

# The Impact of Game-Based Learning on Computational Thinking and Language Learning Attitudes in Higher Education Students

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## Abstract

*Computational thinking (CT) is recognized as a fundamental skill in the 21st century, potentially improving problem-solving and creative thinking abilities. Given its broad applicability, there is a growing emphasis on introducing CT in education. Additionally, Oman Vision 2040 underscores the importance of advancing education and nurturing a highly skilled workforce, emphasizing the need for computational thinking, problem-solving, critical thinking, and algorithmic reasoning skills. Thus, since previous research has primarily focused on middle and high school students, and the studies for higher education showed that students lack CT competencies, this study extends the investigation to higher education students. Moreover, integrating CT into the curriculum calls for innovative teaching methods, such as game-based learning, which promises to engage students in complex activities closely aligned with CT principles. This research endeavors to investigate the impact of game-based learning on the CT skills and attitudes towards language learning of higher education students with consideration of potential gender-based differences. The problem statement highlights CT's significance and the pressing need for improved CT competencies among students. A comprehensive methodology employed a quasi-experimental design, encompassing pre-and post-tests, interviews, and questionnaires, to gather data from 24 Sultan Qaboos University Foundation students. The findings showed a considerable positive impact on students' CT skills as well as their language learning attitudes. In light of the research findings, it is recommended that game-based learning be incorporated into higher education curricula to enhance CT skills and engagement.*

**Keywords:** *Game-based Learning; Computational Thinking; Language Learning Attitudes; 21st-century skills; Kaboot! Higher Education.*

## Introduction

The rapid advancement of technology significantly impacts our personal, social, and professional lives, and consequently shaping our future. As a result, schools, colleges and universities are under immense pressure to give students the knowledge and skills necessary to face future challenges. The Future of Jobs Report 2020, released by the World Economic Forum, identifies the most skills required in 2025, grouped into four categories: self-management, problem-solving, teamwork, and technological skill and development. Analytical thinking, active learning, complex problem-solving, and learning strategies are the most crucial skills in this ranking. One set of problem-solving skills that has the ability to prepare students for future requests is computational thinking (CT).

Computational thinking (CT) is a crucial skill in the 21st century. It is known that CT qualifies students with the ability to cultivate and develop creative thinking and problem-solving skills, which also allows them to deal efficiently with more complex problems, “Computational thinking is a fundamental skill for individuals, not just for Computer scientists; it is a knowledge that crosses countless areas” (Wing, 2006). Due to the significance of computational thinking in different areas, recently, more attention has been given to the CT concept, and studies in this area have notably increased. Voon et al. (2023), has stated the importance of integrating CT skills in education; as a result, their study focused on preservice teachers; to equip them with CT skills so that they implement and integrate CT strategies in their classroom to develop their students' CT skills. Although, there has been more focus on CT in education; there are some studies targeting middle school students as it is a critical stage for individuals because they will be establishing a relationship with their academic field and deciding their career paths, so it is important to master CT skills

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to excel in that. In addition, Oliveira et al., (2022), in their systematic study, stated that there are several studies in CT in education for different audiences, including elementary to high school and undergraduate students; however, most of the studies concentrated on elementary to high school students, although CT is equally important to undergraduate students. Moreover, it is worth mentioning that integrating CT into the education curriculum requires different strategies and methods, such as game-based learning. The effectiveness of this approach has been demonstrated in engaging students in various complex activities that align with CT aspects. Game-based learning is a novel instructional strategy with the potential for language learning as it promotes interactions among learners (Adipat et al. 2021). According to Reinhardt and Sykes (2012), game-based learning is a familiar approach among native speakers, and it has the potential to offer enjoyable and engaging learning experiences for language learners. Chen and Law (2015) support the claim of Hitosug et al. (2014) that language learners can enhance their cognitive abilities to synthesise, analyse, and evaluate information through game-based learning. Regarding attitudes, game-based learning can boost an active learning approach and decrease anxiety among EFL learners. Typically, anxiety alludes to “the subjective feeling of tensions, apprehensions, nervousness, and worries related to an excitement of the autonomic nervous system” (Ireland et al. 2020). Communicative apprehensions are commonly linked to the fear of public speaking. This feeling is unfortunately familiar with the physical symptoms such as an increased heart and breathing rate, rapid reactions, and tension in the neck and shoulders. Anxiety is a reaction related to physiology and is often described as a nervousness state and vague fears (Scovel, 1991 as cited Ahmed et al. 2022) Motivation is another attitude that can be influenced by game-based learning. Motivation is the driving force that encourages individuals to commit to an activity, exert effort, and persist in action, and it is derived from the Latin word *movere*. Motivation is an essential, pervasive attitude determinant of students, teachers, and administrators (Schunk et al 2013).

