

AN EXPLORATION OF DIGITAL
HANDHELD GAME FEATURES FOR ENHANCING EFL VOCABULARY
LEARNING OUTCOMES

by

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To my wife and son

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PREFACE

The rapid growth of handheld and mobile gaming technologies has opened up new avenues for educational interventions, especially in the domain of language learning. As English remains a dominant global language, the efficient and effective teaching of English as a Foreign Language (EFL) is of paramount importance. This dissertation encompasses two interrelated studies that dive deep into the realm of using handheld games to improve EFL vocabulary learning outcomes.

The first part of this dissertation presents a systematic review of empirical studies from the past decade that examined the relationship between handheld/mobile game features and EFL vocabulary learning outcomes. Through a meticulous exploration, this study revealed significant insights into specific game features such as Holograms, Customized Word Lists, Gamified Assessments, and In-game Hints that can augment vocabulary learning. This rigorous review forms the foundation for the subsequent study, highlighting the need to isolate and test game features to understand their pedagogical utility better.

Building upon the insights gleaned from the systematic review, the second part of the dissertation shifts its focus to a practical application by examining the impact of competition as a game feature on vocabulary learning outcomes. Conducted with freshman students in China, this study scrutinizes the effects of integrating competition in a handheld game, Vocarena, designed to enhance EFL vocabulary acquisition. The findings are compelling, suggesting that gamified elements like competition can not only amplify learning outcomes but also bolster motivation and engagement in learners.

Together, these studies illuminate the potential of handheld gaming as an innovative tool in the EFL pedagogical toolkit. The dissertation offers invaluable implications for future research, the design of educational games, and the broader realm of teaching practices. By weaving together theory, empirical evidence, and practical application, this dissertation aspires to bridge the gap between technology and pedagogy, paving the way for a brighter, technology-rich future in language education.

ABSTRACT

AN EXPLORATION OF DIGITAL HANDHELD GAME FEATURES FOR ENHANCING EFL VOCABULARY LEARNING OUTCOMES

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Adviser: Tanya Christ, Ph.D.

This dissertation delves into the pedagogical implications of handheld/mobile game features on EFL learners' vocabulary learning outcomes. The research is segmented into two comprehensive studies. The first study, a systematic review spanning from 2011 to July 2022, scrutinizes empirical research detailing the correlation between various game features and vocabulary learning outcomes. Key findings highlight the effectiveness of Holograms, Customized Word Lists, Gamified Assessments, and In-game Hints in fostering enhanced vocabulary learning. In the subsequent study, the emphasis shifts to the practical application, where the impact of 'competition' as a game feature is critically assessed. Executed with 331 freshman students in China over four weeks, participants engaged with two variants of the game, 'Vocarena', designed to elucidate the meanings of a hundred unfamiliar English words. Crucially, one version incorporated a competitive element, spurring participants to vie against one another, while the counterpart lacked this feature. Quantitative analysis revealed three pivotal results: the competition feature augmented participants' game-playing duration, bolstered English vocabulary learning outcomes, and was significantly associated with elevated

motivation levels. Collectively, these findings underscore the potential of game-specific features in optimizing EFL vocabulary learning, offering valuable insights for future research, educational game development, and innovative teaching methodologies.

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LIST OF ABBREVIATIONS

EFL	English as a Foreign Language
ESL	English as a Second Language
MALL	Mobile-Assisted Language Learning
CALL	Computer-Assisted Language Learning

CHAPTER ONE

DIGITAL HANDHELD GAME FEATURES AND THEIR IMPACT ON EFL VOCABULARY LEARNING

For EFL (English as a Foreign Language) learners, possessing an extensive vocabulary is fundamental to mastering the foundational skills of reading, writing, listening, and speaking (Nation & Coady, 1988; Schmitt, 2000). The prominence of vocabulary in language learning is epitomized by Wilkins (1972), who stated, “without grammar very little can be conveyed, without vocabulary nothing can be conveyed” (p. 110). Yet, EFL learners in non-English speaking environments often face limited opportunities to consistently recall and practice their vocabulary (Cheon, 2003; Elaish et al., 2019), presenting challenges in retaining and reinforcing new words, as postulated by the Forgetting Curve Theory (Zheng, 2015).

Digital handheld/mobile games have emerged as pivotal tools in bridging this gap. They offer EFL learners a platform to frequently revisit and practice English vocabulary, thereby enhancing learning outcomes (Cerezo et al., 2019; Cha, 2020). In these games, "game features" are design elements, functional modules, and mechanisms that foster user engagement and learning, providing challenge, feedback, fantasy, control, and social interaction (Prensky, 2001a). While many games have reported positive outcomes for EFL vocabulary learning, the nuances of how specific game features contribute to these outcomes remain largely unexplored.

This research aims to delve into these game features, with particular emphasis on one pervasive feature: peer competition. Peer competition, a staple in educational games

(Vorderer et al., 2003), posits that the dynamic of competing with peers can motivate and enhance learning. However, the effectiveness of peer competition, especially when embedded within handheld/mobile vocabulary games, has seen limited empirical study. This gap becomes even more pronounced when focusing on particular aspects of vocabulary learning, such as word meaning.

Combining the above perspectives, this dissertation seeks to address two interconnected research needs: 1) a comprehensive review of how game features in digital handheld/mobile vocabulary learning games relate to EFL students' vocabulary learning outcomes, and 2) an empirical exploration of the impact of the peer competition game feature on EFL vocabulary learning outcomes, especially word meaning. The aim is to provide a robust understanding that could guide game design, selection, and EFL pedagogy in the digital age.

CHAPTER TWO

FEATURES IN DIGITAL HANDHELD/MOBILE EFL AND ESL VOCABULARY GAMES AND STUDENTS' LEARNING OUTCOMES: A SYSTEMATIC REVIEW

Introduction

For EFL (English as a Foreign Language) learners and ESL (English as a Second Language) learners, an extensive lexicon is vitally important for building the four basic literacy skills: reading, writing, listening, and speaking (Nation & Coady, 1988; Schmitt, 2000). To emphasize the importance of vocabulary, Wilkins (1972) argued that “without grammar very little can be conveyed, without vocabulary nothing can be conveyed” (p. 110). However, EFL learners who live in non-English speaking environments have few chances to recall and practice vocabulary in their daily lives (Cheon, 2003; Elaish et al., 2019; Hwang et al., 2016; Shadiev et al., 2015; Tsou, 2005). This makes it more challenging to learn EFL and ESL vocabulary because, according to the Forgetting Curve Theory (Zheng, 2015), the retention of new vocabulary is reinforced by regular revisiting and practicing of words. Digital handheld/mobile educational games make it possible for EFL and ESL learners to revisit and practice English vocabulary “anytime and anywhere” (Lin & Lin, 2019, p. 879), and improve their vocabulary learning outcomes (Cerezo et al., 2019; Cha, 2020; Chen et al., 2019; Huang & Huang, 2015; Chang et al., 2017; Reynolds, 2017; Sandberg et al., 2014; Wu & Huang, 2017; Wu, 2018; Yang et al., 2020).

In the present review, game features refer to the design elements, functional modules, and gaming mechanisms that provide the players (learners) with challenge,

feedback, fantasy, control, and social interaction (Prensky, 2001a). For example, the game feature Badges provides the player with feedback and social interaction by giving the players badges when they accomplish certain tasks and letting the players show their badges to other players. Table 3 shows the game features the present review study identifies. Different game features may or may not contribute to EFL and ESL learners' vocabulary learning (DeRouin-Jessen, 2008; Huang et al., 2013). Understanding which game features are related to EFL and ESL learners' greatest vocabulary learning gains would inform both game design and game selection to improve vocabulary learning opportunities. Thus, there is a need for a review of studies that focus on the relation between handheld/mobile game features and EFL and ESL vocabulary learning outcomes.

However, no previous literature reviews have focused on how specific game features from handheld/mobile games are related to EFL or ESL students' vocabulary learning outcomes. While previous reviews focused on EFLs' or EFLs' vocabulary learning via Mobile-Assisted Language Learning programs (MALLs), these are not the same as digital handheld/mobile games because (1) they are not handheld/mobile games, and (2) most of these programs do not have the essential game elements that Prensky (2001b) illustrated (fun, play, and story) to provide game-play experience (Afzali et al., 2017; Ahmad et al., 2013; Derakhshan & Khodabakhshzadeh, 2011; DeRouin-Jessen, 2008; Lin & Lin, 2019; Mahdi, 2018). For example, the MALL programs Kahoot, Quizlet, and Quizizz just turn conventional instructional approaches, such as flashcards and quizzes, into digital or online versions (Alhebshi & Gamlo, 2022; Arnedo-Moreno, 2021). The lack of game elements, such as fun, play, or story (Prensky, 2001b),

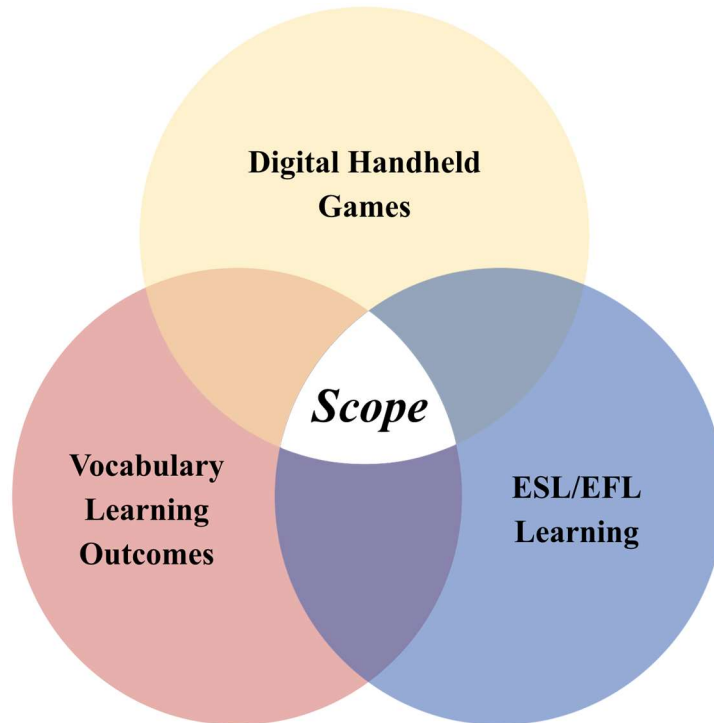
differentiates these MALL programs from vocabulary learning games. For handheld/mobile ESL/EFL vocabulary games, the relations between the game features and EFL and ESL learners' vocabulary outcomes have not been examined in existing reviews (e.g., Afzali et al., 2017). This paper addresses this issue and is guided by the following question:

Based on previous empirical studies, how are features in digital handheld/mobile vocabulary learning games related to EFL and ESL students' vocabulary learning outcomes?

Figure 1 presents a visual image of our literature review's scope.

Figure 1

The Scope of the Present Literature Review

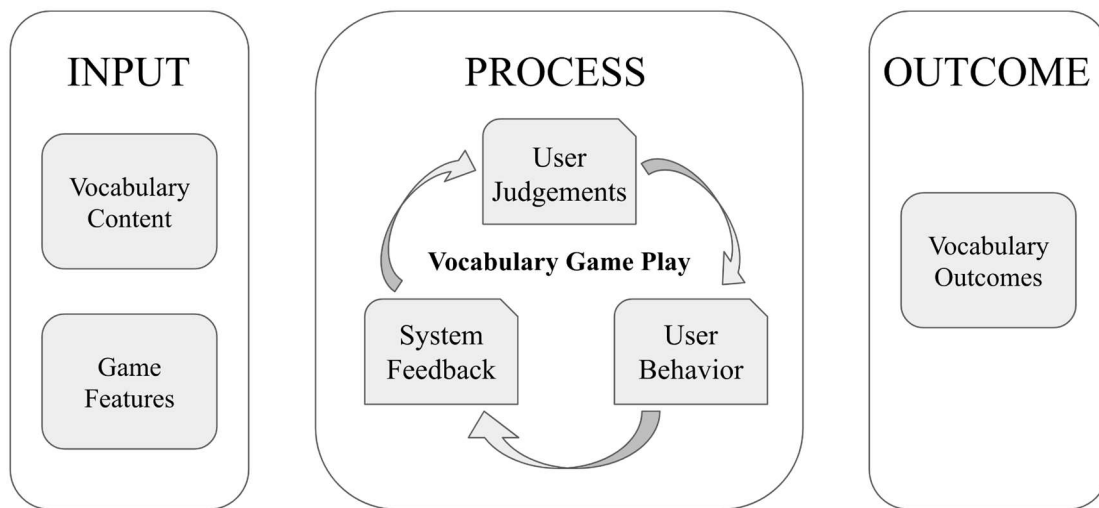


Theoretical Framework

To help identify the relations between game features in handheld/mobile games and EFL and ESL vocabulary learning outcomes, we were guided by the “Input-Process-Outcome Game” model introduced by Garriss and colleagues (2002), which is illustrated in Figure 2.

Figure 2

Input-Process-Outcome Game Model (Garris et al., 2002)



The Input-Process-Outcome Game Model demonstrates how game features, in combination with instructional content, support the learning process and desired outcomes (see Figure 2).

The Input part of the model depicts how both instructional content is and game features provide critical input into the learning process. Since game features are the mechanisms that the players actually interact with in games, educational games need to integrate instructional content with game features to deliver instructional content to the players. Game features play the role of vehicles that carry the instructional goals through

the game-playing process. For example, an English vocabulary learning game asks players to control the cannon to shoot the balloons that have the right spellings of given words. The game feature that asks the players to shoot the balloons is acting as the vehicle that carries the instructional content, which is the English words. In this way, the instructional goal of reinforcing the spelling of the English words is facilitated.

The Process part of the model explains how the player engages in the learning. For example, a player makes judgments based on the rules of the games and their understanding of given conditions. Then the players turn their judgments into actions to interact with the game. The game then gives feedback to the players' actions based on if the actions meet the rules and conditions of the game. In the aforementioned example, after the players make their judgments about choosing the right balloons to shoot, they take action and shoot the balloons. The game gives feedback to the players based on whether they shoot the right balloons, and the game cycle can restart again. The Outcome part of the model reflects the learning that occurs based on the inputs and learning process. It is important to note that multiple rounds of learning might need to occur, with varied inputs, before learning outcomes occur.

Method

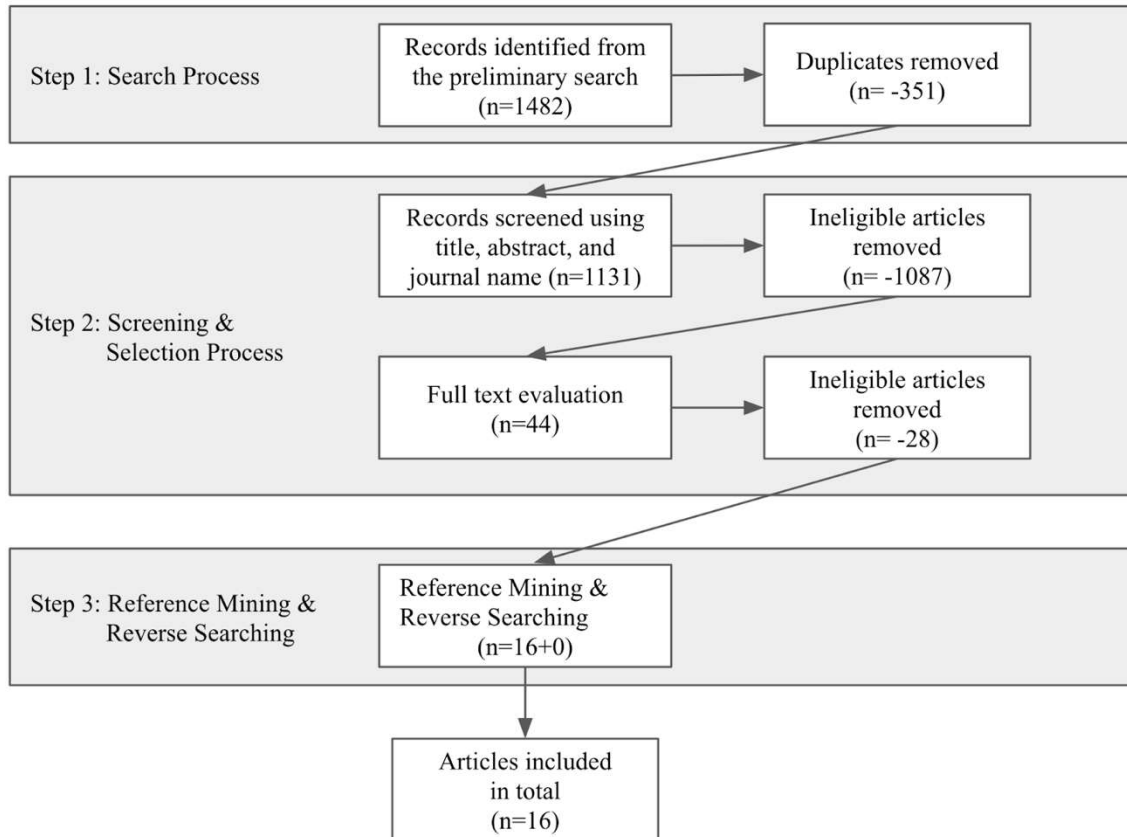
We used a systematic review to “offer novel insights” about how game features in handheld/mobile games are related to players' vocabulary learning outcomes (Alexander, 2020, p. 8). To accomplish this, we undertook “an orchestrated search of literature,” which is described across the following sections (Alexander, 2020, p. 8).

