



An artificial vocabulary learning assistant

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Abstract

This article presents an online application developed to improve vocabulary learning through games, quizzes and interaction with a chatbot. The application was tested experimentally on a sample of twenty proficiency-level students divided into two groups and tested on English vocabulary learning in two stages. In the first stage, the first group of students was the control group, who studied a vocabulary section from the book. The second group was the experimental group, which studied using the proposed application. In the second stage, the two groups were reversed and asked to learn the vocabulary of the second unit. According to experiment results, using the particular application improved students' performance, as, in both tests, students of the experimental group outperformed those of the control group. In addition, the analysis of a questionnaire answered by all students confirmed that most prefer this application over traditional learning methods as they consider it quite enjoyable and easy while agreeing that it helped them learn vocabulary. The application is available on the website: <http://users.sch.gr/polizipan>.

Keywords Vocabulary learning · Digital game-based learning (DGBL) · English as a foreign language (EFL) · Computer-assisted language learning (CALL) · Digital game-based language learning (DGBLL) · Digital game-based vocabulary learning (DGBVL)

1 Introduction

Globalization and the opening of international borders to increasing flows of goods, ideas and services have led to the imperative need to learn foreign languages (Chu et al., 2019). English is an international language in all areas of human communication (Chu et al., 2019; Chen & Lee, 2018; Tan & Hsu, 2017; Tan & Hsu, 2018;

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Tan, 2019). Therefore, more and more people choose to learn English as a second language (L2) or foreign language (EFL) (Chu et al., 2019; Tan, 2015; Tan & Hsu, 2017; Tan, 2019).

As vocabulary is an essential component of a language, learning it helps to understand that language better (Ghanbaran & Ketabi, 2014; Fithriani, 2021; Calvo-Ferrer, 2021). Vocabulary acquisition is a foundation for acquiring other essential skills in learning a foreign language, such as listening, speaking, writing and reading (Ghanbaran & Ketabi, 2014; Fithriani, 2021). Thus, vocabulary learning positively affects better understanding and acquisition of a foreign language (Calvo-Ferrer, 2021; Zou et al., 2018a). Nevertheless, learning vocabulary is a complex and time-consuming process that requires memorization as it entails memory and recall of words which sometimes causes fatigue and negative feelings in students (Chu et al., 2019; Fithriani, 2021; Calvo-Ferrer & Belda-Medina, 2021; Mohamed, 2021).

Hence, it is of utmost importance to find innovative ways of learning vocabulary through enjoyable processes that will enhance students' motivation and commitment to learning, rendering the educational process more interesting (Calvo-Ferrer & Belda-Medina, 2021; Mohamed, 2021).

For this reason, in this paper, an online English vocabulary assistant was developed, which tries to include innovative educational technologies and modern learning methods. Mainly, this paper aims to present an online application to learn English vocabulary pleasantly and effectively. More specifically, this paper seeks to answer, in total, the following five research questions:

RQ1. Is this online application effective in English vocabulary learning?

RQ2. Compared to traditional learning methods, is using this application more effective?

RQ3. Is it more enjoyable than traditional learning methods?

RQ4. According to students' perceptions, does this online application enhance learning motivation and interest?

RQ5. Is this online application easy to use, or are there obstacles and difficulties while using the application?

The rest of this paper is organised as follows: Sect. 2 briefly references digital game-based vocabulary learning. In contrast, Sect. 3 contains information regarding digital games and their relation to existing learning theories. Section 4 provides an overview of related papers presenting digital games aimed at helping English vocabulary acquisition. Section 5 describes the research methodology followed in conducting this paper. Section 6 introduces the vocabulary assistant, its games, and the technologies used for its development. In Sect. 7, the experimental procedure followed to investigate the effectiveness of the proposed dictionary assistant, and its results are presented. Finally, Sect. 8 concludes this paper and presents plans.

2 Advantages of Digital game-based vocabulary learning—DGBVL

As technology has been developing rapidly in recent years, exerting a significant influence on all areas of our lives, including education, the use of technology in the educational process can bring new perspectives and possibilities for learning (Xu et al., 2019). As a subfield of technology that can be used in education, computer-based learning or e-learning can facilitate the educational process as learners can access the educational material at any time of the day, from anywhere, and learn even without the help of a teacher (Tan, 2015; Tan & Hsu, 2017; Tan & Hsu, 2018; Tan, 2019). Furthermore, through e-learning, students are allowed to learn by themselves and at their own pace, adapting learning to their personal experiences, thus achieving optimal learning outcomes that meet their personal goals (Tan & Hsu, 2018; Tan & Hsu, 2017).

Digital game-based learning (DGBL) is one of the most widespread uses of technology in the educational process (Xu et al, 2019). Through educational games, students can easily overcome difficulties caused by stress, lack of motivation and interaction and stay more focused on the educational process, resulting in better learning performance (Fithriani, 2021; Xu et al, 2019; Chen et al, 2020). In addition, computer games are often used in education as they facilitate long-term learning and provide immediate feedback, making them optimal learning tools (Calvo-Ferrer, 2021). Thus, foreign language learning through computer games can be very efficient, especially for vocabulary acquisition (Klimova & Kacetl, 2018).

Regarding L2 digital game-based vocabulary learning (DGBVL), previous research has shown that using games in the educational process can positively affect learning if used correctly and following pedagogical values (Tsai & Tsai, 2018). First, they are an educational tool that provides high motivation levels (Rasti, 2021). More specifically, through visual representations, fun, challenges and imagination, computer games enhance students' self-confidence and curiosity, making them willing to learn new words (Rasti, 2021). Feedback provided during the game also enhances motivation, encouraging users to try harder to learn the words (Rasti, 2021). Moreover, they are authentic learning environments that closely simulate the natural world and represent sociocultural relationships promoting students' desire for communication and enhanced interactions while reducing stress and increasing their enthusiasm (Calvo-Ferrer, 2018; Zou et al., 2019; Rasti, 2021). Therefore, words studied using computer games can be more easily transferred to the real world as they are better processed through user interaction and the development of communication skills (Calvo-Ferrer, 2018).

Another critical advantage of computer games is the ability of the user to actively participate in learning, changing the learning process by himself (Rasti, 2021). In this way, through trial and error, he can learn more efficiently (Rasti, 2021). Therefore, computer games significantly influence vocabulary acquisition while also strengthening students' engagement in communication (Klimova & Kacetl, 2017) as they have an active role in their learning. This results in a better understanding of vocabulary and a change in students' attitudes towards foreign languages (Ghanbaran & Ketabi, 2014).

In addition, computer games allow the continuous repetition of words resulting in better understanding and memorization (Rasti, 2021). In general, computer games can positively affect the promotion of short-term and long-term vocabulary learning and, by extension, a better understanding of reading and listening (Zou et al, 2019).

Furthermore, video games facilitate the deeper processing of words (Calvo-Ferrer, 2018). Computer games provide various multimedia elements, such as images, videos, graphics, and audio, that enable dual encoding (storing concepts visually and linguistically), thus leading to better word retention and recall (Rasti, 2021). The last feature of computer games, which makes them very effective in learning vocabulary, is the exposure of students to different instances of a word and, therefore, to varying meanings of a word resulting in a deeper and more complete understanding of that word (Rasti, 2021).

However, teachers' lack of knowledge about games and high interaction can significantly hinder vocabulary learning (Klimova & Kacet, 2017). Consequently, the selection of appropriate software and training of teachers and students are deemed necessary to achieve vocabulary learning in an effective manner (Klimova & Kacetl, 2018).

