Examining EFL learners' Vocabulary Learning Engagement and Outcomes in a Seamless Learning Environment Mediated by an Augmented Reality App -VocabGO in Mainland China

by

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Statement of Originality

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Abstract

Despite that Augmented Reality (AR) has been integrated into English as a Foreign Language (EFL) instruction, few studies have been conducted, focusing on AR-supported vocabulary learning both inside and outside the classroom at a primary level. Against this background, this study aimed to examine the impact of an AR app – VocabGo on primary students' vocabulary learning in a seamless learning environment, specifically in the context of a private school in Shenzhen, China. This empirical study adopted mixed research methods and lasted for 26 weeks. Seventy-two Grade 4 students from a private school in Shenzhen, China, were randomly divided into three groups with 24 participants for each group. Group 1 adopted VocabGo both in-class and out-of-class, Group 2 adopted VocabGo in-class only, and Group 3 adopted VocabGo out-of-class only. The framework of AR-supported vocabulary acquisition in a seamless learning environment was employed in this study. The research questions probed into the impact of VocabGo on students' engagement and vocabulary learning outcomes in various contexts: (1) in-class, (2) out-of-class, and (3) a combination of both. Data collection involved student pre- and post-engagement questionnaires, student focus group interviews, pre- and post-vocabulary tests and log data. The research findings show that students in Group 1 outperformed significantly those in Group 2 and Group 3 in terms of engagement and learning outcomes, lending support to the potency of a seamless learning environment that integrates formal and informal learning experiences. Additionally, the research findings show that a positive correlation was established between engagement levels and learning outcomes, providing insights into the relationship between these two

dimensions.The study contributes to the literature in three aspects. First, theoretically, the study substantiates the effectiveness of the framework of AR-supported vocabulary learning in a seamless learning environment, advancing our understanding of EFL vocabulary acquisition and the potential of seamless learning environments. It also deepened our understanding of the Dual Coding Theory, underscoring the effectiveness of integrating verbal and non-verbal information, using real-world objects, and providing contextualized learning experiences. Secondly, practically, the research underscores the potential of AR technology like VocabGo as a pedagogical tool, offering important considerations for instructional design and practice in EFL education. It highlights the importance of providing technical support and training for teachers and students, aligning AR technology use with the curriculum and learning objectives, and factoring in the logistical and infrastructural requirements for AR implementation. Finally, the study serves as a basis for further research on AR in EFL instruction, suggesting avenues for investigating the utility of other mobile-assisted language learning applications, exploring different learner populations and contexts, and examining the long-term impact of AR on vocabulary learning engagement and outcomes, particularly within the Mainland China context.

Keywords: AR, VocabGo, EFL vocabulary learning, engagement

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List of Abbreviations

AR	Augmented Reality
ANOVA	Analysis of Variance
RQ	research question
MALL	mobile-assisted language learning

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Chapter 1 Introduction

1.1 Background and Context

In recent years, the integration of technology into education has emerged as a significant trend, particularly with the growing interest in innovative teaching methods for enhancing EFL learning(Li et al., 2022). One of the technological advancements that has captured the attention of educators and researchers is AR, which has shown potential for improving students' engagement and learning outcomes (Ibáñez & Delgado-Kloos, 2018). The application of AR in EFL education, specifically in vocabulary learning, has become a focal point of research due to its potential for enhancing learners' motivation, engagement, and language acquisition (Akçayır & Akçayır, 2017).

Mainland China, a country with an increasing demand for English language proficiency, has seen a surge in the adoption of technology-mediated teaching approaches (Lin & Lin, 2019). This growth is driven by the desire to equip young learners with the necessary linguistic competencies for communication in the globalized world (Cenoz & Gorter, 2019). As a result, researchers and educators have been exploring the potential of AR applications, such as VocabGo, to facilitate vocabulary learning in Mainland China (Song et al., 2023).

In this context, the concept of seamless learning has emerged as a promising approach for EFL vocabulary learning, combining in-class and after-class learning experiences (Wong et al., 2021). This approach is especially relevant during the COVID-19 pandemic, where

traditional classroom instruction has been disrupted, and educators are searching for effective ways to bridge the gap between academic and informal learning environments (Li et al., 2022).

1.2 Research Gaps

Despite the growing interest in the application of AR for EFL vocabulary learning and the potential of seamless learning environments, several research gaps have been identified in the literature. Firstly, most studies on AR-supported vocabulary learning have been conducted in controlled environments, such as schools and laboratories (Zhou, 2021). These studies may not fully capture the dynamic nature of language learning, which often occurs in diverse contexts and through various interactions with the environment (Li et al., 2022).

Secondly, there is a scarcity of research on the use of AR applications for vocabulary learning both within and outside the classroom (Zhou, 2021). Seamless learning environments, which aim to integrate academic and informal learning experiences, have not been sufficiently explored in the context of AR-supported EFL vocabulary learning (Wong et al., 2021).

Thirdly, research on engagement in AR-enhanced language learning, particularly in Mainland China, is limited (Zhou, 2021). Engagement is a critical factor in the learning process, as it influences learners' motivation, persistence, and ultimately their learning outcomes (Ibáñez & Delgado-Kloos, 2018). However, current research on how AR applications, such as VocabGo, can foster engagement among EFL learners in Mainland China remains limited.

Lastly, the majority of studies on AR-supported vocabulary learning have employed small sample sizes and short-term research designs (Zhou, 2021). Consequently, these studies may not provide a comprehensive understanding of the long-term effects of AR on vocabulary learning or the potential scalability of such interventions for broader educational contexts (Akçayır & Akçayır, 2017).

To address these research gaps, the present study aims to examine EFL learners' vocabulary learning engagement and outcomes in a seamless learning environment mediated by the VocabGo AR app in Mainland China. By adopting a mixed-methods approach and a quasi-experimental research design over a 24-week period, this study seeks to provide a more comprehensive understanding of the impact of AR-supported vocabulary learning in various learning contexts and explore the relationship between engagement and learning outcomes among the participating students.

In addition to addressing the identified research gaps, this study aims to contribute to the literature on AR-enhanced EFL vocabulary learning, engagement, and seamless learning environments. By examining the effectiveness of VocabGo in promoting engagement and improving vocabulary learning outcomes in a seamless learning environment, the study hopes to provide valuable insights for educators, researchers, and policymakers in Mainland China and beyond. Furthermore, the findings of this study can inform the design of future AR applications and instructional strategies, potentially leading to more effective and engaging

language learning experiences for EFL students.

Ultimately, this study endeavors to shed light on the potential of AR applications like VocabGo to enhance EFL vocabulary learning, with the aim of scaling up innovative practices nationwide. By addressing the identified research gaps and contributing to the growing body of literature on AR-enhanced language learning, this study hopes to pave the way for more effective, engaging, and accessible EFL vocabulary learning experiences supported by mobile technologies in seamless learning environments for young learners in Mainland China and beyond.

1.3 Research Purposes and Questions

The primary purpose of this study is to investigate the effectiveness of the VocabGo app in promoting EFL learners' vocabulary learning engagement and outcomes in a seamless learning environment in Mainland China. This study seeks to address the research gaps identified in the literature review and contribute to the understanding of AR-supported vocabulary learning in various learning contexts. To achieve this purpose, the study has the following objectives:

To explore the impact of the VocabGo app on students' engagement in vocabulary learning, taking into account the different contexts in which the app is used (in-class, outside class, and both in-class and outside class).

To examine the effects of the VocabGo app on students' vocabulary learning outcomes, including immediate and delayed post-test scores, in comparison to other groups using different learning contexts (Tsai, 2018; Cenoz & Gorter, 2019).

To investigate the relationship between students' engagement and vocabulary learning outcomes in the three different learning contexts, with a focus on understanding how different levels of engagement may relate to learning outcomes (Li et al., 2022).The study employed a quasi-experimental research design and lasted for 24 weeks, involving 72 participants from three Grade 4 classes in a private school in Shenzhen, China. The students, aged between 9 and 10, have similar learning ability and motivation levels. They were randomly divided into three groups: Group 1 used VocabGo both in class and outside class; Group 2 used VocabGo only in class; and Group 3 used VocabGo outside class. All groups adopted the same teaching methods based on the four-stage second language vocabulary acquisition process (Ma, 2014). Parents' collaboration was sought to ensure that students spend the same amount of time on their vocabulary learning homework.The teacher will assign homework to the students and ask them to finish it within 20 minutes. According to Hwuang and Fu(2019),"Short-term" refers to studies lasting less than 10 weeks."Medium-term" encompasses studies that span from 10 weeks to 4 months."Long-term" indicates studies that extend beyond 4 months.

In order to address these objectives, the study aims to answer the following research questions:

RQ1: What is the impact of the VocabGo app in a seamless learning environment compared

to other two groups on students' engagement on their vocabulary learning?

RQ2: What is the impact of the VocabGo app in a seamless learning environment compared to other two groups on the students' vocabulary learning outcomes?

RQ3: Is there any relationship between students' engagement and outcomes among the three groups? If yes, what are the relationships?

These research questions and objectives aim to address the current gaps in the literature on AR-supported vocabulary learning, particularly in the context of Mainland China. The study will employ a mixed-methods approach, combining quantitative and qualitative data to provide a comprehensive understanding of the effects of the VocabGo app on EFL learners' engagement and vocabulary learning outcomes. By examining the impact of the VocabGo app in different learning contexts, the study will contribute to the understanding of how AR technology can be effectively integrated into EFL vocabulary learning to enhance student engagement and learning outcomes (Tsai, 2018).

The study will also shed light on the relationship between engagement and learning outcomes in the context of AR-enhanced vocabulary learning. This is an important aspect to investigate, as it can inform the development of future AR applications and instructional strategies that can effectively increase engagement and lead to better learning outcomes for EFL learners (Li et al., 2022).

Finally, by examining the effects of the VocabGo app on vocabulary learning outcomes, the

study can inform educators and policymakers about the potential benefits of incorporating AR technology into EFL vocabulary instruction. The results of this study can help support the case for adopting AR-based learning tools like VocabGo to improve vocabulary learning experiences for EFL students in Mainland China and elsewhere (Godwin-Jones, 2019; Cenoz & Gorter, 2019).

In summary, this study seeks to contribute to the field of EFL vocabulary learning by investigating the effectiveness of the VocabGo app in promoting engagement and learning outcomes in a seamless learning environment. The findings of this study can inform the design and implementation of AR-enhanced vocabulary learning tools and strategies, potentially leading to more effective and engaging language learning experiences for EFL students in seamless learning environments.

1.4 Significance of the Study

The significance of this study lies in its potential contributions to the fields of EFL vocabulary learning, instructional design, and augmented reality in education. By examining the impact of the VocabGo app in a seamless learning environment, the study aims to address the existing research gaps and provide valuable insights into the effectiveness of AR-supported vocabulary learning both within and outside the classroom (Li et al.,2022).

First, the study contributes to the understanding of how AR technology could be effectively integrated into EFL vocabulary learning. Although previous research has demonstrated the

potential benefits of AR in EFL learning (Lin & Lin, 2019), few studies have specifically focused on vocabulary learning, particularly in Mainland China. By examining the impact of the VocabGo app on students' engagement and learning outcomes, the study provides empirical evidence to support the use of AR technology in EFL vocabulary instruction (Cenoz & Gorter, 2019).

