their CT and attitudes toward language learning and to allow the opportunity for them to share their thoughts on the use of this approach. The interview is also conducted with the teacher to record her observations and to understand her perspective on the integration of technology and this pedagogy as part of TPACK since she hasn't used this approach before. The interviews were conducted online through Google Meet, and they were recorded; the interview focused on two main components, CT and attitudes, as the participants were asked questions that were intended to investigate the improvement of students' CT and the change in their attitudes. However, it is also meant to reveal the point of view of both the teacher and the students on the integration of technology in language learning classes.

Validity. Four educational professors and lecturers from Sultan Qaboos University, College of Education, reviewed the validity of the interview. Based on their feedback, the interview questions were considered valid, taking into consideration their comments on their clarity and relevance.

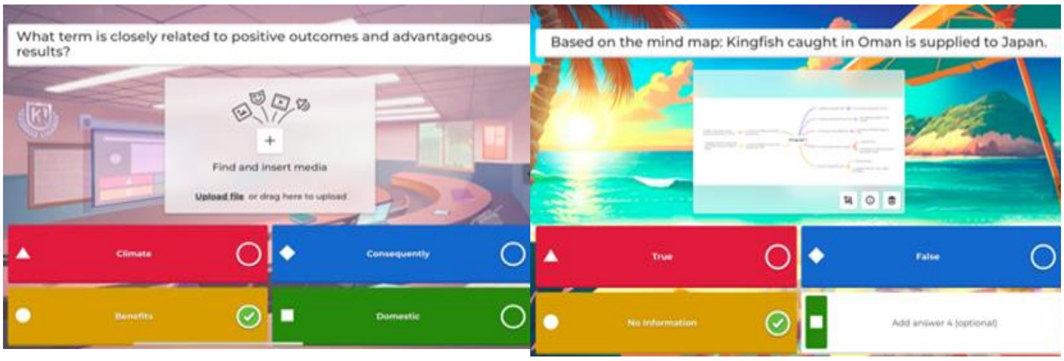
Procedure

The experiment was conducted in Spring 2023-2024 for Sultan Qaboos University Foundation students, at the Centre for Preparatory Studies (CPS). Due to lower spring intake, each section had 12 students, with male students comprising 63.6% of the sample. Before the start of the intervention, the researcher collaborated with the experimental group's teacher to clarify objectives and establish a timeline. The study focused on reading and vocabulary classes, integrating GBL through Kahoot!. The teacher was new to Kahoot! So, she was provided with training materials and orientation videos. The teacher shared the course materials, accordingly the tasks were created and uploaded to Kahoot! Tasks were designed to enhance CT skills. The first task, reading comprehension, was played in a classic mode, focused on decomposition by breaking down texts into smaller parts. The winner will be announced at the end of the game. The second task was a vocabulary using, "Colour Kingdom" mode, engaged students in recognizing word relationships. Another reading comprehension task incorporated visualization and decomposition through mind maps. Different tasks were designed, and each task has a time limit to increase challenge levels, and game modes were chosen based on the targeted skills. The table (Table 6) below illustrates the type of each task and the implemented game mode. It can be also noticed from (Figure 5) that the theme of each task is different when using Kahoot! The class is transferred to game show mode.

Table 6. Kahoot! Quizzes

Quizzes	Main Focus	Game Mode
Quiz 1	Reading Comprehension	Classic Mode
Quiz 2	Vocabulary – Definition	Colour Kingdom Game mode
Quiz 3	Vocabulary- Part of Speech	Tallest Tower Game Mode
Quiz 4	Reading Comprehension	Classic Mode
Quiz 5	Vocabulary- Definition & Part of Speech	Team Mode
Quiz 6	Vocabulary- Pattern Recognition- Suffixes	Submarine squad
Quiz 7	Vocabulary – Definition & Part of Speech	Chill art

Figure 5. Kahoot! Quizzes



Data Collection

In this study, quantitative and qualitative data were collected from the pre-test and post-test scores, the CT and language attitude questionnaire and the interview. The researcher explained the aim of this study to the teacher of the experiment section and the students were informed of the study's objectives, procedure and the instruments that will be used. The questionnaires were done during class time in order to ensure that the students comprehend all questions. All these procedures were taken to increase internal study validity.

Data Analysis

Since this study adopted quantitative and qualitative methods of data collection, different tools were followed to analyze the data. For quantitative methods, before conducting statistical comparisons, normality of the data was assessed using the Shapiro-Wilk test. Results showed that the CT questionnaire data did not meet the assumption of normality. As a result, a non-parametric test Mann-Whitney U was employed to compare students' results in the pre-test and post-test. However, for language learning attitudes, data was roughly normally distributed; thus, a parametric test paired-samples t-test was appropriate. In addition to p-values, effect sizes were calculated using r for non-parametric tests and Cohen's d for t-tests to determine the magnitude of the observed effects. Where applicable, 95% confidence intervals were also reported.