Furthermore, the Sultanate of Oman has been making an effort to promote information technology education at the governmental level. To achieve this, a strategic plan, Oman's 2040 Vision, was introduced in 2019. The vision aims to help the country become one of the world's developed nations. Oman's 2040 vision focuses on improving the educational sector by empowering human capabilities, preparing national talents with competitive skills and capabilities, updating school curriculums based on sustainable development and future skills, and supporting diverse learning pathways.

The philosophy of Education in the Sultanate of Oman is based on certain principles that guide the development of all elements related to the education process. The Society of Knowledge and Technology principle emphasizes the importance of reinforcing students' ability to deal with current information and modern technology, developing students' high-order skills, and providing learning environments that stimulate thinking, exploration, research, and creativity. The aim is to train learners to observe, analyze, experiment, and explore while providing an environment that promotes learning. (Source: Oman Educational Council (O.E.C, 2017)

In other words, Oman's Vision 2040 strongly emphasizes improving education and building a highly skilled workforce. Computational thinking skills, such as problem-solving, critical thinking, and algorithmic reasoning, are vital in preparing Oman's students to adapt to evolving technologies and challenges. Thus, this research aims to investigate the impact of game-based learning on higher education students' CT skills and attitudes towards language learning.

## Review of Literature

This section displays different studies that have been done in the field of game-based learning, CT and language learning attitudes. Ahmed et al. (2022) have done a study on the impact of game-based learning on students' learning attitudes, focusing on two major attitudes: anxiety and motivation. A quasi-experimental research design was implemented in this research as 58 ESL intermediate Iranian students were selected based on their results on the Oxford Quick Placement Test (OQPT), and they were divided equally into two groups, a control group and an experimental group. The researchers applied quantitative methods to assess the impact as they used the OQPT to evaluate participants' English proficiency levels and the Foreign Language Classroom Anxiety Scale (FLCAS) to assess anxiety levels pre- and post-

intervention. Moreover, an Attitude/Motivation Test Battery (AMTB) questionnaire was implemented to measure the participants' attitudes and motivations towards language learning. The main findings of this research were that a game-based learning approach is a factor that can improve students' proficiency and decrease their anxiety because the result of the experimental group showed that the anxiety level notably decreased after the intervention in comparison to the control group. Additionally, this approach led to improved student's motivation as well. Therefore, the researchers recommended that game-based learning should be integrated in language learning classrooms to reinforce students-centered learning, to boost students' motivations and reduce the level of anxiety.

Another study titled "The effect of using Kahoot!- Literature Review" Done by Wang & Tahir, (2020) aimed to assess the impact of game-based learning on students' performance, engagement, classroom dynamics and the teachers' and students' perceptions in educational settings. The target was students and teachers in the higher education institutions. The methodology implemented in this literature review was classified as a narrative synthesis, as the thematic analysis was followed, and the appraisal did not include quality assessment. The significant outcomes of this study were that plenty of studies have highlighted the positive impact of game-based learning on students' performance and the cognitive aspect. Also, Kahoot! found to be effective in improving students' engagement and level of motivation which created an interactive class dynamic. The students' perceptions towards using Kahoot! were positive as they pointed out that it enhanced their concentration, and they were more motivated to learn. However, they have doubts that Kahoot! may cause anxiety due to its competitive features. Similarly, the teachers reported the same concerns regarding the level of anxiety because students were competitive; nevertheless, they emphasized that Kahoot! could improve students' enjoyment and engagement.

Nadeem et al., 2023 conducted another research in the field of game-based learning. However, their study focused on engineering classes as they aimed to investigate the effect of a game-based approach on engineering students' motivation and engagement. The main purpose of this study was to improve students' engagement through having interactive activities that boost enjoyment. The hypothesis of Nadeem et al. (2023) research is that effective learning is the result of deep engagement, which is caused by intrinsic motivation. They followed a survey-based research design with 126 undergraduate students enrolled in a sophomore seminar course in engineering education who participated in the survey; 63 female students and 44 males. After taking the survey the participants were divided into different groups, the control group and the experimental group. The experimental group was taught using game-based activities (Vortex game), and the control group was taught non-game activities (MBQAs). In the second phase, both groups completed game-based activities to assess gender differences in game-based instructions. The result indicated that game-based learning positively affected students' engagement and performance. The implementation of a leaderboard seemed to have two effects as it could motivate some students, but at the same time demotivate others. Additionally, regarding gender differences, female students reported high levels of enjoyment in comparison to the males, but they were against being compared with other participants. As a result, Nadeem et al. (2023) suggested that digital games should be incorporated into engineering education because they demonstrated a great potential to effectively motivate students and sustain their interest in the course material.