Second, the study sheds light on the relationship between students' engagement and vocabulary learning outcomes in the context of AR-enhanced vocabulary learning. Understanding this relationship is essential for the development of instructional strategies and tools that could effectively increase engagement and improve learning outcomes for EFL learners (Tsai, 2018; Godwin-Jones, 2019). By exploring the relationship between engagement and outcomes, the study informs the design of future AR applications and instructional strategies that could better support EFL vocabulary learning.

Third, the study contributes to the field of instructional design, particularly in the context of seamless learning environments. Seamless learning environments, which bridged in-class and after-class learning through the use of technology, has the potential to enhance students' engagement and learning outcomes (Wong et al., 2021). By examining the impact of the VocabGo app in a seamless learning environment, the study provides valuable insights into the design and implementation of AR-enhanced vocabulary learning tools and strategies that promotes student engagement and improved learning outcomes (Li et al., 2022).

Fourth, the study has practical implications for educators and policymakers in Mainland China and beyond. As the demand for English language proficiency continued to grow, it is essential to explore innovative instructional methods and tools that could enhance the effectiveness of EFL vocabulary learning (Nation, 2006). The findings of this study informs the development and adoption of AR-based learning tools like VocabGo, which could potentially improve vocabulary learning experiences for EFL students in Mainland China and other contexts (Godwin-Jones, 2019; Cenoz & Gorter, 2019).

Lastly, the study contributes to the ongoing dialogue on the role of technology in language learning during and beyond the COVID-19 pandemic. As educational institutions around the world continues to adapt to the challenges posed by the pandemic, it is crucial to explore how technology could be leveraged to support effective and engaging learning experiences for students (Al Seghayer, 2020). The results of this study provides insights into the potential of AR-enhanced vocabulary learning to address the challenges faced by EFL learners in Mainland China and other contexts during these unprecedented times (Tsai, 2018).

In summary, this study holds significance for the fields of EFL vocabulary learning, instructional design, and augmented reality in education. By addressing existing research gaps and providing valuable insights into the effectiveness of the VocabGo app in a seamless learning environment, the study has the potential to inform the development of future AR applications and instructional strategies that can effectively engage students and improve their vocabulary learning outcomes.

1.5 A Brief Synopsis of the Study

This study aimed to investigate the effectiveness of the VocabGo app, an AR application, in enhancing EFL learners' vocabulary learning engagement and outcomes within a seamless learning environment in Mainland China. VocabGo has been specifically developed to support young EFL learners in acquiring vocabulary by leveraging AR technology and theoretical frameworks from dual coding theory (Paivio, 1971; Paivio & Clark, 2006), technical vocabulary learning generation theory (Mayer, 2019), second language acquisition (Nation, 2006), and the concept of seamless learning (Wong et al., 2021).

The results of this study contributed to the growing body of literature on AR-supported vocabulary learning, particularly in Mainland China, where previous research has been limited(Li et al., 2022). Furthermore, the findings provided insights into how instructional design mediated by AR apps can engage young learners in vocabulary learning, potentially leading to innovative practices being scaled up nationwide (Godwin-Jones, 2019).

The study's outcomes had implications for instructional design, teaching practices, and policy-making in the realm of EFL education, particularly in the context of integrating AR technology and seamless learning environments for vocabulary acquisition. Additionally, the findings may help address the research gaps identified in the literature, such as the scarcity of studies focusing on engagement and the limited research conducted in Mainland China.

1.6 Organization of the Dissertation

The dissertation is divided into six chapters, which are briefly described below.

Chapter 1: Introduction

This introductory chapter sets the stage for the study by providing the background and context of EFL vocabulary learning in Mainland China and the use of AR technology in this process. It also identifies research gaps in the current literature and explains the study's purposes and research questions. Moreover, the significance of the study is presented, highlighting the potential contributions of the research to the field of EFL education, particularly in the context of seamless learning and AR-supported vocabulary learning(Li et al., 2022).

Chapter 2: Literature Review

This chapter offers a comprehensive review of the literature related to AR in EFL vocabulary learning, seamless learning environments in the EFL context, and engagement in EFL vocabulary learning (Tsai, 2018; Wong et al., 2021). The review aims to provide a solid foundation for the study, grounding it in the relevant theoretical frameworks and empirical research. It also highlights the research gaps that this study seeks to address (Godwin-Jones, 2019).

Chapter 3: This Study and Methodology

The methodology chapter presents the research design, participants, the VocabGo app, and

the procedure and implementation of the study (Cenoz & Gorter, 2019). It also details the data collection instruments

Chapter 4: Results

In this chapter, the results of the study are presented, addressing each of the research questions. The findings are organized into three sections: (1) engagement in vocabulary learning, (2) vocabulary learning outcomes, and (3) the relationship between engagement and outcomes among the three groups (Tsai, 2018). The results are discussed in detail, providing evidence for the impact of the VocabGo app in a seamless learning environment on students' engagement and vocabulary learning outcomes.

Chapter 5: Discussion

The discussion chapter offers an interpretation of the findings, connecting them to the existing literature on AR-supported EFL vocabulary learning, seamless learning environments, and engagement in vocabulary learning (Godwin-Jones, 2019; Li et al., 2022). It also presents the implications of the study for instructional design and practice in EFL education, as well as the limitations of the research. Finally, recommendations for future research in the field of AR-supported EFL vocabulary learning and seamless learning environments are provided.

Chapter 6: Conclusion

The concluding chapter provides a summary of the study, reiterating its main findings and contributions to the field of EFL vocabulary learning and AR technology integration . It highlights the potential of the VocabGo app in enhancing students' engagement and learning outcomes within a seamless learning environment. The chapter ends with final remarks, reflecting on the overall significance of the research and its implications for EFL education in Mainland China.

Chapter 2 Literature Review

2.1 EFL Vocabulary Learning

2.1.1 EFL Vocabulary Learning

Vocabulary acquisition is a pivotal aspect of EFL learning, often being considered the lifeblood of language proficiency (Schmitt, 2008). The rationale behind this assertion lies in the fact that vocabulary knowledge underpins all language skills, be they reading, writing, listening, or speaking (Nation, 2006). Thus, the ability to comprehend and use a broad and diverse range of lexical items significantly impacts a learner's overall language competence.

In the context of EFL, vocabulary learning has historically been a challenging endeavor. EFL learners often struggle to recall and correctly use newly learned words, facing particular difficulties(Laufer & Hulstijn, 2001). Furthermore, the sheer volume of vocabulary that needs to be mastered in English—estimated at around 9,000 word families for understanding authentic spoken discourse (Nation, 2006) — presents a daunting task for learners. This

requirement becomes even more onerous when learners are expected to attain fluency, which necessitates a knowledge of up to 20,000 word families (Nation & Meara, 2013).

To navigate these challenges, EFL learners have traditionally relied on various vocabulary learning strategies, such as the use of flashcards and mnemonic devices (Schmitt, 1997). Notably, the effectiveness of these strategies often hinges on the learner's individual cognitive capabilities, as well as their motivation and engagement in the learning process (Dörnyei, 2005).

The advent of digital technologies has introduced new dimensions to EFL vocabulary learning. The use of computer-assisted language learning (CALL) tools, mobile applications, and online resources has been shown to enhance vocabulary acquisition by providing diverse, interactive, and learner-centered environments (Chapelle, 2001; Godwin-Jones, 2018). Specifically, such technologies can offer immediate feedback, multimedia input, and opportunities for repeated exposure and practice, all of which contribute to more effective and engaging vocabulary learning experiences (Stockwell, 2010).

However, despite these advancements, EFL vocabulary learning remains a complex and multifaceted process that is influenced by a myriad of factors, including individual learner differences, contextual elements, and the nature of the words being learned (Schmitt, N. 2008). In the following sections, we delve deeper into the strategies and models that have been proposed to facilitate this process.

2.1.2 Vocabulary Learning Strategies and Learning Models

Vocabulary learning is a vital aspect of EFL instruction. Over the years, several strategies have been proposed and examined in the literature to optimize vocabulary acquisition. This section focuses on four significant strategies: discovery and acquisition, repetition and review, Use of Technology, and Multimodal Learning, alongside the discussion of two key models: Brown and Payne's (1994) five-stage model and Ma's (2015) four-stage model.

The discovery and acquisition strategy refers to the process where learners encounter and comprehend new words (Peters& Webb, 2018). This strategy involves learners actively engaging with new vocabulary in context, often through reading or listening activities. Schmitt (2019) suggested that the effectiveness of this strategy is influenced by factors such as learners' language proficiency, the complexity of the text, and the density of unfamiliar words.

Repetition and review strategies involve learners re-encountering vocabulary items over time to reinforce memory (Nation, 2006). Studies have shown that repeated exposure to vocabulary in varied contexts can enhance word retention and recall (Kang,W.C, 2020). Spaced repetition, where review sessions are strategically spaced over time, has been found to enhance long-term vocabulary retention (Karpicke & Roediger, 2008).

The use of technology in vocabulary learning has become increasingly prevalent due to its potential to individualize instruction and make learning more engaging. Digital tools can provide interactive multimedia content and immediate feedback, which can support

vocabulary learning. Studies have demonstrated that using mobile applications for vocabulary learning can significantly improve learners' vocabulary knowledge (Godwin-Jones, 2019).

Multimodal learning, which involves the use of various sensory modalities in the learning process, has been found to enhance vocabulary acquisition (Paivio, 1971; Paivio & Clark, 2006). For example, combining text with relevant images or sounds can improve word retention (Mayer & Moreno, 2019). This is particularly effective in technology-enhanced learning environments, where multimedia and interactive elements can be seamlessly integrated (Al-Seghayer, 2021).

While these strategies are important, they are not sufficient in isolation. Vocabulary learning is a complex process that requires an understanding of both the form and meaning of words, and this knowledge needs to be integrated into the learner's existing linguistic system. Thus, learning models that consider this complexity are essential.

One such model is Brown and Payne's (1994) five-stage model of vocabulary learning. This model consists of five stages: (1) having sources for encountering new words, (2) getting a clear image, either visual or auditory or both, of the forms of the new words, (3) learning the meaning of the words, (4) making a strong memory connection between the forms and the meanings of the words, and (5) using the words. Brown and Payne(1994) argue that each stage requires different types of processing and strategies, emphasizing the multifaceted nature of vocabulary learning.

More recently, Ma's (2015) process-focused learning model for vocabulary acquisition provides a comprehensive view of vocabulary learning. The model consists of four stages: perceiving the word form, accessing the word meaning, mapping the form with meaning, and using the word. The model also includes a vocabulary learning strategy questionnaire based on the four stages (Ma, 2015). The model aims to provide a comprehensive and practical way of assessing and enhancing L2 learners' vocabulary knowledge.

In the next section, we will examine Ma's (2014, 2015) Vocabulary Learning Framework in greater detail, exploring its potential to address these limitations and provide a more comprehensive and nuanced understanding of EFL vocabulary learning.

2.1.3 Ma's (2014, 2015) Vocabulary Learning Framework

In the context of other learning models, Ma's (2015) Process-focused Learning Model for L2 Vocabulary Acquisition stands out for its comprehensiveness and attention to the dynamic nature of vocabulary learning. It is a model that explains how L2 learners learn new words by going through four steps: noticing, understanding, remembering, and using. The model also helps learners and teachers measure and improve their vocabulary learning strategies. Unlike traditional models that often present vocabulary learning as a linear, static process, Ma's model recognizes vocabulary learning as an iterative, cyclical process that is influenced by various factors, including the learner's cognitive abilities, learning strategies, and the learning context.

