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Effectiveness of a competitive educational game with a game controller in English game-based language learning

Galang Prihadi Mahardhika*[1], Astari Husna Masitha[2], Masaru Kamada[1]
Ibaraki University, Hitachi, Ibaraki, Japan[1]
Sekolah Menengah Atas Masa Depan, Yogyakarta, Indonesia[2]

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*Corresponding author.
Galang Prihadi Mahardhika
E-mail address:
24nd303x@vc.ibaraki.ac.jp

Abstract
Game-based language learning has emerged as a promising approach to language learning activities. Despite its potential, concepts for implementing game-based language learning that emphasize player-to-player and player-to-game interactions have not been widely adopted. This study presents an educational game as a game-based language learning application that incorporates face-to-face interaction concepts and competitive game approaches to enhance player-to-player interaction. Additionally, the game utilizes a specially designed game controller to improve player-to-game interaction. The impact of the proposed educational game on the students' learning experience, gaming experience, and motivation was evaluated through a process involving 42 high school students (14 females and 28 males). The findings suggest that integrating concepts of face-to-face interaction in competitive game scenarios and the game controller design proposed in this study fosters social interactions among players, positively influencing students' learning experience, gaming experience, and motivation. Furthermore, the findings reveal that students prefer game controllers with microswitch buttons because they provide a physical feel that reduces errors during gameplay. This underscores the importance of ergonomic, easy-to-use game controller designs that minimize errors when playing educational games. By focusing on the interplay between player-to-player and player-to-game interactions, this study provides insight into designing interactive educational games that utilize interaction technology, particularly for language learning.

1. Introduction

English proficiency is a critical skill for students in many countries [1]. Mastery of English enables students to access a wide range of information [2], express creative ideas [3], and understand different cultures and perspectives from around the world [4]. Despite its importance, English language teaching faces numerous challenges [5], [6], with weak learning motivation being a significant obstacle. Motivation is essential for successful language acquisition [7], [8], [9]. In Indonesia, low motivation among high school students often stems from a lack of confidence, learning anxiety, and an unsupportive learning environment [10], which leads to poor English proficiency outcomes. To address these issues, teachers must continuously innovate to foster active and creative learning environments that boost student motivation [11].

Innovations in English language learning have evolved over time [12], [13]. Research indicates that Game-Based Language Learning (GBLL) can significantly enhance language learning activities [14], [15], [16]. Implementing GBLL in classrooms can improve student engagement, learning behavior, motivation, immersion, and performance [17], thereby fostering positive emotions [18]. GBLL's effectiveness lies in its ability to create student-centered learning environments and provide opportunities for students to socialize in cooperative and competitive group-based learning contexts [19]. Due to its several advantages, many researchers believe that GBLL is one of the best approaches, and therefore, they highly recommend it to drive improvements in the quality of language learning in schools [20], [21]. However, GBLL still has room for enhancement, particularly in player immersion through player-to-player and player-to-game interactions. Some researchers believe these interactions encourage students to immerse themselves in the game environment, enabling them to improve their learning competencies more easily [22], [23].

Player-to-player interactions foster engagement through technical and social interactions [24]. Technical interactions occur within the game, while social interactions take place outside the game, including verbal communication, eye contact, gestures, and emotional expressions [25]. Well-designed social interactions in game systems significantly impact both gaming and learning experiences [26], [27]. One strategy to promote player-to-player interaction is competitive learning [28], which is considered highly effective in GBLL, particularly in role-playing games, simulations, puzzles, and strategy games [29]. Conversely, player-to-game interactions can create a more natural,

engaging, and enjoyable player experience [30]. Enhancing these interactions can be achieved by using tools like game controllers [31].

Given this background, traditional GBLL applications often fail to fully leverage competitive social interaction and innovative game technologies, such as specially designed game controllers, thereby limiting student motivation and engagement. This study aims to enhance GBLL performance in English language learning by proposing an educational game called "Spider Board Game System" [32]. In this educational game, player-to-player interaction is implemented through competitive gameplay between two students sitting face-to-face with a single smartphone. Face-to-face environments offer real-time communication and immediate feedback, both of which are ideal for fostering social interaction [33], particularly within active learning platforms such as educational games [34]. The competitive setting further increases student participation and motivation [35]. To facilitate this, the research team developed the Spider Board game system with a specially designed game controller. The use of general game controllers [31] in the development of GBLL applications has not been academically explored. Due to the focus on ease of use, GBLL applications are currently developed primarily for mobile devices with standard input devices, such as touchscreens [36]. Furthermore, the use of game controllers proposed in this study can contribute to the advancement of GBLL research and serve as a reference regarding the potential use of specially designed game controllers in learning activities. This research hypothesizes that combining face-to-face competitive gameplay with a specially designed game controller can improve the effectiveness of English language learning for high school students. This paper presents the evaluation process and findings, demonstrating that face-to-face competitive game scenarios supported by a specially designed game controller can enhance students' learning experiences, gaming experiences, and motivation.