Article Search and Selection Process

The article searching and selecting process occurred across three steps, which are summarized in Figure 3.

Figure 3

Article Selection and Analysis Process



Step 1: Search Process

Due to the intersectional focus of this review across digital handheld/mobile games, EFL or ESL learning, and vocabulary learning outcomes (see Figure 1), the following databases were searched to identify target articles: ERIC (ProQuest), Educational Source (EBSCO), PsycINFO (EBSCO), Academic Search Complete

(EBSCO), IEEE Xplore, JSTOR, Scopus, Educational Abstracts, and LLBA (EBSCO).

To identify articles that fell within our scope, we used the following sets of search terms in each of the databases. Boolean operators are used to present the search terms.

- (“mobile game” AND ESL AND vocabulary) OR
- (“handheld game” AND ESL AND vocabulary) OR
- (“mobile game” AND EFL AND vocabulary) OR
- (“handheld game” AND EFL AND vocabulary) OR
- (“mobile game” AND “foreign language” AND vocabulary) OR
- (“handheld game” AND “foreign language” AND vocabulary) OR
- (“mobile game” AND “second language” AND vocabulary) OR
- (“handheld game” AND “second language” and vocabulary) OR
- (“mobile game” AND ELL AND vocabulary) OR
- (“handheld game” AND ELL AND vocabulary)

We delimited each search to publications between 2011-2022 because handheld/mobile digital devices and high-speed mobile networks have dramatically developed across the past decade. In December 2010, the 4G Network (The Fourth Generation Mobile Network), which allows high-speed audio and video streams, started running in the U.S. Meanwhile, smartphones and portable tablet computers evolved significantly to be capable of running more feature-rich application programs, such as massive multiplayer online games. These technological conditions matured in the last 11 years enabling learners to access and enjoy feature-rich handheld/mobile educational games anytime and anywhere. Therefore, studies that focused on mobile educational

games before 2010 were not able to represent the current digital applications.

Additionally, we delimited our search to studies published in English.

Table 1 shows the records returned from the preliminary search, totaling 1,482 articles. Amongst these, there were 351 articles that were identified across multiple database searches. So, in total, 1,131 unique articles remained to be considered after removing the duplicate search results.

Table 1

Records Identified After The Initial Search

Database	Returned Records
ERIC	32
Educational Source	28
PsycINFO	11
Academic Search Complete	21
IEEE Xplore	3
JSTOR	247
Scopus	413
Educational Abstracts	11
LLBA	716
Total	1,482

Step 2: Screening and Selection Process

All 1,131 articles went through a two-step process to be considered for inclusion in the literature review. First, articles were screened using just the title, abstract, and journal background to evaluate whether they seemed to meet the following criteria:

- (1) Published in a peer-reviewed journal to ensure quality (Rothstein & Hopewell, 2009),
- (2) Reflected empirical research in which data were collected and analyzed, and
- (3) Focused on the effectiveness of handheld/mobile game features for supporting English vocabulary learning outcomes.

Only 44 articles that seemed to meet these criteria were further considered for inclusion in the literature review (see Table 2). All of these articles focused on EFL. We found no studies that met the criteria that focused on ESL. This seems to be because most studies that focused on ESL learners explored the use of digital games vs. non-use of these games, but not the effects of the games' features. The other 1,087 articles were excluded from consideration because they did not meet one or more of the criteria.

Table 2

Records Remaining After Screening Using The Title, Abstract, And Journal Name

Database	Returned Records
ERIC	6
Educational Source	5
PsycINFO	4
Academic Search Complete	11
IEEE Xplore	1
JSTOR	0
Scopus	5
Educational Abstracts	7
LLBA	2
Total	41

Second, the 44 articles that seemed to meet the criteria were read in their entirety to further evaluate whether they really did meet all three criteria. Through this process, 25 more articles were excluded for not meeting all three criteria. For example, what Kassem (2018) used were actually MALL (Mobile Assistant Language Learning) applications instead of handheld/mobile games. Hung and Young's (2015) study focused on using handheld games for ESL vocabulary learning but did not report the participants' vocabulary learning outcomes. In addition, three articles were excluded because they focused on learning the vocabulary of languages other than English. After this step, 16 articles met the criteria to be included in this literature review.

All the 16 yielded articles focused on EFL participants from non-English speaking countries in which they were learning English as a foreign language. Although one of these studies used the term "ESL" to represent "Early Second Language" (Sandberg et al., 2014, p. 122) game for Dutch primary school students, the participants were also learning English as a foreign language.

Step 3: Reference Mining and Reverse Searching

For each of the 16 articles identified for inclusion in the literature review, both reference mining (using each article's reference list to potentially find new articles that met our inclusion criteria) and reverse searching (using the Google Scholar "cited by" feature) were conducted to identify any additional articles that might meet the inclusion criteria for the literature review. However, no additional articles were identified through these processes.

Analytic Methods

Phase 1: Cataloging Article Information

A database was used to catalog information from the 16 reviewed articles included in the present literature review, including research questions, research designs, participants' age groups, participants' first languages, handheld/mobile game genres, the game features utilized, game availability (i.e., off-the-shelf, researcher-modified, or researcher-created), and gaming environment (i.e., off-line, asynchronously online, or synchronously online). The focus of the cataloging process is the information of the handheld/mobile vocabulary learning games in the reviewed articles and how these games used various features to engage the EFL or ESL players and help improve their vocabulary learning outcomes. To identify the game features used in the games across the reviewed articles and reveal the relations between the game features and English vocabulary learning outcomes, three steps of analysis were undertaken.

First, we started with using the terminologies or the immediate description of the features from the reviewed articles, and then used constant comparative methods (Corbin & Strauss, 2014) to merge or parse each code so that the best goodness-of-fit with the feature definition could be achieved. In this process, we constantly checked whether the features found in the articles were aligned with our criteria for game features, which is providing the players with challenge, feedback, fantasy, control, and social interaction (Prensky, 2001a). For each article, all game features that could be found in the handheld/mobile game were coded. Table 3 shows the names and definitions of the 23 features that the handheld/mobile games from the reviewed studies incorporated.

Table 3*Game Features And Their Definitions*

Feature Name	Definition
Badge	The in-game reward based on the players' gameplay behavior
Leading Board	The feature that shows the players current achievement in the games
Gamified Competition	The feature encourages the players to reach certain goals faster or better than other players or groups
Graphic Definition	Using graphics, including pictures and photos to show the meaning of the words
Gamified Assessment	Game-like assessments in the game to provide periodical feedback to the players or to indicate the players' progress
Multiple Game Levels (Not tested)	The feature that provides different game difficulty levels for the players
Customized Word List	The feature that provides a unique word list with the players based on their prior behavior
Timer	The time limit for each action in the games
Video Clip	Videos present the words' definition, story background, or the game playing environment
Digital Pronunciation	The feature that provides pronunciation of words or sentences.
In-Game Hint	The feature gives the players clues to find the answers or solutions
Randomly Moving	The feature that locates the players to random stages of the games or makes random choices for the next step.
Real-world Interaction	The feature that allows the players to use the real world as part of the game
Story	The feature that sets an overall background or vision of the game
Gamified Cooperation	The feature that encourages the players to work with other players to achieve the goals of the game
Hologram	The 3D scenes, figures, or/and objects in games created by holography technology
In-game Dictionary	The feature that allows students to look up new words in E-dictionary

Table 3 - Continued

Feature Name	Definition
In-game Teacher Aid	The feature that allows the teachers to supervise the players' gameplay behavior and provide necessary help during the gameplay process
Sharing To Social Media (Not tested)	The feature that allows the players to share their status and achievement on social media
Word List (Whole) (Not tested)	The feature demonstrates all the words that the players need to learn
Automatically Adjusting Frequency (Not tested)	The feature that adjusts the present frequency of a word based on the players' action
In-game Currency	The feature that encourages the players to earn as a reward and can be used to exchange for other game rewards
Background Music	The feature that plays background music while the players play the game

Second, we merged the game features that had the same functions across the handheld/mobile games. Some of these features functioned in the same way and served the same instructional goals but had different names across the reviewed studies. Such game features were merged into one feature in Table 3. For example, in VocabGame (Elaish et al., 2019), the winners of the competition were awarded Medals while Saving Alice (Yang et al., 2020), another handheld/mobile vocabulary game, gave the players Stars when they unlocked the new level of the game. The features Stars and Medals are both symbols to award the Winning State (Prensky, 2001b) players earned from competitions or challenges. Thus, they were merged into one game feature Badges.

Finally, across the reviewed articles, we mapped the vocabulary learning outcomes related to each game feature or feature group. According to the findings that the reviewed articles reported, the handheld/mobile EFL or ESL vocabulary games contributed to and examined how the participants learned (1) the pronunciations of new

English words, (2) the definitions of new English words, (3) the spellings of new English words, and (4) to use new English words in various contexts. Since the same handheld/mobile vocabulary game or the same game feature may have had different impacts on different vocabulary learning aspects, it was necessary to distinguish the relations between game features and different aspects of vocabulary learning outcomes.

Phase 2: Analysis

Step one. We divided the game features from the reviewed studies into two groups based on whether they were tested in isolation (without other confounding features in the game) or tested simultaneously with other game features (i.e., features were used as a group in the game). For example, Cerezo and colleagues (2019) tested the Hologram feature (the vocabulary game uses a set of mirrors to create a hologram virtual figure to interact with the students) in isolation—the only difference between the handheld/mobile game used for the experimental and control groups was the Hologram feature. Therefore, the difference between the learning outcomes from the two groups can be ascribed to the Hologram feature. By contrast, other reviewed studies used games that had multiple game features tested simultaneously in the experimental group, while the control group did not use the games, or used a simpler version of the games that lacked two or more game features compared to the games the experimental group used (e.g., Chang et al., 2017; Reynolds, 2017; Yang et al., 2020). For these studies, the different learning outcomes cannot be simply ascribed to any one specific game feature from the experimental group game.

Step two. For the features that were tested in isolation, we synthesized the findings across studies to indicate, for each game feature, what kind of vocabulary

learning it affected and whether the relation was positive. For example, the Gamified Competition feature had a statistically significant positive relation with word meaning learning outcomes in Chen and colleagues' (2019) study, but it had no significant relation with word meaning learning outcomes in Dindar and colleagues' (2021) study. In this way, the relations between various game features and different vocabulary learning outcomes were reported across studies to identify patterns.

Step three. For the game features that were not tested in isolation, their relations with vocabulary learning outcomes were summarized as groups of features. For example, Chang and colleagues (2017) designed experimental games that included Badges, In-game Teacher Aids, Random Moving Direction, Gamified Competition, and Real-world Interaction features. This group of game features had a statistically significant positive relation with EFL learners' word meaning learning outcomes as compared to traditional instruction.

Findings

Across the studies, 23 game features were identified from the handheld/mobile EFL or ESL vocabulary games (see Table 3 for a list and definitions of the features). However, four game features existed in both the experimental and the control groups in the studies in which they were found. Thus, the effectiveness of these features was not able to be ascertained related to players' vocabulary learning outcomes. Therefore, these features were excluded from the findings. The remaining 19 game features' relations with vocabulary learning outcomes are reported in this section.

Out of the 16 studies reviewed, five tested game features in isolation (Cerezo et al., 2019; Cha, 2020; Chen et al., 2019; Dindar et al., 2021; Huang & Huang, 2015).

Eleven studies tested game features within a group of features in the game . In the following sections, we first summarize the findings from the studies that tested game features in isolation. Second, we summarize findings from studies that tested game features as a group (i.e., without isolating game features).

Studies that Tested Game Features in Isolation

Table 4 provides a summary of the relations between game features tested in isolation and the players' vocabulary learning outcomes. Of note is that each study explored a different game feature or features or the same game feature for different word learning outcomes, thus, no synthesis of findings across these studies was possible.

Table 4

The Relation Between Game Features Tested In Isolation And Vocabulary

Learning Outcomes

1. Study	2. Game Feature	3. Vocabulary Learning Outcome	4. Statistically Significant Positive relation?
Cerezo et al., 2019	Hologram	Pronunciation	Yes
Cha, 2020	Customized Word List	Word Meaning	Yes
Cha, 2020	Customized Word List	Using Words in Different Contexts	No
Chen, et al., 2019	Gamified Assessment	Word Meaning & Word Spelling	Yes
Dindar et al., 2021	Gamified Competition	Word Meaning	No
Dindar et al., 2021	Gamified Cooperation	Word Meaning	No

Table 4 - Continued

1. Study	2. Game Feature	3. Vocabulary Learning Outcome	4. Statistically Significant Positive relation?
Huang & Huang, 2015	In-game Hint	Word Meaning & Word Spelling (only for low-achieving students)	Yes
Huang & Huang, 2015	In-game Hint	Word Meaning & Word Spelling (For high- and medium-achieving students)	No

Of the five studies that isolated game features, two compared the use of a feature in a handheld mobile game to a similar paper game without the feature. Cerezo and colleagues (2019) found that when EFL learners played a handheld/mobile game with a virtual figure feature (created by a hologram), they had better pronunciation of targeted vocabulary words than did EFL learners who played the same game but without the hologram virtual figure or played a similar paper-based game. Cha (2020) found that when EFL learners played a handheld/mobile game with the Customized Word List feature for each learner based on the words they missed, they had better word-meaning outcomes as compared to learners who played a similar paper-based game. The other three of the five studies compared the use of a feature in a handheld/mobile game to the use of the same handheld/mobile game without the feature. Chen and colleagues (2019) found that when EFL learners played a handheld/mobile game with the Gamified Assessment features, such as Tic-Tac-Toe, Tug-of-VOC (VOC stands for vocabulary), and Star VOC, they had better learning outcomes on word meaning and word spellings as compared to learners who played the same handheld/mobile without the Gamified Assessment features. Huang and Huang (2015) found that when low-achieving EFL learners played a handheld/mobile vocabulary game with the In-game Hint feature, which

provided hints about words' meanings or spellings when a player needed it, their word meaning and spelling outcomes were better than learners who played the same handheld/mobile game without the hint feature. However, Dindar and colleagues (2021) found that when EFL learners played a handheld/mobile game with the Gamified Competition feature versus a Gamified Cooperation feature, there were no significant differences in the learners' word meaning learning outcomes.

Studies that Tested Game Features as a Group

Table 5 summarizes the relations between groups of game features and the participants' vocabulary learning outcomes. While most of these studies found positive effects of game features on EFL or ESL learners' vocabulary outcomes (Berry, 2021; Chang et al., 2017; Hasram et al., 2021; John et al., 2021; Reynolds, 2017; Sandberg et al., 2014; Wu & Huang, 2017; Wu, 2018; Yang et al., 2020), a couple of studies did not (Elaish et al., 2019; Huang et al., 2017).

Table 5

Relations Between Groups Of Features And Vocabulary Learning Outcomes

1. Study	2. Game Features Grouped Together in the Study	3. Vocabulary Learning Outcome	4. Statistically Significant Positive Relation?
Berry, 2021	Real-World Interaction Customized Word List Gamified Competition Gamified Cooperation Story	Pronunciation	Yes

Table 5 - Continued

1. Study	2. Game Features Grouped Together in the Study	3. Vocabulary Learning Outcome	4. Statistically Significant Positive Relation?
Chang et al., 2017	Badge In-Game Teacher Aid Randomly Moving Gamified Competition Real-World Interaction	Word Meaning	Yes
Hasram et al., 2021	Graphic Definition Customized Word List	Word Meaning, Word Spelling & Using Words in Different Contexts	Yes
John et al., 2021	Graphic Definition In-game Cooperation Background Music	Word Meaning & Using Words in Different Contexts	Yes
Reynolds, 2017	Graphic Definition Badge In-Game Currency Gamified Competition	Word Meaning	Yes
Sandberg et al., 2014	Graphic Definition Story Video Clip In-Game Teacher Aid	Word Meaning	Yes
Wu & Huang, 2017	Customized Word List Gamified Assessment In-Game Currency Leading Board Timer	Word Meaning & Word Spelling	Yes
Wu, 2018	Customized Word List Gamified Assessment In-Game Currency Leading Board Timer	Word Meaning & Word Spelling	Yes

Table 5 - Continued

1. Study	2. Game Features Grouped Together in the Study	3. Vocabulary Learning Outcome	4. Statistically Significant Positive Relation?
Yang et al., 2020	Story Video Clip Gamified Assessment Badge Leading Board Customized Word List	Word Meaning, Word Spelling, & Using Words in Different Contexts	Yes
Elaish et al., 2019	Graphic Definition In-Game Dictionary Badge Hint Sharing To Social Media	Word Meaning	No
Huang et al., 2017	Timer Badge Gamified Assessment Leading Board Customized Word List	Word Meaning	No

Berry (2021) used the game Spaceteam ESL, which had the features Real-World Interaction, Customized Word List, Gamified Competition, Gamified Cooperation, and Story to help improve learners' English word pronunciation. The study's setting required the players to communicate with each other (in the real world while playing the game) using the embedded target English words to accomplish the missions and beat other teams. The findings demonstrated a statistically significant improvement in English word pronunciation amongst players in the experiment group. Although Berry (2021) claimed that it was mainly the real-world verbal communication between the players that helped the players improve their English pronunciation in the experimental group (vs. a control group that did not play the game), we cannot separate the game features from the

conversations to clearly attribute the effectiveness of the game to either. Further, Chang and colleagues (2017) found that when EFL learners played a handheld/mobile game that had Badges, In-game Teacher Aid, Random Moving, Gamified Competition, and Real-world Interaction features, they learned more word meanings than learners who used a non-game paper-based learning approach. Additionally, for 5th-grade EFL learners, Hasram et al. (2021) selected a simple online mobile game World of Words, which has Graphic Definition and Customized Word List features. Their findings showed that playing the online game was related to EFL learners' outcomes for better word meaning, word spelling, and using words in different contexts. John and colleagues (2021) created a mobile vocabulary game for their research study, which had Graphic definition, In-game Cooperation, and Background Music features. Reynolds (2017) reported that EFL learners who played a handheld/mobile game with Graphic Definition, Badge, In-game Currency, and Gamified Competition features incidentally learned word meanings. Sandberg and colleagues (2014) found ESL learners who played a handheld/mobile game with Graphic Definition, Story, Video Clip, and In-game Teacher Aid features learned more word meanings compared to learners who played the same handheld/mobile game without these features. Two studies found that EFL learners who played a handheld/mobile game with Customized Word List, Gamified Assessment, In-game Currency, Leading Board, and Timer features had better word meaning and spelling outcomes than learners who were taught via lectures (Wu, 2018; Wu and Huang, 2017). Yang and colleagues (2020) found that when EFL learners played a handheld/mobile game with Story, Video Clip, Gamified Assessment, Badge, Leading Board, and Customized Word List features, they were better able to recall the meanings and spellings

of the words and apply the words to new contexts, as compared to their achievement before the game.