In the realm of language learning and teaching, vocabulary acquisition stands as a critical determinant of learners' proficiency and communicative competence (Nation & Meara, 2013). The vocabulary learning framework developed by Ma Qing (2014, 2015) provides a process-oriented approach, focusing on learners' engagement with new words at different stages. This model, consisting of four key stages – Discovering the new word, Obtaining the word meaning, Mapping the Form with Meaning, and Using the Word – offers a comprehensive view of vocabulary learning that aligns with cognitive theories of language acquisition.

1. Discovering the new word: The initial stage of Ma's model involves the recognition of the new word's form. The learners are exposed to the phonological and orthographic aspects of the word. They learn to identify the word based on its sound (phonemes) and written form (graphemes). The focus here is on enhancing the learners' ability to accurately perceive and recognize the word in different contexts (Ma, 2015). This stage is in line with the lexical processing model suggested by Aitchison (2012), which highlights the importance of word recognition in vocabulary learning.

2. Obtaining the word meaning: Once learners are familiar with the word form, the next stage is to understand the meaning of the word. This involves learning the semantic aspects of the word, including its denotation (literal meaning) and connotation (implied or associated meanings). Ma (2014) emphasizes that learners should engage with the

word in various contexts to gain a comprehensive understanding of its meanings. This resonates with the depth of processing hypothesis by Craik and Lockhart (1972), which suggests that deeper, more meaningful processing of information leads to better retention.

3. Mapping the Form with Meaning: The third stage involves connecting the form and meaning of the word. It is at this stage that learners start integrating the new word into their existing mental lexicon. They associate the phonological and orthographic forms of the word with its meaning, thus establishing a mental representation of the word (Ma, 2014). This aligns with the connectionist models of language acquisition, such as the Parallel Distributed Processing model (Rumelhart and McClelland, 1986), which emphasize the importance of forming associations between different aspects of language.

4. Using the Word: The final stage of Ma's model is the active use of the word. It is at this stage that learners begin to use the word in their speech and writing. Ma (2015) posits that active usage facilitates deeper processing of the word, thereby enhancing retention and recall. This is consistent with the usage-based theories of language acquisition (Tomasello, 2003) which argue that language learning is driven by meaningful use of language in social contexts.

Ma's vocabulary learning framework reflects a holistic and process-oriented approach to vocabulary acquisition. It underscores the importance of cognitive engagement with new

words at multiple levels, from recognition and understanding to active usage. The model is supported by a wealth of empirical evidence from studies investigating vocabulary learning strategies and outcomes in English as a second language (ESL) contexts (Ma, 2015).

2.1.4 Issues in EFL Vocabulary Learning

Many English as a foreign language EFL learners encounter various challenges and difficulties in learning and using vocabulary effectively. Vocabulary acquisition is a critical component of language learning, with issues that have persisted for years, yet are evolving with the advent of digital technologies. This section explores contemporary challenges in EFL vocabulary learning.

According to Nation (2006), some of the major issues in EFL vocabulary learning are:Limited Exposure. EFL learners often have limited exposure to English outside the classroom. This limits opportunities for incidental vocabulary learning and reinforcing new words through repetition. Studies show a correlation between exposure and vocabulary knowledge (e.g., Cobb, 2007; Horst, Cobb, & Meara, 1998). Therefore, EFL learners need to find ways to increase their exposure to authentic and rich input in English, such as reading, listening, and watching.

The large size of the English lexicon means that EFL learners face a considerable challenge in learning thousands of words to achieve proficiency. This learning burden can lead to frustration and a sense of being overwhelmed. EFL learners need to prioritize and select the

most useful and relevant words for their needs and goals, and use various strategies to learn and remember them efficiently and effectively (Nation, 2006; Schmitt, 2008). They also need to be aware of the different aspects of word knowledge, such as meaning, form, pronunciation, spelling, collocation, register, and usage (Schmitt et al., 2020).

Traditional methods such as rote memorization and the use of decontextualized word lists have been criticized for their limitations in promoting meaningful vocabulary use and long-term retention (Nation, 2006; Schmitt, 2008). EFL learners need to adopt more effective and varied learning strategies that suit their learning styles, preferences, and objectives. Some examples of effective learning strategies are: using context clues, word parts, mnemonics, imagery, word associations, semantic mapping, word cards, glossaries, games, quizzes, etc (Nation & Webb, 2011; Schmitt, 2014). EFL learners also need to review and recycle the words they learn regularly and systematically to consolidate their memory and prevent forgetting.

The emergence of digital technologies has added another layer of complexity to EFL vocabulary learning. While these technologies offer new opportunities for vocabulary learning, they also bring about new challenges. For example, integrating technology into vocabulary instruction requires not only technical proficiency but also a sound understanding of how to employ these tools to facilitate learning (Godwin-Jones, 2019). Moreover, potential distractions in digital environments and the lack of face-to-face interaction can impact learning negatively.

As digital technologies continue to evolve, the landscape of EFL vocabulary learning is shifting. Studies are increasingly focusing on the potential of technology-enhanced learning environments to address the issues mentioned above. With the development of digital technologies, studies on EFL vocabulary learning in technology-enhanced learning environments become more and more popular. In the next section, we will explore the literature on EFL vocabulary learning in technology-enhanced learning environments.

2.2 EFL Vocabulary Learning in Technology-enhanced Learning Environments

2.2.1 Role of Technology in EFL Vocabulary Learning

As we move into the digital era, technology has undeniably transformed many facets of life, including education. In particular, the field of EFL vocabulary learning has seen significant shifts with the introduction and integration of various digital technologies. This section will discuss the role of technology in EFL vocabulary learning, drawing on recent research in the field (Al-Seghayer 2021; Nguyen & Nguyen, 2020; Sari et al., 2019).

The integration of technology in EFL vocabulary learning has been largely facilitated by the emergence of Computer-Assisted Language Learning (CALL) approaches. CALL, which involves using computers or related technologies in language teaching and learning, has been found to be effective in improving learners' vocabulary knowledge (Al-Seghayer, 2021). These technologies can provide learners with interactive and authentic learning experiences, which can enhance vocabulary retention and recall. They also allow for individualized

learning, as learners can engage with the material at their own pace and according to their own learning styles and preferences.

Technology-enhanced learning environments also offer various tools that can support vocabulary learning. For instance, digital flashcards, such as those found on apps like Quizlet, provide a modern twist on a classic vocabulary learning strategy (Nguyen & Nguyen, 2020). These flashcards can incorporate multimedia elements, such as images and sounds, which can make the learning experience more engaging and can aid in memory retention through dual coding – a concept we will discuss in detail in the next subsection.

Furthermore, gamified apps can create a fun and engaging learning environment, which can boost motivation and enhance vocabulary learning outcomes (Al-Seghayer, 2021). Games often involve repetitive use and practice of target vocabulary, which can promote long-term retention. They also often require players to use vocabulary in context to solve problems or complete tasks, further promoting meaningful vocabulary use.

Lastly, technology allows for immediate and adaptive feedback, which is a key factor in language learning (Nguyen & Nguyen, 2020). Digital tools can provide learners with immediate corrections and explanations, helping them to rectify mistakes and misunderstandings promptly. Some tools can even adapt to learners' performance, providing more practice with words that learners are struggling with, and progressing to new material when learners are ready.

Overall, technology plays a multifaceted and significant role in EFL vocabulary learning, offering a range of tools and approaches that can enhance learning outcomes. However, it is also important to note that the use of technology in vocabulary learning is not without its challenges, which we will discuss in detail in section 2.2.3.

2.2.2 Vocabulary Learning Underpinned by Multimedia Learning and Dual Coding Theories

The role of technology in EFL vocabulary learning is closely intertwined with the cognitive theories of multimedia learning and dual coding. These theories help explain the cognitive processes involved in learning from multimedia resources and provide a foundation for designing effective multimedia learning experiences (Mayer, 2019;Paivio & Clark, 2006).

The Multimedia Learning Theory, developed by Mayer (2019), posits that learners learn more deeply from words and pictures than from words alone. It is premised on the idea that the human cognitive system has two separate channels for processing visual and auditory information. When both channels are engaged through the use of multimedia - that is, a combination of words (either spoken or written) and images (static or dynamic) - it leads to a more effective learning process. This is due to the increased cognitive engagement and the facilitation of the integration of new information with existing knowledge.

In EFL vocabulary learning, multimedia learning environments can present new words along with relevant images, sounds, or videos, thereby making the learning experience more

engaging and effective. For instance, a digital flashcard might present a new word, its definition, an image representing the word, and the word used in a sentence. This multi-modal representation can help learners better understand and remember the new word (Mayer, 2019).

The Dual Coding Theory, proposed by Paivio (1971), further supports the use of multimedia in vocabulary learning. According to this theory, human cognition consists of two interconnected but separate coding systems: the verbal system, which deals with language, and the nonverbal system, which handles non-linguistic objects and events, such as images and sounds. These two systems can operate independently but can also interact to enhance cognition.

When applied to vocabulary learning, the Dual Coding Theory suggests that learning new words with both verbal (the word and its definition) and nonverbal (images, sounds) representations can lead to dual coding of the information, with the word being stored in both the verbal and nonverbal memory systems. This dual coding can enhance recall and understanding of the new word, as the learner can retrieve and understand the word through either the verbal or nonverbal system (Paivio, 1971; Paivio & Clark, 2006).

The integration of multimedia learning and dual coding theories in EFL vocabulary learning has been facilitated by digital technologies, which offer a multitude of multimedia resources and interactive learning experiences. For instance, vocabulary learning apps can integrate text,

images, sounds, and interactive exercises to provide a rich, multimedia learning environment that aligns with the principles of multimedia learning and dual coding theories (Aloraini & Cardoso, 2022).

Despite the promising benefits of applying multimedia learning and dual coding theories in technology-enhanced vocabulary learning, it is essential to acknowledge that there are challenges and issues associated with this approach. These challenges will be discussed in the next subsection (2.2.3).

2.2.3 Issues and Challenges

While technology-enhanced learning environments present promising opportunities for EFL vocabulary learning, it is crucial to address the challenges and issues associated with this approach. These challenges encompass technical issues, cognitive overload, digital divide, and the need for pedagogical adaptation.

Firstly, technical issues can pose significant challenges. These issues can range from hardware and software glitches, internet connectivity problems, to difficulties in navigating complex digital platforms . For example, software updates can disrupt the learning process, and poor internet connectivity can limit access to online resources. This can result in frustration and disengagement from learning. Therefore, robust technical support and user-friendly design are necessary to ensure a smooth learning experience.

Secondly, the potential for cognitive overload is another significant concern. Both the Multimedia Learning Theory and Dual Coding Theory advocate for the use of multimedia resources in learning; however, these resources must be carefully designed to avoid overwhelming learners' cognitive capacities. For instance, presenting too much information at once, or combining unrelated images and text, can confuse learners and hinder their learning. Therefore, it is crucial to apply the principles of cognitive load theory, such as segmenting, pre-training, and signaling, in the design of multimedia learning materials (Sweller et al., 2011).

Thirdly, the digital divide issue should not be overlooked. Access to digital technologies and high-speed internet is not equally distributed across different regions and populations, and this digital divide can exacerbate educational inequalities (Van Dijk, 2021). For example, learners in rural areas or low-income communities may not have access to the necessary technologies for online learning. This highlights the need for policies and initiatives to increase digital access and literacy.