3 Relevant Learning Theories and digital games

Throughout the history of education, many learning theories have attempted to explain its basic processes through different philosophies and methodologies. In addition, many educational theorists, such as Piaget, Vygotsky and Rousseau, have accepted the importance of play in a child's cognitive and emotional development. Nowadays, with computers having an important place in human activity, computer games can play a crucial role in education and reinforce the above view (Acquah & Katz, 2020).

Piaget's theory of cognitive development emphasizes the inner strength of the child's soul. Based on this theory, knowledge is gradually built and added to existing knowledge, enriching the child's mental structures and reaching the highest desired level (Fenrich, 2016). According to Piaget's constructivism theory, the learner constructs knowledge independently, with the instructor as a guide. At the centre of the educational process, students learn according to their interests and needs. At the same time, the teachers provide them with the necessary motivation and feedback to continue (Karoulis et al., 2008). Therefore, based on the constructivist learning model, the appropriate educational tools should be used, allowing students to practice according to their own pace so that through interactivity and pleasant processes, they will master the new knowledge (Fenrich, 2016).

Digital games facilitate learner-driven activities, as they are virtual environments in which the student can self-direct his learning and, through problem-solving and appropriate feedback, assimilate knowledge to use later in real life (Acquah & Katz, 2020). Student self-regulation and motivation enhancement through computer games can improve learning effectiveness (Alkhalifah, 2022). Especially for L2 learning, it has been shown that computer games can enhance learners' self-regulation and consequently increase their performance (Hromalik & Koszalka, 2018). This happens

because computer games reduce the role of the teacher in the classroom and favour a student-centred approach to learning a foreign language, making them the perfect tool to implement constructivism theory in education (Poonpon et al., 2021).

Regarding vocabulary learning, the meaning of a word that varies according to context must be mapped to the learner's mental schema for it to be understood. Then, they can make sentences following syntactic and morphological rules incorporated through cognitive constructivism (Ang & Zaphiris, 2008). Computer games use several multimedia and provide various instantiations of words, thus facilitating students to more thoroughly understand the meaning of these words (Rasti, 2021).

Vygotsky had similar perceptions to Piaget, with the difference that he considered the social context of education more critical (Ang & Zaphiris, 2008). According to Vygotsky's sociocultural theory, human knowledge is developed and determined through collaboration and social interaction (Ang & Zaphiris, 2008; Che Mustafa et al, 2018; Fahim & Haghani, 2012). Then, through internalization, the knowledge is transformed into an introspective function and mastered (Fahim & Haghani, 2012). Therefore, language acquisition is a process of constructing and interpreting meanings within the context of linguistic interaction of individuals (Ang & Zaphiris, 2008). Social constructivism in computer-based education occurs primarily through computer-user interaction (Ang & Zaphiris, 2008). Communicating with others in the game strengthens students' self-esteem and self-confidence, resulting in their positive attitude towards foreign languages and, consequently, better acquisition of those languages (Poonpon et al., 2021).

We developed a game-based vocabulary learning web application based on the learning theories and advantages of computer games in education. The proposed application, available on: <http://users.sch.gr/polizipan>, facilitates the easy acquisition of foreign words through pleasant processes such as games, continuous feedback and communication with a chatbot.

4 Literature review

In recent years, several authors have developed digital games aiming at helping students to improve their vocabulary acquisition of a language and, consequently, better understand that language. The methodology followed to determine whether vocabulary learning software was suitable was roughly the same in most studies. The trainees were mainly divided into two groups, the experimental group, in which computer-based training was applied, and the control group, whose training was carried out with traditional teaching methods. In addition, the applications' effectiveness was analyzed through pre-tests, post-tests and questionnaires, and the students' opinions on these applications were investigated.

In (Soyoof et al, 2022), the game "Saving Lives" was used to teach Iranian nursing students English vocabulary and health care knowledge. The systematic results study showed that the students of the experimental group outperformed those of the control group due to the continuous exposure to target words and their positive attitude towards the game. Similar results were presented from the experimental study (Fithriani, 2021), which aimed to investigate the effectiveness and benefits of

learning English vocabulary based on mobile games and the student's perceptions of the specific learning method. Experimentation and analysis of results confirmed that mobile game-based vocabulary learning had beneficial effects on performance and students' motivation and enjoyment.

A similar procedure was followed by (Mohamed, 2021) in their study. Their results strengthen the belief that digital games are effective in the educational process, as the research findings proved that through the use of a digital game, there was an improvement in educational progress because it provided motivation, interaction and the ability to retain the acquired vocabulary through a pleasant environment. Chu et al. (2019) also claimed that the software increased students' vocabulary learning performance and enhanced their self-regulation, simultaneously reducing anxiety during the educational process.

In (Ebrahimzadeh, 2017), 241 boys aged 12–18 were divided into three groups: Readers who practised vocabulary through reading, players who studied through playing the commercial digital video game "Warcraft III: The Frozen Throne", and watchers who watched those playing. The results showed that players and watchers ultimately performed better than readers and confirmed that games could be used with traditional teaching methods to assist vocabulary learning.

Hwang and Wang (2016) proposed a situated computer game for vocabulary learning in which two different approaches were applied, a cloze and a multiple-choice guiding strategy, in two different groups of students, respectively. The authors found that the students who learned with the cloze instructional strategy had better learning achievements than those who learned with the multiple-choice instructional strategy. Additionally, if the first group of students could not solve a problem, they reviewed the learning content, resulting in better memorization of the words. On the contrary, students who learned through the multiple-choice technique admitted that they sometimes answered by guessing the answers, which was not helpful for vocabulary learning.

Calvo-Ferrer (2021) used the game "The Conference Interpreter", designed for L2 vocabulary acquisition, to investigate whether word exposure frequency and feedback provided can influence short-term and long-term foreign language vocabulary learning. Research has found positive feedback affects learning more than negativeword exposure frequency. It was also found that computer-based educational games can be a suitable medium for assisting L2 vocabulary learning. The same authors (2021) have conducted a study investigating the impact of using the multiplayer game "among us" for L2 vocabulary learning. The researchers have found that game players could retain words more easily, while word repetition enhanced vocabulary learning.

In (Hartfill, et al., 2020), the virtual reality educational game "Word Saber" is presented. According to the authors, the purpose of the game, vocabulary learning, has been achieved as compared to traditional teaching methods; it has been shown that vocabulary learning becomes more fun and efficient with this game. However, compared to a flashcard method, it was less efficient in word recognition and recall. The authors (Zou et al., 2018b) compared the "Alphabet vs Aliens" app with other vocabulary learning apps. They found similar features, such as visualized help, detailed definitions and examples, and user-to-user communication. All of the above

enhance deeper word processing and, as a result, help better comprehension and learning of vocabulary.

Although several applications aimed at vocabulary acquisition have been developed, no equivalent has been found that supports the Greek language. For this reason, we developed the "Vocabulary Assistant", a digital assistant that aims to help students learn English vocabulary more quickly. This application is online and compatible with computers, mobile phones, and tablets. Moreover, while it is designed to help Greek students learn English vocabulary, it can also be used by students to study any language as it allows teachers to upload their vocabulary.

5 Research methodology

Our scientific interests revolve around learning English vocabulary through new computer-based teaching methods. English, as one of the most widely spoken languages worldwide, attracts more and more learners every day (Tan , 2015). In addition, the development and widespread use of technology nowadays has created the appropriate background for the benefit of more effective methods of teaching the English language. Through these technologies, learning English becomes more enjoyable while enhancing learning motivation. In this paper, after examining the existing technologies used to learn English vocabulary through a computer as opposed to traditional methods, it was found that the results were mostly satisfactory and beneficial to the learner. Based on the above assumption, an online application for teaching English vocabulary was created.