2. Method

2.1 The Spider Board Game System

The Spider Board game system consists of two main parts: a software-based application and a hardware-based game controller. The educational game application was developed using the Unity Game Engine, based on the designed gameplay. To allow both players to play together on a single Android smartphone, the screen is divided into two parts: one for the first player and the other for the second. Color coding was applied to facilitate the identification of players and screen areas: red for Player 1 and blue for Player 2. The identification of the playing areas (red and blue sides) in the application was achieved by assigning a basic color to the components for each player.

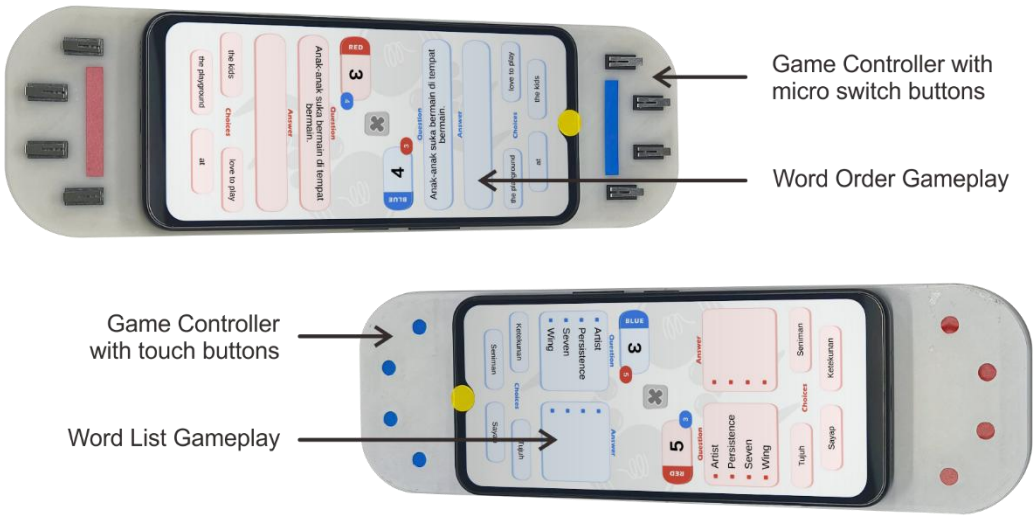

Figure 1. Game Controller with Microswitch Buttons (Top) and Game Controller with Touch Buttons (Bottom) of Spider Board Game System

There are three approaches to game controller development for single-application gameplay: playing simultaneously using multiple game controllers, playing simultaneously using a single shared controller, or playing in turns using a single controller [37]. This study adopted the simultaneous play with a shared controller approach, allowing both players to use a single device concurrently. The game controller was built using an ESP32-C3 development board, powered by a lithium-ion polymer battery for enhanced mobility. It communicates with the game application via Bluetooth Low Energy (BLE). The game controller features a power switch and eight input buttons (four for each player). Two versions were developed: one utilizing microswitch buttons and another using capacitive touch buttons based on the TTP223 IC. All components were integrated into a custom-designed, 3D-printed case, which also serves as a mat for

the smartphone during gameplay. Figure 1 shows the Spider Board game system with the two types of game controllers: one based on microswitch buttons and the other on touch buttons.

Two gameplay modes were developed: Word Order and Word List. The scenarios for both gameplay modes are shown in Figure 2. In Word Order gameplay, players arrange four sentence fragments into a correct sentence by pressing the corresponding buttons. A player earns one point for each correct arrangement, and gameplay continues until one player reaches 30 points. In Word List gameplay, players translate a set of four vocabulary words by selecting the correct translations. The scoring system is identical: one point per correct translation, with victory achieved at 30 points. The application utilized a dataset of 200 Indonesian sentences with English translations for the Word Order mode and 760 English vocabulary items with Indonesian translations for the Word List gameplay.