Moreover, pedagogical adaptation is another critical challenge. Traditional teaching methods may not translate well into digital environments, and teachers may need to develop new pedagogical strategies to effectively integrate technology into their teaching (Hockly, 2018). For instance, they may need to learn how to use digital tools, design multimedia learning materials, and facilitate online discussions. In addition, teachers need to consider individual learners' needs and preferences in technology-enhanced learning, as learners have diverse

cognitive styles, prior knowledge, and digital literacy levels (Mohandes et al, 2021).

Despite these challenges, it is important to note that they are not insurmountable. Various strategies can be employed to address these issues, such as providing technical support and training, designing learner-friendly multimedia materials, implementing policies to bridge the digital divide, and promoting pedagogical innovation and professional development in technology-enhanced teaching.

In summary, while technology-enhanced learning provides significant benefits for EFL vocabulary learning, it is essential to address the technical, cognitive, access, and pedagogical challenges that may arise. By taking a proactive approach to these issues, educators and institutions can make the most of the opportunities provided by these new learning environments.With the development of mobile technologies, learning can happen anywhere, anytime. Thus, the concept of mobile learning emerged, which is presented in the next section (2.3).

2.3 EFL Vocabulary Learning in Mobile Learning Environments

2.3.1 Mobile Learning

Mobile learning, often referred to as m-learning, has emerged as a significant area of interest in the field of educational technology and language learning. It is defined as the use of mobile or wireless devices for learning, whether these devices are handheld computers, PDAs, mobile phones, MP3 players, or any other device that has some form of wireless connectivity

(Crompton, 2013).

This form of learning is unique due to its inherent characteristics of mobility and reach. Mobile learning is not confined to a specific location and allows learning to take place anytime and anywhere. It also provides a personalized learning experience, enabling learners to learn at their own pace and according to their own needs and preferences (Traxler, 2018). Furthermore, mobile learning promotes active and situated learning experiences, engaging learners in real-world tasks and promoting the transfer of learning across contexts (Kukulska-Hulme & Viberg, 2018).

One of the emerging trends in mobile learning is the use of mobile devices for language learning. EFL learners can benefit from mobile learning due to its accessibility, flexibility, and the ability to provide a supportive learning environment tailored to individual learner's needs (Pegrum, 2014). Mobile devices can provide a variety of language learning resources and tools, such as dictionaries, flashcards, pronunciation guides, and interactive language learning games. These resources can be accessed anytime and anywhere, making vocabulary learning more engaging and interactive (Godwin-Jones, 2018).

Moreover, mobile learning supports the development of autonomous learning skills. It empowers learners to take control of their own learning, deciding what, when, where, and how they learn. This autonomy is particularly important in language learning as it encourages learners to engage in regular and sustained language practice, which is critical for vocabulary

acquisition and retention (Lai et al., 2023).

In the context of EFL vocabulary learning, mobile learning can support both intentional and incidental vocabulary learning. Intentional vocabulary learning can be facilitated through the use of digital flashcards, vocabulary quizzes, and other interactive vocabulary learning apps. On the other hand, incidental vocabulary learning can occur when learners engage with authentic English language content, such as news articles, podcasts, videos, and social media posts (Lin & Lin, 2019).

Despite its potential, mobile learning also presents a number of challenges. These include technical issues, such as connectivity problems, battery life, and small screen sizes; pedagogical issues, such as the need for effective instructional design and the risk of cognitive overload; and contextual issues, such as the need for learner training and support, and issues related to privacy and data security (Khaddage et al., 2016).

The next section will delve into the impact of mobile learning on EFL vocabulary learning, exploring how this novel form of learning is changing the way vocabulary is taught and learned.

2.3.2 Impact on EFL Vocabulary Learning

The influence of mobile learning on EFL vocabulary learning has been a prominent research area in recent years. Mobile devices can provide varied and interactive ways to learn and

review vocabulary, thereby enhancing motivation and engagement among learners (Chang, Lin, & Lu, 2020). Moreover, the portability of mobile devices allows learners to utilize spare time and various contexts for vocabulary learning, which can significantly increase the exposure and use of the target language (Godwin-Jones, 2019).

A significant advantage of mobile learning in EFL vocabulary learning is the support for personalized learning. Mobile applications often offer personalized vocabulary lists and learning activities based on the learners' proficiency level, learning style, and learning goals. This personalized learning approach can cater to individual learners' needs and preferences, enhancing their learning efficiency and effectiveness (Neumann & Waight, 2020).

Moreover, mobile devices can provide immediate feedback and scaffolding, which are beneficial for vocabulary learning. Immediate feedback can help learners correct their mistakes promptly and reinforce their learning, while scaffolding can support learners' understanding and use of new words (Kukulska-Hulme, 2019). For instance, learners can use mobile dictionaries to check the meaning, pronunciation, and usage of new words instantly, which can facilitate their vocabulary learning and retention (Viberg & Grönlund, 2013).

Furthermore, mobile learning can promote collaborative vocabulary learning. With the help of mobile technologies, learners can engage in collaborative vocabulary learning activities, such as group discussions, peer assessment, and collaborative writing, which can enhance their vocabulary learning outcomes and social skills (Lai, 2023).

However, the impact of mobile learning on EFL vocabulary learning is not without challenges. First, the effectiveness of mobile learning in vocabulary learning largely depends on the quality of mobile applications and resources, the design of learning activities, and learners' attitudes towards mobile learning (Stockwell & Hubbard, 2013). Second, distractions from mobile devices can hinder learners' concentration and learning outcomes (Rosen, Carrier, & Cheever, 2013). Lastly, issues related to privacy and data security can also affect learners' usage of mobile devices for vocabulary learning (Khaddage et al., 2016).

Despite these challenges, mobile learning holds great potential in enhancing EFL vocabulary learning, provided that appropriate strategies and measures are employed. The following sections will delve into the role of AR in mobile vocabulary learning, an emerging area that warrants attention.

2.3.3 AR-supported learning

AR is an interactive experience that enhances the real-world environment with computer-generated perceptual information. In essence, AR superimposes digital information such as images, sounds, videos, and texts onto the physical world, thus augmenting the user's perception of reality (Milgram & Kishino, 1994). AR has the potential to change how we interact with the world around us and can be particularly impactful in the field of education, including EFL vocabulary learning.

The AR technology offers a unique learning experience that combines the advantages of both physical and digital environments. Compared to traditional learning environments, AR offers a more immersive and engaging experience, which can enhance learners' motivation and engagement in learning activities (Ibáñez & Delgado-Kloos, 2018). This is particularly important for vocabulary learning, as motivation and engagement are critical factors influencing learners' vocabulary acquisition and retention (Lan et al., 2015).

AR can also support situated learning, which refers to the idea that learning is most effective when it is part of the learners' activity and context (Lave & Wenger, 1991). In the context of vocabulary learning, AR can provide contextual cues to help learners understand and remember new words. For instance, when learners point their mobile devices at a particular object, the corresponding English word can be displayed on the screen, which can facilitate learners' understanding and memorization of the word (Chen & Tsai, 2012).

Moreover, AR can support interactive and collaborative learning. With the help of AR technology, learners can interact with the augmented objects and environments, which can enhance their learning outcomes (Wu et al., 2013). Learners can also collaborate with others in the augmented environments, which can foster their social skills and collaborative problem-solving skills (Dunleavy, Dede, & Mitchell, 2009).

Furthermore, AR can provide immediate feedback and adaptive learning experiences. When learners make mistakes in vocabulary exercises, AR can provide immediate feedback to help

them correct their mistakes promptly. AR can also adapt the learning content based on learners' performance, which can cater to individual learners' needs and enhance their learning efficiency (Zhou, 2021).

Despite its potential, the use of AR in vocabulary learning also presents a number of challenges. These include technical issues, such as the high requirement for hardware and software, and the possible visual and physical discomfort caused by prolonged use of AR devices (Billinghurst & Duenser, 2012). Pedagogical issues include the need for effective instructional design that integrates AR technology into the vocabulary learning process in a meaningful way (Godwin-Jones, 2016). There are also issues related to learner training and support, as learners may need time and guidance to get familiar with the AR technology and use it effectively for learning (Bacca et al., 2014).

The following section will review the existing research on AR-supported vocabulary learning, shedding light on the potential and challenges of using AR for EFL vocabulary learning.

2.3.4 Research on AR-Supported Vocabulary Learning

The application of AR in vocabulary learning has gained increasing attention in recent years. A significant number of studies have reported positive effects of AR on vocabulary learning outcomes.

One of the key advantages of using AR in vocabulary learning is its ability to provide

contextualized and immersive learning experiences. For instance, Santos et al. (2014) conducted a study where learners used an AR application to learn English vocabulary. The AR application overlaid text labels onto real-world objects in the learners' environment, providing contextual cues to facilitate vocabulary learning. The study found that the learners achieved higher scores in vocabulary tests after using the AR application, suggesting that the contextualized and immersive learning experiences provided by AR can enhance vocabulary learning outcomes.

The motivational effects of AR in vocabulary learning have also been highlighted in several studies. Hwang et al. (2021) conducted a study with EFL learners using an AR-based vocabulary learning game. The study found that the learners showed increased motivation and engagement in vocabulary learning. This suggests that the interactive and game-like nature of AR can enhance learners' motivation, which is a critical factor for successful vocabulary learning.

Moreover, AR can support collaborative vocabulary learning. In a study by Bower et al. (2014), learners used an AR application to engage in collaborative vocabulary learning activities. The study found that the learners not only improved their vocabulary knowledge but also developed their collaborative problem-solving skills.

However, the use of AR in vocabulary learning also presents challenges. The technical issues include the high requirement for hardware and software, and the possible visual and physical

discomfort caused by prolonged use of AR devices (Billinghurst & Duenser, 2012). Pedagogical issues include the need for effective instructional design that integrates AR technology into the vocabulary learning process in a meaningful way (Godwin-Jones, 2016). There are also issues related to learner training and support, as learners may need time and guidance to get familiar with the AR technology and use it effectively for learning (Bacca et al., 2014).

Despite these challenges, the research on AR-supported vocabulary learning has generally shown promising results. With appropriate strategies and measures, AR has the potential to provide an engaging, interactive, and effective approach to vocabulary learning. Further research is needed to explore the optimal ways to integrate AR into vocabulary learning and to address the potential challenges.

2.3.5 Issues and Challenges

Mobile learning environments have emerged as a promising tool for EFL vocabulary learning, leveraging the ubiquity of smartphones and tablets to facilitate learning anytime and anywhere. However, as with any instructional technology, mobile learning presents its own set of issues and challenges that need to be addressed to optimize its efficacy for vocabulary acquisition.

Need for Research on Learner Experience: Most research to date has concentrated on learning outcomes, often neglecting the learners' perspectives, attitudes, and experiences

(Pegrum et al., 2013). Understanding these aspects is crucial as they can significantly influence learning engagement and outcomes. For instance, if learners find a mobile app difficult to navigate or if they feel that it doesn't align with their learning style or preferences, their engagement and learning might be hampered. Future research needs to delve into these aspects to design more learner-centered mobile learning environments and to better understand how learners interact with and perceive mobile learning tools.

AR and Cognitive Load: AR, an innovative feature that's being increasingly incorporated in mobile learning apps, overlays digital information onto the physical environment, providing an immersive learning experience. However, there's a debate around its impact on cognitive load (Marcel, 2019). On the one hand, AR can enhance learning by providing rich, contextual information that can aid understanding and retention. On the other hand, the wealth of information and stimuli provided by AR might overload learners' cognitive capacities, impeding learning. This is particularly relevant in vocabulary learning, where learners often need to focus on discrete items like word forms and meanings. More research is needed to understand the optimal balance of AR use in mobile learning environments to maximize learning without overwhelming learners.