For qualitative data, thematic data has been implemented as the interviews were coded and classified to get the theme and patterns (Table 7).

Table 7. *Research Matrix*

Research Question	Sample	Measurement Tool	Analysis Method
1. To what extent does game-based learning affect students' computational thinking?	24 SQU Foundation Students Level 5	• CT Questionnaire • Interview	• Mann Whitney Test • Thematic Analysis
2. To what extent does game-based learning affect students' attitudes towards language learning?	24 SQU Foundation Students Level 5	• Pre & Post language test • Questionnaire • Interview	• Paired Sample Statistics • Mann Whitney Test • Thematic Analysis

Research Findings

This research aimed to assess the impact of GBL on students' CT and language learning attitudes through Kahoot! a GBL tool. The target sample is foundation students at Sultan Qaboos University. The research used quantitative and qualitative methods to measure the impact and the results were analysed using SPSS and thematic analysis. Due to the small sample the Mann-Whitney U test was employed to analyze the results. In this research, each group had a sample size of 12 (n1 and n2), making the critical value of the Mann-Whitney U test 37 at a 0.05 alpha level (Bobbitt, 2018). Therefore, the U statistics will be analyzed; accordingly, if it is higher than the critical value, then there is no significant difference; however, if it is lower than the critical value, then the difference is substantial, and there is a positive impact of GBL on higher students' CT and language learning attitudes.

A CT Questionnaire has been conducted before and after the intervention to address question one; "To what extent does GBL affect students' computational thinking?" The questionnaire has been analyzed skill-wise, as the focus of this research was on the following CT skills: abstraction (AB), visualization (V), algorithm thinking (AL), generalization (G), testing and debugging (TD), pattern recognition (PR) and decomposition (D). Nevertheless, the mean was considerably lower for the same skills in the control group, as shown in Table 8.

Table 8. *CT Skills Descriptive Statistics for the posttest: Section 70 Experimental Group*

Descriptive Statistics[a]					
	N	Minimum	Maximum	Mean	Std. Deviation
Abstract	12	3.17	4.67	3.81	.48
Visualization	12	2.00	4.50	3.33	.88
Algorithm thinking	12	2.25	4.25	3.60	.63
Generalization	12	3.00	4.50	3.79	.47
Testing & Debugging	12	3.57	4.57	4.11	.33
Pattern recognition	12	2.50	5.00	3.83	.80
Decomposition	12	2.75	4.25	3.83	.51
Valid N (listwise)	12				
a. Section = 70					

Table 9. *CT Skills Descriptive Statistics: Section 80 Control Group*

Descriptive Statistics[a]					
	N	Minimum	Maximum	Mean	Std. Deviation
Abstract	12	1.50	2.50	2.00	.31
Visualization	12	1.50	3.50	2.37	.60
Algorithm thinking	12	1.75	2.75	2.20	.33
Generalization	12	1.75	2.75	2.06	.33
Testing & Debugging	12	1.29	2.71	1.97	.44
Pattern recognition	12	2.00	3.50	2.66	.44
Decomposition	12	1.50	3.75	2.35	.55
Valid N (listwise)	12				
a. Section = 80					

Based on the Likert scale, which was developed by using max (5) and min (1) of the Likert scale (Table 10), it can be noticed that experimental group responses (Table 8) showed that they acquired CT skills, and they tended to use CT strategies. However, the result of the control group (Table 9) revealed that they probably had no clear idea of the CT skills, and they were not implementing as much as the experimental group as most of their responses were "Neutral".

Table 10. *Likert Scale for CT questionnaire responses*

Scale	Mean Range	Verbal Interpretation
5	4.24-5.03	Strongly Agree
4	3.43-4.23	Agree
3	2.62-3.42	Neutral
2	1.81-2.61	Disagree
1	1.00-1.80	Strongly Disagree

Alongside the descriptive statistics, a Mann-Whitney Test was performed to compare the results before and after the experiment, highlighting the differences between the two groups. According to the results presented in Table 11 and Table 12, there was no significant difference between the two groups in the pre-test. Additionally, the mean ranks for both groups were very similar, indicating comparable performance levels at the start.