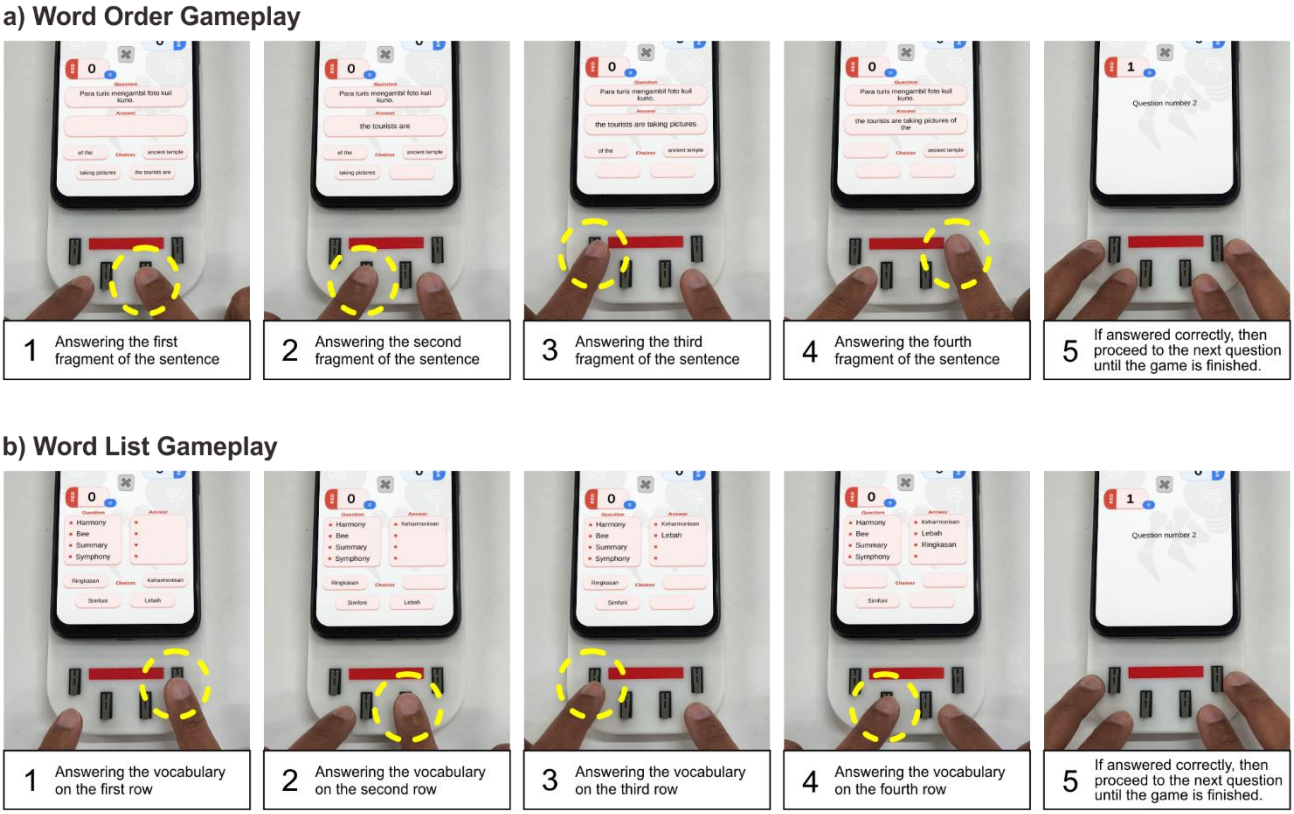

Figure 2. The Spider Board Game System, a) Game Scenario of Word Order Gameplay, b) Game Scenario of Word List Gameplay

2.2 Participants and Research Design

This study employed a mixed-methods approach, involving 42 students (14 females and 28 males) from three different classes at a high school in Yogyakarta, Indonesia. The students voluntarily agreed to participate in the study, and their ages ranged from 15 to 18 years. To ensure that the Spider Board game system aligned with the characteristics and objectives of English language learning, the study also involved an English teacher who served as both an expert in English language education and a validator during the development of the educational game. The evaluation process consisted of two sessions: a playtesting session and a focus group discussion (FGD) session.

In the playtesting session, students were given the opportunity to play the developed educational game for a set period. After completing the gameplay, they were asked to fill out a research questionnaire before proceeding to the FGD session. The FGD session included both the students and the English teacher. It was conducted to gather findings and suggestions expressed verbally, along with ideas for further development and the potential adaptation of similar concepts to other subjects. All students participated in both the playtesting and FGD sessions, while the English teacher participated only in the FGD session.

2.3 Instruments and Data Collection

Quantitative data were collected through a closed-ended questionnaire covering four aspects: learning experience [38], [39], gaming experience [40], [41], motivation [8], [9], and game controller evaluation [31], [42]. The questionnaire consisted of 15 Likert-type items on a 10-point scale (ranging from 1 = strongly disagree to 10 = strongly

agree). There were four statements representing learning experience, four representing gaming experience, four representing motivation, and three representing the game controller evaluation. The mapping of statements for each aspect is presented in Table 1. Additionally, the research team assessed the game controller experience by comparing students' experiences when playing the Spider Board game system with and without the game controller. Qualitative data were collected from students and the English teacher during the FGD session. The FGD was guided by four main topics: experiences during gameplay, difficulties encountered, feedback on gameplay, and future application development.

Table 1. The Mapping of Evaluation Statements

No.	Aspect	Statement
1	Learning experience	I learned new vocabulary in this game.
2		I find out the meaning of vocabulary that I don't understand.
3		I feel like I can learn while playing this game.
4	Gaming experience	Learning from this game is very fun.
5		This game is easy to play.
6		This game is very fun to play.
7		This game is played in an interesting way.
8	Motivation	I want to play this game in other subjects.
9		I want to create my own questions in this game.
10		I feel like I can beat my opponent in this game.
11		I want to play this game again.
12		I want to play this game with the new opponents.
13	Game controller	The game controller could be configured easily.
14		I like the game controller with touch buttons.
15		I like the game controller with microswitches.