The methodology followed to develop and test the web application is divided into the following four steps:

1. Firstly, the theoretical approaches to education were studied, and the pedagogical value of using new learning methods was investigated.
2. Subsequently, an extensive search was conducted for papers on existing technologies aimed at computer-based English vocabulary learning and the advantages of their use were explored.
3. In the next phase, the design and development of the application were carried out following the principles of the basic theoretical approaches of education while also aiming to fully cover the advantages of using new technologies.
4. Finally, the experimentation of the application and the analysis of the results were carried out to establish its suitability for learning English vocabulary. More specifically, an experimental study was conducted in which the application was tested through a group of 20 students. Through vocabulary tests, the effectiveness of the application was evaluated against traditional learning methods. In contrast, through questionnaires, the students' opinions regarding the benefits of the application on cognitive and emotional levels were investigated. The analysis of the above tests and questionnaires was carried out through the SPSS statistical package to establish the application's effectiveness. For this reason, dependent and independent samples t-tests were conducted on the findings of the experimental procedure to verify their validity.

6 Development of the vocabulary assistant

6.1 The application

In this study, an English vocabulary assistant is presented. It is an online application compatible with both computers and mobile devices. The application provides connection capability for two types of users, teachers and students, with different features for each user. More specifically, teachers can create new lessons, upload dictionaries and monitor their students' educational process through their game scores. On the other hand, students can enrol in courses and then, after choosing a dictionary, they can play games to practice the vocabulary. In addition, students can view their scores to get feedback on their performance at any time.

Moreover, a chatbot has been designed, which interacts with learners aiming to help them with vocabulary acquisition. For this reason, it asks appropriate questions regarding synonyms, translation and word definition, encouraging students to answer and providing them with proper positive feedback. We decided to use computer-based games to support vocabulary learning because of the multiple advantages they provide for successful vocabulary acquisition, as mentioned in Sect. 2.

6.2 The games of the application – Their selection criteria

The digital vocabulary assistant includes the following games: drag and drop, hangman and quiz. These games concern the words of a vocabulary and provide information such as translating words in the Greek language, English synonyms, definitions and examples.

More specifically, in the drag and drop game, vocabulary words are presented along with their part of speeches, interpretations, translations, synonyms and an example of their use. Also, the user can choose to listen to the pronunciation of a word through text-to-speech technologies. The user then shuffles any of the above word features he wishes and puts them back in their correct position through the drag-and-drop process. The drag-and-drop game was chosen because it can be pretty flexible and easy to play on mouse-based computers and finger-based touchscreens. Furthermore, drag-and-drop games are ideal for strengthening vocabulary through enjoyable processes and are a suitable means of self-monitoring learning while having fun (EduGamery, 2020).

We also chose to design a hangman game as it has proven to be an effective tool for practising pronunciation and spelling of words with the ultimate goal of learning vocabulary while simultaneously being a fun and enjoyable process for students (Tanjung & Rahmansyah, 2019). In general, hangman can be played by people of all ages, leading to learning how to spell words (Tanjung & Rahmansyah, 2019). Sometimes finding a word can be down to luck (Tanjung & Rahmansyah, 2019). Still, our game provides word help and hints, such as translation, interpretation, part of speech and synonyms, which help better understand the vocabulary rather than just guessing words. Hence, this game motivates the students to learn vocabulary pleasantly and interestingly and helps them concentrate during the lesson, while teachers can easily control and observe the educational process (Munikasari et al, 2021).

Regarding the quiz game we developed, it allows students to choose what they would like to practice (given the word and find the translation, interpretation or synonyms or conversely, given the above elements and find the requested word). Four alternative answers are shown in the game, from which the student must find the correct one. At the end of the game, feedback is provided with correct and incorrect answers. Multiple-choice questions were chosen as this examination is common in foreign language learning and familiar to teachers and students (Javid, 2014). Also, multiple-choice quizzes are a fairly structured examination method that can check various skills of students who answer even the most difficult questions (Javid, 2014). The evaluation of these quizzes is quite efficient, easy and quick. It is also considered reliable and valid as it is objective (Javid, 2014; Ghafournia, 2013). These tests can assess most language skills without testing language in communication (Javid, 2014). Of course, in the present work, we are mainly interested in learning vocabulary and not so much in the use of language in communication.

In addition, we used a chatbot as an English language learning assistant. The purpose is to simulate the interaction with another user within the framework of the social constructivism approach as mentioned in Sect. 3. We chose to use a chatbot as this technology has several advantages in learning foreign languages. For example, chatbots are an always-on technology that supports students and allows them to communicate at any time of the day. In contrast, a teacher is not always available (Huang et al., 2022).

Moreover, chatbots are tireless partners that can answer repetitive questions and be used continuously to support students' foreign language practice (Huang et al., 2022). Additionally, chatbots enable students to learn a wide range of information about the characteristics of a foreign language (Huang et al., 2022). Furthermore, chatbots encourage the socialization of students through pleasant, easy, emotional and personal conversation and stress-free communication (Huang et al., 2022). They are an educational tool that can enhance students' motivation through a friendly environment, which gives students the feeling that they are not dependent on teachers or other students, thus reducing their stress during communication. Therefore, authentic environments lead to student's positive attitudes towards foreign languages, strengthening their willingness to actively participate and communicate using these new languages (Jeon, 2022).

Text-to-speech and speech-to-text assistive technologies were also used to facilitate the educational process and simulate communication to a higher degree to help better assimilation of sociolinguistic skills.

6.3 Technology

The following technologies have been used to implement the Vocabulary Learning Assistant:

- HTML (What is HTML?) and Javascript programming language (An Introduction to JavaScript.) for user interface development and dynamic interactivity of the website.

- PHP programming language (PHP: What is PHP?—Manual.) for server-side scripting and connection to the database.
- The query language SQL (SQL Tutorial) for managing and editing databases (MySQL).
- RiveScript scripting language (Petherbridge, 2016) for authoring/programming chatbot.
- The SpeechSynthesisUtterance interface (SpeechSynthesisUtterance) of the Web Speech API for Text to Speech conversion.
- The SpeechRecognition interface (SpeechRecognition) of the Web Speech API for converting speech into text.
- WordnikAPI RandomWords (Wordnik API Documentation) for the generation of random words from the internet for the drag-and-drop game.
- Oxford Dictionaries (Oxford Dictionaries) to display interpretation, synonyms, translation and examples of online words in the drag-and-drop game.

7 Experimental design

7.1 Participants

Twenty proficiency-level students were selected to be tested in the English course and specifically in vocabulary learning. These students were divided into two equal groups of 10 people and studied two different vocabularies in two stages. In each stage, they studied the vocabulary words differently, either using the app or the traditional way from the book.

7.2 Experimental tools

Two different instruments were used to collect the data, specifically vocabulary tests and questionnaires, each of which aimed to investigate different aspects of vocabulary learning. Pre-tests and post-tests were used before and after the experimental procedure to check the student's cognitive level. Each test contained 10 questions covering various vocabulary features such as translation, word interpretation, synonyms and the use of words in sentence examples.

The questionnaire, which was constructed using Google forms, contained 20 questions of various types, such as multiple choice questions, yes/no questions, linear scale questions (0: not at all, 1: a little, 2: moderate, 3: enough, 4: a lot, 5: very much) and a short answer question. This questionnaire was sent electronically to students to explore their opinions regarding the benefits of the application on cognitive and emotional levels. More specifically, the questionnaire questions aimed to explore the students' views on four aspects of the application, which are the increase of interest in learning, the effectiveness of the application in terms of vocabulary acquisition, the students' enjoyment as well as the ease of use regarding the device they used to practice. The possibility of any improvements was also considered through the questionnaire questions, in addition to the ease of use and the application's functionality. The questionnaire was

anonymous so the students could freely express their opinion, and the application evaluation would be more objective. Lastly, the Google Analytics platform was used to collect data regarding the application's traffic and information such as basic pageviews and device type, operating system, and browser type of users.