Besides studies on the impact of game-based learning and attitudes, there is research on the effect of game-based learning on students' computational thinking. Lu et al. (2022) have done a meta-analysis to investigate the impact of a game-based learning approach on students' computational thinking. The research's main focus was to synthesize the existing research outcome to present a comprehensive understanding of how game-based learning interventions can improve students' computational thinking skills. The significant findings of this study are that game-based learning has an interesting positive impact on students' CT. The calculated effect size of 0.677 (95% confidence interval 0.532–0.821). Moreover, the study emphasized that the game type has demonstrated a different level of impact on students' CT. Several game types were analyzed, such as role-playing, puzzles, and adventures. Thus, the type of game plays a crucial role on the amount of the influence of GBL on students' CT. Another finding regarding the duration of the interventions indicated that GBL interventions that last between four hours and one week revealed the largest effect size on computational thinking, then those interventions which were for over four weeks, up

to four hours, and between one week and four weeks. This highlights that the duration of GBL interventions can influence their effectiveness.

Lathifah et al., (2023) have conducted a study titled “Development of Game-based Learning Media to Encourage Students’ Computational Thinking.” They primarily concentrated on developing interactive and engaging classes by creating a GBL platform which promotes different CT skills. The sample of this study was 58 junior high school students, and they were divided into two groups: the control group and the experimental group. The researcher developed a game-based media that involves computational thinking components, including abstraction, decomposition, algorithm, evaluation, and generalization. To assess the impact, pre and post-tests were conducted for both groups, and the results were analyzed statistically using SPSS as a paired t-test was conducted. The findings illustrated that GBL has significantly enhanced students’ CT skills; the scores of the post test of the experimental group were very high compared to the results of the control group. Additionally, the incorporation of the CT components developed students’ problem-solving abilities. However, the research also emphasized the need to train teachers to implement GBL platforms to effectively optimize student learning outcomes.

## Methodology

A quasi-experimental research design was followed in this research. In the context of investigating the impact of game-based learning on students’ computational thinking and language learning attitudes, quasi-experimental design allows for the evaluation of causal relationships without significantly disturbing the normal learning environment. This study involves three variables; the independent variable is game-based learning, which is reflected in using Kahoot, which is a game-based learning platform that consists of different games and allows interactive learning. The dependent variables are students’ computational thinking and learning attitudes toward language learning. Two sections are part of the research because the two-group pre-test and post-test design were followed to assess the impact of game-based learning on the two dependent variables. After all, lack of randomization reduces the control over extraneous variables, which may affect the result of research; however, the pre-test is considered one of the methods to control the extraneous variables as it tests the equivalence of both groups before the experiment. Another way that is claimed to reduce the intervention of the extraneous variables is having two groups with the same characteristics, so the two groups are both in the same foundation level, the same age, the same major and the same number of students in both sections. The control group was taught following the traditional methods while in the experimental group, game-based learning was implemented. For both groups, a pre-test was conducted, and two questionnaires related to computational thinking and language attitudes to ensure the equivalence of the two group participants. Then a post-test was done for the two groups after the experiment to measure the effectiveness of game-based learning on students’ computational thinking and attitudes towards language learning. In addition, computational thinking and language questionnaires were distributed along with conducting interviews with some of the students and the teacher of the experimental group. The pre-test and post-test were the same it was a vocabulary test since this research focuses on language learning. The experiment was done during the Spring 23/24 semester, and it was conducted for eight sessions, and neither the students nor the teacher had used Kahoot before.

## Results

The first research question focused on the impact of game-based learning on students’ computational thinking. To answer the Man-Whitney U Test was conducted to compare experiment and control groups. The results showed a significant difference between the groups,  $U=5$ ,  $n_1= 12$ ,  $n_2= 12$ ,  $p<0.001$ . The results suggest that the experimental group has significantly higher score than control group. (See, table 1). Additionally, the z-score was -3.87, which is below the critical value of -1.96 for a two-tailed test at the 0.05 significance level, indicating a statistically significant difference between the two groups. Therefore, the Mann-Whitney statistics imply that students (experimental group) who received game-based learning had higher CT scores than the control group, as the p-value indicated that game-based learning positively impacts students’ computational thinking.

Table 1 Game-based learning impacts on CT

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

*Results of Research Question Two*

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?” The results of the Mann-Whitney Test showed that the Mann-Whitney U statistic was 17.00, which is a low value, and the Z-score was -3.18, which was below the critical value of -1.96 for a two-tailed at the 0.05 significant level. Additionally, the Asymp. Sig. (2-tailed) p-value was 0.001, less than the commonly used 0.05 alpha level, the same as the exact sig. (2-tailed) p-value was 0.001 confirming the statistical significance of the result.