3. Result

3.1 Playtesting

Playtesting was conducted in three batches: the first batch involved 13 students, the second involved 15 students, and the third involved 14 students. The rules for the playtesting sessions were as follows: (1) each student had to try both gameplay modes (Word Order and Word List); (2) each student had to try both types of game controllers (microswitch button type and capacitive touch button type) as well as gameplay without a game controller; (3) students who were challenged to play could not refuse; and (4) students were not allowed to challenge the same opponent more than once. Playtesting continued until students gained sufficient experience. Students were free to choose their opponents and mutually agree upon the gameplay mode. An overview of the playtesting activities is presented in Figure 3.

Figure 3. The Overview of the Playtesting Activity

After playing the developed educational game, students were asked to complete the research questionnaire. The results regarding the learning experience, gaming experience, motivation, and game controller evaluation are summarized in Table 2. In the learning experience aspect, responses to Statements 1 and 2 indicated that the content materials had a positive, albeit moderate, impact on students' efforts to learn new vocabulary. To explore this result

further, the research team analyzed potential causes for the modest effect. Two key factors were identified. First, the relatively high standard deviation (SD) suggested significant variation in students' English proficiency levels. This was confirmed by the English teacher, who noted considerable differences in the students' abilities. Second, the educational content provided in the game was relatively limited and had been developed without direct student involvement, possibly leading to a mismatch between the material and the students' actual learning needs.

Table 2. The Results on Aspects of Learning Experience, Game Experience, Motivation, and Game Controller

Aspect	Statement	Female (N=14)		Male (N=28)		All Student (N=42)		95% CI
		M	SD	M	SD	M	SD	
Learning experience	1. I learned new vocabulary in this game	5.857	3.009	6.214	2.898	6.095	2.903	[5.217 - 6.973]
	2. I find out the meaning of vocabulary that I don't understand	6.643	3.054	6.321	2.970	6.429	2.964	[5.532 - 7.325]
	3. I feel like I can learn while playing this game	8.214	1.968	8.536	1.990	8.429	1.965	[7.834 - 9.023]
Gaming experience	4. Learning with this game is very fun	8.357	1.550	8.786	1.475	8.643	1.495	[8.191 - 9.095]
	5. This game is easy to play	8.500	1.454	8.143	2.031	8.262	1.849	[7.703 - 8.821]
	6. This game is very fun to play	8.357	1.737	9.000	1.610	8.786	1.661	[8.283 - 9.288]
	7. This game is played in an interesting way	8.714	1.139	8.464	1.990	8.548	1.742	[8.021 - 9.074]
	8. I want to play this game in other subjects	8.357	2.499	8.643	2.297	8.548	2.340	[7.840 - 9.255]
Motivation	9. I want to create my own questions in this game	7.643	3.272	6.750	2.605	7.048	2.837	[6.190 - 7.905]
	10. I feel like I can beat my opponent in this game	7.357	2.023	6.857	2.368	7.024	2.247	[6.344 - 7.703]
	11. I want to play this game again	9.000	1.468	8.429	2.559	8.619	2.252	[7.938 - 9.300]
	12. I want to play this game with the new opponents	9.000	0.961	7.536	3.073	8.024	2.646	[7.224 - 8.824]
Game controller	13. The game controller could be configured easily.	8.286	1.139	7.964	2.317	8.071	1.993	[7.469 - 8.674]
	14. I like the game controller with touch buttons.	5.571	2.593	5.357	2.231	5.429	2.328	[4.724 - 6.133]
	15. I like the game controller with microswitches.	9.071	0.917	8.786	1.397	8.881	1.253	[8.502 - 9.260]

Despite this, Statement 3 indicated that students believed the Spider Board game system could support their learning activities. This finding reinforces the research team's view that involving students in the content design process enhances the game's effectiveness in teaching vocabulary and sentence patterns. Additionally, Statement 4 highlighted that students found the learning activities enjoyable, suggesting that the game successfully applied the principles of GBLL. Figure 4 presents the data distribution for the learning experience aspects.

Regarding the gaming experience, Statement 5 demonstrated the ease of use of the Spider Board game system. It also confirmed that the simple application flow design effectively reduced players' anxiety [43], [44]. With reduced anxiety, players were better able to engage with and enjoy the educational game. Statement 6 revealed that students enjoyed playing the game, which positively influenced their learning [45]. Furthermore, Statement 7 showed that the Spider Board game system concept proposed was highly effective in enhancing the gaming experience. This positive gaming experience, in turn, positively impacted students' learning activities [46]. Finally, statement 8 indicated that students were confident the approach could be applied to subjects beyond English language learning. The data distribution for the gaming experience aspects is presented in Figure 5.

In terms of motivation, Statement 9 was used to assess whether the GBLL approach implemented in this study motivated students. The results showed that some students were highly motivated to participate in the game's development. However, a significant gap (SD = 2.837) suggested that others were either disinterested or lacked the confidence to be involved in the development process. Statement 10 indicated that students had high levels of self-confidence in their ability to defeat opponents in the game. Self-confidence is a key factor in fostering creativity [47] and is strongly correlated with increased learning motivation [48]. Furthermore, the research team believes that self-confidence can encourage students to engage with the educational game outside the classroom (Statement 11) and

with new opponents (Statement 12). An interesting finding was that female students were more motivated to seek out new opponents outside the classroom (M = 9.000; SD = 0.961) compared to male students (M = 7.536; SD = 3.073). Further research is needed to explore this difference. The data distribution for motivation aspects is presented in Figure 6.