7.3 Experimental procedure

The experimental study was carried out within two weeks in the context of the English course of a proficiency level class. For the experimentation, the vocabularies of two units were selected, which were asked to be learned by 20 students. Before conducting the experimental study, the application was presented and detailed instructions were given to the students. Then, in two more meetings, the concepts under study were taught, and the students were assigned homework to learn the words of each unit respectively. They were also allowed to read at their own pace and have time to learn these words. The experimental procedure followed is described in detail below.

Firstly, the students completed a pre-test to investigate their English level. Based on the students' results in this test, they were divided into groups A and B, so both groups have students of approximately the same level.

The experimental procedure was carried out in two stages. In the first stage, the students of the first group (group A) constituted the control group (CG), while the students of the second group (group B) constituted the experimental group (EG). The experimental group of students studied the first unit's vocabulary exclusively using our vocabulary assistant. In contrast, the control group students traditionally studied the vocabulary from the book. In the second stage, the groups were reversed, and the students of group A assigned to the experimental group. In contrast, the students of group B were assigned to the control group and studied the vocabulary of the second unit. At the end of each stage, the students were asked to answer a post-test to ascertain if the specific software was effective in learning vocabulary compared to the traditional way of learning.

In addition, all students completed a questionnaire to investigate their perceptions and degree of satisfaction with using the specific vocabulary assistant. This questionnaire included questions about the student's opinion of the benefits of the application, both cognitively and emotionally. In addition, it contained questions regarding the app's functionality and ease of use and its improvement for further study. The questionnaire did not require entering their name or email to preserve the students' anonymity.

7.4 Data analysis

The results of the pre-tests and the post-tests were first hand-scored and then entered for further processing in the SPSS statistical program. The questionnaire responses were also entered into the SPSS package and analyzed. Through the analysis of the above, the Mean (M), Median (Md), Mode (Mo), and Standard Deviation (SD) were found to establish the effectiveness of the specific vocabulary assistant and the degree of students' satisfaction with its use. In addition, dependent samples t-tests were conducted to investigate the relationship between pre-tests and post-test scores

and, thus, the effectiveness of the two vocabulary learning practices. Independent samples t-tests were conducted to compare the performance of the control and experimental groups to determine which practice was most effective.

7.5 Results

7.5.1 First stage—experiment 1

According to the descriptive analysis performed on the test scores using the SPSS statistical package, as shown in the 5th column of Table 1, the mean of the two groups (EG: Experimental Group, CG: Control Group) in the pre-test of the first stage was approximately the same ($M_{EG}=5.8$ and $M_{CG}=5.9$). At the same time, it is seen that the performance of both groups in the post-test increased. More specifically, in Table 1, in the post-test, the experimental group has a mean of $M_{EG}=8.7$, while the control group has a mean of $M_{CG}=7.4$. The two groups had median $Md_{EG}=5$ and $Md_{CG}=5.5$ and standard deviation $SD_{EG}=1.69$, $SD_{CG}=1.45$ in pre-test and $Md_{EG}=9$ and the groups improved (RQ1). $Md_{CG}=7.5$ and standard deviation $SDEG=7.34$, $SDCG=1.27$ in post-test. At first glance, the above findings prove that both methods of learning English vocabulary were effective as the performance of both

Further analysis followed to investigate the effectiveness of the two approaches. More specifically, an independent samples t-test was performed to ascertain the equality of the two means of the pre-tests and verify the distribution of students into groups of similar performance. The normality test performed on the results of the pre-tests (Table 2, column 6) proved that both samples follow a normal distribution as the level of statistical significance of the Shapiro–Wilk test is in both cases greater than 0.05 ($p_{EG}=0.118 > 0.05$, $p_{CG}=0.205 > 0.05$). In addition, from the cluster design test, the variances of the two groups are equal. According to Leven's test, the significance level is $0.517 > 0.05$, as in column 8 of Table 2. Therefore, since the above two assumptions have been validated, an independent t-test was conducted. The 11th column of Table 2 confirms the initial belief that the means of the preliminary tests are equal ($p=0.888 > 0.05$). Thus, the two groups were assumed to

Table 1 Descriptive statistics analysis results

	Group	Test	N	Mean	Median	Mode	SD
1	2	3	4	5	6	7	8
Test A	EG	Pre-test	10	5.8	5.0	5.0	1.68655
		Post-test	10	8.7	9.0	9.0	7.33749
	CG	Pre-test	10	5.9	5.5	5.0	1.44914
		Post-test	10	7.4	7.5	7.0	1.26491
Test B	EG	Pre-test	10	5.3	5.0	5.0	1.25167
		Post-test	10	7.6	8.0	8.0	1.57762
	CG	Pre-test	10	5.6	6.0	6.0	1.07497
		Post-test	10	6.1	6.0	5.0	1.52388

have approximately the same level of knowledge before performing the experimental procedure.

Independent t-tests were then employed to investigate whether the means of the post-tests differed. The Shapiro–Wilk normality test (Table 2, Column 6) shows that the post-tests of both groups follow a normal distribution ($p_{EG}=0.067>0.05$ and $p_{CG}=0.445>0.05$). Moreover, column 8 of Table 2 shows that the criterion of equal variances also can be assumed as Levene's test has a value of $p=0.953>0.05$. Therefore, the above two assumptions allowed the independent t-test to be performed. Table 1 shows that the means of the two groups in the post-test are $M_{EG}=8.7$ and $M_{CG}=7.4$, which shows that they differ, with the experimental group presenting a higher score. This fact is also reinforced by the t-test ($t(18)=2.23$, $p=0.038<0.05$), as can be seen in column 11 of Table 2, which proves that the two means are not equal. Therefore, from the above, it can be assumed that the experimental group performed better than the control group in the post-test (RQ2).

Later, after confirming the assumption of normality for the two groups of students, as can be seen in column 5 of Table 3 ($p_{EG}=0.246>0.05$ and $p_{CG}=0.061>0.05$) it was found that it is possible to perform dependent t-tests on both samples. Column 8 of Table 3 also shows both methods were effective ($p_{EG}=0.001<0.05$ and $p_{CG}=0.005<0.05$). Therefore, there is a statistically significant difference in the student's scores in the post-tests with the corresponding pre-tests, which means that both ways of learning vocabulary are effective (RQ1). However, according to the results of Table 1 and Table 2, it is seen that the proposed application is more effective in learning vocabulary (RQ2). The average of the experimental group's post-test is higher than the corresponding average of the control group ($M_{EG}=8.7$, $M_{CG}=7.4$) (Table 1). At the same time, according to the t-test of independent samples, this difference is statistically significant ($p=0.038<0.05$) (Table 2, column 11). Therefore, according to the above findings, it is clearly seen that the first and second research questions we posed are answered, that are, if the application has positive results in vocabulary learning (RQ1), and if it is more effective than traditional teaching methods (RQ2).