However, two studies found no significant relation between game features and EFL learners' English vocabulary learning outcomes. Elaish and colleagues (2019) found that when EFL learners played a handheld/mobile game with Graphic Definition, In-game Dictionary, Badge, Hint, and Sharing to Social Media features, they did not recall significantly more meanings of new English words than learners who learned through lectures. Huang and colleagues (2017) reported that after EFL learners played a handheld/mobile game with Timer, Badge, Leading Board, and Customized Word List feature their word meaning and spelling outcomes were not significantly better than before they played the game. Notably, the game features Customized Word List had been isolated and tested in another study (Cha, 2020), but did not have a significant positive effect on the participants' learning outcomes when used together as a group of features in Huang and colleagues' study (2017).

Discussion

The goal of this literature review was to identify handheld/mobile game features that support EFL or ESL students' vocabulary learning. Based on our review, we concluded that, of the game features that were isolated and tested, Hologram, Customized Word List, Gamified Assessment, and In-game Hints had a positive impact on EFL/ESL vocabulary learning (see Table 4). Additionally, we concluded that, for the game features that were tested in groups (not individually), most of the game feature groups (nine out of eleven) have a positive impact on different aspects of EFL/ESL vocabulary learning (see Table 5). Given this finding, group testing makes it difficult to discern which

features have the greatest positive impact on ESL/EFL vocabulary learning.

Based on our findings, we generated implications for (1) language teachers who utilize handheld/mobile games for EFL or ESL students' vocabulary learning, (2) educational game developers, and (3) researchers of handheld/mobile games for EFL or ESL students' vocabulary learning. These are presented in the subsequent sections.

Implications for Language Teachers

For digital game-based learning environments, our findings suggest that teachers should choose games that incorporate Holograms, Customized Word Lists, and Gamified Assessment since they have been shown to produce positive vocabulary learning outcomes. When teachers create new games or modify existing games for ESL/EFL vocabulary learners, they can add these features to the games they create or modify for better learning outcomes. However, it is notable that the feature In-game Hint only worked for low-achieving students when learning word meaning and word spelling. When incorporating In-game Hint feature in vocabulary games, low-achieving students could benefit more from this feature compared with high- and medium-achieving students.

Additionally, several other potential directions for home and classroom practice can be explored . For example, using classroom vocabulary activities that incorporate game features that had positive relation with vocabulary learning outcomes could be investigated. For example, based on the finding that the game feature Gamified Assessment had a positive impact on learning the meaning and spelling of English words (Chen et al., 2019; Huang et al., 2017; Wu, 2018; Wu & Huang, 2017, see Table 4 and Table 5), language teachers might try to gamify their classroom assessments, such as

turning a vocabulary quiz into a “Tug-of-VOC” game (Chen et al., 2019, p.175) in which students spell English words as quickly as possible to win a tug of war. Also, based on the finding that the game features In-game Hints and In-game Teacher Aid had a positive impact on learning word meanings and spellings, language teachers might try to give students more hints at the right time to improve their performance. For those game features that had positive impacts on vocabulary learning but are not often seen in classrooms as traditional pedagogical strategies, such as Customized Word List (Berry, 2021; Hasram et al., 2021; Cha, 2020; Huang et al., 2017; Wu, 2018; Wu & Huang, 2017; Yang et al., 2020, see Table 4 and Table 5), the benefit of these in the classroom could be explored.

Implications for Educational Game Developers

Across the present review, the relations between the features tested in isolation and players’ outcomes provided the clearest information about what features are valuable for game design to promote positive English vocabulary learning. Game design should consider integrating Holograms and Customized Word Lists, which were related to better EFL vocabulary learning outcomes (Cerezo et al., 2019). Specifically, to improve the EFL learners’ pronunciation of new English words, game designers should integrate Holograms that include virtual figures that model pronunciation for EFL students because these have been shown to be positively related to better EFL pronunciation outcomes (Cerezo et al., 2019).

Additionally, game designers should consider incorporating Customized Word Lists and Gamified Competition into future EFL vocabulary handheld/mobile games. These two game features are effective in word meaning learning (Cha, 2020; Chen et al.,

2019). Another game feature that designers could consider utilizing is In-Game Hints, which are helpful in improving EFL learners' meaning and spelling of new English words (Huang & Huang, 2015).

Further, game designers can use clusters of game features that have been shown to be effective in supporting vocabulary learning when used together (see Table 5 for all statistically significant clusters of game features). For example, when Badges, In-Game Teacher Aids, Random Moving Directions, Competition, and Real-World Interactions were used together in a handheld/mobile game, EFL learners' vocabulary meaning outcomes for new English words were better (Chang et al., 2017).

Implications for Researchers of Handheld/mobile Games

Among the 16 reviewed empirical studies, most did not isolate game features when they tested their effectiveness (Berry, 2021; Chang et al., 2017; Hasram et al., 2021; John et al., 2021; Reynolds, 2017; Sandberg et al., 2014; Wu & Huang, 2017; Wu, 2018; Yang et al., 2020; Elaish et al., 2019; Huang et al., 2017). Thus, the effectiveness of specific features of handheld/mobile vocabulary games is unclear. To address this, future studies should create game-based learning environments and then isolate target game features to test the relations between individual game features and EFL or ESL players' vocabulary learning outcomes.

Also, it is notable that the same game features functioned differently in different games and learning environments. For example, the feature Gamified Competition had a significantly positive impact on word meaning learning in Chen and colleagues' (2019) study, but was not statistically significant for word meaning learning in Dindar and colleagues' study (2021). Different gameplay environments, vocabulary learning levels,

and first language backgrounds could all be potential confounding factors that might explain these different results. For example, the participants from the reviewed studies were from various age groups and were at different stages of learning English as a second/foreign language. Therefore, the same game feature might have a different impact on vocabulary learning related to these differences. When future research isolates and tests individual game features to identify their effectiveness, the researchers should also test for the potential interactions between these factors, the features, and learners' vocabulary learning outcomes.

Limitations and Future Research Directions

First, the number of studies available to review was small. Secondly, for each feature tested in isolation, there were only 1-3 studies that reported the feature's effectiveness. For example, there was only one study that focused on Hologram as a game feature (Cerezo et al., 2019) and one study that tested the effectiveness of Customized Word Lists (Cha, 2020). More empirical studies are needed to reveal the effectiveness of these and other game features in different handheld/mobile EFL and ESL vocabulary learning games.

Second, the present literature review did not discuss the psychological and cognitive science mechanisms that make the game features effective for EFL and ESL vocabulary learning. However, these mechanisms are fundamentally important for teachers, students, and game designers. For example, the Customized Word Lists feature exposed EFL learners to the words that they were least familiar with based on the gameplay record. Thus, these should be explored.

Third, due to issues of access, this review study did not include studies on the target topic in languages other than English. Future reviews might include studies across multiple languages to garner a broader scope of findings.

Conclusion

This literature review study addressed the following research question: “Based on previous empirical studies, how are features in digital handheld/mobile vocabulary learning games related to EFL and ESL students’ vocabulary learning outcomes?” Based on our analysis, we found the following. First, for the game features that were isolated and tested, we found that game features Hologram, Customized Word List, Gamified Assessment, and In-game Hints have a positive impact on different aspects of EFL/ESL vocabulary learning (see Table 4). Second, for the game features that were tested in groups (not isolated and tested), most of the game feature groups (nine out of eleven) have a positive impact on different aspects of EFL/ESL vocabulary learning (see Table 5).

CHAPTER THREE

FEATURES IN DIGITAL HANDHELD/MOBILE EFL VOCABULARY GAMES AND STUDENTS' LEARNING OUTCOMES: A SYSTEMATIC REVIEW

Introduction

For EFL (English as a Foreign Language) learners, an extensive lexicon is vitally important for building the four basic literacy skills: reading, writing, listening, and speaking (Nation & Coady, 1988; Schmitt, 2000). To emphasize the importance of vocabulary, Wilkins (1972) argued that “without grammar very little can be conveyed, without vocabulary nothing can be conveyed” (p. 110). However, EFL learners who live in non-English speaking environments have few chances to recall and practice vocabulary in their daily lives (Cheon, 2003; Elaish et al., 2019; Hwang et al., 2016; Shadiev et al., 2015; Tsou, 2005). This makes it more challenging to learn EFL vocabulary because, according to the Forgetting Curve Theory (Zheng, 2015), the retention of new vocabulary is reinforced by regular revisiting and practicing of words. Digital handheld/mobile educational games make it possible for EFL learners to revisit and practice English vocabulary “anytime and anywhere” (Lin & Lin, 2019, p. 879), and improve their vocabulary learning outcomes (Cerezo et al., 2019; Cha, 2020; Chen et al., 2019; Huang & Huang, 2015; Chang et al., 2017; Reynolds, 2017; Sandberg et al., 2014; Wu & Huang, 2017; Wu, 2018; Yang et al., 2020).

In the present review, game features refer to the design elements, functional modules, and gaming mechanisms that provide the players (learners) with challenge, feedback, fantasy, control, and social interaction (Prensky, 2001a). For example, the

game feature Badges provides the player with feedback and social interaction by giving the players badges when they accomplish certain tasks and letting the players show their badges to other players. Table 3 shows the game features the present review study identifies. Different game features may or may not contribute to EFL learners' vocabulary learning (DeRouin-Jessen, 2008; Huang et al., 2013). Understanding which game features are related to EFL learners' greatest vocabulary learning gains would inform both game design and game selection to improve vocabulary learning opportunities. Thus, there is a need for a review of studies that focus on the relation between handheld/mobile game features and EFL vocabulary learning outcomes.

However, after rounds of searching, we found that no previous literature reviews focused on the scope of the present review study, which is overlapped by the foci of 1) handheld/mobile learning, 2) digital games, 3) EFL learning, 4) vocabulary learning, and 5) how specific game features from handheld/mobile games are related to EFL students' vocabulary learning outcomes (See Figure 1). The previous literature reviews we found included some but not all of these foci. For example, some previous reviews focused on EFL vocabulary learning via Mobile-Assisted Language Learning programs (MALLs) (Afzali et al., 2017; Ahmad et al., 2013; Derakhshan & Khodabakhshzadeh, 2011; DeRouin-Jessen, 2008; Lin & Lin, 2019; Mahdi, 2018; Xu et al., 2020), which are different from handheld/mobile vocabulary learning games because these programs do not have the essential game elements that Prensky (2001b) illustrated (fun, play, and story) to provide game-play experience and, as a result, the effectiveness of game features was not investigated. . For example, the MALL programs Kahoot, Quizlet, and Quizizz just turn conventional instructional approaches, such as flashcards and quizzes,

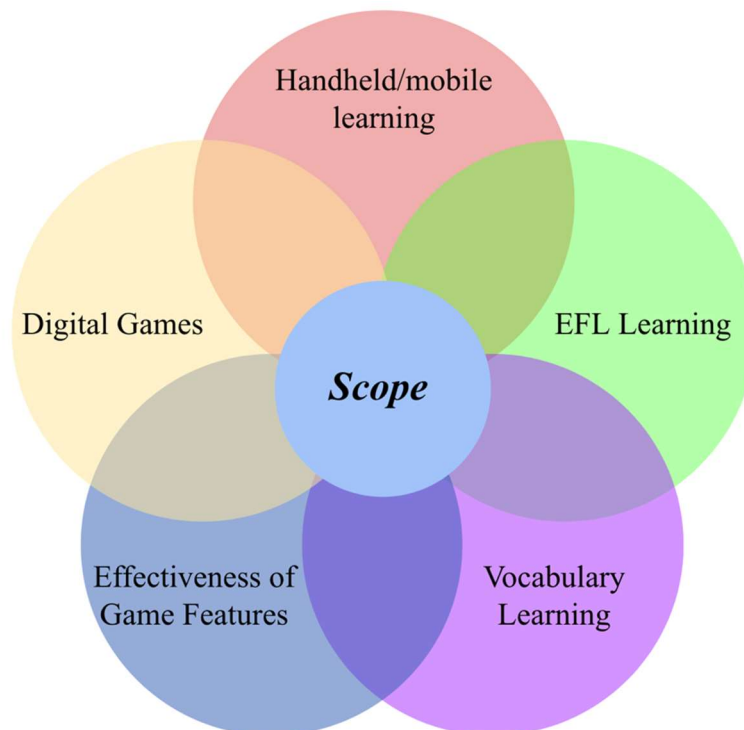
into digital or online versions (Alhebshi & Gamlo, 2022; Arnedo-Moreno, 2021). The lack of game elements, such as fun, play, or story (Prensky, 2001b), differentiates these MALL programs from vocabulary learning games. For handheld/mobile EFL vocabulary games, the relations between the game features and EFL learners' vocabulary outcomes have not been examined in existing reviews (e.g., Afzali et al., 2017). This paper addresses this issue and is guided by the following question:

Based on previous empirical studies, how are features in digital handheld/mobile vocabulary learning games related to EFL students' vocabulary learning outcomes?

Figure 1 presents a visual image of our literature review's scope.

Figure 1

The Scope of the Present Literature Review

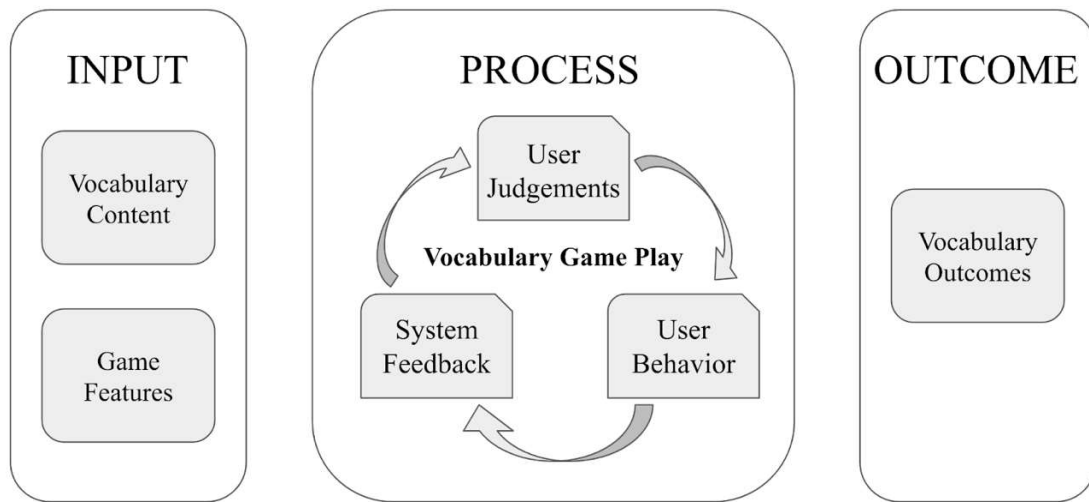


Theoretical Framework

To help identify the relations between game features in handheld/mobile games and EFL and vocabulary learning outcomes, we were guided by the “Input-Process-Outcome Game” model introduced by Garriss and colleagues (2002), which is illustrated in Figure 2.

Figure 2

Input-Process-Outcome Game Model (Garriss et al., 2002)



The Input-Process-Outcome Game Model demonstrates how game features, in combination with instructional content, support the learning process and desired outcomes (see Figure 2).