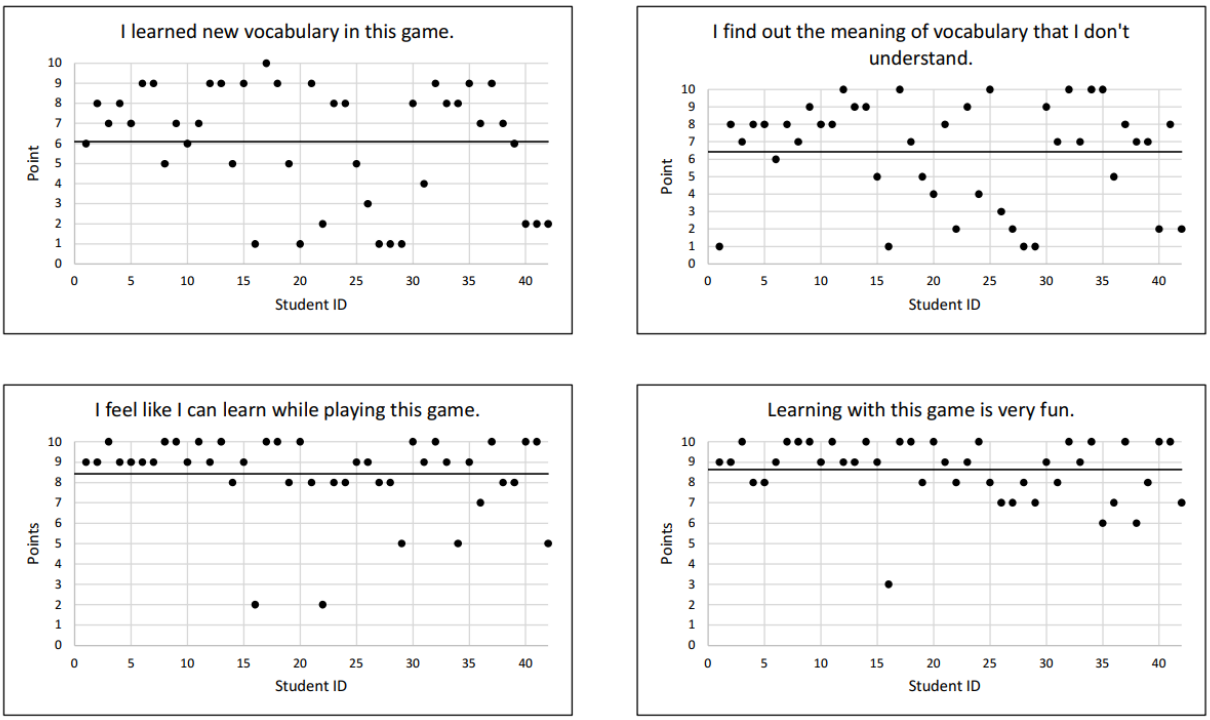

Figure 4. The Distribution of Data on Learning Experience Aspects

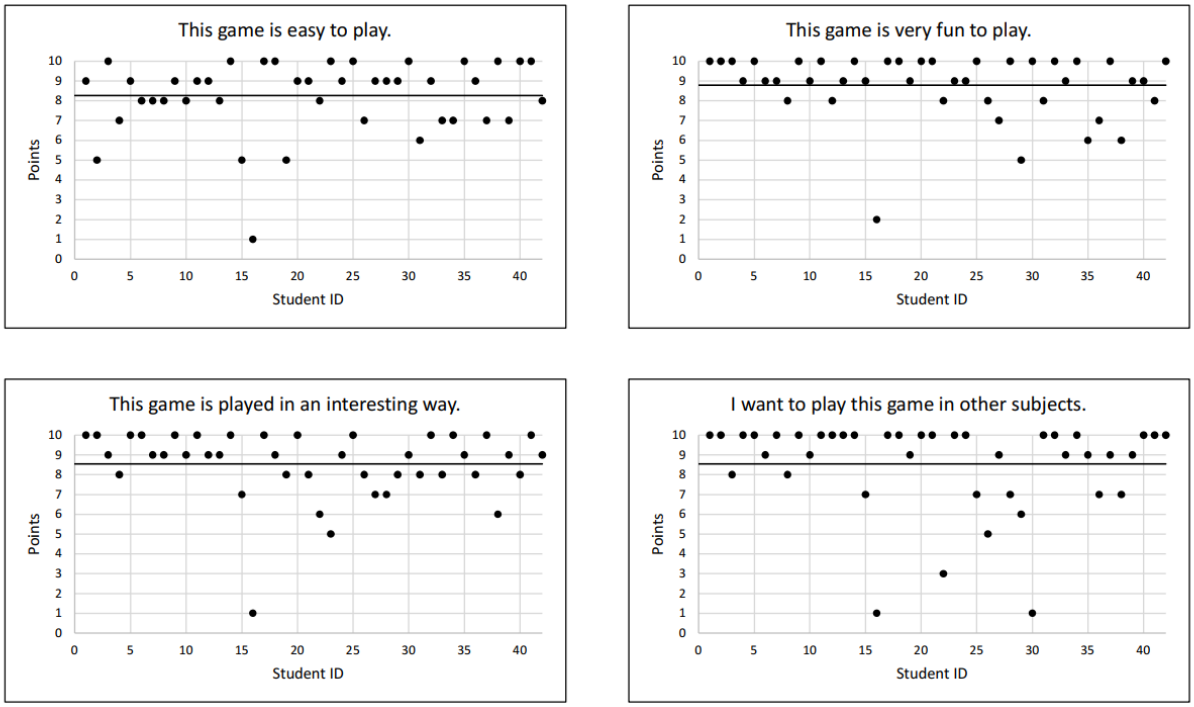

Figure 5. The Distribution of Data on Gaming Experience Aspects

In terms of the game controller, the assessment of Statement 13 revealed that the developed game controller was easy to use, particularly during the setup process. Statements 14 and 15 were then used to assess student preferences for the two types of controllers. The results showed a clear preference for the game controller with

microswitch buttons over the one with touch buttons. This preference was further explored in the FGD session. The data distribution related to the game controller aspects is presented in Figure 7.