Table 2 Normality and homogeneity test and independent samples *t*-test

Test		Group	Shapiro-Wilk			Levene's test			Independent sam- ples <i>t</i> -test	
			Statistic	df	Sig.	F.	Sig.	<i>t</i>	df.	Sig. (2- tailed)
<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>
Test A	Pre-test	EG	0.876	10	0.118	0.438	0.517	−0.142	18	0.888
		CG	0.897	10	0.205					
	Post-test	EG	0.855	10	0.067	0.004	0.953	2.233	18	0.038
		CG	0.930	10	0.445					
Test B	Pre-test	EG	0.929	10	0.436	0.076	0.785	−0.575	18	0.572
		CG	0.892	10	0.177					
	Post-test	EG	0.953	10	0.709	0.127	0.726	2.163	18	0.044
		CG	0.929	10	0.441					

Table 3 Normality tests and dependent samples t-test

I	Group	Shapiro—Wilk			Paired samples t-test		
		Statistic	df	Sig	t	df	Sig (2- tailed)
	2	3	4	5	6	7	8
Test A	EG	0.905	10	0.246	-5.118	9	0.001
	CG	0.852	10	0.061	-3.737	9	0.005
Test B	EG	0.871	10	0.102	-4.271	9	0.002
	CG	0.907	10	0.258	-2.236	9	0.052

7.5.2 Second stage—experiment 2

A similar procedure was followed in the interpretation of the results of the second test. Initially, a descriptive statistical analysis of the two tests (pre and post-test) was carried out, and it was found that the means of scores of the two groups in the pre-test were approximately the same ($M_{EG}=5.3$ and $M_{CG}=5.6$), as can be seen in the 5th column of Table 1. Additionally, the t-test for independent samples proved the equality of these two means since $p=0.572>0.05$, as shown in column 11 of Table 2, therefore, the hypothesis that the two groups had approximately the same level of knowledge was verified. Before conducting the t-test, hypothesis testing was performed to ensure normality and constant variance of the data. In the 6th column of Table 2, the values $p_{EG}=0.436$ and $p_{CG}=0.177$ of the Shapiro–Wilk test are higher than 0.05, proving that both groups follow a normal distribution. In addition, in the same table's (Table 2) 8th column, the value of Leven's test is $0.785>0.05$, which means that the variances are approximately equal in the two groups.

Then, since in the 5th column of Table 1, the means of the two groups in the post-tests seem pretty different from each other ($M_{EG}=7.6$ and $M_{CG}=6.1$), a t-test for independent samples was performed to ascertain if this difference is statistically significant. In the 6th column of Table 2, the $p_{EG}=0.709>0.05$ and $p_{CG}=0.441>0.05$ prove the normality of the experimental and control groups, respectively. In addition, the value $p=0.726>0.05$ of Leven's test in the 8th column of Table 2 proves the equality of variances. The above two assumptions allowed the implementation of the independent t-test, according to which the value $p=0.044<0.05$ in the 11th column of Table 2 proves that the means of the two groups differ in the post-test.

The 5th column of Table 1 confirmed that both groups improved their performance since the means increased (from 5.3 to 7.6 for the experimental group and 5.6 to 6.1 for the control group) (RQ1). However, the experimental group performs better on the post-test than the control group. The assumption of normality of the Shapiro–Wilk test in column 5 of Table 3 ($p_{EG}=0.102>0.05$ and $p_{CG}=0.258>0.05$) allowed the dependent samples t-test to be performed to determine if this increase of performance is statistically significant. Looking at the 8th column of the same table (Table 3), it is found that for the students in the control group, there was no significant improvement in vocabulary acquisition ($p=0.052>0.05$). In contrast, the students who used the specific assistant for vocabulary learning had a significantly improved performance ($p=0.002<0.05$) (RQ1–RQ2). These findings imply that the

application for vocabulary learning was very effective (RQ1), in contrast to the traditional teaching method, which was not found to have the same significant effects on vocabulary learning (RQ2). With this assumption, our first two research questions concerning the effectiveness of the application are answered positively.

Therefore, the results of the two experiments confirmed that the use of the specific vocabulary assistant had a statistically significant effect on word learning, confirming our first research question (RQ1).

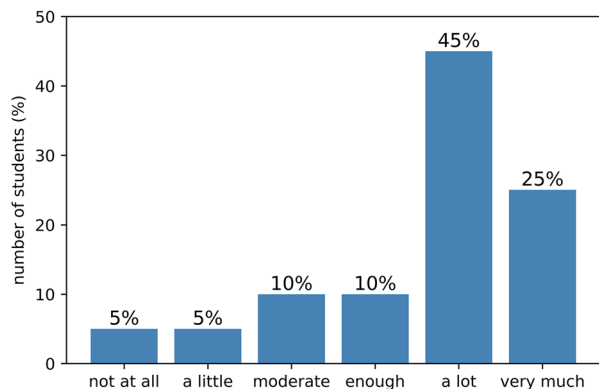
7.6 Questionnaire analysis

The responses to the questionnaire were analyzed with the SPSS statistical program to obtain information regarding the students' perceptions of various aspects of the application such as the ease of use (RQ5) and the effectiveness (RQ1- RQ2) of the application, as well as the enjoyment (RQ3) and interest (RQ4) students derive from using the application.

7.6.1 Interest in learning(RQ4)

As shown in Fig. 1, most of the students found vocabulary learning with the use of this assistant interesting. In contrast, few saw it as indifferent, little or not at all interesting (Table 5: 25%—very much interesting, 45%—a lot interesting, 10%—fairly interesting, 10%—moderately interesting, 5% a little, 5%—not at all interesting). Figure 2 shows that most students (90%) stated that they re-read the vocabulary using the specific assistant. According to Fig. 3, 75% of the students preferred using our vocabulary assistant over the traditional vocabulary learning method. They found reading through the specific application more interesting than reading from the book. Therefore, the students' responses to the questionnaires proved that the students found the application interesting for vocabulary acquisition and were motivated to re-read using the specific vocabulary assistant. All the above, answer positively to our research question 4 which concerns the interest and motivation of learning through the specific vocabulary assistant.

Fig. 1 How interesting was studying English vocabulary using this particular vocabulary assistant? (RQ4)



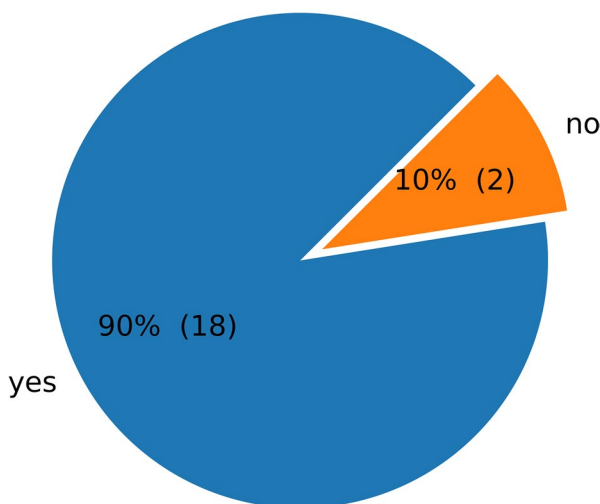


Fig. 2 Would you choose to re-read the vocabulary by using this assistant?

7.6.2 Effectiveness of the application(RQ1)

Regarding the effectiveness of the application (RQ1), it is shown in Fig. 4 that most students (85%) answered that the proposed application helped them learn English vocabulary. More specifically, Table 5 shows that most students consider that the application helped them enough, a lot or very much (30%—enough, 35%—a lot, 20% very much), while only 5% think it helped them a little. According to Table 4, the drag-and-drop game and hangman were the games that helped the students learn English vocabulary the most, while the quiz helped them the least. These responses are in complete agreement with the results of the analysis of student performance during the two experiments, according to which our research question (RQ1) confirmed that using this particular application was very beneficial for vocabulary acquisition.