The Input part of the model depicts how both instructional content is and game features provide critical input into the learning process. Since game features are the mechanisms that the players actually interact with in games, educational games need to integrate instructional content with game features to deliver instructional content to the players. Game features play the role of vehicles that carry the instructional goals through

the game-playing process. For example, an English vocabulary learning game asks players to control the cannon to shoot the balloons that have the right spellings of given words. The game feature that asks the players to shoot the balloons is acting as the vehicle that carries the instructional content, which is the English words. In this way, the instructional goal of reinforcing the spelling of the English words is facilitated.

The Process part of the model explains how the player engages in the learning. For example, a player makes judgments based on the rules of the games and their understanding of given conditions. Then the players turn their judgments into actions to interact with the game. The game then gives feedback to the players' actions based on if the actions meet the rules and conditions of the game. In the aforementioned example, after the players make their judgments about choosing the right balloons to shoot, they take action and shoot the balloons. The game gives feedback to the players based on whether they shoot the right balloons, and the game cycle can restart again.

The Outcome part of the model reflects learning that occurs based on the inputs and learning process. It is important to note that multiple rounds of learning might need to occur, with varied inputs, before learning outcomes occur.

Methods

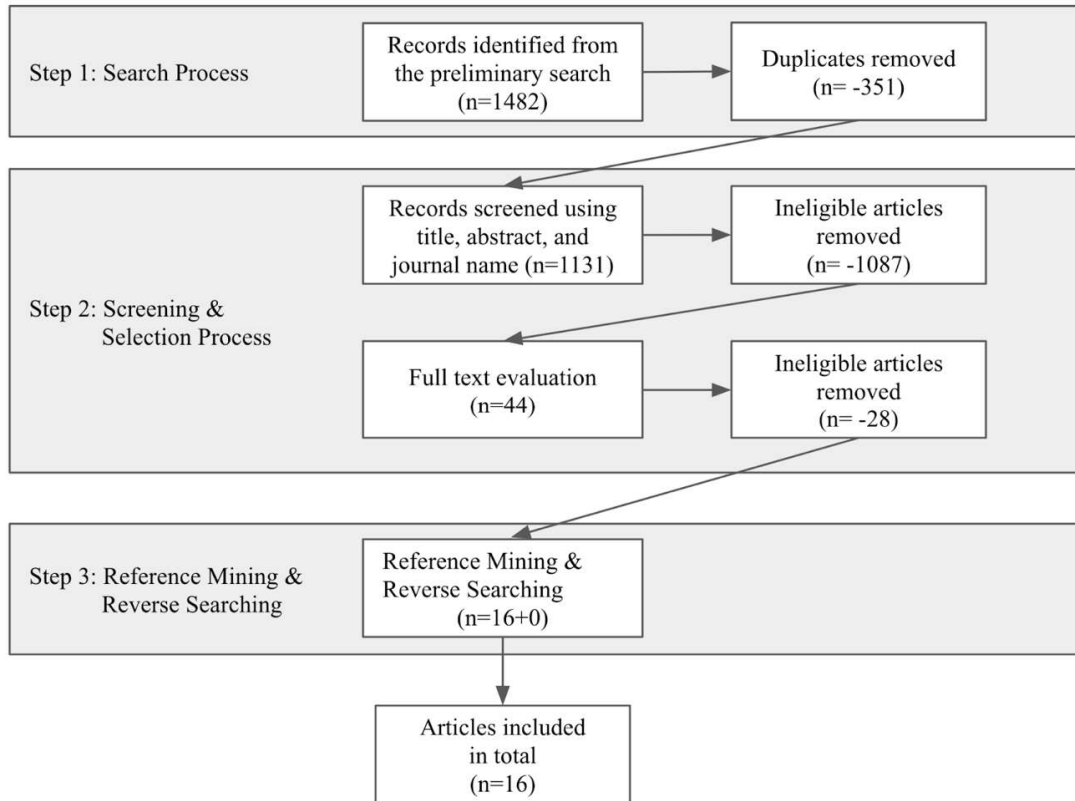
We used a systematic review to “offer novel insights” about how game features in handheld/mobile games are related to players' vocabulary learning outcomes (Alexander, 2020, p. 8). To accomplish this, we undertook “an orchestrated search of literature,” which is described across the following sections (Alexander, 2020, p. 8).

Article Search and Selection Process

The article searching and selecting process occurred across three steps, which are summarized in Figure 3.

Figure 3

Article Selection and Analysis Process



Step 1: Search Process

Due to the intersectional focus of this review across digital handheld/mobile games, EFL learning, and vocabulary learning outcomes (see Figure 1), the following databases were searched to identify target articles: ERIC (ProQuest), Educational Source (EBSCO), PsycINFO (EBSCO), Academic Search Complete (EBSCO), IEEE Xplore, JSTOR, Scopus, Educational Abstracts, and LLBA (EBSCO). To identify articles that

fell within our scope, we used the following sets of search terms in each of the databases.

Boolean operators are used to present the search terms.

- (“mobile game” AND EFL AND vocabulary) OR
- (“handheld game” AND EFL AND vocabulary) OR
- (“mobile game” AND “foreign language” AND vocabulary) OR
- (“handheld game” AND “foreign language” AND vocabulary) OR
- (“mobile game” AND “second language” AND vocabulary) OR
- (“handheld game” AND “second language” and vocabulary) OR
- (“mobile game” AND ELL AND vocabulary) OR
- (“handheld game” AND ELL AND vocabulary)

We delimited each search to publications between 2011-2022 because handheld/mobile digital devices and high-speed mobile networks have dramatically developed across the past decade. In December 2010, the 4G Network (The Fourth Generation Mobile Network), which allows high-speed audio and video streams, started running in the U.S. Meanwhile, smartphones and portable tablet computers evolved significantly to be capable of running more feature-rich application programs, such as massive multiplayer online games. These technological conditions matured in the last 11 years enabling learners to access and enjoy feature-rich handheld/mobile educational games anytime and anywhere. Therefore, studies that focused on mobile educational games before 2010 were not able to represent the current digital applications. Additionally, we delimited our search to studies published in English.

Table 1 shows the records returned from the preliminary search, totaling 1,482 articles. Amongst these, there were 351 articles that were identified across multiple database searches. So, in total, 1,131 unique articles remained to be considered after removing the duplicate search results.

Table 1

Records Identified After The Initial Search

Database	Returned Records
ERIC	32
Educational Source	28
PsycINFO	11
Academic Search Complete	21
IEEE Xplore	3
JSTOR	247
Scopus	413
Educational Abstracts	11
LLBA	716
Total	1,482

Step 2: Screening and Selection Process

All 1,131 articles went through a two-step process to be considered for inclusion in the literature review. First, articles were screened using just the title, abstract, and journal background to evaluate whether they seemed to meet the following criteria:

1. Published in a peer-reviewed journal to ensure quality (Rothstein & Hopewell, 2009),

2. Reflected empirical research in which data were collected and analyzed, and
3. Focused on the effectiveness of handheld/mobile game features for supporting English vocabulary learning outcomes.

Only 44 articles that seemed to meet these criteria were further considered for inclusion in the literature review (see Table 2). The other 1,087 articles were excluded from consideration because they did not meet one or more of the criteria.

Table 2

Records Remaining After Screening Using The Title, Abstract, And Journal Name

Database	Returned Records
ERIC	6
Educational Source	5
PsycINFO	4
Academic Search Complete	11
IEEE Xplore	1
JSTOR	0
Scopus	5
Educational Abstracts	7
LLBA	2
Total	41

Second, the 44 articles that seemed to meet the criteria were read in their entirety to further evaluate whether they really did meet all three criteria. Through this process, 25 more articles were excluded for not meeting all three criteria. For example, what Kassem (2018) used were actually MALL (Mobile Assistant Language Learning) applications

instead of handheld/mobile games. Hung and Young's (2015) study focused on using handheld games for EFL vocabulary learning but did not report the participants' vocabulary learning outcomes. In addition, three articles were excluded because they focused on learning the vocabulary of languages other than English. After this step, 16 articles met the criteria to be included in this literature review.

All the 16 yielded articles focused on EFL participants from non-English speaking countries in which they were learning English as a foreign language. Although one of these studies used the term "ESL" to represent "Early Second Language" (Sandberg et al., 2014, p. 122) game for Dutch primary school students, the participants were also learning English as a foreign language.

Step 3: Reference Mining and Reverse Searching

For each of the 16 articles identified for inclusion in the literature review, both reference mining (using each article's reference list to potentially find new articles that met our inclusion criteria) and reverse searching (using the Google Scholar "cited by" feature) were conducted to identify any additional articles that might meet the inclusion criteria for the literature review. However, no additional articles were identified through these processes.

Analytic Methods

Phase 1: Cataloging Article Information

A database was used to catalog information from the 16 reviewed articles included in the present literature review, including research questions, research designs, participants' age groups, participants' first languages, handheld/mobile game genres, the game features utilized, game availability (i.e., off-the-shelf, researcher-modified, or

researcher-created), and gaming environment (i.e., off-line, asynchronously online, or synchronously online). The focus of the cataloging process is the information on the handheld/mobile vocabulary learning games in the reviewed articles and how these games used various features to engage the EFL players and help improve their vocabulary learning outcomes. To identify the game features used in the games across the reviewed articles and reveal the relations between the game features and English vocabulary learning outcomes, three steps of analysis were undertaken.

First, we started with using the terminologies or the immediate description of the features from the reviewed articles, and then used constant comparative methods (Corbin & Strauss, 2014) to merge or parse each code so that the best goodness-of-fit with the feature definition could be achieved. In this process, we constantly checked whether the features found in the articles were aligned with our criteria for game features, which is providing the players with challenge, feedback, fantasy, control, and social interaction (Prensky, 2001a). For each article, all game features that could be found in the handheld/mobile game were coded. Table 3 shows the names and definitions of the 23 features that the handheld/mobile games from the reviewed studies incorporated.

Table 3

Game Features And Their Definitions

Feature Name	Definition
Badge	The in-game reward based on the players' gameplay behavior
Leading Board	The feature that shows the players current achievement in the games
Gamified Competition	The feature encourages the players to reach certain goals faster or better than other players or groups

Table 3 - Continued

Feature Name	Definition
Graphic Definition	Using graphics, including pictures and photos to show the meaning of the words
Gamified Assessment	Game-like assessments in the game to provide periodical feedback to the players or to indicate the players' progress
Multiple Game Levels (Not tested)	The feature that provides different game difficulty levels for the players
Customized Word List	The feature that provides a unique word list with the players based on their prior behavior
Timer	The time limit for each action in the games
Video Clip	Videos present the words' definition, story background, or the game playing environment
Digital Pronunciation	The feature that provides pronunciation of words or sentences.
In-Game Hint	The feature gives the players clues to find the answers or solutions
Randomly Moving	The feature that locates the players to random stages of the games or makes random choices for the next step.
Real-world Interaction	The feature that allows the players to use the real world as part of the game
Story	The feature that sets an overall background or vision of the game
Gamified Cooperation	The feature that encourages the players to work with other players to achieve the goals of the game
Hologram	The 3D scenes, figures, or/and objects in games created by holography technology
In-game Dictionary	The feature that allows students to look up new words in E-dictionary
In-game Teacher Aid	The feature that allows the teachers to supervise the players' gameplay behavior and provide necessary help during the gameplay process
Sharing To Social Media (Not tested)	The feature that allows the players to share their status and achievement on social media
Word List (Whole) (Not tested)	The feature demonstrates all the words that the players need to learn

Table 3 - Continued

Feature Name	Definition
Automatically Adjusting Frequency (Not tested)	The feature that adjusts the present frequency of a word based on the players' action
In-game Currency	The feature that encourages the players to earn as a reward and can be used to exchange for other game rewards
Background Music	The feature that plays background music while the players play the game

Second, we merged the game features that had the same functions across the handheld/mobile games. Some of these features functioned in the same way and served the same instructional goals but had different names across the reviewed studies. Such game features were merged into one feature in Table 3. For example, in VocabGame (Elaish et al., 2019), the winners of the competition were awarded Medals while Saving Alice (Yang et al., 2020), another handheld/mobile vocabulary game, gave the players Stars when they unlocked the new level of the game. The features Stars and Medals are both symbols to award the Winning State (Prensky, 2001b) players earned from competitions or challenges. Thus, they were merged into one game feature Badges.

Finally, across the reviewed articles, we mapped the vocabulary learning outcomes related to each game feature or feature group. According to the findings that the reviewed articles reported, the handheld/mobile EFL vocabulary games contributed to and examined how the participants learned (1) the pronunciations of new English words, (2) the definitions of new English words, (3) the spellings of new English words, and (4) to use new English words in various contexts. Since the same handheld/mobile vocabulary game or the same game feature may have had different impacts on different

vocabulary learning aspects, it was necessary to distinguish the relations between game features and different aspects of vocabulary learning outcomes.

Phase 2: Analysis

Step one. We divided the game features from the reviewed studies into two groups based on whether they were tested in isolation (without other confounding features in the game) or tested simultaneously with other game features (i.e., features were used as a group in the game). For example, Cerezo and colleagues (2019) tested the Hologram feature (the vocabulary game uses a set of mirrors to create a hologram virtual figure to interact with the students) in isolation—the only difference between the handheld/mobile game used for the experimental and control groups was the Hologram feature. Therefore, the difference between the learning outcomes of the two groups can be ascribed to the Hologram feature. By contrast, other reviewed studies used games that had multiple game features tested simultaneously in the experimental group, while the control group did not use the games, or used a simpler version of the games that lacked two or more game features compared to the games the experimental group used (e.g., Chang et al., 2017; Reynolds, 2017; Yang et al., 2020). For these studies, the different learning outcomes cannot be simply ascribed to any one specific game feature from the experimental group game.

Step two. For the features that were tested in isolation, we synthesized the findings across studies to indicate, for each game feature, what kind of vocabulary learning it affected and whether the relation was positive. For example, Cha's (2020) study reported that the Customized Word List feature has statistically significant positive relations with outcomes in learning both word meanings and using words in different

contexts. In this way, the relations between various game features and different vocabulary learning outcomes were reported across studies to identify patterns.

Step three. For the game features that were not tested in isolation, their relations with vocabulary learning outcomes were summarized as groups of features. For example, Chang and colleagues (2017) designed experimental games that included Badges, In-game Teacher Aids, Random Moving Direction, Gamified Competition, and Real-world Interaction features. This group of game features had a statistically significant positive relation with EFL learners' word meaning learning outcomes as compared to traditional instruction.

Findings

Across the studies, 23 game features were identified from the handheld/mobile EFL vocabulary games in the reviewed studies (see Table 3 for a list and definitions of the features). However, four game features existed in both the experimental and the control groups in the studies in which they were found. Thus, the effectiveness of these features was not able to be ascertained related to players' vocabulary learning outcomes. Therefore, these features were excluded from the findings. The remaining 19 game features' relations with vocabulary learning outcomes are reported in this section.

Out of the 16 studies reviewed, five game features were tested in isolation (Cerezo et al., 2019; Cha, 2020; Chen et al., 2019; Dindar et al., 2021; Huang & Huang, 2015). Eleven studies tested game features in groups. In the following sections, we first summarize the findings from the studies that tested game features in isolation. Second, we summarize findings from studies that tested game features as a group (i.e., without isolating game features and testing them).

Studies that Tested Game Features in Isolation

Table 4 provides a summary of the relations between game features tested in isolation and the players' vocabulary learning outcomes. Of note is that each study explored a different game feature or features, or the same game feature for different word learning outcomes (i.e., Pronunciation, Word Meaning, Word Spelling, or Using Words in Different Contexts). Thus, no synthesis of findings across these studies was possible.

Table 4

The Relation Between Game Features Tested In Isolation And Vocabulary

Learning Outcomes

1. Study	2. Game Feature	3. Vocabulary Learning Outcome	4. Statistically Significant Positive relation?
Cerezo et al., 2019	Hologram	Pronunciation	Yes
Cha, 2020	Customized Word List	Word Meaning	Yes
Cha, 2020	Customized Word List	Using Words in Different Contexts	No
Chen, et al., 2019	Gamified Assessment	Word Meaning & Word Spelling	Yes
Dindar et al., 2021	Gamified Competition	Word Meaning	No
Dindar et al., 2021	Gamified Cooperation	Word Meaning	No
Huang & Huang, 2015	In-game Hint	Word Meaning & Word Spelling (only for low-achieving students)	Yes
Huang & Huang, 2015	In-game Hint	Word Meaning & Word Spelling (For high- and medium-achieving students)	No

Of the five studies that isolated game features, two compared the use of a feature in a handheld mobile game to a similar paper game without the feature. Cerezo and colleagues (2019) found that when EFL learners played a handheld/mobile game with a virtual figure feature (cartoon-style figures created by a hologram, such as robots, animals, or people), they had better pronunciation of targeted vocabulary words than did EFL learners who played the same game but without the hologram virtual figure or played a similar paper-based game. Cha (2020) found that when EFL learners played a handheld/mobile game with the Customized Word List feature for each learner based on the words they missed, they had better word-meaning outcomes as compared to learners who played a similar paper-based game. The other three of the five studies compared the use of a feature in a handheld/mobile game to the use of the same handheld/mobile game without the feature. Chen and colleagues (2019) found that when EFL learners played a handheld/mobile game with the Gamified Assessment features, such as Tic-Tac-Toe, Tug-of-VOC (VOC stands for vocabulary), and Star VOC, they had better learning outcomes on word meaning and word spellings as compared to learners who played the same handheld/mobile without the Gamified Assessment features. Huang and Huang (2015) found that when low-achieving EFL learners played a handheld/mobile vocabulary game with the In-game Hint feature, which provided hints about words' meanings or spellings when a player needed it, their word meaning and spelling outcomes were better than learners who played the same handheld/mobile game without the hint feature. However, Dindar and colleagues (2021) found that when EFL learners played a handheld/mobile game with the Gamified Competition feature versus a Gamified

Cooperation feature, there were no significant differences in the learners' word meaning learning outcomes.