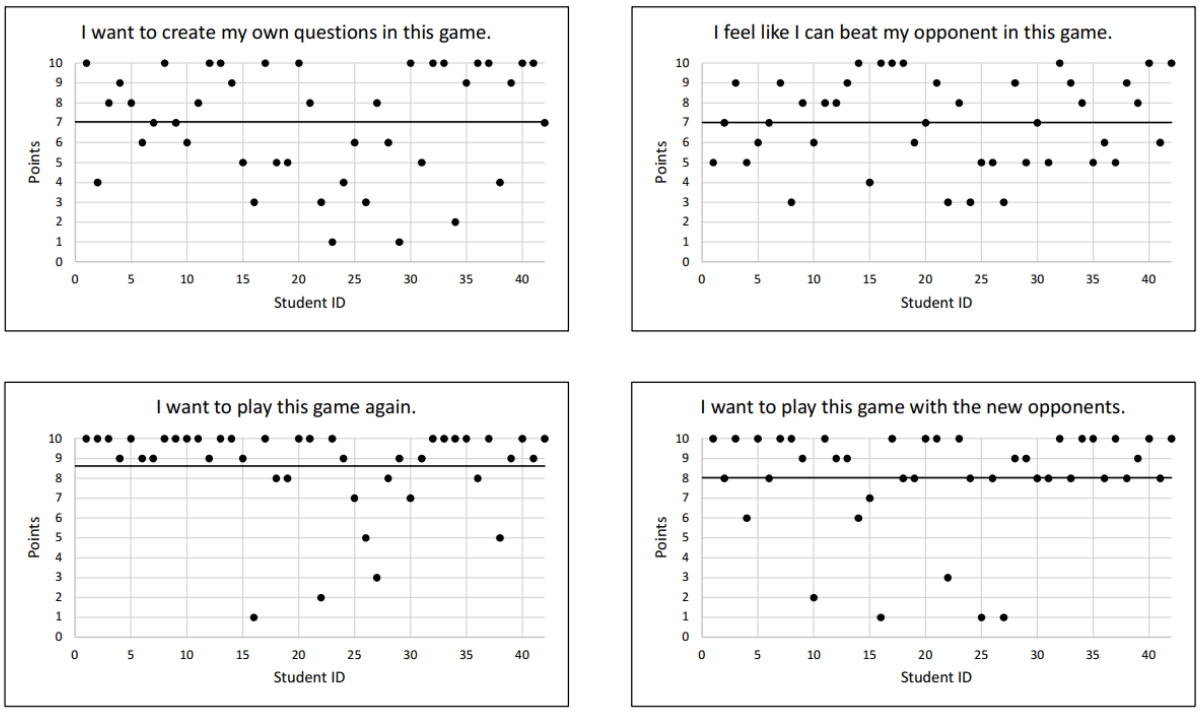

Figure 6. The Distribution of Data on Motivation Aspects

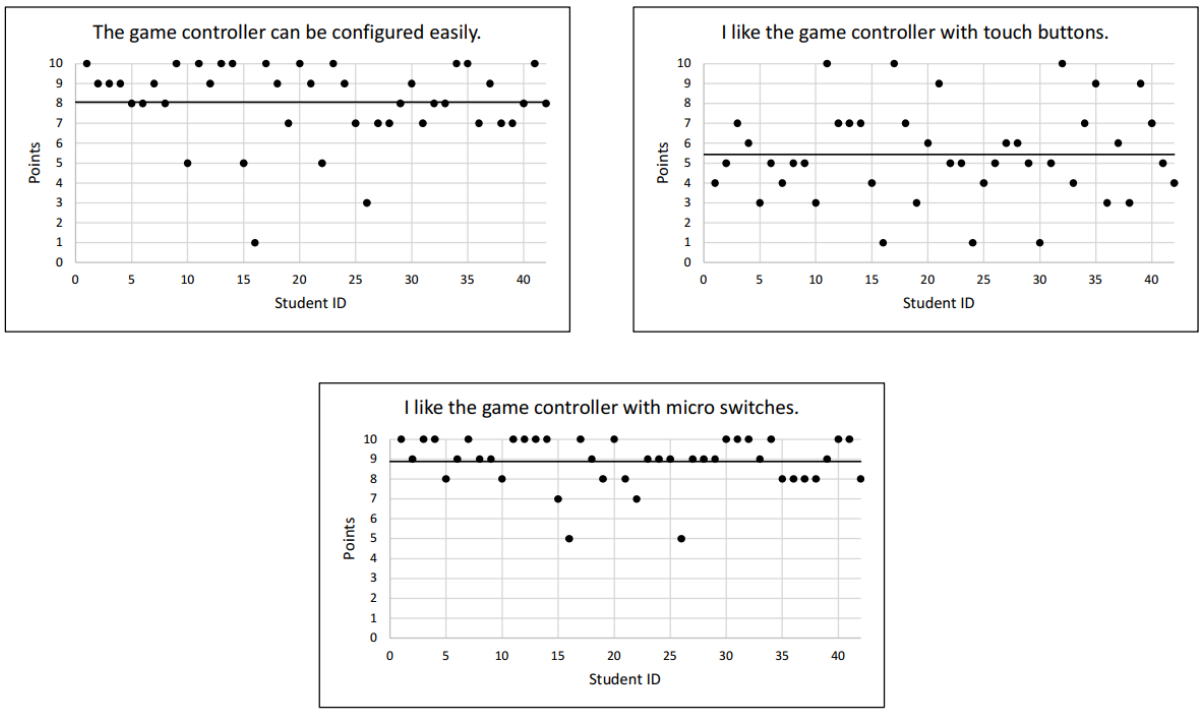

Figure 7. The Distribution of Data on Game Controller Aspects

To investigate whether the use of the game controller in the Spider Board game system significantly impacted students' learning and gaming experience, the research team conducted a descriptive analysis using a paired one-tailed t-test with a 5% significance level ($\alpha = 0.05$). The results of this analysis are summarized in Table 3. In the test,

students played the educational game both without and with a game controller and then provided an assessment based on their gaming experience. The descriptive analysis indicated that the use of a game controller significantly improved students' learning and gaming experiences (t-stat < t-critical). Therefore, the use of the game controller positively influenced students' engagement in language learning activities.

Table 3. The Results of the Descriptive Analysis on the Impact of Using the Game Controller

	Without Game Controller	With Game Controller
Mean	6.381	8.000
Standard Deviation	2.575	2.095
Variance	6.632	4.390
Pearson Correlation	-0.470	
Degrees of Freedom	41	
t-stat	-2.615	
α	0.05	
p-value	0.006	
t-critical	-1.683	

3.2 Focus Group Discussion

Four main topics guided the FGD session: experiences during gameplay, difficulties encountered, feedback on gameplay, and future application development.

3.2.1 Experiences During Gameplay

Students generally agreed that the developed educational game provided a positive learning and gaming experience. Some students suggested additional gameplay scenarios to address other language skills, such as listening and reading. The research team also gathered feedback on the game controller used in the educational game. Overall, students enjoyed using the game controller, with a survey revealing that 69.05% of students expressed interest in applying a game controller approach to other educational games.