Effectiveness of Mobile Learning: While mobile learning offers several benefits, its effectiveness for vocabulary acquisition compared to more traditional methods is still an area of ongoing research. Studies have reported mixed results, with some suggesting that mobile learning can be as effective as, if not more than, traditional classroom instruction (Chen &

Hsieh, 2008), while others found no significant differences (Wang & Smith, 2018). Further, the conditions under which mobile learning is most effective—such as the types of tasks or the duration and frequency of use—are still not well-understood. More rigorous, comparative studies are needed to provide clearer insights into these aspects.

Learner Perceptions and Experiences: Research on learners' perceptions and experiences in mobile learning environments is still relatively sparse, particularly in the context of EFL vocabulary learning. Preliminary studies suggest that learners generally perceive mobile learning positively and appreciate its flexibility and accessibility (Park, 2011). However, there can be variations in perceptions based on factors like learners' familiarity with technology, their language proficiency levels, and their cultural backgrounds. Moreover, learners' experiences with mobile learning can be influenced by technical issues, the quality of the learning content, and the extent of support and guidance provided. More in-depth and nuanced research is needed to better understand these dynamics and to cater to diverse learner needs and contexts.

In summary, while mobile learning environments hold significant potential for EFL vocabulary learning, there are several issues and challenges that need to be addressed. By focusing on these areas, future research can contribute to more effective and engaging mobile learning experiences for vocabulary acquisition.

With the development of mobile technologies and wireless internet networks (e.g., WiFi),

learning can happen ubiquitously across different spaces. Thus the concept of seamless learning emerged which is elaborated in the next section.

2.4 EFL Vocabulary Learning in Seamless Learning Environments

2.4.1 Foundations of Seamless Learning Environments

Seamless learning environments, as a concept, have gained significant attention in the field of educational technology and language acquisition in the past few years. The term "seamless learning" was initially designed to encapsulate learning experiences that bridged various locations, times, technologies, and social settings. This learning paradigm aims to create a fluid learning experience that can flow across different learning scenarios (Formal, Non-Formal, and Informal), different locations (in-class and out-of-class), and different times (during class, after class, and beyond the school term) (Wong, 2020).

Seamless learning environments offer a new perspective on education, advocating for the removal of boundaries between different learning settings, and promoting the integration of different learning approaches (Hwang & Tsai, 2011). It provides learners with the opportunity to learn anytime and anywhere, enabling them to take advantage of both academic and informal learning opportunities.

Technology plays a crucial role in seamless learning environments. The advent and proliferation of mobile devices and wireless networks have made it possible for learning to be ubiquitous, transcending traditional classroom boundaries (Kuh, 2009). Mobile technologies,

such as smartphones and tablets, are central to the realization of seamless learning as they can provide the necessary tools and resources for learners to engage with content and activities across various contexts (Kukulska-Hulme, 2010).

The digital platforms and applications that support seamless learning have also evolved in recent years. For example, cloud-based services allow learners to access learning resources from anywhere and at any time, fostering a sense of continuity and cohesiveness in the learning experience (Crompton, 2013). Moreover, the rise of social media and collaborative online tools has enhanced the social and collaborative aspects of learning, further enriching the seamless learning experience (Koole, 2009).

Finally, seamless learning environments are learner-centered. They promote learner autonomy and self-regulation, encouraging learners to take control of their own learning and to actively engage with the learning materials (Sharples, 2015). The interactive and participatory nature of these environments can foster motivation and engagement, which are key to successful language acquisition (Ushioda, 2011).

In summary, the foundations of seamless learning environments lie in their ability to provide a fluid, learner-centered, and technology-enhanced learning experience that transcends traditional learning boundaries. These environments have the potential to revolutionize the way we approach language learning, and more specifically, EFL vocabulary learning.

2.4.2 EFL Vocabulary Learning in Seamless Learning Environments

In the contemporary education landscape, the importance of EFL vocabulary learning in the context of seamless learning environments has gained substantial recognition. A "seamless learning" environment refers to a learning process that is consistent, readily accessible, and integrated across various contexts, including formal, non-formal, and informal settings (Yang et al., 2020; Wong et al., 2021). The expansion of digital technologies, which allow learners to access and engage with learning materials anytime and anywhere, has substantially driven the development of such environments.

Recent studies have concentrated on the impact of seamless learning environments on EFL vocabulary learning. For instance, Song et al.(2022) emphasized that these environments can bolster EFL vocabulary learning by offering real-world contexts for learners to apply and practice new vocabulary. The researchers also argued that incorporating mobile technologies into seamless learning environments can elevate vocabulary learning by enabling learners to more deeply and meaningfully interact with learning content.

Echoing this perspective, Hwang and Chang (2019) discovered that seamless learning environments that incorporate mobile technologies can stimulate EFL vocabulary learning by nurturing learner autonomy. Their research findings indicated that students who learned English vocabulary in a seamless learning environment demonstrated higher learner autonomy than those learning in traditional classroom settings. This suggests that seamless learning environments can empower learners by granting them flexibility and control over

their learning process.

The potential of seamless learning environments to foster learner engagement further underscores their significance in EFL vocabulary learning. Studies indicate that the integration of mobile technologies in seamless learning environments can involve learners in interactive and cooperative learning activities, thereby enhancing vocabulary learning (Hwang et al., 2020). For example, learners can use mobile applications to collaborate with peers on vocabulary learning tasks, such as vocabulary quizzes and games. The interactive and cooperative nature of these environments can make vocabulary learning more engaging and enjoyable, consequently leading to improved learning outcomes.

Furthermore, seamless learning environments can enhance EFL vocabulary learning by offering personalized learning experiences. Through adaptive and intelligent systems, these environments can deliver custom learning content that aligns with learners' needs and preferences (Chang et al., 2018). This personalized approach to vocabulary learning can boost learning efficiency and effectiveness by enabling learners to concentrate on the vocabulary items that are most relevant to them.

In conclusion, the role and impact of EFL vocabulary learning within seamless learning environments are multifaceted. These environments can enhance vocabulary learning by providing authentic contexts for vocabulary use, promoting learner autonomy, enhancing learner engagement, and delivering personalized learning experiences. As digital technologies

continue to evolve, it is anticipated that seamless learning environments will become increasingly vital in EFL vocabulary learning.

Moving forward, the next section, 2.5 AR-aided Vocabulary Learning: The Intersection of Technology and Language Acquisition, will delve into how the integration of AR technology can further enhance the vocabulary learning experience within these seamless learning environments.

2.5 AR-supported Vocabulary Learning in Seamless Environments

2.5.1 Evaluating the Impact of AR on EFL Vocabulary Learning

The use of AR in seamless learning environments has shown significant promise in enhancing EFL vocabulary learning. Its potential is underscored by the immersive experiences it provides, offering learners an enriched context that supports understanding and retention of new vocabulary(Song et al., 2023).

Several studies have aimed to evaluate the outcomes and effectiveness of AR-aided vocabulary learning in seamless learning environments. For instance, Zang et al. (2022, November) conducted an experimental study comparing the vocabulary learning outcomes of learners using AR technology with those using traditional flashcards. The results revealed that learners using AR achieved significantly better scores in post-tests, suggesting that AR can effectively support vocabulary learning.

Likewise, the study by Chen and Wang (2018) demonstrated that AR could enhance students' motivation and engagement in vocabulary learning activities. These researchers attributed the heightened engagement to the immersive and interactive experiences that AR provides, fostering a more enjoyable and stimulating learning environment.

Moreover, the integration of AR in seamless learning environments has shown to improve learner autonomy. According to a study by Lin and Lan (2015), learners who used AR were more likely to take charge of their learning, exploring and interacting with the AR content at their own pace. This increased learner autonomy is seen as a crucial factor in successful language learning.

However, merely incorporating AR technology does not guarantee effective learning. The design of the AR applications and the pedagogical approach taken can greatly impact the learning outcomes. In a study conducted by Godwin-Jones (2019), it was highlighted that AR applications that provided immediate feedback and allowed for repeated practice led to better vocabulary retention among learners. This highlights the importance of well-structured AR content and feedback mechanisms in facilitating effective vocabulary learning.

While these studies provide promising evidence of the effectiveness of AR in EFL vocabulary learning, it's important to remember that every learning environment is unique. The success of AR technology can be influenced by various factors, such as learners' familiarity with the technology, the availability of devices, and the design of the AR content.

In summary, the use of AR in seamless learning environments can significantly enhance EFL vocabulary learning. However, the successful integration of this technology requires careful consideration of various factors, including the design of the AR application and the context in which it is used.

With the increasing prevalence of AR in education, it's expected that future research will continue to evaluate its effectiveness and explore ways to maximize its benefits in EFL vocabulary learning. However, while AR provides exciting opportunities for vocabulary learning, it also presents new challenges, as discussed in the next section.

2.5.2 Challenges and Considerations for AR Integration in Seamless Learning

While seamless learning environments present compelling advantages, they are not without challenges that need to be addressed.

At the forefront of these challenges is the delicate transition between academic and informal learning. Seamless learning is an innovative concept that aspires to bridge the gap between these two fundamentally different learning environments (Wong et al., 2021). In formal settings, learning is usually structured and led by educators, often resulting in higher levels of learner motivation. Conversely, informal learning relies heavily on self-motivation, which can vary significantly amongst learners. The pedagogical challenge, therefore, lies in maintaining a balance and ensuring a seamless transition between these learning modalities.

Further research is needed to explore effective strategies for motivating learners in informal learning settings and to understand how to blend these learning environments more effectively (Song et al., 2020).

Secondly, there is the issue of pedagogical integration. The integration of AR into vocabulary learning activities necessitates the reconceptualization of pedagogical designs to ensure that the technology supports and enhances learning rather than distracting from it (Kukulska-Hulme, 2010). The successful integration of AR in seamless learning environments calls for professional development initiatives that equip educators with the necessary knowledge and skills to design and implement AR-aided vocabulary learning activities(McKinney et al, 2023).

Lastly, the lack of robust evaluative frameworks for assessing the impact of AR-aided vocabulary learning in seamless environments is a challenge. While there have been studies on the effectiveness of AR for vocabulary learning, there is a need for more rigorous research designs that capture the multifaceted impacts of AR on learners' vocabulary acquisition, retention,and engagement (Godwin-Jones, 2020).

It is important to recognize these challenges and seek strategies to address them to maximize the potential of seamless learning environments for EFL vocabulary learning. As technology and pedagogical practices evolve, so too must our understanding and application of seamless learning concepts.

Transitioning to our next section, while seamless learning environments have been widely explored in various contexts globally, it's crucial to investigate how these theories and practices apply in different cultural and regional contexts. We will now delve into the specific context of mainland China, a rapidly developing region with its unique characteristics, constraints, and potentialities in the realm of EFL vocabulary learning in a seamless learning environment.

2.6 EFL Vocabulary Learning in a Seamless Learning Environment in Mainland China

2.6.1 Digital Learning Landscape in Mainland China: Understanding the Context

The digital learning landscape in mainland China has seen a dramatic shift over the last decade (Textor, 2021) This transition has been expedited due to the rapid advancements in technology, increasing internet penetration, and the government's push towards digitalizing education. A strong impetus behind this shift has been the Chinese government's 'Internet Plus' action plan rolled out in 2015, which called for integrating the internet with traditional industries to fuel economic growth. As a part of this plan, education, especially EFL teaching and learning, has been a significant focus, leading to a new era of technology-enhanced language learning.