Studies that Tested Game Features as a Group

Table 5 summarizes the relations between groups of game features and the participants' vocabulary learning outcomes. While most of these studies found positive effects of game features on EFL learners' vocabulary outcomes (Berry, 2021; Chang et al., 2017; Hasram et al., 2021; John et al., 2021; Reynolds, 2017; Sandberg et al., 2014; Wu & Huang, 2017; Wu, 2018; Yang et al., 2020), a couple of studies did not (Elaish et al., 2019; Huang et al., 2017).

Table 5

Relations Between Groups Of Features And Vocabulary Learning Outcomes

1. Study	2. Game Features Grouped Together in the Study	3. Vocabulary Learning Outcome	4. Statistically Significant Positive Relation?
Berry, 2021	Real-World Interaction Customized Word List Gamified Competition Gamified Cooperation Story	Pronunciation	Yes
Chang et al., 2017	Badge In-Game Teacher Aid Randomly Moving Gamified Competition Real-World Interaction	Word Meaning	Yes
Hasram et al., 2021	Graphic Definition Customized Word List	Word Meaning, Word Spelling & Using Words in Different Contexts	Yes

Table 5 - Continued

1. Study	2. Game Features Grouped Together in the Study	3. Vocabulary Learning Outcome	4. Statistically Significant Positive Relation?
John et al., 2021	Graphic Definition In-game Cooperation Background Music	Word Meaning & Using Words in Different Contexts	Yes
Reynolds, 2017	Graphic Definition Badge In-Game Currency Gamified Competition	Word Meaning	Yes
Sandberg et al., 2014	Graphic Definition Story Video Clip In-Game Teacher Aid	Word Meaning	Yes
Wu & Huang, 2017	Customized Word List Gamified Assessment In-Game Currency Leading Board Timer	Word Meaning & Word Spelling	Yes
Wu, 2018	Customized Word List Gamified Assessment In-Game Currency Leading Board Timer	Word Meaning & Word Spelling	Yes
Yang et al., 2020	Story Video Clip Gamified Assessment Badge Leading Board Customized Word List	Word Meaning, Word Spelling, & Using Words in Different Contexts	Yes
Elaish et al., 2019	Graphic Definition In-Game Dictionary Badge Hint Sharing To Social Media	Word Meaning	No

Table 5 - Continued

1. Study	2. Game Features Grouped Together in the Study	3. Vocabulary Learning Outcome	4. Statistically Significant Positive Relation?
Huang et al., 2017	Timer Badge Gamified Assessment Leading Board Customized Word List	Word Meaning	No

Berry (2021) used the game Spaceteam ESL, which had the features Real-World Interaction, Customized Word List, Gamified Competition, Gamified Cooperation, and Story to help improve learners' English word pronunciation. The study's setting required the players to communicate with each other (in the real world while playing the game) using the embedded target English words to accomplish the missions and beat other teams. The findings demonstrated a statistically significant improvement in English word pronunciation amongst players in the experiment group. Although Berry (2021) claimed that it was mainly the real-world verbal communication between the players that helped the players improve their English pronunciation in the experimental group (vs. a control group that did not play the game), we cannot separate the game features from the conversations to clearly attribute the effectiveness of the game to either. Further, Chang and colleagues (2017) found that when EFL learners played a handheld/mobile game that had Badges, In-game Teacher Aid, Random Moving, Gamified Competition, and Real-world Interaction features, they learned more word meanings than learners who used a non-game paper-based learning approach. Additionally, for 5th-grade EFL learners, Hasram et al. (2021) selected a simple online mobile game World of Words, which has

Graphic Definition and Customized Word List features. Their findings showed that playing the online game was related to EFL learners' outcomes for better word meaning, word spelling, and using words in different contexts. John and colleagues (2021) created a mobile vocabulary game for their research study, which had Graphic definition, In-game Cooperation, and Background Music features. Reynolds (2017) reported that EFL learners who played a handheld/mobile game with Graphic Definition, Badge, In-game Currency, and Gamified Competition features incidentally learned word meanings. Sandberg and colleagues (2014) found EFL learners who played a handheld/mobile game with Graphic Definition, Story, Video Clip, and In-game Teacher Aid features learned more word meanings compared to learners who played the same handheld/mobile game without these features. Two studies found that EFL learners who played a handheld/mobile game with Customized Word List, Gamified Assessment, In-game Currency, Leading Board, and Timer features had better word meaning and spelling outcomes than learners who were taught via lectures (Wu, 2018; Wu and Huang, 2017). Yang and colleagues (2020) found that when EFL learners played a handheld/mobile game with Story, Video Clip, Gamified Assessment, Badge, Leading Board, and Customized Word List features, they were better able to recall the meanings and spellings of the words and apply the words to new contexts, as compared to their achievement before the game.

However, two studies found no significant relation between game features and EFL learners' English vocabulary learning outcomes. Elaish and colleagues (2019) found that when EFL learners played a handheld/mobile game with Graphic Definition, In-game Dictionary, Badge, Hint, and Sharing to Social Media features, they did not recall

significantly more meanings of new English words than learners who learned through lectures. Huang and colleagues (2017) reported that after EFL learners played a handheld/mobile game with Timer, Badge, Leading Board, and Customized Word List feature their word meaning and spelling outcomes were not significantly better than before they played the game. Notably, the game features Customized Word List had been isolated and tested in another study (Cha, 2020), but did not have a significant positive effect on the participants' learning outcomes when used together as a group of features in Huang and colleagues' study (2017).

Discussion

The goal of this literature review was to identify handheld/mobile game features that support EFL students' vocabulary learning. Based on our review, we concluded that, of the game features that were isolated and tested, Hologram, Customized Word List, Gamified Assessment, and In-game Hints had a positive impact on EFL vocabulary learning (see Table 4). Additionally, we concluded that, for the game features that were tested in groups (not individually), most of the game feature groups (nine out of eleven, 82%) have a positive impact on different aspects of EFL vocabulary learning (see Table 5). Given this finding, group testing makes it difficult to discern which features have the greatest positive impact on EFL vocabulary learning.

Based on our findings, we generated implications for (1) language teachers who utilize handheld/mobile games for EFL students' vocabulary learning, (2) educational game developers, and (3) researchers of handheld/mobile games for EFL students' vocabulary learning. These are presented in the subsequent sections.

Implications for Language Teachers

For digital game-based learning environments, our findings suggest that teachers should choose games that incorporate Holograms, Customized Word Lists, and Gamified Assessment since they have been shown to produce positive vocabulary learning outcomes. When teachers create new games or modify existing games for EFL vocabulary learners, they can add these features to the games they create or modify for better learning outcomes. However, it is notable that the feature In-game Hint only worked for low-achieving students when learning word meaning and word spelling. When incorporating In-game Hint feature in vocabulary games, low-achieving students could benefit more from this feature compared with high- and medium-achieving students.

Additionally, several other potential directions for home and classroom practice can be explored, such as using classroom vocabulary activities that incorporate game features that had positive relation with vocabulary learning outcomes could be investigated. For example, based on the finding that the game feature Gamified Assessment had a positive impact on learning the meaning and spelling of English words (Chen et al., 2019; Huang et al., 2017; Wu, 2018; Wu & Huang, 2017, see Table 4 and Table 5), language teachers might try to gamify their classroom assessments, such as turning a vocabulary quiz into a “Tug-of-VOC” game (Chen et al., 2019, p.175) in which students spell English words as quickly as possible to win a tug of war. Also, based on the finding that the game features In-game Hints and In-game Teacher Aid had a positive impact on learning word meanings and spellings, language teachers might try to give students more hints at the right time to improve their performance. For those game

features that had positive impacts on vocabulary learning but are not often seen in classrooms as traditional pedagogical strategies, such as Customized Word List (Berry, 2021; Hasram et al., 2021; Cha, 2020; Huang et al., 2017; Wu, 2018; Wu & Huang, 2017; Yang et al., 2020, see Table 4 and Table 5), the benefit of these in the classroom could be explored.

Implications for Educational Game Developers

Across the present review, the relations between the features tested in isolation and players' outcomes provided the clearest information about what features are valuable for game design to promote positive English vocabulary learning. Game design should consider integrating Holograms and Customized Word Lists, which were related to better EFL vocabulary learning outcomes (Cerezo et al., 2019). Specifically, to improve the EFL learners' pronunciation of new English words, game designers should integrate Holograms that include virtual figures that model pronunciation for EFL students because these have been shown to be positively related to better EFL pronunciation outcomes (Cerezo et al., 2019).

Additionally, game designers should consider incorporating Customized Word Lists and Gamified Competition into future EFL vocabulary handheld/mobile games. These two game features are effective in word meaning learning (Cha, 2020; Chen et al., 2019). Another game feature that designers could consider utilizing is In-Game Hints, which are helpful in improving EFL learners' meaning and spelling of new English words (Huang & Huang, 2015).

Further, game designers can use clusters of game features that have been shown to be effective in supporting vocabulary learning when used together (see Table 5 for all

statistically significant clusters of game features). For example, when Badges, In-Game Teacher Aids, Random Moving Directions, Competition, and Real-World Interactions were used together in a handheld/mobile game, EFL learners' vocabulary meaning outcomes for new English words were better (Chang et al., 2017).

Implications for Researchers of Handheld/mobile Games

Among the 16 reviewed empirical studies, many (11 of them, 69%) did not isolate game features when they tested their effectiveness (Berry, 2021; Chang et al., 2017; Hasram et al., 2021; John et al., 2021; Reynolds, 2017; Sandberg et al., 2014; Wu & Huang, 2017; Wu, 2018; Yang et al., 2020; Elaish et al., 2019; Huang et al., 2017). Thus, the effectiveness of specific features of handheld/mobile vocabulary games is unclear. To address this, future studies should create game-based learning environments and then isolate target game features to test the relations between individual game features and EFL players' vocabulary learning outcomes.

Also, it is notable that the same game features functioned differently in different games and learning environments. For example, the feature Gamified Competition had a significantly positive impact on word meaning learning in Chen and colleagues' (2019) study, but was not statistically significant for word meaning learning in Dindar and colleagues' study (2021). Different gameplay environments, vocabulary learning levels, and first language backgrounds could all be potential confounding factors that might explain these different results. For example, the participants from the reviewed studies were from various age groups and were at different stages of learning English as a second/foreign language. Therefore, the same game feature might have a different impact on vocabulary learning related to these differences. When future research isolates and

tests individual game features to identify their effectiveness, the researchers should also test for the potential interactions between these factors, the features, and learners' vocabulary learning outcomes.

Limitations and Future Research Directions

First, the number of studies available to review was small. Secondly, for each feature tested in isolation, there were only 1-3 studies that reported the feature's effectiveness. For example, there was only one study that focused on Hologram as a game feature (Cerezo et al., 2019) and one study that tested the effectiveness of Customized Word Lists (Cha, 2020). More empirical studies are needed to reveal the effectiveness of these and other game features in different handheld/mobile EFL vocabulary learning games.

Second, the present literature review did not discuss the psychological and cognitive science mechanisms that make the game features effective for EFL vocabulary learning. However, these mechanisms are fundamentally important for teachers, students, and game designers. For example, the Customized Word Lists feature exposed EFL learners to the words that they were least familiar with based on the gameplay record. Thus, these should be explored.

Third, due to issues of access, this review study did not include studies on the target topic in languages other than English. Future reviews might include studies across multiple languages to garner a broader scope of findings.

Conclusion

This literature review study addressed the following research question: "Based on previous empirical studies, how are features in digital handheld/mobile vocabulary

learning games related to EFL students' vocabulary learning outcomes?" Based on our analysis, we found the following. First, for the game features that were isolated and tested, we found that game features Hologram, Customized Word List, Gamified Assessment, and In-game Hints have a positive impact on different aspects of EFL vocabulary learning (see Table 4). Second, for the game features that were tested in groups (not isolated and tested), most of the game feature groups (nine out of eleven) have a positive impact on different aspects of EFL vocabulary learning (see Table 5).

CHAPTER FOUR

COMPARING THE EFFECTIVENESS OF PEER COMPETITION VERSUS NO COMPETITION IN HANDHELD/MOBILE GAMES FOR EFL STUDENTS' VOCABULARY LEARNING

Need and Significance

While vocabulary is vitally important for EFL (English as a Foreign Language) learning outcomes (Nation & Coady, 1988; Schmitt, 2000; Wilkins, 1972), computer-assisted language learning (CALL) tools for EFL vocabulary learning have been developed significantly in the past two decades, including handheld/mobile vocabulary games (Bin-Hady, 2021). Although Many of these games have a positive impact on EFL vocabulary learning (Cerezo et al., 2019; Cha, 2020; Chen et al., 2019; Huang & Huang, 2015; Chang et al., 2017; Reynolds, 2017; Sandberg et al., 2014; Wu & Huang, 2017; Wu, 2018; Yang et al., 2020), the effectiveness of specific game features that relate with the positive impact has not been elucidated. In this study, game features refer to the design elements, functional modules, and gaming mechanisms that allow the players to communicate with the games in designated ways, utilize the resources in the games, and get responses from the games (Garris et al., 2002). Understanding which game features are related to EFL learners' greatest vocabulary learning gains would inform both game design and game selection to improve vocabulary learning opportunities. Different game features, such as peer competition, may or may not contribute to EFL students' vocabulary learning (DeRouin-Jessen, 2008; Huang et al., 2013). Thus, there is a need for studies that test the game feature's effectiveness . In this study I aimed to reveal the relation between the peer competition game feature and EFL vocabulary learning. While

there are multiple aspects of vocabulary learning, including word meaning, pronunciation, spelling, context to use, collocation and parts of speech (Carroll, 2013), this study focused specifically on word meaning learning outcomes (i.e., definitions).

Peer competition is one of the most pervasively used game features in educational games (Vorderer et al., 2003). As of August 2022, only one previous empirical study had tested the effectiveness of peer competition in handheld/mobile vocabulary games (Dindar et al., 2021). However, in Dindar and colleagues' study, peer competition was not a feature embedded in the game. The competitive environment was created by the researchers by presenting a leading board to the participants from the real world (out of the game). The effectiveness of peer competition was measured but not as an impact of the game feature. In contrast, this study measured the effectiveness of competition on EFL vocabulary learning outcomes as a game feature in *Vocarena*, a handheld game developed by the author.

Theoretical Framework

Given that this study aims to reveal the effectiveness of peer competition, as a game feature, on EFL students' vocabulary learning, it is essential to articulate the relationship between game features and instructional outcomes, and how they interact reciprocally. The Input-Process-Outcome Game Model (Garris et al., 2002, see Figure 1) illustrates such relationships and thus was used as the theoretical framework of this study.

First, The Input-Process-Outcome Game Model addresses the interaction between the game features in educational games and instructional goals. In this model, game features act as vehicles that carry the instructional content through the game-playing process. For example, the game feature Adaptive Word List in a vocabulary game shows

the words that the learner makes the most mistakes about on the top of the list. This feature helps the learners revisit the hardest words for each of them. The list for each learner differs based on the learner's learning record in the game. Aligned with the Input-Process-Outcome model, the game feature Adaptive Word List integrates the instructional content, which is the target words, into the game and carries the target words through the game circle. Such relation between game features and instructional goals is depicted and articulated in the "Input" section of the Input-Process-outcome Game Model.