Table 11. *Mann Whitney Test U Test*

Ranks				
	Section	N	Mean Rank	Sum of Ranks
Pre	70	12	12.79	153.50
	80	12	12.21	146.50
	Total	24		

Table 12. *Mann Whitney Test Statistics (pre-test)*

Test Statistics[a]	
	Pre
Mann-Whitney U	68.50
Wilcoxon W	146.50
Z	-.203
Asymp. Sig. (2-tailed)	.839
Exact Sig. [2*(1-tailed Sig.)]	.843[b]

a. Grouping Variable: Section

b. Not corrected for ties.

However, the result post-test (Table 13 & Table 14) revealed a statistically significant difference between the experimental and control groups (U = 5.00, Z = -3.87, p < .001). The calculated effect size was r = 0.79, indicating a large effect of the intervention on students' computational thinking.

Also, the mean rank of the experimental group (70) was considerably higher than the control group (80).

Table 13. *Mann Whitney Test U Test*

Ranks				
	Section	N	Mean Rank	Sum of Ranks
Post	70	12	18.08	217.00
	80	12	6.92	83.00
	Total	24		

Table 14. *Mann Whitney Test Statistics (post-test)*

Test Statistics[a]	
	Post
Mann-Whitney U	5.00
Wilcoxon W	83.00
Z	-3.87
Asymp. Sig. (2-tailed)	.000
Exact Sig. [2*(1-tailed Sig.)]	.000[b]

a. Grouping Variable: Section

b. Not corrected for ties.

Besides the questionnaire, an interview with six students and their teacher from section 70 explored GBL's impact on CT. The teacher observed notable progress in students' CT skills, including text deconstructions, word analysis, and strategy application. Students also reported a positive impact, stating that GBL helped them practice and apply CT strategies beyond the experiment. Thematic analysis confirmed improvements in organization, decomposition, pattern recognition, comprehension and strategic thinking, leading to greater problem-solving accuracy (Table 15).

Table 15. *Thematic Analysis*

Meaning Unit (Statement)	Subtheme	Theme
"It made it easy for me to organize ideas, analyze the text, and answer the questions."	Organizing and Analyzing Information	Enhancing Computational Thinking Skills through Game-Based Learning
"I was able to understand more and differentiate between the words."	Pattern Recognition and Differentiation	Enhancing Computational Thinking Skills through Game-Based Learning
"I learned to focus on the important points such as numbers, causes, reasons."	Focus on Important Information	Developing Selective Attention, Decomposition and Critical Thinking
"When I made a mistake, it helped me to memorize these words."	Error Recognition and Memorization	Testing and Debugging Enhancement through Feedback

Pre-test and post-test were done to answer the second research question, "To what extent does game-based learning affect students' language learning attitude?" and to compare the participants' performance before and after the experiment. To answer question two, paired sample statistics were used to compare the pre-test and the post-test scores. Descriptive statistics, including means and standard deviation, were also calculated (Table 16). The test was out of 20. Thus, the result indicated a difference between both tests as the mean scores obtained by the experimental group participants on the pre-test was 9.50, while the mean obtained on the post-tests was 15.33. Additionally, the calculated effect size was Cohen's d = 1.21, indicating a large effect. The test was done because, according to Getie (2020), the student's attitudes are reflected in their performance and not the opposite, and there is a direct relation between language learning attitudes and performance. The results of this test showed that students' performance has increased, which can be interpreted as a reflection of the impact of GBL on their language learning attitudes.

Table 16. *Paired Sample t-test for Language Learning Attitudes test*

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-Test	9.50	12	4.33	1.25
	Post Test	15.33	12	5.29	1.53

Additionally, the result of the Independent samples t-test (Table 18) indicated that there was no significant difference between the experimental and control groups in their pre-test scores, suggesting that both groups had a comparable starting level. Levene's test for equality of variance showed a p-value of 1.000, indicating that the assumption of equal variances was met. The t-test results further confirmed this, as the mean difference was 0.000, and the p-value was also 1.000, demonstrating no statistically significant difference between the two groups, with a t-value of 3.135 and a p-value of 0.005, with a 95% confidence interval ranging from 1.861 to 9.139, further confirming the reliability of the observed difference.