Seamless learning has been leveraged in various educational settings in China, from K-12 schools to higher education institutions. According to a study by Lin and Lin (2019), seamless learning environments can foster students' autonomous learning, critical thinking

skills, and digital literacy. This is particularly relevant for EFL learning, where exposure to the target language outside the classroom is crucial for enhancing vocabulary acquisition and language proficiency.

Additionally, seamless learning environments have been further enriched with the advent of AR. AR superimposes digital information onto the physical world, providing an immersive and interactive learning experience. It has been increasingly integrated into EFL vocabulary learning in China, showing promising results in improving learners' vocabulary retention and motivation (Chen & Hsu, 2020).

However, it's important to note that the digital learning landscape in China is not without its challenges.These issues, along with the specific implementation of seamless learning for EFL vocabulary acquisition in the Chinese context, will be further discussed in the following sections.

2.6.2 EFL Vocabulary Learning in China: Current Practices and Trends

EFL vocabulary learning in China has been shaped by various factors, including traditional teaching methods, examination-oriented education, and the rise of digital technologies. The significance of English vocabulary acquisition in China is underscored by the fact that vocabulary knowledge plays a crucial role in successful language comprehension and use (Nation, 2006). As such, vocabulary learning has been a focal point in the Chinese EFL context, attracting considerable attention from educators, researchers, and policy-makers

alike.

In terms of current practices, rote memorization has been a dominant approach to vocabulary learning in the Chinese EFL classroom, largely influenced by the examination-oriented education system. With the English examinations emphasizing vocabulary knowledge, students are often encouraged to memorize word lists, with less emphasis placed on contextualized vocabulary learning. However, this learning strategy has been criticized for its lack of effectiveness.

Despite this, a trend towards more interactive and engaging vocabulary learning methods has emerged in recent years. The integration of digital technologies into EFL instruction is driving a shift away from traditional rote learning towards more communicative and interactive vocabulary learning practices (Li, 2018). For example, online platforms and mobile applications providing interactive vocabulary exercises and games are increasingly popular among Chinese EFL learners. These digital tools offer learners opportunities to encounter and use new words in various contexts, which can enhance their vocabulary knowledge and retention (Sung et al., 2016).

Another noteworthy trend is the growing interest in Computer-Assisted Language Learning (CALL) in the Chinese EFL context. Research has shown that CALL can offer a variety of advantages for vocabulary learning, such as providing immediate feedback, promoting learner autonomy, and enhancing motivation (Chen, 2020). For instance, digital flashcards

with multimedia annotations have been found to facilitate vocabulary memorization and recall among Chinese EFL learners (Li et al., 2022).

Furthermore, the incorporation of AR into EFL vocabulary instruction is an emerging trend in China, owing to the technological advancements and the increasing accessibility of AR devices (Zhou, 2021). AR can create an immersive and interactive learning environment, which has been suggested to promote vocabulary learning by engaging learners' multiple senses and enhancing their cognitive processing (Li et al., 2018).

2.6.3 AR-supported EFL Vocabulary Learning in China

The advent of AR in China's educational framework has initiated a paradigm shift in language learning, specifically in the EFL vocabulary learning realm. The immersive nature of AR enhances learner interaction with the target language, fostering a more engaging and motivating learning environment.

In recent years, various research studies have spotlighted the implementation of AR in EFL vocabulary learning within China's educational context. One such study by Wang (2021) investigated the effectiveness of an AR-based mobile application for EFL vocabulary learning among Chinese university students. Their findings suggested that the use of AR could enhance vocabulary learning outcomes by providing a more engaging and immersive learning experience. The application integrated 3D models, audio pronunciation, and example sentences in AR, thus offering learners a multidimensional perspective of the words being

studied.

Similarly, a study conducted by Liu and Wu (2022) explored the potential of AR flashcards in promoting vocabulary retention among Chinese primary school students learning English. The AR flashcards incorporated visual and auditory cues, making the learning process more interactive and appealing. The study found a significant increase in vocabulary retention rates among students who used AR flashcards compared to traditional paper flashcards, signifying the potential of AR in enhancing vocabulary learning.

The integration of AR in EFL vocabulary learning in China is still in its early stages, with a limited number of schools and institutions adopting this technology. However, with the increasing emphasis on technological integration in education and the growing recognition of AR's potential benefits, it is anticipated that AR will become a more prominent tool in EFL vocabulary learning in the years to come.

In summary, the implementation of AR in EFL vocabulary learning in China offers considerable potential in enhancing students' learning experiences and outcomes. However, to fully harness the benefits of this technology, it is critical to address the existing challenges and barriers, particularly in terms of technology readiness, professional development for teachers, and ensuring equitable access to technology across all regions and schools in the country.

As AR's application in education continues to expand, its effectiveness in aiding EFL vocabulary learning has gained significant attention, particularly in the context of Mainland China. Evaluating the effectiveness of AR-aided EFL vocabulary learning involves a comprehensive understanding of the outcomes in terms of students' learning performance, engagement, motivation, and attitudes.

A surge in empirical studies has reported the enhanced learning performance with the use of AR in EFL vocabulary learning. For instance, a study conducted by Liu and Wu (2022) involving Chinese EFL students revealed that the group using AR-based flashcards significantly outperformed the group using traditional flashcards in vocabulary tests. This could be attributed to the immersive and interactive nature of AR, which may enhance memory retention and facilitate deeper understanding of vocabulary items.

Moreover, the potential of AR to improve learner engagement and motivation has been highlighted. An investigation conducted by Wu et al.(2013) found that AR-aided vocabulary learning activities were perceived as more enjoyable and stimulating by Chinese EFL learners, leading to higher engagement and intrinsic motivation levels. This is consistent with the motivational theories of learning that underscore the role of enjoyment and interest in promoting learning outcomes (Ryan & Deci, 2020).

In addition, the positive attitudes towards AR-aided EFL vocabulary learning are noteworthy. Zhang and Liu (2022) found that Chinese EFL learners demonstrated positive attitudes

towards AR-aided vocabulary learning. They perceived AR as a useful tool that made learning more interesting and efficient. Such positive attitudes can be a significant factor driving the successful integration of AR into EFL vocabulary learning, as learners' attitudes towards technology can directly influence their acceptance and use of it (Davis, 1989).

Nonetheless, it should be noted that while AR shows promising results, its effectiveness may vary depending on various factors, such as the design of AR applications, the appropriateness of tasks, and learners' individual differences. For example, an over-reliance on the novelty effect of AR might lead to a decline in its effectiveness over time once the novelty wears off (Koutromanos et al., 2020). Therefore, future studies should focus on exploring these factors to optimize the effectiveness of AR-aided EFL vocabulary learning in the Chinese context.

In summary, the preliminary evidence suggests that AR can be a powerful tool to enhance EFL vocabulary learning in China. However, it is imperative to conduct more rigorous and longitudinal studies to provide a deeper understanding of how to leverage AR most effectively for EFL vocabulary learning. The future of AR-aided EFL vocabulary learning in China looks promising, but more effort is needed to fully realize its potential.

2.6.4 Issues and Challenges in Implementing Seamless Learning Environments for EFL Vocabulary Learning in China

As promising as the prospects of AR-assisted EFL vocabulary learning in seamless learning environments may seem, its implementation in Mainland China faces a number of issues and challenges. The first major hurdle is related to the digital divide that persists between rural

and urban areas in China. Rural areas tend to have less access to advanced digital technologies, including AR (Wang, 2019). This gap extends to the uneven distribution of trained teachers capable of utilizing AR technologies for EFL instruction. Teachers in remote and underprivileged areas might not have the necessary skills and knowledge to design AR-enhanced vocabulary lessons, which could limit the effectiveness of the technology in these regions (Wu et al., 2013).

Moreover, the concern over data privacy and security cannot be overlooked. The use of AR and other digital technologies in the classroom involves the collection, storage, and processing of substantial amounts of personal data. In the Chinese context, the issue of data privacy in educational settings is not yet fully addressed, raising questions about students' and teachers' privacy rights (Li et al, 2022).

Even with these challenges, there is still a need to ensure quality and effectiveness in learning outcomes. Despite the technological advancements brought about by AR, the effectiveness of its application in vocabulary learning should be subject to continuous assessment and improvement. Ensuring that the technology actually enhances learning and doesn't become a distraction is a challenge faced by educators (Li, 2018).

Moreover, the fast-paced development of digital technology, including AR, requires constant updates in teaching and learning resources. This means that teachers, students, and educational institutions need to continually adapt to new versions and types of technology,

which may place a burden on all parties involved, particularly in terms of time, effort, and financial resources (Zhou, 2021).

It is important to note that these challenges are not unique to China, but they are critical considerations for all educators interested in harnessing the power of AR and seamless learning environments for EFL instruction. Furthermore, these challenges underscore the significance of another key aspect of EFL instruction: student engagement. In the next section, we delve into the role of engagement in EFL language learning, an area that has garnered significant attention in recent years due to its potential to enhance learning outcomes.

2.7 Engagement in EFL Language Learning

2.7.1 Conceptualizing Engagement in EFL Language Learning

Student engagement is a critical component in the success of EFL learning. It is multi-dimensional and can be broadly categorized into four constructs: behavioral, agentic, cognitive, and emotional engagement (Reeve & Tseng, 2011).

Behavioral engagement pertains to students' participation in the learning process. In an EFL context, this might involve active participation in class discussions, consistent attendance, and timely completion of assignments. The advent of digital technology in education, especially in EFL learning, has broadened this concept to include engagement with online resources, participation in virtual classrooms, and the use of language learning apps (Hsu et al., 2023).

Agentic engagement, a relatively new facet of engagement, is rooted in the concept of agency – the capacity of learners to take control of their own learning. In EFL language learning, agentic engagement implies learners' active involvement in their learning journey. This includes seeking feedback, setting personal learning goals, and making conscious efforts to overcome challenges in language acquisition. It is particularly relevant in the era of digital learning, where learners have access to a plethora of resources and the autonomy to design their learning paths (Reeve, 2021).

Cognitive engagement, on the other hand, revolves around the investment and effort students put into comprehending and mastering new material. In the context of EFL learning, cognitive engagement can be observed when learners employ various strategies to understand and remember new vocabulary, grapple with complex grammatical structures, or navigate the nuances of English pronunciation. Cognitive engagement also extends to learners' willingness to engage with challenging tasks and their persistence in the face of language learning difficulties (Rotgans & Schmidt, 2020).

Finally, emotional engagement refers to the emotional responses and attitudes learners have towards their learning. In EFL, this may include feelings of interest, enjoyment, or frustration during the learning process. Emotional engagement is significant as it can directly influence learners' motivation and commitment to learning the English language. It can also impact other dimensions of engagement, as positive emotions can fuel cognitive processes and

promote active participation, while negative emotions may hinder these processes (Pekrun & Linnenbrink-Garcia, 2012).

To note, while the concept of engagement is widely accepted as integral to successful language learning, its operationalization and measurement can vary across different educational contexts, reflecting cultural, institutional, and individual differences. Thus, understanding engagement in EFL learning necessitates considering these nuances and complexities.

2.7.2 Strategies to Enhance Engagement in EFL Learning

The role of technology in enhancing engagement in EFL learning is becoming increasingly significant. In recent years, with the rapid advancement of digital technologies and their subsequent integration into educational settings, the potential for fostering and improving student engagement in EFL learning has grown remarkably (Huang, Huang, & Wu, 2021).