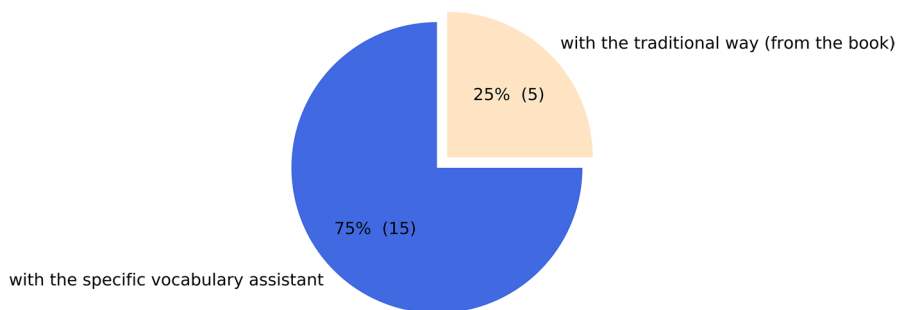
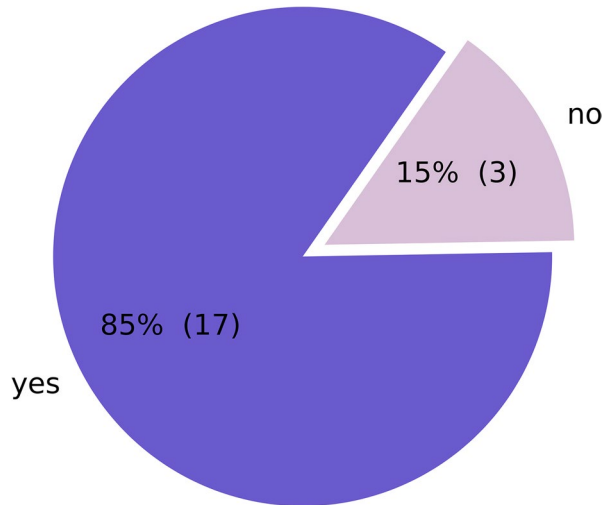


Fig. 3 How do you prefer to read English vocabulary?

Fig. 4 Do you think this application helped you learn English vocabulary? (RQ1)



7.6.3 Ease of use(RQ5)

Students used various devices to navigate the vocabulary helper. Among the devices mainly used was the computer (55%), while fewer students used mobile phones (25%) and tablets (20%), as can be seen in Fig. 5. As shown in Fig. 6, most students claimed it was quite easy to navigate the vocabulary assistant pages from the device they used (Table 5 – Table 6). In addition, according to Fig. 7, most did not need help using the application (85%). At the same time, the most challenging activity was considered the drag-and-drop game (Table 4), especially for mobile and tablet users. According to the above, our research question 5 regarding the application's ease of use is answered positively.

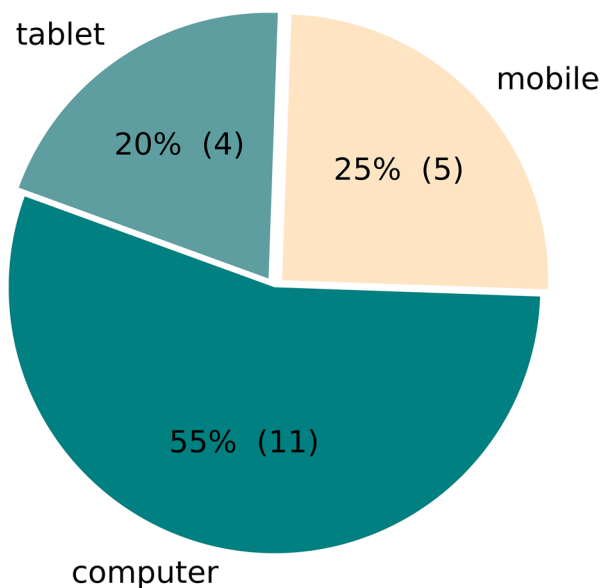
7.6.4 Enjoyment (RQ3)

Regarding the students' enjoyment while engaging with this application, Fig. 8 shows that most of the students liked the specific application. More specifically,

Table 4 Students' perceptions of games -Percentages (%)

Question (Percent of cases)	Drag and drop	Hangman	Quiz	Chatbot	None	Total
Which activity helped you the most?	60%	55%	20%	25%	0%	160%
Which activity helped you the least?	5%	15%	55%	35%	10%	120%
Which activity did you enjoy the most?	20%	60%	15%	50%	5%	150%
Which activity did you like least?	35%	5%	45%	20%	5%	110%
Which activity was easier?	5%	75%	80%	15%	0%	175%
Which activity was more difficult?	89.5%	0%	5.3%	26.3%	5.3%	126.3%

Fig. 5 What device did you use to navigate this vocabulary assistant?



most students claimed they enjoyed the app's games moderately or a lot (Table 5), with the hangman and chatting with the chatbot being the most enjoyable games (Table 4). Particularly, for the chatbot, most students claimed that they liked chatting with it, while 90% of students said that they would like the dialogues to be enriched to discuss even more topics. Additionally, 70% of students said they would like more games to be added to the vocabulary assistant.

Table 5 and Table 6 contain information concerning the 4 aspects that the particular questionnaire wanted to study, for which the students were given the possibility to choose from a linear scale (0 – not at all, 1 – a little, 2 moderately, 3—enough, 4—a lot, 5 very much). The above aspects concern the answers to 4 of the 5 research questions raised during the research methodology carried out for the development of the application. These questions concern the effectiveness (RQ1),

Fig. 6 How easy was it to play the games and navigate the assistant on the particular device you used? (RQ5)

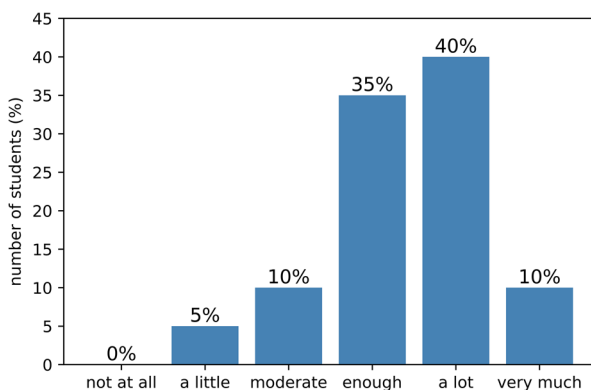


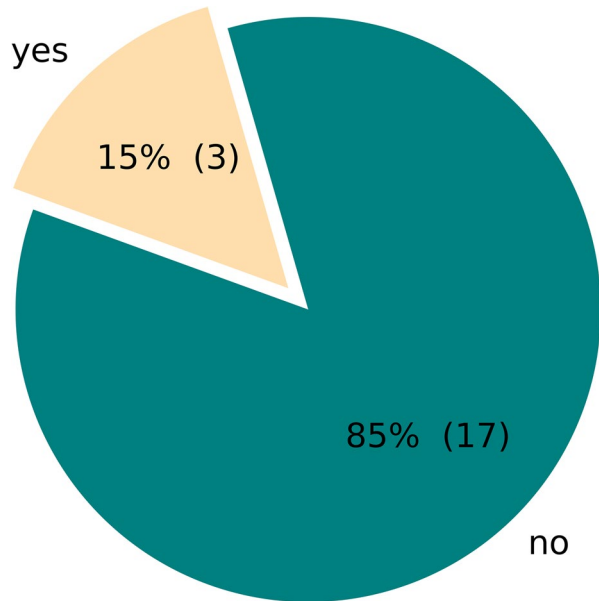
Table 5 Linear Scale Questions (0: Not at all – 5: Very much)—Percentages %