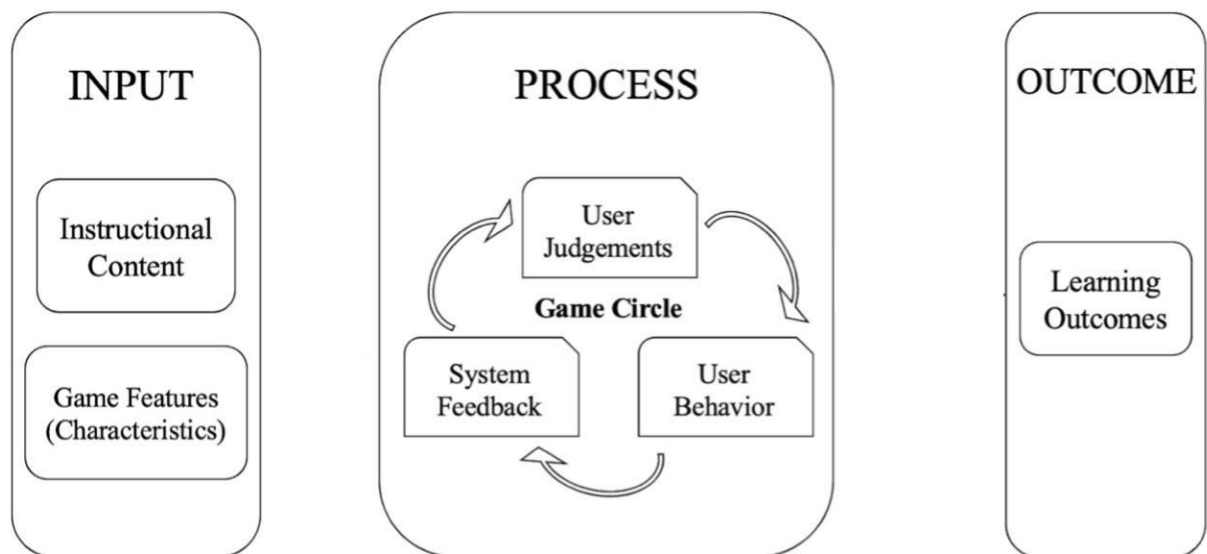
Second, the "Game Circle," which is the Process section of the Input-Process-Output Game Model, presents the micro process of how the learners of educational games interact with specific game features. Game features guide the learners to make judgments about certain situations, and then the learners take action based on their own judgments. Based on the feedback the system (the educational games) gives the learners based on their actions, the learners adjust their judgments and enter the next round of the game circle. In the case of Adaptive Word List, the learners will give answers to the questions the game raises, such as choosing the right definition of a word or spelling a word correctly. When the learners finish their actions (choosing and spelling), the system will give feedback to the learner, in this case, which is reordering the words based on how many times the learners choose the right definition or spell it correctly.

Third, the Outcome section of the model illustrates the goal and essence of educational games and the game features within, that is, to serve the learning outcomes. All structures and features in educational games, regardless of how they function to

engage and motivate learners, are to create desired learning outcomes. This is also how the researcher-developed EFL vocabulary game in this empirical study was designed.

Figure 1

The Input-Process-Outcome Game Model



Literature Review

Vocabulary Learning

A sufficient English vocabulary is vitally important for EFL learners. It is essential for the four basic language skills (reading, writing, listening, and speaking) (Nation & Coady, 1988; Schmitt, 2000). Without being able to recognize the words in texts and speech, EFL learners' reading and listening comprehension will be drastically limited. Likewise, without extensive vocabulary knowledge, it can be difficult for EFL learners to express their ideas well in their writing and speaking. To highlight the magnitude of vocabulary, Wilkins (1972) noted that "without grammar, very little can be conveyed, without vocabulary, nothing can be conveyed" (p. 110). Nevertheless, in non-

English-speaking countries, EFL learners barely have chances to reinforce and practice their vocabulary in the real world (Cheon, 2003; Elaish et al., 2019; Hwang et al., 2016; Shadiev et al., 2015; Tsou, 2005). Without regularly revisiting and recalling the English words they learn, it will be extremely difficult for EFL learners to build their vocabulary efficiently and effectively per the Forgetting Curve Theory (Zheng, 2015).

Fortunately, with the development of high-speed wireless networks and portable digital devices, CALL application programs, including online language learning games, can be run disregarding the players' geographic locations and allow EFL learners to revisit and practice the words they learn "anytime and anywhere" (Lin & Lin, 2019, p. 879). Previous literature provided solid evidence that handheld/mobile educational games help EFL learners improve their vocabulary learning outcomes. Cerezo and colleagues (2019) found that a Hologram handheld game helped EFL students from Spain improve their English word pronunciation. Handheld games with adaptive word lists helped students in Korea remember more English words' definitions (Cha, 2020). When gamified assessments and automatic hints were embedded in handheld vocabulary games, the players of the game from Taiwan had significantly better learning outcomes in learning word definitions and spellings (Chen et al., 2019; Huang & Huang, 2015). When integrating multiple game features in handheld vocabulary games, students from non-English-speaking countries gain significant improvement in learning word definitions, spellings, and using the right English words in different contexts (Chang et al., 2017; Reynolds, 2017; Sandberg et al., 2014; Wu, 2018; Wu & Huang, 2017; Yang et al., 2020).

Competition

Competition has existed in human groups since the beginning of civilization, and has been called a “pervasive trait of human nature” (Cornaglia et al., 2019, p. 136). In the history of the earth, plants and animals have competed in the struggle for existence, including biotic competition among human beings and other species (Powell, 1888). In wild conditions, animals compete for food, territory, and the chances of reproducing. In modern societies, people compete with each other for limited resources (Cornaglia et al., 2019). Cantador and Conde (2010) define human competition as “a contest where two or more people strive for a goal that cannot be shared, usually resulting in a victor and a loser” (p. 11). This definition implies two indispensable factors of human competition: (1) “a goal that cannot be shared,” which usually means resources for survival or/and development; (2) such resources are limited and cannot meet all group members’ needs. The occurrence of human competition is based on both of these factors (Johnson & Johnson, 1989). In modern society, the scarcity of educational resources is pervasive. For instance, peer competition is often seen between students who are working on securing enrollment places from outstanding high schools or universities where such enrollment places are limited. Similar competition can also be seen in the job market and commercial activities, especially when the number of positions or products cannot be shared by all parties (Butera, 2021; Nelson & Dawson, 2017).

In the realm of education, the history of competition, as a pedagogical element, is controversial. At schools in the U.S., the debate about whether competition is a constructive teaching approach for students’ learning outcomes has lasted for decades (Butera, 2021; Rich, 1988). On the one hand, previous studies found that competition

could undermine students' learning motivation (Deci et al., 1981; Kohn, 1992, 2019), increase students' anxiety (Deci & Flaste, 1996; Schaefer et al., 2016; Yang et al., 2020), and impede cooperative and inquiry learning (Tracy & Morrow, 2017). As a result, while the tendency of the occurrence of competition had always been in the classrooms, many teachers favored cooperative learning over competition in their classrooms, (Butera, 2021; Rich, 1988; Rich & DeVitis, 1992; Sarid, 2021). On the other hand, empirical evidence from previous studies also suggests that competition increased students' learning efficiency, created a high excitement level in students, and helped students to pay attention to the learning contents during the learning process (Atanasijevic-Kunc et al., 2010; Cheng et al., 2009). Although competition could undermine students' intrinsic learning motivation (Deci et al., 1981), their extrinsic learning motivation could be improved by incorporating competition in classroom learning (Burguillo, 2010; Bazylev et al., 2014; Cagiltay et al., 2015; Chen, 2019). Other empirical studies showed that students' academic performance is positively related to implementing competition in the learning process (Burguillo, 2010; Johnson et al., 1985).

Research Questions and Hypotheses

Research Question 1

Across the intervention, is there a significant difference between EFL students' total length of time playing the researcher-developed vocabulary learning game (Vocera) when played with the competition feature (i.e., experimental group) versus without the competition feature (i.e. the control group)?

Research Question 2

Is there a significant difference between all EFL students' (i.e., those who played both with and without the competition feature) vocabulary knowledge scores between the pretest (before playing the Vocera game) and posttest (after the Vocera game intervention)?

Research Question 3

Is there a significant difference between EFL students' change in vocabulary knowledge scores (from pretest to posttest) across the experimental (competition) and control (non-competition) groups?

Research Question 4

Is the total length of time that EFL students play the Vocera game related to their vocabulary knowledge change scores?

Methods

Setting

This study was conducted in a large university in a less-developed mid-sized city in southwest China. It is a four-year university that has about 60,000 students living and studying on campus. During the spring semester of 2023, the participants used the vocabulary learning game Vocareana to potentially help them learn 100 likely unfamiliar English words across four weeks.

Participants

Sample Size and Grade Level

Participants included 331 freshmen from a Chinese university who speak Mandarin as a native language and are learning English as a foreign language. The

present study focused on freshman students because 1) they needed to prepare for the required College English Test to be taken in their sophomore year, and 2) I could be more assured that the target English words chosen would be unlikely to already be known by these students since the words to be learned in this study were all from College English Test which the freshmen had not started to prepare for at the time the study was conducted.

Recruiting and Incentive

A colleague who is an English professor at the focal Chinese university recruited the participants from four intact College English classes which were being taught by two other English professors. These two professors helped the colleague to introduce this empirical study and encouraged the students to participate in. Participants were not offered any incentive for participating in the study. However, participation would likely support their success in their English class and on the National College English Test.

Grouping and Sampling

The participants were divided into two groups: the experimental group, in which there was peer competition during their vocabulary learning process, and the control group, in which there was no competition. This study used a quasi-experimental design involving four intact classes (the classes already created by the focal university), since the setting in the focal university prevented us from assigning participants randomly into the groups. After the author's colleague (the English professor at the focal university) introduced the study in the classes, the students were asked to sign an online consent form, where they could choose either to participate in the study or not. In total, 331

students agreed to participate, and 42 students (11.26%) chose not to participate in the study.

Classes were similar in size and English proficiency, but since classes were organized based on students' majors and course selections, the number of participants in each intact class differed slightly. Each intact class was assigned a condition. This assignment was done to protect against contamination of the conditions by students in the same class talking about the study. Two intact classes (with 144 students who consented to participate in this study) were assigned to the experimental condition, and the other two intact classes (with 187 students who consented to participate in this study) were assigned to the control group.

Materials

Background Characteristics Survey

The participants completed a survey (see Appendix A, Table A1) about their background characteristics that could potentially affect their performance in the study (Creswell & Guetterman, 2019), including

- gender,
- age,
- English learning experience,
- previous English test scores,
- how difficult the participants think vocabulary learning is,
- experience of playing handheld/mobile English vocabulary games, and
- how confident the participants are about their English learning ability.

Since I was not able to control the participants' gender, age, English learning level, or experience of using handheld English learning apps, I conducted statistical tests (chi-square tests for categorical measures, t-tests for continuous measures) to test the pre-existing differences that could potentially impact the statistical analyses of this study.

Table 1 shows the statistical parameters of these tests.

Table 1

Statistical Results of Testing Background Differences between Experiment and Control Groups

Characteristic	Test Statistic ^A	Degrees of Freedom	Significance
Gender	0.76	2	0.69
Previous experience	0.33	1	0.57
Age	1.28	342.9	0.20
Years learning English	0.66	345	0.51
CET score	0.80	345	0.42

^A Chi-Square value for gender and previous experience, t-test value for age, years learning English, and CET score

None of the characteristics examined differed significantly between groups.

Researcher-Constructed Target Vocabulary PreTest

A pretest was taken by all the participants to identify the baseline of their vocabulary knowledge for words targeted for instruction by the game. The pretest had all multiple choice questions requiring the participants to choose the correct meaning (in

Chinese) of the English words. Sample questions are provided in Appendix A, Figure A3.

The pretest scores of the control group were significantly higher than that of the experimental group ($t = 2.57$, $df = 345$, $p = .01$).

Researcher-Constructed Target Vocabulary PostTest

After the participants played the game for four weeks, they took the posttest to determine their improvement (or regression) in target vocabulary learning. The posttest questions were the same as the pretest to ensure the validity of the statistical comparison between across tests.

Researcher-developed Vocabulary Game: Vocarena

Vocera is the researcher-created handheld vocabulary learning game used to conduct the experiment. The game provided the following functions:

1. story of simulation for the participants to play (i.e., fighting in a virtual boxing ring);
2. 100 researcher-chosen target vocabulary words for all the participants;
3. timer that tracked minutes of game-playing shown to players and recorded to a log file;
4. leading board that showed the rank of each participant in the competition group based on the daily quiz scores;
5. log records of the participants, including time points when the students logged in and out of the game, how long they stayed in the game, and how many times they took the daily quizzes;
6. quiz outcomes for the participants to assess their learning progress; and

7. connection to a control panel computer to upload the data (scores, playtime, and log-in records).

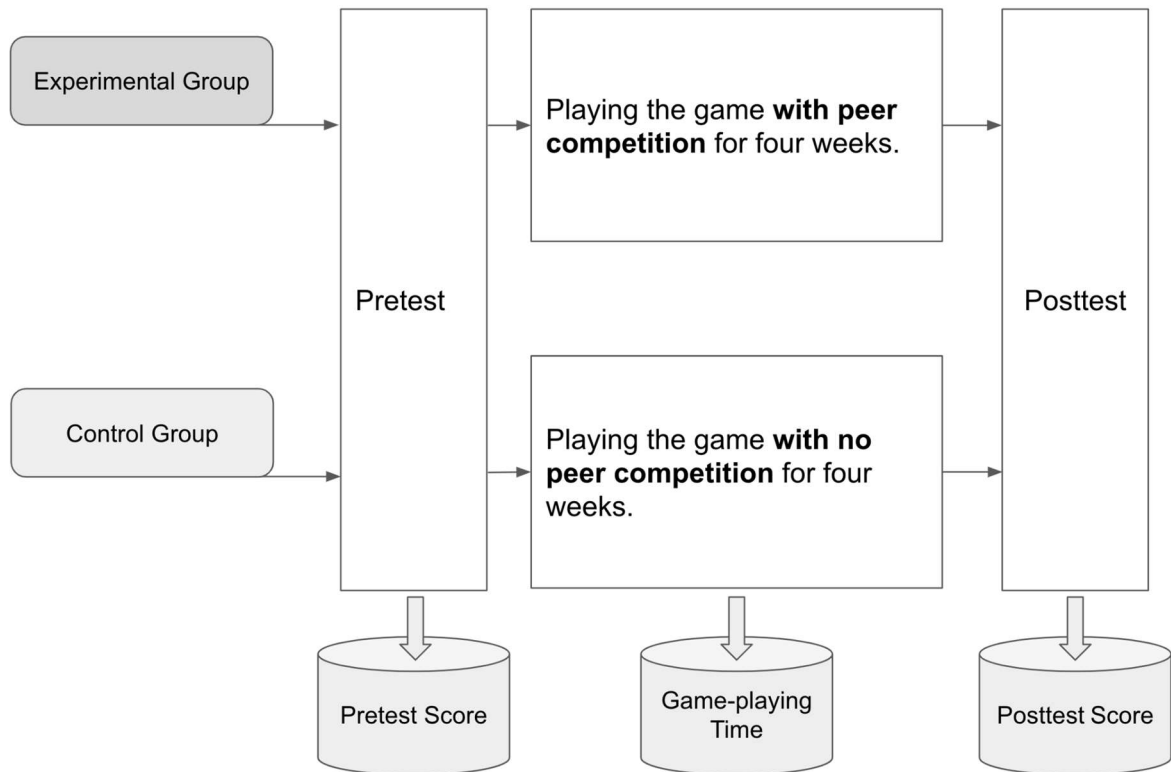
A control panel computer was operated by the author to collect and record the data. The game had three modes to help the participants learn the target words: 1) the Word Browsing Mode, 2) the Quiz Open Mode, and 3) the Quiz Mode. The Word Browsing mode showed in the game when the participants browsed the daily words for the first time. This mode did not show the “Take the Quiz” button to make sure the participants would not directly take the quiz by guessing the answers. When the participants browsed the daily words more than once, the Quiz Open Mode showed to allow the students to take the quiz if they liked to. When the participants pushed the “Take the Quiz” button, the game entered the Quiz Mode, which showed the daily quizzes to the participants and recorded their scores. The user interfaces of the three game modes for the experimental groups are shown in Appendix A Figure A1 and the game interfaces for the control group are shown in Appendix A Figure A2.

Procedures

The procedures in this study included a pretest, Vocera intervention, and posttest. Figure 2 summarizes the procedures for this study.

Figure 2

Experimental Procedures



Pretest

All participants took the pretest to collect their initial target vocabulary knowledge. These scores were used as a control variable.

Vocera Intervention

All participants used the mobile vocabulary game to help them learn the 100 target vocabulary words across four weeks. Participants in both experimental (competition) and control (non-competition) groups had the same words to learn every day. When the participants opened the game every day after 6:00 a.m., it showed the ten daily new words to learn by flashcards and allowed the participant to review the words as many times as needed. There was a quiz about the daily words for all participants every

day. The participants could take the quiz at any time during the day and they could retake the quiz as many times as they want. After they submitted the quiz, the participants in the experimental group saw a page showing their quiz scores and how many positions they had moved up or down in the rankings on the leaderboard. Participants in the control group only saw their own scores from the daily quiz and a page congratulating them on finishing the quiz. The timer that recorded the participants' game-playing time (in seconds) was triggered after the participants submitted the daily quiz. Thus, the game-playing time recorded for each participant was the time that they voluntarily spent in the game since they had finished the daily quiz and were not able to see the new daily words for the next day. The time of retaking the quizzes was counted as game-playing time (an independent variable). The participants were able to review the words of the day and retake the quizzes until 6:00 a.m. the next morning when the daily words for the next day were open to review. The participants in both the experimental and control groups were encouraged to review the daily words after the quiz for better learning outcomes by the prompts in the game. Figure 2 shows the daily timeline of the participants in both control and experimental groups.

Posttest

At the end of the four-week intervention, all participants took the same posttest. These scores were used as dependent variables.

Data Analysis

IBM SPSS was used as the statistical software for all of the data analyses.

To answer RQ1, I compared the experimental and control group participants' total length of time playing the Vocarena game across the intervention. The time lengths were from two different groups, so an independent sample t-test was conducted.