3.2.2 Difficulties Encountered

Regarding difficulties, the FGD session revealed that students did not encounter issues accessing the application menus. Pairing the game controller via Bluetooth was also not problematic, as students were familiar with pairing Bluetooth devices like earphones and speakers. The only technical challenge reported was with the touch buttons on the game controller. Because the touch buttons activated immediately upon contact, students had to ensure that their fingers did not accidentally touch the buttons, which sometimes led to poor game control. In contrast, the microswitch buttons could be pressed without immediate activation, allowing students to position their fingers more easily. Additionally, the microswitch buttons provided a satisfying mechanical feel, minimizing accidental presses.

3.2.3 Feedback on Gameplay

Regarding gameplay, students agreed that the proposed gameplay was both enjoyable and challenging. The gameplay scenario allowed interaction with opponents; however, students' confidence diminished when competing against those with significantly better English proficiency. This disparity led to frustration, particularly when students fell behind in scoring. In these situations, students often wanted to end the game quickly, which sometimes reduced their motivation.

3.2.4 Future Application Development

Several valuable suggestions were made. Some students proposed incorporating additional gameplay scenarios to integrate skills such as reading and listening. They also suggested increasing the number of players per game, such as allowing six players to participate using three Android smartphones. Additionally, students recommended introducing a scoreboard or leaderboard to display player rankings [49]. The English teacher suggested adapting this approach for other subjects and recommended developing a similar concept with a collaborative approach, where students would work as a team to complete a challenge [50].