Questions	Not at all	A little	Moderate	Enough	A lot	Very much
1. <i>How interesting was studying English words using this particular vocabulary assistant?(RQ4)</i>	5%	5%	10%	10%	45%	25%
2. <i>How much do you think this app helped you learn English vocabulary?(RQ1)</i>	0%	5%	10%	30%	35%	20%
3. <i>How easy was playing the games and navigating the assistant pages on your device?(RQ5)</i>	0%	5%	10%	35%	40%	10%
4. <i>Did you like the games of vocabulary assistant?(RQ3)</i>	0%	5%	5%	20%	55%	15%

Table 6 Linear Scale Questions—Descriptive statistics analysis

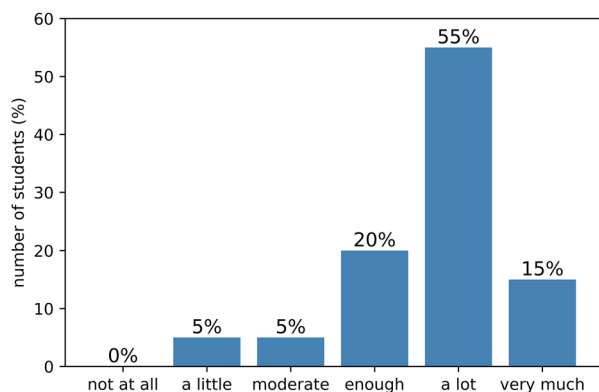
Questions	N	Minimum	Maximum	Mean	Std. Deviation
1. How interesting was studying English words using this particular vocabulary assistant? (RQ4)	20	0	5	3.60	1.392
2. How much do you think this app helped you learn English vocabulary? (RQ1)	20	1	5	3.55	1.099
3. How easy was it to play the games and navigate the assistant pages on your particular device? (RQ5)	20	1	5	3.40	0.995
4. Did you like the games of vocabulary assistant? (RQ3)	20	1	5	3.70	0.979

Fig. 7 Did you need help from someone to use the app?



the enjoyment resulting from its use (RQ3), the provoking of interest and learning motivation (RQ4) as well as the ease of use of this application (RQ5). According to the above tables, it is observed that the student's perception of the specific application was quite good to very good. Therefore, this application has largely achieved its goal of helping students learn English vocabulary while also trying to increase their interest in learning through an easy-to-use and enjoyable environment. As seen from the above, our research questions had a positive response from the students. In addition, the results of the experimental process and their analysis contacted in sub-Sect. 7.5 through the statistical package SPSS proved that in the cognitive domain, the application could succeed (RQ1), and prevail over the traditional methods of teaching English vocabulary (RQ2).

Fig. 8 Did you like games of vocabulary assistant? (RQ3)



8 Conclusion and future works

In this work, a vocabulary learning assistant was presented, which aims to strengthen students' understanding of English language vocabulary through games and chat-bot communication. After studying the basic theoretical approaches to education, exploring the advantages of using computer games and searching for previous corresponding studies, the specific application was designed and developed. The results of its use were examined.

According to the experimental study carried out, it was found that the use of this application is effective in learning vocabulary. The experiment results showed that using the application for learning vocabulary led to a statistically significant increase in student performance compared to study using traditional methods. In addition, the analysis of the questionnaires proved that the students obtained excellent impressions from using the specific assistant as they considered that the assistant helped them learn vocabulary. At the same time, they found it exciting and easy as a process.

However, some changes are deemed necessary to improve this application. One of the future goals is to add additional games and quizzes such as crosswords, word search puzzles, anagrams and memory games. Plans also include adding more multimedia elements such as images, audio and video to enhance vocabulary learning. In addition, artificial intelligence activities can lead to the improvement of the application.

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Data availability The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy restrictions.

Declarations

Conflicts of interest The authors declare no conflict of interest.

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References

- Acquah, E. O., & Katz, H. T. (2020). Digital game-based L2 learning outcomes for primary through high-school students: A systematic literature review. *Computers & Education*, 143, 103667. <https://doi.org/10.1016/j.compedu.2019.103667>
- Alkhalifah, T. (2022). Gamified English App: A Mobile Application to Enhance Second Language Learning via Gamification. 2022 11th International Conference on Educational and Information Technology (ICEIT), pp. 112–117 <https://doi.org/10.1109/ICEIT54416.2022.9690761>.
- An Introduction to JavaScript. (2022) Retrieved 09 06, 2022, from An Introduction to JavaScript.: <https://javascript.info/intro>
- Ang, C. S., & Zaphiris, P. (2008). Computer Games and Language Learning.
- Calvo-Ferrer, J. R. (2021). Effectiveness of Type of Feedback and Frequency on Digital Game-Based L2 Vocabulary Acquisition. *International Journal of Game-Based Learning*, 11, 38–55. <https://doi.org/10.4018/IJGBL.2021070103>
- Calvo-Ferrer, J. R., & Belda-Medina, J. (2021). The Effect of Multiplayer Video Games on Incidental and Intentional L2 Vocabulary Learning: The Case of Among Us. *Multimodal Technologies and Interaction*, 5, <https://doi.org/10.3390/mti5120080>.
- Calvo-Ferrer, J. R. (2018). Exploring digital nativeness as a predictor of digital game-based L2 vocabulary acquisition. *Interactive Learning Environments*, 28, <https://doi.org/10.1080/10494820.2018.1548489>.
- Che Mustafa, M., Masnan, A. H., Alias, A., & Mashitah, M. R. (2018). Sociocultural Theories in Second Language Acquisition. *International Journal of Academic Research in Business and Social Sciences*, 7, <https://doi.org/10.6007/IJARBS/v7-i12/3747>.
- Chen, C.-H., Shih, C.-C., & Law, V. (2020). The effects of competition in digital game-based learning (DGBL): a meta-analysis. *Educational Technology Research and Development*, 68, <https://doi.org/10.1007/s11423-020-09794-1>.
- Chen, Z.-H., & Lee, S.-Y. (2018). Application-driven Educational Game to Assist Young Children in Learning English Vocabulary. *Journal of Educational Technology & Society*, 21, 70–81.
- Chu, S.-T., Hwang, G.-J., Chien, S.-Y., & Chang, S.-C. (2019). Incorporating teacher intelligence into digital games: An expert system-guided self-regulated learning approach to promoting EFL students' performance in digital gaming contexts. *British Journal of Educational Technology*. <https://doi.org/10.1111/bjjet.13260>
- Drag and drop games. (2020). Drag and drop games.
- Ebrahimzadeh, M. (2017). Readers, Players, and Watchers: EFL Students' Vocabulary Acquisition through Digital Video Games. *English Language Teaching*, 10, 1. <https://doi.org/10.5539/elt.v10n2.p1>
- EduGamery. (2020). Retrieved 10, 12, 2022, from EduGamery: <https://edugamery.com/educational-games-portfolio/drag-and-drop-games/>
- Fahim, M., & Haghani, M. (2012). Sociocultural Perspectives on Foreign Language Learning. *Journal of Language Teaching and Research*, 3, <https://doi.org/10.4304/jltr.3.4.693-699>.
- Fenrich, P. (2016). Evaluation of education software and paper-based resources for teaching logical-thinking skills to grade six and seven students. *logical*. The Eurasia Proceedings of Educational & Social Sciences.
- Fithriani, R. (2021). The utilization of mobile-assisted gamification for vocabulary learning: Its efficacy and perceived benefits. *CALL-EJ*, 22, 146–163.
- Ghafournia, N. (2013). The Relationship between using Multiple-Choice Test-Taking Strategies and General Language Proficiency Levels. *Procedia - Social and Behavioral Sciences*, 70, 90–94. <https://doi.org/10.1016/j.sbspro.2013.01.043>
- Ghanbaran, S., & Ketabi, S. (2014). Multimedia Games and Vocabulary Learning. *Theory and Practice in Language Studies*, 4, <https://doi.org/10.4304/tpls.4.3.489-496>.
- Hartfill, J., Gabel, J., Neves-Coelho, D., Vogel, D., Räthel, F., Tiede, S., et al. (2020). *Word Saber: An Effective and Fun VR Vocabulary Learning Game*. <https://doi.org/10.1145/3404983.3405517>
- Hromalik, C. D., & Koszalka, T. A. (2018). Self-regulation of the use of digital resources in an online language learning course improves learning outcomes. *Distance Education*, 39, 528–547. <https://doi.org/10.1080/01587919.2018.1520044>