To answer RQ2, I compared the participants' target vocabulary knowledge between the pretest and posttest. The test scores were from the same participants, so a Repeated Measures One Factor ANOVA was used to answer this research question.

To answer RQ3, I measured the difference between the experimental and control group participants' changes in target vocabulary knowledge from pretest to posttest (without considering game-playing time as a covariant). A two-factor repeated measures ANOVA was used.

To answer RQ4, I tested whether the total length of time participants played the game was related to their pretest to posttest change in target vocabulary knowledge scores. To do this, I included the game-playing time as a covariant and measured the difference between the experimental and control group participants' change in vocabulary knowledge from pretest to posttest vocabulary. A two-factor repeated measure ANOVA with covariance was used.

Findings

The primary focus of the present study is on four essential research questions that investigate whether there were significant differences in game-playing time and vocabulary learning outcomes between the two groups before and after the four-week experiment. Additionally, the research delved into exploring the relationship between the

total length of time spent playing the game and the enhancement of participants' target vocabulary knowledge. The quantitative data analyzed provided substantial insights and evidence to answer these research questions, revealing intricate patterns and correlations. The following sections will detail the specific findings related to each research question.

Research Question 1

Through RQ1, I explored the difference in the total length of time playing the Vocarena game between the control and experimental groups. There was a statistically significant difference in the total length of time participants played the Vocarena game across the control and experimental groups ($t_{(245.72)} = -3.10, p = 0.02$). The results showed that the participants in the experimental group spent a longer time playing the Vocarena game ($M = 189.57, SD = 356.48$) than the participants in the control group ($M = 86.56, SD = 227.51$).

Research Question 2

In RQ2 I focused on whether there was a significant difference in all the participants' target English vocabulary knowledge between the pretest (before playing the Vocarena game) and posttest (after playing the Vocarena game). The results showed that the mean ($M = 61.72$) of the posttest score for all participants is significantly higher than the mean ($M = 38.11$) of their pretest score ($F_{(1, 333)} = 491.8, p < .001$).

Research Question 3

In the third research question of this study, I sought to determine whether there was a statistically significant difference between the experimental and control group participants' change in vocabulary knowledge scores from pretest to posttest. The results showed that there was still an overall significant change in scores across the pretest and

posttest ($F = 492.33$, $p < .001$). In comparing the test score change between the two groups, a marginally significant difference was observed ($F = 2.86$, $p = 0.09$). Table 2 shows the results of the different significance testing within and between groups.

Table 2

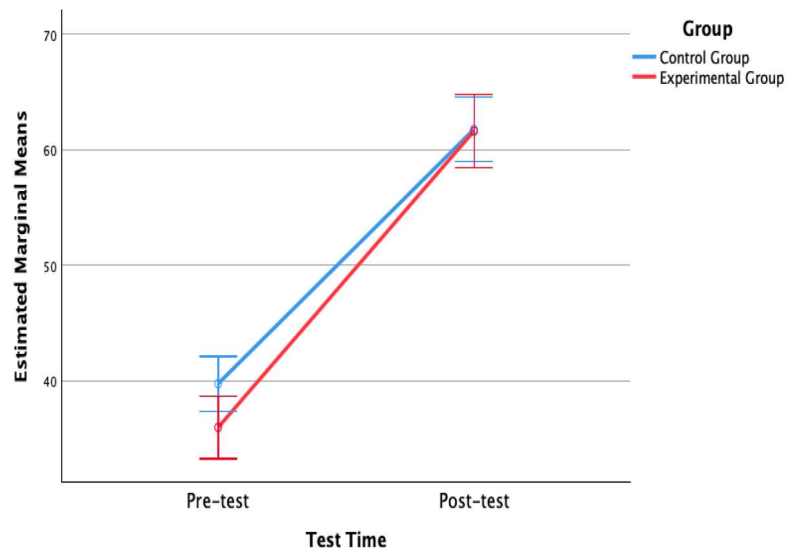
Repeated Measures ANOVA Results on the Difference between the Experimental and Control Groups Participants' Change (from pretest to posttest) in Vocabulary Knowledge Scores

Source	Sum of Squares	Degree of freedom	Mean square	F	Sig.
Within-Subjects					
Test Time	92925.54	1.00	92925.54	492.33	0.00
Test Time by Group	539.44	1.00	539.44	2.86	0.09
Error (Test Time)	62474.60	331.00	188.75		
Between-Subjects					
Intercept	1618467.01	1.00	1618467.01	3474.69	0.00
Group	634.84	1.00	634.84	1.36	0.24
Error	154175.49	331.00	465.79		

To illustrate the difference in change over time between groups, Figure 3 shows the average scores for the control group (blue line) and experimental group (red line) from pretest to posttest.

Figure 3

Comparison of Change in Test Scores from Pretest to Posttest between the Control Group and Experimental Group



As Figure 3 presents, the overall trend showed a significantly higher test score on the posttest. Although the difference between the two groups' change in test scores was only marginally significant, the experimental group gained a greater improvement (i.e., score change) in learning the target English vocabulary during the four-week experiment. While having lower pretest scores ($M = 35.94$) than the control group ($M = 39.73$), the experiment group's posttest scores ($M = 61.60$) were close to the control group's posttest scores ($M = 61.75$), indicating more of a gain over that period.

Research Question 4

In addressing RQ4 of the study, I explored whether the amount of game-playing time in the Vocarena game had a significant impact on the change in test scores from pretest to posttest. The result shows that the model significantly predicted the posttest

scores ($F = 39.63, p < .001$). The coefficients for this analysis, along with their significance, are shown in Table 3.

Table 3

Testing Time In Game As A Predictor Of The PostTest Scores

	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	<i>Sig.</i>
	<i>B</i>	<i>Std. Error</i>	<i>Beta</i>		
(Constant)	41.886	2.428		17.252	.000
Pretest	.493	.058	.423	8.524	.000
Time in Game	.007	.003	.112	2.259	.025

As Table 3 shows, after taking pretest into account, game-playing time was positively related to improved scores in posttest ($t = 2.26, p = 0.025$), after taking the strong relationship between pre- and posttest into account.

To find whether the group difference in gains in vocabulary scores was maintained after taking game-playing time into account, I conducted another linear regression analysis.

Table 4*Testing Group As An Independent Variable For Predicting Posttest Scores*

	Unstandardized Coefficients		Standardized Coefficients	<i>t</i>	<i>Sig.</i>
	<i>B</i>	<i>Std. Error</i>	<i>Beta</i>		
(Constant)	41.253	2.651		15.563	0
Pretest	0.496	0.058	0.426	8.498	0
Time in Game	0.007	0.003	0.106	2.1	0.036
Group	1.222	1.998	0.031	0.611	0.541

When including “group” (control or experimental) as another independent variable, the results (see Table 4) showed that group difference did not have a significant independent impact on the participants’ posttest scores after taking game-playing time into account ($p > .5$), while pretest scores and time playing the game significantly influenced the posttest scores ($p < .05$). The result indicated that the improvement participants gained across the pretest and posttest was significantly related to their pretest scores and the time they spent playing the Vocarena game. Given the results from research question 1, which found that the experimental group had significantly longer playing time than the control group, one could infer that there was an indirect effect of the experimental condition (i.e., peer competition) on improved vocabulary scores through the mechanism of increasing game playing time.

Discussion

The present study aimed to investigate the potential relationship between competition, as a pedagogical design element in educational handheld vocabulary games, and the vocabulary learning outcome. The time length that the participants spent in the

game was measured and analyzed as a covariant to show the potential interpretations. The following are the discussions of the findings in relation to each research question.

RQ1: Game-playing Time Differences Between Control and Experimental Groups

Previous research has shown that in a non-digital game participants played longer when there was no competition (Deci et al., 1981). However, in the digital game environment, participants can play the game anytime and anywhere without time constraints. Thus, I had hypothesized that, in a competitive environment, the participants would spend significantly more time playing the Vocarena game when they had the flexibility to engage in the game on-demand.

Aligned with my hypothesis, the findings reported in this study found that the experimental group played the Vocarena game more than two times longer than the control group with competition integrated into the game. This finding contradicts the finding of the previous study (Deci et al., 1981). There are three factors that could potentially result in this contradiction. First and most important, the participant sampling could result in different findings. The present study found large standard deviations in both the control and experimental groups' game-playing time (see the finding of RQ1), while the standard deviation of the experimental group is even larger than that of the control group. The sizes and difference of the standard deviations indicated that the competition feature encouraged only a part of the experimental group participants to spend more time in the game, while other participants were not motivated by competition. Further research might be needed to investigate the student differences that lead some, but not others, to be motivated by competition so that we can better target its effective use with students. Second, different from the previous study above, the present

study has a multi-session design in which participants could engage in peer competition every day by trying to get higher scores from the daily quizzes. They could have expectations of doing better in the following days by practicing more in the game. Third, the handheld game (Vocarena) allowed the participants to review the words and retake the quizzes multiple times a day. This design would encourage the participants in the experimental group to spend more time reviewing the daily words and retaking the daily quiz multiple times to get a higher position on the leading board.

RQ2: Overall EFL Vocabulary Learning Improvement

In addressing RQ2, this study found a significant improvement in EFL vocabulary knowledge for all participants from pretest to posttest. This finding suggests that the handheld vocabulary game Vocarena can be an effective tool for EFL vocabulary learning, with and without the competition feature integrated. This finding aligns with previous research that confirmed the effectiveness of handheld vocabulary games for learning EFL word definitions (Cha, 2020; Chen et al., 2019; Huang & Huang, 2015). More specifically, the daily quiz in the Vocarena game was acting as a gamified assessment feature, and the effectiveness of assessment features has been shown in previous research as well (Chen et al., 2019; Huang & Huang, 2015).

RQ3: Differences in Learning Improvements between Control and Experimental Groups

Although the present study found only a marginally significant impact from competition on participants' EFL vocabulary learning outcomes, it still extends the previous research in the following two ways. First, previous studies tested the impact of competition on EFL vocabulary learning outcomes (Dindar et al., 2021), but competition

was an experimental design that encouraged the participants to compete with each other out of the game, instead of a game feature in the vocabulary game. The present study presents the effectiveness of competition as a game feature, which contributes to a broader understanding about the effectiveness of competition—that is, how competition works in both the physical world and digital games. Second, when competition was tested as a game feature in EFL vocabulary games in a previous study (Chang et al., 2017), it was tested with other game features together. Although the EFL vocabulary game was found positively effective for participants' learning outcomes, the effectiveness of the competition game feature remained unclear since it was tested in a game feature cluster. The present study isolated and tested competition as a game feature in EFL vocabulary games and, aligned with the previous study (Chang et al., 2017), found a positive effect, if not significant. This finding of the present study is an extension of the previous study that brings the investigation of competition game features into a single-feature level. The design of the present study could be used to investigate the effectiveness of other individual game features.

In terms of why significantly different game-playing time between the two groups did not lead to significant differences in learning outcomes, the large deviations of game-playing time provide a potential explanation. While the competition game feature motivated only a part of the experimental group participants to spend more time practicing the daily words, as discussed about RQ1 above, other participants (in the experimental group) did not increase their learning (game-playing) time, and thus, they did not gain relatively higher scores in the posttest compared to the control group. When calculating the means of the posttest scores and running the regression analyses, these un-

motivated participants' scores reduced the difference between the two groups' learning outcomes.

RQ4: Relationship Between Game-playing Time and Vocabulary Improvement

In addressing RQ4, the findings indicate that, after taking pretest scores into account, game-playing time was a significant positive predictor of students' improvement in vocabulary outcomes. This reinforces the findings of previous research (Lin & Lin, 2019; Zheng, 2015) that consistent and prolonged interaction with a digital language-learning tool can lead to better learning outcomes. The finding of RQ4 also extends the previous research about the relationship between vocabulary learning game engagement and learning outcomes. Yang and colleagues' study (2020) found that when participants engaged in a vocabulary game more often, their EFL vocabulary learning outcomes increased. However, Yang and colleagues' study measured the participants' game-playing frequency instead of the amount of time playing the game. As an extension of their research, the present study found that game-playing time, other than game-playing frequency, is also a significant predictor of EFL vocabulary learning outcomes.

Implications

Implications for Educational Game Developers

While off-the-shelf educational games usually have rich game features to help the players reach their educational goals, the research-developed EFL vocabulary learning game used in this study had only a few game features that can be found in off-the-shelf educational games, such as anytime and anywhere access, graphical word definitions, in-game assessment, and in-game competition. However, the Vocarena game showed a significant impact on EFL vocabulary definition learning outcomes. Based on the Input-

Process-Outcome Game Model (Garris et al., 2002), these features worked as a group to deliver the instructional content, which is the EFL vocabulary learning. Given this, an implication for educational game developers, especially the developers of vocabulary learning games, is that handheld games with limited game features could also be beneficial for the players (learners) to engage in content that needs regular revisiting and practice, such as EFL vocabulary.

Also, in-game competition could be a game feature that helps some of the players improve their learning outcomes. Based on the findings of this study, an integrated competition game feature would encourage some players to spend more time engaging in educational games. When students engage in the games' educational content more frequently and for longer times, better learning outcomes occur. However, it is notable that some of the players of Vocarena did not increase their game-playing time with the competition feature embedded in the game. Therefore, an optional competition feature for the player to choose from would encourage the players who are more comfortable with competition to increase their game-playing time while avoiding putting extra pressure on the players who are more sensitive to competition.

Implications for EFL Educators

The present study found competition encouraged a part of the participants to increase their game-playing time, which indicated that some of the students could be motivated to engage more in educational games. Educators may consider utilizing competition as an optional pedagogical tool for the students to choose to engage them more in instructional activities. Also, since this study found that game-playing time is significantly related to EFL vocabulary learning outcomes, EFL educators could employ

pedagogical strategies to increase EFL learners' learning time to yield favorable learning outcomes.

Implications for Educational Researchers

The previous empirical studies investigated the effectiveness of more complex vocabulary learning games that had multiple game features (Chang et al., 2017; Reynolds, 2017; Sandberg et al., 2014; Wu, 2018; Wu & Huang, 2017; Yang et al., 2020), but did not isolate and test the effectiveness of competition as an independent game feature in handheld educational games. The present study took this step by isolating and testing the competition game feature to test its impact on EFL vocabulary learning outcomes. Further studies are needed to isolate and test more game features to understand their independent impact on students' learning outcomes.

Limitations and Future Research Directions

First, this study found large standard deviations of the game-playing time, which suggested only a part of the participants were motivated to engage more in the game. Further research might be needed to investigate the student differences that led some, but not others, to be motivated by competition so that we can better target its effective use with students.

Second, the participants were not randomly assigned to the control and experimental groups due to the focal university's class schedule. I collected the related background information from the participants and analyzed the statistical differences between the two groups (see Table 1) to reduce the potential interference from this design issue. However, a random sampling design will help create an unbiased representation of the total population.

Third, the effectiveness of the Vocarena game was not compared with traditional vocabulary learning approaches or other games. RQ2 of this study found the Vocarena game helped the participants improve their EFL vocabulary definition learning outcomes over the pretest and posttests. However, this study did not compare the participants' improvement with traditional learning approaches or other vocabulary learning games. To demonstrate the effectiveness of EFL vocabulary learning games, future research could compare the effectiveness of the handheld vocabulary game with traditional non-digital vocabulary learning approaches or games with different features.

Last but not least, in this quantitative study, I did not explore qualitative aspects of the game-playing experience, such as excitement level, anxiety level, and gameplay strategies, to better understand the underlying factors driving the observed outcomes. This should be explored in future research, to more deeply understand these findings.

Conclusion

In conclusion, while the Vocarena game demonstrated an overall significantly positive impact on EFL vocabulary learning (RQ2), the integrated competition game feature showed only a marginal impact on EFL vocabulary learning outcomes (RQ3). It is notable that game-playing time did play a critical role in predicting better vocabulary learning outcomes (RQ4), but part of the freshmen students were not motivated by the competition game feature to increase their game-playing time.