One of the key ways in which technology can enhance engagement in EFL learning is by providing a plethora of resources that cater to diverse learning styles and preferences. Interactive multimedia content, for instance, can appeal to visual and auditory learners by offering dynamic and immersive language learning experiences. These resources can stimulate learners' interest, thereby enhancing their emotional engagement (Song et al., 2023).

Behavioral engagement can also be enhanced through the use of technology. Digital games, for instance, can motivate students to actively participate in learning activities. They often involve tasks that require learners to apply their language skills to progress or win, thereby promoting active engagement (Hamari et al., 2014).

Moreover, the use of technology allows for the personalization of learning experiences. Adaptive learning systems can provide content and tasks tailored to individual learners' needs and proficiency levels, which can lead to more meaningful and engaging learning experiences (Kerly et al., 2007).

Despite the potential benefits, it is crucial to note that the effective use of technology in enhancing engagement in EFL learning requires thoughtful planning and implementation. Teachers play a pivotal role in this process, from choosing appropriate technological tools to facilitating their effective use to enhance engagement.

To sum up, technology can significantly enhance engagement in EFL learning by catering to diverse learning preferences, promoting cognitive engagement, encouraging active participation, and personalizing learning experiences. As such, the integration of technology in EFL learning contexts should be considered as an important strategy to enhance student engagement.

2.7.3 Connection Between Engagement and EFL Vocabulary Acquisition

Seamless Learning Environments (SLEs) have emerged as a promising approach to foster EFL learning engagement, integrating learning experiences across various contexts, times, and devices. SLEs are predicated on the idea that learning is an ongoing process, not limited to specific spaces or times. Hence, SLEs facilitate the continuity of learning experiences from formal to informal settings, thus creating an engaging learning ecosystem (Wong, Looi, & Aw, 2021).

One key characteristic of SLEs that enhances EFL learning engagement is the fluidity of learning contexts. This means that learners can transition smoothly between different learning scenarios, such as moving from classroom-based learning to real-world application. For instance, an EFL learner can practice new vocabulary in the classroom (a formal learning context) and then review and practise these new words at home (an informal learning context). This continuity of learning experiences can foster a deeper engagement with the learning material.

Additionally, SLEs often leverage digital technologies, such as mobile devices and AR applications, to support and enhance EFL learning engagement. Mobile devices enable learners to access learning materials anytime and anywhere, thus providing flexibility and convenience that can boost learner motivation and engagement (Koole, 2018). AR applications can create immersive learning experiences that make vocabulary learning more interactive and enjoyable. For example, learners can use AR applications to visualize and

interact with 3D models of objects representing new vocabulary words, which can stimulate their curiosity and interest in learning (Chen & Hsu, 2020).

Despite these potential benefits, there are also challenges in implementing SLEs for EFL learning engagement. These include the need for stable internet connectivity, the potential for digital distractions, and the requirement for self-discipline in managing one's own learning in SLEs (Wong, Looi, & Aw, 2021). Therefore, these issues should be addressed to optimize the impact of SLEs on EFL learning engagement.

2.7.4 Engagement Strategies in EFL Learning

Evaluating the effectiveness of engagement strategies in EFL learning is crucial to ensure the optimization of learning outcomes. In the context of the growing digital learning environment, this evaluation process has become multifaceted, encompassing the use of digital technologies, seamless learning environments, and conventional classroom strategies.

One of the primary engagement strategies used in EFL learning is the incorporation of technology-enhanced activities, such as gamification, interactive multimedia lessons, and online discussion forums . Research has demonstrated that these activities can significantly increase students' engagement, thereby leading to improved learning outcomes (Wu et al., 2021). For instance, gamified learning activities can motivate students to participate actively in the learning process, as they provide an enjoyable and competitive learning environment. Meanwhile, online discussion forums can foster social engagement by facilitating

communication and collaboration among learners (Richardson & Swan, 2019).

Evaluating the effectiveness of these activities usually involves a combination of quantitative and qualitative methods. On the one hand, quantitative data such as test scores, participation rates, and time spent on learning activities can provide measurable evidence of the activities' effectiveness (Laird et al., 2009). On the other hand, qualitative data such as students' feedback and reflections can offer in-depth insights into the quality of students' engagement and the perceived benefits and challenges of the activities (Dixson, 2020).

Seamless learning environments, which integrate learning experiences across various contexts and devices, are another engagement strategy commonly used in EFL learning. As discussed earlier, these environments can enhance engagement by providing continuity and flexibility in learning experiences, leveraging digital technologies, and supporting social engagement. To evaluate the effectiveness of seamless learning environments, researchers often use mixed methods approaches that combine the analysis of learning analytics data with surveys and interviews to understand learners' experiences and perceptions (Wong, Looi, & Aw, 2021).

Lastly, conventional classroom strategies such as collaborative learning activities, project-based learning, and learner-centered instruction continue to play a vital role in promoting EFL learning engagement. These strategies are effective in fostering cognitive, emotional, and behavioral engagement, which are critical components of overall learning

engagement (Fredricks et al., 2019). Evaluation of these strategies typically involves a combination of assessments, observations, and student feedback.

In conclusion, evaluating the effectiveness of engagement strategies in EFL learning involves a comprehensive and multifaceted approach. This process is critical for ensuring that these strategies are achieving their intended outcomes and contributing positively to students' learning experiences.

2.7.5 Issues and Challenges in Fostering Engagement in EFL Language Learning

Despite the numerous advantages and promising developments surrounding engagement in EFL language learning, there are still several issues and challenges that need to be addressed.

The first challenge pertains to the teacher's role in creating an engaging learning environment. While technological tools and seamless learning environments provide opportunities for increased engagement, the teacher's role is crucial in effectively implementing and utilizing these resources. Teachers need to possess digital literacy skills and pedagogical knowledge to incorporate technology into their teaching practices effectively (Kim, 2022). However, many teachers lack the necessary training to use technology effectively in language learning, which can undermine student engagement (DOLMACI, A., & KILIÇ, A. 2021).

Second, the varying degrees of students' digital literacy skills also pose a challenge. Not all students have the same level of familiarity or comfort with using digital tools for learning.

This digital divide can lead to disparities in learning outcomes and engagement levels (Hargittai & Hinnant, 2008). It is crucial to provide support and training for students to ensure they can effectively utilize the technological tools available for language learning.

Third, the issue of student motivation in EFL learning is a critical factor affecting engagement. While technology can make learning more interactive and enjoyable, it does not automatically guarantee increased motivation. Some studies have found that the novelty of using technology can wear off over time, leading to reduced engagement (Hamidi & Chavoshi, 2018). Therefore, it is essential to continually innovate and update teaching practices to sustain students' interest and motivation.

Fourth, assessing engagement in EFL learning can be complex due to its multifaceted nature. Traditional assessment methods may not capture the full extent of student engagement, especially in online or blended learning contexts. New forms of assessment that can accurately measure student engagement in these contexts are needed (Laird et al., 2009).

Lastly, maintaining engagement in EFL learning is challenging in the face of distractions that come with technology use. With a myriad of applications, websites, and digital content competing for students' attention, it is increasingly challenging to keep students focused on learning tasks.

In sum, while engagement in EFL learning holds great potential for enhancing language

acquisition, several issues and challenges need to be considered to maximize its benefits. As we move forward, it is important to address these challenges and develop strategies that can effectively promote and sustain engagement in EFL learning. We shall now turn to identifying the research gaps and formulating the objectives of the current study in the next section, 2.7 Research Gaps and Objectives, to further illuminate these issues and propose potential solutions.

2.8 Research Gaps and Objectives

2.8.1 Summary of the Issues Identified

The existing literature provides a comprehensive overview of various challenges and complexities in the field of EFL vocabulary learning and its intersection with technology. This section aims to summarize these issues without identifying research gaps, which will be discussed in the subsequent section.

1) EFL Vocabulary Learning

The literature highlights the challenges faced by learners in acquiring English vocabulary. These challenges include limited exposure to the English language in non-native English-speaking countries, which hampers incidental vocabulary learning (Nation, 2006). Additionally, the sheer volume of the English lexicon can be intimidating for learners, complicating the vocabulary acquisition process (Webb & Nation, 2012). Traditional methods, while foundational, have been critiqued for their limitations in fostering long-term retention and meaningful usage of vocabulary (Nation, 2006).

Technology-Enhanced Learning:

The integration of technology in learning environments is a double-edged sword. On one hand, it offers innovative ways to enhance learning; on the other, it introduces challenges such as technical difficulties and cognitive overload. These issues can lead to learner disengagement and hinder the learning process (Tondeur et al., 2017; Selwyn, 2019).

2) Mobile Learning Environments

Mobile learning offers the promise of flexibility and convenience but also brings its own set of challenges. These include the potential for cognitive overload, especially when augmented reality (AR) is incorporated into learning apps (Kukulska-Hulme, 2010; Godwin-Jones, 2018).

3) Seamless Learning Environments

The concept of seamless learning aims to bridge the gap between academic and informal learning settings. However, challenges arise in maintaining this smooth transition, such as the need for different levels of motivation in various settings and the effective integration of AR technology (Wong et al., 2021).

4) Context of China

In the specific context of China, the rapid development of digital technology has led to challenges related to the quality and effectiveness of learning outcomes. The constant need

for updates in teaching and learning resources further complicates the landscape (Huang et al., 2020).

5) Fostering Engagement

Engagement in EFL learning is influenced by multiple factors, including the teacher's role and students' digital literacy skills. The literature indicates that maintaining student engagement is a complex task that requires continuous innovation in teaching practices (Henrie et al., 2020; Bond, 2020).

By summarizing these issues, this section provides a foundation for understanding the complexities involved in EFL vocabulary learning, particularly in technology-enhanced settings.

2.8.2 Statement of Research Gaps

The preceding analysis of issues in EFL vocabulary learning, technology-enhanced learning, and mobile learning environments has revealed several critical research gaps. For the sake of focus and clarity, these gaps have been condensed into five main areas that warrant further investigation:

1) Impact and Adaptation of Digital Technologies

While digital technologies offer new possibilities for EFL vocabulary learning, their precise impact remains unclear. This gap extends to how traditional pedagogical methods can be

adapted for digital and mobile learning environments. More research is needed to explore both these facets.

2) Learner Experience and Engagement

Despite the growing adoption of mobile and digital learning, there is a scarcity of research focusing on learners' perceptions, attitudes, and experiences. This extends to the assessment of student engagement in online or seamless learning contexts, which current methods may not adequately capture.

3) Role of AR in Vocabulary Learning

The integration of AR into vocabulary learning is an emerging trend, but there is a lack of robust frameworks for evaluating its impact. This gap is further widened by the limited focus on learner engagement in AR-supported vocabulary learning, especially in non-traditional environments like homes or outdoor spaces.

4) Methodological Considerations:

Many existing studies suffer from methodological limitations, such as short research periods and small participant groups. These limitations restrict the generalizability of findings and call for more robust and comprehensive research methods (Addresses gap 8).

5) Quality and Effectiveness of Learning Outcomes

As digital technologies, including AR, become more integrated into learning environments,

there is a pressing need to evaluate their effectiveness in enhancing learning outcomes, particularly in specific contexts like Mainland China.

By focusing on these condensed research gaps, future studies can provide more targeted and comprehensive insights into the challenges and opportunities in EFL vocabulary learning, particularly in technology-enhanced settings.