- Hsu, P. J.-H. (2018). Designing a System for English Evaluation and Teaching Devices:. Eurasia Journal of Mathematics, Science and Technology Education, pp. 2107–2119 <https://doi.org/10.29333/ejm-ste/86467>
- Huang, W., Hew, K. F., & Fryer, L. K. (2022). Chatbots for language learning—Are they really useful? A systematic review of chatbot-supported language learning. *Journal of Computer Assisted Learning*, 38, 237–257. <https://doi.org/10.1111/jcal.12610>
- Hwang, G.-J., & Wang, S.-Y. (2016). Single loop or double loop learning: English vocabulary learning performance and behavior of students in situated computer games with different guiding strategies. *Computers & Education*, 102, 188–201. <https://doi.org/10.1016/j.compedu.2016.07.005>
- Javid, L. (2014). The Comparison between Multiple-choice (MC) and Multiple True-false (MTF) Test Formats in Iranian Intermediate EFL Learners' Vocabulary Learning. *Procedia - Social and Behavioral Sciences*, 98, <https://doi.org/10.1016/j.sbspro.2014.03.482>.
- Jeon, J. (2022). Exploring AI chatbot affordances in the EFL classroom: young learners' experiences and perspectives. *Computer Assisted Language Learning*, 0, 1–26. <https://doi.org/10.1080/09588221.2021.2021241>
- Karoulis, A., Stamelos, I., & Angelis, L. (2008). Experimental Evaluation of an Instructional Supporting Tool in Distance Learning. *Educational Technology & Society*, 11, 67–81.
- Klimova, B., & Kacetl, J. (2018). Computer Game-Based Foreign Language Learning: Its Benefits and Limitations.
- Klimova, B., & Kacetl, J. (2017). Efficacy of computer games on language learning. *Turkish Online Journal of Educational Technology*, 16, 19–26.
- Mohamed, A. M. (2021). *The Impact of Educational Games on Enhancing Elementary Stage Students' Acquisition and Retention of English Vocabulary.*, 3, 67–76.
- Munikasari, M., Sudarsono, S., & Riyanti, D. (2021). The effectiveness of using hangman game to strengthen young learner's vocabulary. The Effectiveness of Using Hangman Game to Strengthen Young Learners' Vocabulary, 2 . Tanjungpura University.
- MySQL. (n.d.). Retrieved 10 17, 2022, from What is MySQL?: <https://www.mysql.com/>
- Oxford Dictionaries. (n.d.) Retrieved from Oxford Dictionaries: <https://developer.oxforddictionaries.com/>
- Petherbridge, N. (2016). Rivescript. Retrieved September 6, 2022, from Rivescript: <https://github.com/aichaos/rivescript/blob/master/README.md>
- PHP: What is PHP? - Manual. (2022) Retrieved 09 06, 2022, from PHP: What is PHP? - Manual.: <https://www.php.net/manual/en/intro-what-is.php>
- Poonpon, K., Chansanam, W., Srisawat, C., & Poochanon, T. (2021). *Design and Evaluation of a Game-Based Language Learning Web Application for English Language Learners in Thailand.*, 1, 521–526.
- Rasti, A. (2021). Why Digital Games Can Be Advantageous in Vocabulary Learning. *Theory and Practice in Language Studies*, 11, 111–118. <https://doi.org/10.17507/tpls.1102.01>
- Soyoo, A., Reynolds, B. L., Shadiev, R., & Vazquez-Calvo, B. (2022). A mixed-methods study of the incidental acquisition of foreign language vocabulary and healthcare knowledge through serious game play. *Computer Assisted Language Learning*, 0, 1–34. <https://doi.org/10.1080/09588221.2021.2021242>
- SpeechRecognition. (2022) Retrieved 09 06, 2022, from SpeechRecognition: <https://developer.mozilla.org/en-US/docs/Web/API/SpeechRecognition>
- SpeechSynthesisUtterance. (2022) Retrieved 09 06, 2022, from SpeechSynthesisUtterance: <https://developer.mozilla.org/en-US/docs/Web/API/SpeechSynthesisUtterance>
- SQL tutorial. (2022) Retrieved 10 17, 2022, from SQL tutorial: <https://www.tutorialspoint.com/sql/index.htm>
- Tan, P. J. (2015). English e-learning in the virtual classroom and the factors that influence ESL (English as a Second Language): Taiwanese citizens' acceptance and use of the Modular Object-Oriented Dynamic Learning Environment. *Social Science Information*, 54, 211–228. <https://doi.org/10.1177/0539018414566670>
- Tan, P. (2019). An Empirical Study of How the Learning Attitudes of College Students toward English E-Tutoring Websites Affect Site Sustainability. *Sustainability*, 11, 1748. <https://doi.org/10.3390/su11061748>
- Tan, P. J., & Hsu, M.-H. (2017). Developing a system for English evaluation and teaching devices. 2017a International Conference on Applied System Innovation (ICASI), pp. 938–941 <https://doi.org/10.1109/ICASI.2017.7988596>.

- Tan, P. J., & Hsu, M.-H. (2018). Designing a System for English Evaluation and Teaching Devices: A PZB and TAM Model Analysis. *EURASIA Journal of Mathematics, Science and Technology Education*, 14, <https://doi.org/10.29333/ejmste/86467>.
- Tanjung, S., & Rahmansyah, H. (2019). The Effect of Hangman Game on Students' Vocabulary Mastery. *Jurnal Liner (language Intelligence and Educational Research)*, 2(3), 77–89.
- Tsai, Y.-L., & Tsai, C.-C. (2018). Digital game-based second-language vocabulary learning and conditions of research designs: A meta-analysis study. *Computers & Education*, 125, 345–357. <https://doi.org/10.1016/j.compedu.2018.06.020>
- What is HTML? Retrieved 09 06, 2022, from What is HTML?: https://html.com/#What_is_HTML
- Wordnik API Documentation. (2022) Retrieved 09 06, 2022, from Wordnik.com: <https://developer.wordnik.com/docs#!/words/getRandomWords>
- Xu, Z., Chen, Z., Eutsler, L., Geng, Z., & Kogut, A. (2019). A scoping review of digital game-based technology on English language learning. *Educational Technology Research and Development*, 1–28 <https://doi.org/10.1007/s11423-019-09702-2>.
- Zou, D., Huang, Y., & Xie, H. (2019). Digital game-based vocabulary learning: where are we and where are we going? *Computer Assisted Language Learning*, 34, 1–27. <https://doi.org/10.1080/09588221.2019.1640745>
- Zou, D., Wang, F. L., Kwan, R., & Xie, H. (2018a). Investigating the Effectiveness of Vocabulary Learning Tasks from the Perspective of the Technique Feature Analysis: The Effects of Pictorial Annotations.
- Zou, D., Wang, F. L., Xie, H., & Kohnke, L. (2018b). Game-Based Vocabulary Learning in China and Hong Kong: Students' Evaluation of Different Word Learning APPs.

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