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Appendix A

Table A1

Background Characteristics Survey

1. What is your student number?
2. What is your age?
3. What is your gender? (woman, man, transgender, non-binary, or “prefer not to answer.”)
4. How many years have you been learning English?
5. What is your English test score from the National College Entrance Examination?
6. How difficult do you think learning English vocabulary is? (6-point Likert scale)
7. Have you used any handheld/mobile English vocabulary learning apps? (Yes/No)
8. (Follow-up question of 7) If yes to the last question, do you think handheld/mobile English learning apps helped you improve your English vocabulary learning outcomes? (6-point Likert scale)
9. Do you think English is one of your strengths (better than others’)? (6-point Likert scale)
11. How helpful do you think learning English vocabulary with your classmates is? (6-point Likert scale)

Figure A1

How the Target Words Are Taught in Vocarena Game for the Experimental Group

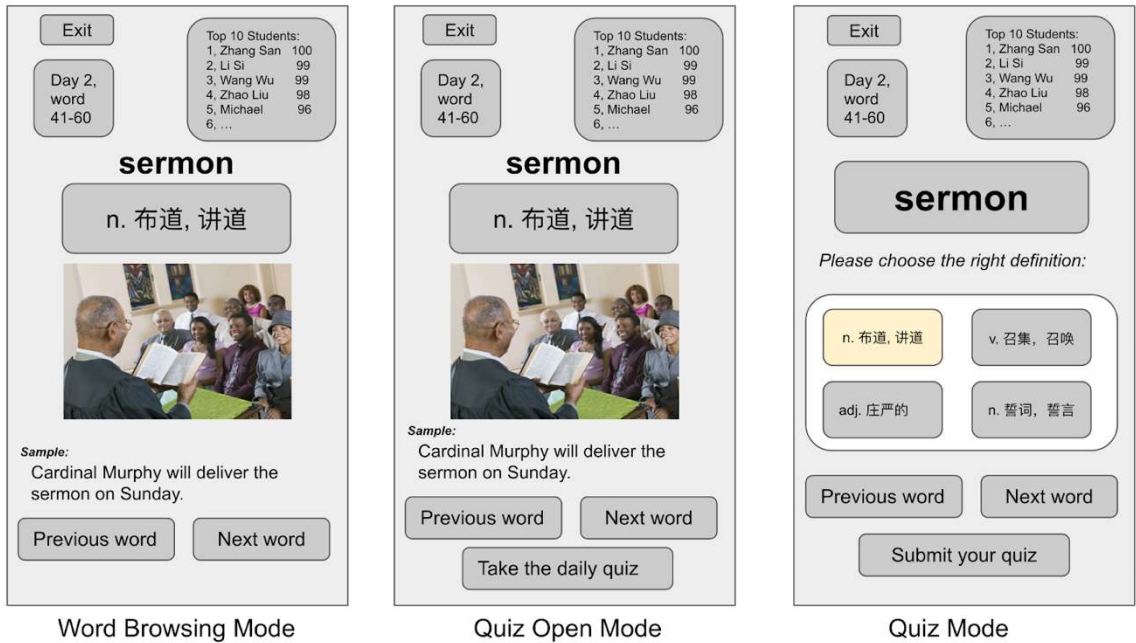


Figure A2

How the Target Words Are Taught in Vocarena Game for the Control Group

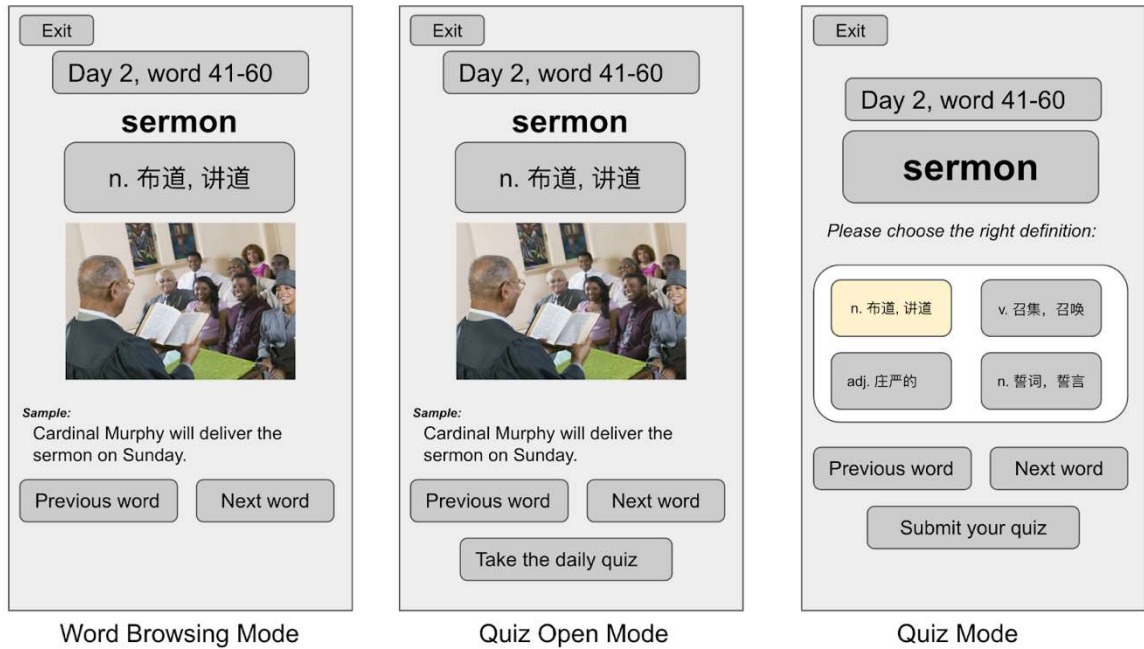


Table A2*Target Words Learned in the Vocarena Game*

Word	Property and Definition
opaque	adj. 不透明的 难理解的, 晦涩的
rigorous	adj. 严密的; 缜密的 严格的, 严厉的
pneumatic	adj. 充气的, 由压缩空气操作〔推动〕的, 风动的
universal	adj. 全体的 广泛的, 普遍的 在世界各地的, 世界性的
optimum	adj. 最适宜的 n. 最佳效果; 最适宜条件
obstinate	adj. 固执的; 顽固的, 倔强的 难克服的, 不易去除的
tabulate	adj. 平板状的; 有平面的 vt. 使成平面; 把...制成表格 vi. 制成表格
junior	adj. 年少的, 较年幼的 资历较浅的, 地位较低的 n. 年少者 地位较低者, 晚辈 (美国中学或大学的) 三年级学生
tensile	adj. 拉力的, 张力的 可伸展的; 可拉长的
versatile	adj. 有多种学问、技能或职业的; 多才多艺的 (指工具、机器等) 多用途的, 多功能的
captive	adj. 被俘虏的; 被迷住的 n. 俘虏; 迷恋者
bourgeois	adj. 资产阶级的 n. 资产阶级分子
radial	adj. 辐射状的; 放射式的; 径向的; 星形的 n. 子午线轮胎; 辐射状轮胎
subsidiary	adj. 附带的, 附属的, 次要的 n. 附属事物, 附属机构, 子公司
valve	n. [机] 阀; [机] 活门; [电子] 真空管; [解] 瓣膜 vt. 装阀于; 以活门调节
nickel	n. 〈化〉 镍 (美国和加拿大的) 五分镍币, 五分钱
lever	n. 〈物〉 杠杆 操作杆 vt. (用杠杆) 撬动
degradation	n. 下降, 降低; 降级 堕落; 丢脸 陵削, 剥蚀 革除神职
terminology	n. 专门用语; 术语; 术语学 术语的正确使用, 术语用法
neutron	n. 中子 adj. 不透中子的

Table A2 - Continued

tangle	n. 乱糟糟的一堆, 混乱 vt. & vi. (使)缠结, (使)乱作一团
scout	n. 侦察员; 侦察机; 人才发掘者, 星探 童子军队员; 童子军 (the Scouts) v. 侦察; 搜索; 寻找
catalyst	n. 催化剂, 触媒 促进因素; 有感染力的人, 能激发对方的人
vowel	n. 元音; 母音 adj. 元音的
rapture	n. 兴高采烈 vt. 使...狂喜
extraction	n. 取出, 拔出; 开采; 拔牙; 血统, 家世
qualification	n. 合格证书 资格, 条件 限制, 限定性条件
wagon	n. 四轮的运货马车 〈英〉铁路货车 〈美〉小手推车
jealousy	n. 妒忌 妒羡
quarterly	n. 季刊 adj. 一年四次的, 每季的 adv. 一年四次地, 每季地
induction	n. 就职, 入伍 吸入 (电或磁的)感应 归纳(法)
magnitude	n. 巨大; 重要性 〈天〉星等
sermon	n. 布道, 讲道, 说教 讲道文章 一大通教训
woe	n. 悲哀, 悲痛; 灾难 int. 唉 (表示痛苦, 悲伤或悔恨)
toss	n. 投掷; 摇荡; 投掷的距离; 掷币赌胜负 vt. 投掷; 使...不安; 突然抬起; 使...上下摇动; 与...掷币打赌 vi. 被乱扔; 颠簸; 辗转; 掷钱币决定某事
mortgage	n. 抵押借款 抵押债款的利息 vt. 抵押
warrant	n. 授权证; 许可证 vt. 使...显得合理; 成为...的根据 保证, 担保
gutter	n. 排水沟; 槽; 贫民区 vi. 流; 形成沟 vt. 开沟于...; 弄熄 adj. 贫贱的; 粗俗的; 耸人听闻的
wrestle	n. 摔跤; 斗争; 搏斗 vi. 斗争; 摔跤; 斟酌 vt. 与摔跤; 与...搏斗; 使劲搬动
bureaucracy	n. 政府机构 官僚主义, 官僚作风

Table A2 - Continued

prose	n. 散文; 单调 adj. 散文的; 平凡的; 乏味的 vi. 写散文; 乏味地讲话 vt. 把... 写成散文
xerox	n. 施乐(商标名, 美国办公设备制造公司); 影印, 静电印刷品 vt. 用静电复印法复印 Xerox n. 复印, 影印; 复印件; 影印本 vt. & vi. 复印, 影印
validity	n. 有效;效力;合法性 正当;正确;确实
jam	n. 果酱 拥挤, 堵塞 困难的处境; 窘境 vt. & vi. (使)塞紧, (使)挤满 发生故障; 夹住, 卡住 vt. 堵塞 (发射无线电波)干扰(信息, 节目)
muse	n. 沉思; 冥想 vt. 沉思; 沉思地说 vi. 沉思; 凝望
saturation	n. 浸湿, 浸透, 饱和 (达到)饱和状态
marsh	n. 湿地; 沼泽 adj. 沼泽的; 生长在沼泽地的
pulley	n. 滑轮; 滑车; 皮带轮 vt. 用滑轮升起
locomotive	n. 火车头, 机车 adj. 移动的, 有移动力的, 产生运动的
ward	n. 监视; 保卫; 病房 vt. 避开; 保卫; 守护
lease	n. 租约; 租期; 租赁物; 租赁权 vt. 出租; 租得 vi. 出租
maintenance	n. 维持; 维护; 保养; 维修 赡养费
synthesis	n. 综合, 综合法 〈化〉合成
jerk	n. 肌肉抽搐; 性情古怪的人; 蠢人; 急拉 vi. 痉挛; 急拉; 颠簸地行进 vt. 猛拉
kidney	n. 肾, 肾脏 (可食用的动物的)腰子
kit	n. 衣物和装备 成套用品 配套元件
ornament	n. 装饰; 装饰物; 教堂用品 vt. 装饰, 修饰
fortress	n. 要塞; 堡垒 vt. 筑要塞; 以要塞防守
calibration	n. 调准; 校准 (测量器具上的)刻度 口径测定
liability	n. 责任, 义务; 倾向 债务 〈口〉妨碍, 不利

Table A2 - Continued

vicinity	n. 近, 接近, 密切 附近, 邻近
parachute	n. 降落伞 vt. & vi. 用降落伞降落
knight	n. 骑士, 武士; 爵士 vt. 授以爵位
waver	vi. 摇曳; 踌躇; 摆动 n. 动摇; 踌躇; 挥动者
wrench	vt. (猛力地)扭, 拧, 扳 扭伤, 挫伤(身体的关节) 使感到痛苦, 使难过; 使悲痛 n. 一拧; 一扳; 猛扭, 猛拉
quench	vt. (用水)扑灭(火焰等) 解(渴) 终止(某事物) 将(热物体)放入水中急速冷却
quiver	vt. & vi. 微颤, 抖动 vt. 使震动 n. 抖动; 颤音
mount	vt. & vi. 登上; 骑上 vi. 增加; 上升 vt. 上演; 配有... 发动攻击; 攻击 n. 山峰 坐骑
reconcile	vt. 使和好; 和解 使一致, 使和谐
ventilate	vt. 使通风, 通风 公开; 公开讨论
smuggle	vt. 偷运, 私运, 走私 不按规章地偷带(人或物)
purify	vt. 净化; 使纯净 vi. 变纯净; 净化
prick	vt. 刺, 扎, 戳 vt. & vi. 刺伤, 刺痛; 使剧痛(使)觉得刺痛 n. 刺痛 刺孔, 刺痕 植物的刺
urge	vt. 力劝; 敦促 鼓励; 极力主张 驱策, 促使 n. 强烈的愿望
retort	vt. 反驳 n. 反驳, 回嘴 反驳的回答
slaughter	vt. 屠杀, 杀戮; 屠宰 n. 屠杀; 残杀 屠宰
repeal	vt. 废除; 撤销; 放弃; 废止; 否定 n. 废除; 撤销
torment	vt. 折磨, 使痛苦; 纠缠, 作弄 n. 痛苦, 苦恼; 痛苦的根源
undertake	vt. 担任, 承揽; 保证 着手, 开始
kindle	vt. 点燃; 照亮; 激起 vi. 发亮; 着火; 激动起来
scorch	vt. 烧焦; 使枯萎; 挖苦 vi. 烧焦; 枯萎 n. 烧焦; 焦痕
lathe	vt. 用车床加工 n. 车床; 机床

Table A2 - Continued

bypass	vt. 绕过, 避开 不顾 n. 旁道
vaccinate	vt. 给...接种疫苗 vi. 注射疫苗; 接种疫苗
fabricate	vt. 编造, 捏造, 虚构; 伪造 建造
rebuke	vt. 责难或指责 n. 非难; 责难
overtake	vt. 赶上; 压倒; 突然来袭 vi. 超车
resign	vt. 辞职; 放弃; 使听从; 委托 vi. 辞职 n. 辞去职务
ferrous	adj. [化]亚铁的; 铁的, 含铁的
reciprocal	adj. 互相给予的; 互惠的; 相互的
haughty	adj. 傲慢的, 目中无人的
unanimous	adj. 全体一致的; 一致同意的; 无异议的
luminous	adj. 发光的; 明亮的; 清楚的
negligible	adj. 可忽略的, 无足轻重的
homogeneous	adj. 同性质的, 同类的
simultaneous	adj. 同时发生的; 同时存在的
extravagant	adj. 奢侈的, 铺张的 过度的, 过分的, 放肆的
qualitative	adj. 定性的, 性质(上)的; 质量的
gigantic	adj. 巨大的, 庞大的
ambiguous	adj. 引起歧义的; 模棱两可的, 含糊不清的

Figure A3

The Sample of Pre- and Post-test

本测试旨在了解你的词汇量情况，不与学校成绩挂钩。测试成绩只有你本人和研究人员可见。本测试共有100个英语单词，请耐心等待，选择正确的词义。如果不认识这个词，请勿猜测，务必选择“不认识这个词”，这将有助于研究人员判断你的单词基准水平！谢谢！

* 1. opaque

- ☒ adj. 不透明的 难理解的, 晦涩的
- ☐ n. 政府机构 官僚主义, 官僚作风
- ☐ adj. 数字的, 用数字表示的, 数值的
- ☐ n. 附件, 配件 同谋, 帮凶, 包庇犯
- ☐ 不认识这个词

* 2. rigorous

- ☐ n. 散文; 单调 adj. 散文的; 平凡的; 乏味的 vi. 写散文; 乏味地讲话 vt. 把...写成散文

Appendix B

Institutional Review Board
(IRB) approval letter



Institutional Review Board

Date: May 25, 2023

Study #: IRB-FY2023-221

Study Title: Measuring the Effectiveness of Peer Competition for EFL Vocabulary Word Meaning Learning in Handheld/Mobile Game-based Learning Environments

Submission Type: Initial

IRB Decision: Approved

Research Team:

Yong Zeng

Tanya Christ, Li Pei

Based on applicable federal regulations, the above referenced study has been determined to involve no more than minimal risk to participants and to be Approved, with the following expedited categories:

6. Collection of data from voice, video, digital, or image recordings made for research purposes.
7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies. (NOTE: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. [45 CFR 46.101\(b\)\(2\)](#) and (b)(3). This listing refers only to research that is not exempt.)

This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

Letter and Consent Document:

This letter along with the IRB approved (date-stamped) consent document can be found in Cayuse in the Submission Details page under Letters and Attachments, respectively.

The IRB approved version of the consent document must be used in consenting participants. Federal regulations require that each participant receive a copy of the consent document. Signed consent forms must be retained for a minimum of three years after the completion of the project. Please remember that informed consent is a process that continues throughout the project, starting with recruitment and assurance of participant understanding of the project, and followed by a signed consent form when applicable.

Appendix B - Continued

Permission from Research Sites:

Please note the following:

- This IRB approval letter means that the research has met the federal criteria for approval per 45 CFR 46.111 Criteria for IRB Approval of Research.
- Before the research is initiated, permission to conduct research at a given site must be obtained from all research locations listed in the IRB submission. You must keep copies of all such permission letters for your records.
- It is the responsibility of each researcher to follow all applicable policies and procedures of any outside institution where the research will be conducted.

Modifications:

Any changes to the approved project must be approved by the IRB prior to initiation by submitting a MODIFICATION request. Do not collect data while the changes are being reviewed. Data collected during this time cannot be used in research.

Incidents:

All unanticipated problems involving risks to participants or others, serious and unexpected adverse events, non-compliance issues and/or serious complaints regarding this project must be reported promptly to the IRB by submitting an INCIDENT report.

You are approved to start the research. Please retain a copy of this notification for your records.

If you have any questions, please contact the IRB office.

Thank you.

The Oakland University IRB