Table 17. *Independent Sample Group Statistics for Language Learning Attitudes test*

Group Statistics					
	Section	N	Mean	Std. Deviation	Std. Error Mean
Pre-Test	70	12	9.50	4.33	1.25
	80	12	9.50	4.33	1.25
Post Test	70	12	15.33	5.29	1.53
	80	12	9.83	2.98	.86

Table 18. *Independent Sample t-test for Language Learning Attitudes test*

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Pre-Test	Equal variances assumed	.000	1.000	.000	22	1.000	.000	1.771	-3.673	3.673
	Equal variances not assumed			.000	22.000	1.000	.000	1.771	-3.673	3.673
Post Test	Equal variances assumed	.870	.361	3.135	22	.005	5.500	1.755	1.861	9.139
	Equal variances not assumed			3.135	17.328	.006	5.500	1.755	1.804	9.196

Moreover, interviews with six students and the experimental group's teacher provided further insights into GBL's impact on language learning attitudes. The teacher reported that GBL enhanced language skills, engagement, and collaboration through activities like text deconstruction and word analysis. Students also expressed increased motivation and enjoyment, attributing their active participation to the interactive nature of GBL. The thematic analysis confirmed that GBL fostered positive attitudes, encouraged collaborative learning and improved language learning outcomes (Table 19).

Table 19. *Thematic Analysis*

Meaning Unit (Statement)	Subtheme	Theme
"We were interacting with each other more."	Increased Collaboration and Communication	Fostering Collaboration and Teamwork through Engagement
"I love it a lot, it developed a competitive atmosphere."	Emotional Engagement and Motivation	Boosting Engagement and Motivation via Game-Based Learning
"I was motivated because we had rewards and our names were mentioned if we won."	Motivation through Rewards	Boosting Engagement and Motivation via Game-Based Learning

This study employed a convergent mixed-methods design (Creswell & Plano Clark, 2017), in which both quantitative and qualitative data were collected and analyzed to understand the impact of game-based learning. To achieve integration, themes emerging from the interview data were compared with the statistical results of the CT and attitude questionnaires. For instance, the quantitative improvement in CT scores was reflected in students' qualitative feedback, such as "It made it easy for me to organize ideas, analyze the text, and answer the questions." Similarly, the statistically significant increase in language learning attitudes was supported by student comments like "I love it a lot, it developed a competitive atmosphere" and "I was motivated." The joint display (Table 20) summarize these connections.

Table 20. *Integration of Quantitative and Qualitative Findings*

Quantitative Finding	Qualitative Insight	Meta-Inference
CT scores improved post-intervention	"I was able to analyze the text more easily."	Kahoot! supports problem-solving and metacognitive strategies.
Increased scores in decomposition	"I broke the passage into pieces to answer better."	GBL promotes decomposition skill (a CT component).
Improved post-test performance	"I remembered the words better after using them in Kahoot!"	Repetition and feedback in GBL improve retention.

Thus, the results showed that the GBL approach had a positive impact on students' CT and language learning attitudes. The findings revealed that the students' CT and language learning attitudes have improved. Therefore, this is an indication that GBL has the potential to teach students complex skills, such as CT skills while providing an engaging and enjoyable environment.

Discussion

This research investigated the impact of GBL on students' CT and attitudes towards language learning. The results indicate that students developed CT skills in GBL settings, aligning with previous research (Lu et al., 2022; A Gamification Approach for the Development of CT Skills, 2019; Lathifah et al., 2023). These studies similarly concluded that GBL enhances students' problem-solving abilities and fosters the application of CT strategies such as decomposition and abstraction. The findings also support Lodi (2020), who emphasized the importance of interactive classroom environments in constructing new knowledge and enhancing cognitive skills. Additionally, the effectiveness of pattern recognition in learning is also notable. As Grabmeier (2018) argued, recognizing patterns facilitates long-term retention. This aligns with Brennan and Resnick (2012), who highlighted that decomposition skills enable students to analyze complex topics more effectively. By reducing cognitive load, GBL simplifies problem-solving and enhances selective attention to crucial information.

Moreover, the pre- and post-test results demonstrated that students' performance improved after GBL intervention, aligning with Wang and Tahir (2020), who found that GBL significantly enhances academic performance. Students' and teachers' perceptions confirmed that GBL fosters motivation, engagement, and collaboration, reinforcing Ahmed et al., (2022), who reported similar effects of Kahoot! on student interaction. These findings also align with Wang and Tahir (2020), who found that 100% of students reported increased engagement and enjoyment when using GBL.

Finally, the study underscores the need for integrating GBL in higher education curricula to enhance CT skills and language learning attitudes. Practical implications include incorporating GBL strategies in instructional design, promoting student-centered learning, and training educators in technology-enhanced teaching methods. Additionally, the small sample size is acknowledged as a limitation, possibly increasing the risk of Type II errors. Future studies with larger samples and a priori power analyses are encouraged to validate the findings and boost statistical robustness. Moreover, the absence of randomization limits the study internal validity, so future research could include wait-list control, a matched group comparison or random assignment to strengthen casual interpretations. Furthermore, extended study durations could provide insights into the long-term effects of GBL on students' performance and engagement.

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