4. Discussion

The educational game developed in this study was found to enhance learning quality by fostering enjoyment during the learning process. The face-to-face interaction further stimulated peer interactions, which are posited to increase students' self-confidence and subsequently promote more active participation. Moreover, competing against familiar classmates introduced challenges that heightened motivation. Further research is warranted to examine whether comparable motivational effects occur when students compete against unfamiliar opponents, such as in inter-school tournaments.

The educational game also demonstrated the capacity to improve students' skills. It is suggested that this outcome could be further reinforced through the involvement of students in the game content design process. Such involvement, however, should be limited to aligning in-game challenges with students' ability levels and interests, rather than allowing them to define the challenges themselves [51]. Variability in student abilities, identified during the study, presents a notable issue. To address this, two strategies are proposed: grouping students according to ability or implementing a leveling system within the educational game [52]. Each strategy offers distinct advantages and disadvantages, necessitating further evaluation to determine their respective impacts.

Gender-related differences were observed in the playtesting results: male students reported a better learning experience, while female students reported a better gaming experience. No conclusive correlation, however, was established between these experiences and academic achievement. Consequently, it is recommended that future evaluations incorporate learning achievement metrics. Notably, a better motivational impact was observed among female students, indicating a need for further studies to investigate the factors influencing motivation across genders in the context of educational games.

The use of game controllers contributed positively to both learning and gaming experiences. Two primary factors were identified as influencing students' interest: first, the novelty of the controller, which stimulated curiosity; and second, the stimulation of dexterity, concentration, and focus. It is suggested that incorporating well-designed scenarios and ergonomic considerations into controller development could further enhance the robustness of educational games [53]. Furthermore, students expressed a preference for controllers equipped with tactile microswitches over touch buttons, as the latter were associated with greater difficulties and higher error rates. These findings highlight the importance of not only the controller's form factor and component placement but also the accessibility and responsiveness of its input mechanisms.

From an educational standpoint, the integration of digital GBLL into curricula remains a pedagogical challenge, particularly among English teachers [54]. This challenge is attributed primarily to limited experience and awareness regarding the educational potential of games. Addressing this issue necessitates the development of innovative, user-friendly educational games that can be readily adopted by teachers. The study contributes by providing an English-learning game that emphasizes both player-to-player and player-to-game interactions. The demonstrated potential to enhance learning experiences, gaming experiences, and motivation is expected to offer valuable insights and practical examples for educators seeking to integrate such tools into classroom practice.

5. Conclusions

The evaluation results indicate that the combination of face-to-face interaction concepts within competitive game scenarios and the specially designed game controllers successfully fostered social interactions among players. These interactions positively influenced high school students' learning experiences, gaming experiences, and motivation. Through enhanced social engagement, students reported increased confidence and a willingness to actively participate in learning activities [55]. Although the evaluation conducted was not sufficient to conclusively demonstrate improvements in learning outcomes, students reported that the educational game concept proposed in this study supports their academic success. These findings reinforce the conclusion that integrating face-to-face interactions in competitive gaming scenarios, combined with interactive game controllers, holds promise for application in other subject areas beyond English language learning.

Moreover, the findings suggest that the proposed game controller design significantly improved tactile feedback compared to the touchscreen inputs typically used on smartphone devices. This supports the notion that the gaming experience in educational contexts can be substantially enhanced through the utilization of specially designed game controllers. Students demonstrated a preference for game controllers equipped with microswitch buttons, citing the superior physical feedback and reduced error rates. This preference underscores the critical importance of ergonomic, intuitive controller design in improving user experience [42]. Future exploration of various input modalities, technologies, and mechanisms in game controller design presents a promising direction for advancing educational game development. Overall, these findings contribute meaningfully to the field of GBLL and may serve as valuable references for researchers, educators, and developers seeking to create more effective educational tools for students.

6. Limitations and Future Work

Several limitations should be acknowledged in this study. First, the limited number of respondents may have reduced the sensitivity to detect statistically significant differences and restricted the generalizability of the findings across broader educational levels and contexts. Second, due to this small sample size, the study did not include a control group when evaluating learning outcomes. The absence of a comparison group hinders the ability to definitively attribute observed effects to the proposed educational intervention, as opposed to other factors specific to the participant cohort. Third, the educational game developed in this study focused exclusively on vocabulary and grammar learning, omitting other critical aspects of English language acquisition, such as listening comprehension and reading comprehension [56].

These limitations confine the study's evaluation to four dimensions: learning experience, gaming experience, motivation, and preference for game controller type. To address these limitations, future research should involve larger sample sizes across diverse educational levels and implement control groups to more accurately assess the impact of the learning intervention on academic performance. Additionally, expanding the gameplay features to encompass listening and reading comprehension activities would broaden the scope of English language learning supported by the educational game. On a parallel track, the development of game controllers should explore more innovative input modalities capable of facilitating collaborative learning among larger groups of students.

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