Table 2 Game-based learning impacts on students’ language learning attitude

Test Statistics <sup>a</sup>	
	Post-test
Mann-Whitney U	17.00
Wilcoxon W	95.00
Z	-3.18
Asymp. Sig. (2-tailed)	.001
Exact Sig. [2*(1-tailed Sig.)]	.001 <sup>b</sup>

a. Grouping Variable: Section

b. Not corrected for ties.

These results can be interpreted as the low Mann-Whitney U statistics along with the negative Z-score indicating a significant difference in language learning attitudes between the experimental group and the control group. (Table 2). Moreover, the extremely low p-value ( $p=0.001$ ) suggested that game-based learning had a significant positive impact on students’ language learning attitudes. Furthermore, the mean rank of section 70 after the experiment was 17.08, while the mean rank of section 80 after the experiment was 7.92, illustrating a huge difference between the two sections, which is a reflection of the impact of game-based learning on the students’ language-learning attitudes.

## Discussions

The main findings indicate that students were able to develop CT skills in game-based learning classrooms, which is in line with the (Lu et al., 2022) research findings as in the meta-analysis that they did, they concluded that game-based learning had demonstrated a substantial positive effect on students’ CT skills. Additionally, the study's findings (A Gamification Approach for the Development of Computational Thinking Skills, 2019) are consistent with this research result as they found that game-based learning has improved students' problem-solving skills and other CT skills, and it motivated students to implement CT strategies. Also, the study’s findings of Lathifah, et al., (2023) are consistent with this research result as they found that game-based learning has improved students' problem-solving skills and other CT skills, including

abstraction, decomposition, algorithm, evaluation and generalization. Moreover, According to Lodi 2020, students will be able to construct new knowledge if they are in an interactive classroom environment where the teacher is the facilitator; therefore, this result is in accordance with Lodi's 2020 because it showed that students were able to improve their cognitive skills and implement new CT strategies as they were in an engaging classroom. They were given the opportunity to interact with different forms of knowledge.

The result of the pre and post-test showed that students' performance improved after the intervention, and this result is consistent with Wang & Tahir's (2020) research findings as they highlighted that game-based learning has a significant effect on students' performance as the students involved in their research scored interestingly higher scores than those who received traditional teaching methods. In addition, the questionnaire responses illustrated students' attitudes toward language learning. This result is in accordance with Leinfellner & Rosunally's (2016), research findings as they stated that using Kahoot! improved students' attitudes and behaviours towards language learning to the extent that the experimental group reported high attendance. Additionally, Wichadee & Pattanpichet (2018) found that implementing game-based learning approaches positively impacted students' language learning attitudes as it improved university students' motivation and level of participation.

The students' and teachers' perceptions and responses revealed that the students were motivated and highly engaged in the game-based learning classes, and they started to collaborate and interact with each other. This is in line with Ahmed et al.'s (2022) research findings, as they also reported that Kahoot! had influenced students' level of motivation, participation, and engagement. It also developed an interactive classroom environment with a comfortable atmosphere where the students were able to collaborate.

The Key Findings of the current study can be summarized as followings:

1. Game-based learning has the potential to improve higher education students' CT skills.
2. Students demonstrate a good level of breaking the reading texts into smaller parts after engaging in game-based learning activities.
3. Game-based learning fosters students' engagement.
4. Higher education students get motivated in game-based learning environments.
5. Game-based learning promotes the level of collaboration between students.
6. Interactive game environments develop higher education students' language proficiency, especially Vocabulary and Reading skills.
7. Game-based learning activities improve students' language performance.
8. Gender differences might have an influence on the impact of game-based learning on students' CT and language learning attitudes; it would be noticed with a larger sample size.

## Conclusions

In summary, this research was a crucial undertaking to assess the impact of game-based learning on higher education students' computational thinking and language learning attitudes since this field aligns with 21st-century requirements. The study illustrated the effectiveness and the positive significant impact of game-based learning on the two mentioned factors through implementing quasi-experimental research design, involving a sample from Foundation program at Sultan Qaboos University. However, it is worth mentioning that although this study has been conducted in an Omani context, its findings are in accordance with the previous literature. Therefore, this research recommends that policymakers, educators and curriculum developers should shed light on incorporating the game-based learning approaches in teaching,

especially to develop complex skills such as CT skills and to enhance learning proficiency. Additionally, the findings of this study can serve as a platform for other studies to build upon and enhance.

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