2.8.3 Research Objectives

Given the identified gaps in the existing body of literature and the scope of the proposed study "Examining EFL learners' vocabulary learning engagement and outcomes in a seamless learning environment mediated by an augmented reality app - VocabGO in Mainland China", the following research objectives can be articulated:

Objective 1: To investigate the impact of the AR app VocabGO on students' engagement in vocabulary learning in EFL context, both in and outside of the classroom, thus addressing the gap related to insufficient exposure to English in non-classroom settings.

Objective 2: To assess the effects of using the AR app VocabGO on students' vocabulary acquisition outcomes, thereby examining the influence of digital technologies on EFL vocabulary learning.

Objective 3: In order to inquire about students' experiences of using the AR app VocabGO for

vocabulary learning, contributing to the under-researched area of learner experience in mobile learning environments.

Objective 4: To evaluate the potential of the AR app VocabGO in fostering vocabulary learning in seamless learning environments, such as homes or outdoor spaces, which is a relatively unexplored area in AR-supported vocabulary learning research.

Objective 5: To examine the relationship between students' engagement and vocabulary learning outcomes in the context of using an AR app for vocabulary learning, thereby addressing the need for more understanding of learner engagement in AR-supported vocabulary learning.

Objective 6: To implement and assess a robust quasi-experimental research design in the study of AR-supported vocabulary learning, offering a potential solution to the issue of limited research methods in this field.

These objectives are congruent with the purpose of the proposed research, which is to investigate the feasibility of employing an augmented reality app to improve the engagement and retention of EFL students as they acquire new vocabulary words in an integrated setting. They fill important voids in the existing research and provide useful insights into the digital age of EFL vocabulary development.

Chapter 3 Methodology

3.1 Augmented Reality App: VocabGo

VocabGo is an innovative mobile application designed to enhance primary school students' vocabulary learning engagement. It incorporates various features and functionalities grounded on the principles of AR, gamification, and seamless learning to improve learning outcomes (Song et al., 2023). Figures 1 and 2 show the homepage and the four learning modes of the app, respectively.

Figure 1: Homepage

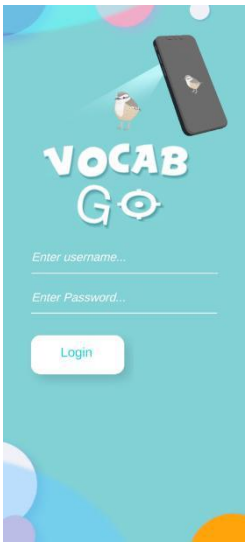


Figure 2: Four learning modes

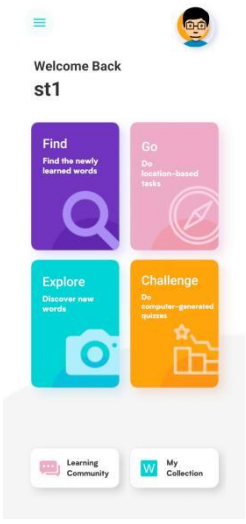


Figure 3: Find mode

Figure 4: Go mode

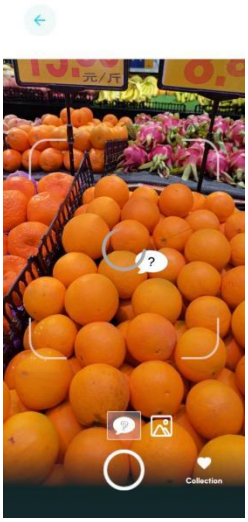
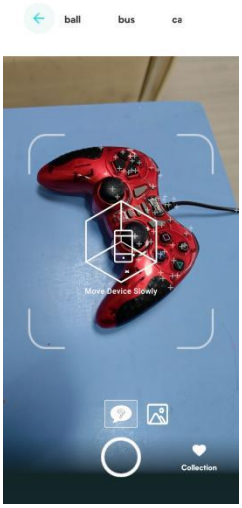


Figure 5: Explore mode

Figure 6: Challenge mode



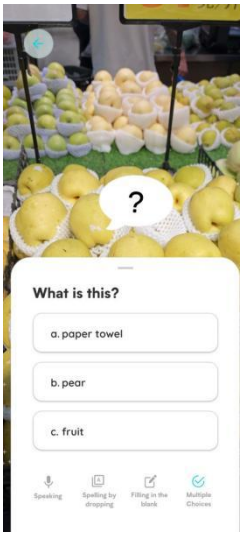
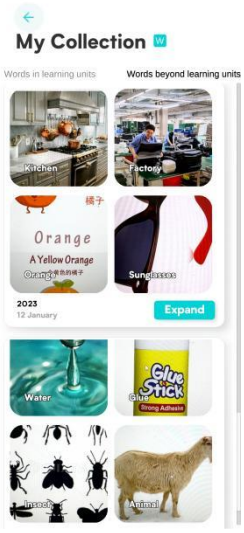
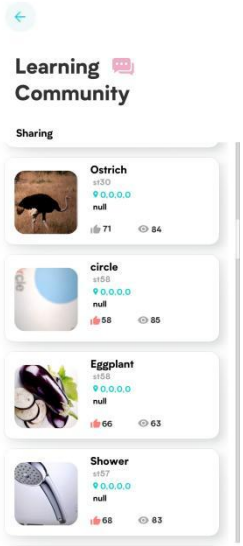


Figure 7: "My Collection" page

Figure 8: "Learning Community" page





The "Find" mode(see Figure 3) of this software is particularly useful since it enables students to scan real-world items and determine the associated English terms from the current curricular unit. This mode encourages students to explore their surroundings and expand their vocabulary by interacting with real-world objects, thereby promoting an engaging and immersive learning experience (Song et al., 2023).

Another noteworthy feature is the "Go" mode (see Figure 4), which has a physical mode that facilitates location-based vocabulary learning tasks and a virtual mode with 360° Google Street View for virtual location-based tasks. This mode fosters contextual learning by allowing students to encounter vocabulary words in authentic settings, thereby bridging the gap between in-class and out-of-class learning experiences.

The "Explore" mode (see Figure 5) enables students to freely scan objects associated with words beyond those included in the curriculum unit . This mode encourages students to expand their vocabulary knowledge and enhance their learning experiences by discovering

new words in various contexts.

The VocabGo app also incorporates gamification elements to enhance student motivation and engagement. The "Challenge" mode (see Figure 6) includes game-based learning activities and quizzes . This mode caters to different learning styles and preferences and incentivizes students through rewards, such as points and badges (Song et al., 2020).

The VocabGo app's goal is to provide a stress-free setting for studying, hence it incorporates augmented reality and game elements. This method encourages pupils to study whenever and wherever they have the opportunity (Song et al., 2020). Through the "My Collection" section of the app (see Figure 7), students have access to their own personal library of study resources, thus fostering a continuous learning experience that extends beyond traditional classroom boundaries.

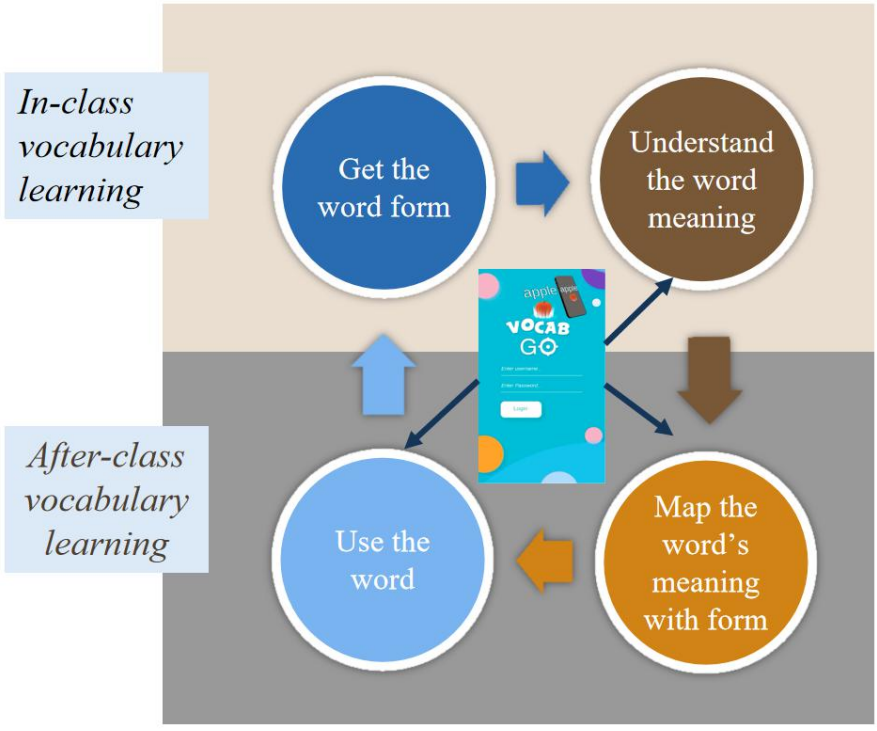
VocabGo also supports collaborative learning through the "Learning Community" block (see Figure 8), which allows students to work together on vocabulary tasks and share their progress with their peers. This feature fosters a sense of community among learners and promotes social interaction, which has been shown to enhance learning outcomes (Song et al., 2023). Another important functionality of the VocabGo app is its tracking and analytics capabilities. The app collects detailed data on student usage, including time spent on tasks, words learned, and progress made on quizzes and games (Song et al., 2023).

In summary, the VocabGo app offers a comprehensive suite of features and functionalities designed to support seamless vocabulary learning for primary students. Its "Find," "Go," "Explore," and "Challenge" modes, collaborative features, and analytics capabilities make it a powerful tool for engaging students and promoting effective vocabulary acquisition.

3.2. Theoretical Framework

The theoretical framework adopted in this study was based on multimedia learning and dual coding theories (Mayer, 2005, 2009; Paivio & Clark, 2006) and aimed to enhance students' vocabulary learning supported by VocabGo. Using Ma's (2014, 2015) instructional design and building off of his theoretical foundations, VocabGo was used to support seamless vocabulary learning (see Figure 9).

Figure 9 Theoretical framework for EFL vocabulary learners



The study framework was grounded on two fundamental theories: multimedia learning theory and dual coding theory. These theoretical frameworks informed the design and implementation of an augmented reality app, VocabGo, to foster a conducive environment for seamless vocabulary learning.

The study adopted a seamless vocabulary learning approach supported by VocabGo. The approach followed Ma's four-step vocabulary acquisition process (Ma, 2014, 2015), which involves the following: (a) getting the word form, (b) understanding the word meaning, (c) mapping the word meaning with form, and (d) using the word. This comprehensive process allowed students to fully comprehend and effectively use new vocabulary, thereby enriching their English language proficiency.

In summary,this study's theoretical framework integrated the benefits of the dual coding and multimedia learning theories to provide empirical evidence for the efficacy of VocabGo's method of vocabulary acquisition. It offers a solid framework for investigating how augmented reality may influence students' enthusiasm for and success with vocabulary study. The research strategy, data collection, and analysis were all informed by this theoretical framework.

3.3 Methodology

This research study employed a quasi-experimental design that utilized mixed methods to examine the engagement and vocabulary learning outcomes of EFL learners in a seamless

learning environment mediated by VocabGo. The adoption of a mixed methods approach provided a comprehensive and robust understanding of the phenomenon under investigation by triangulating findings from both quantitative and qualitative data for an in-depth interpretation (Creswell & Clark, 2018).

3.3.1 Quasi-experimental Design Using Mixed Research Methods

A quasi-experimental design was selected because it provided the opportunity to investigate causal relationships and measure the effect of the intervention, which involved the application of VocabGo, on participants' vocabulary learning outcomes and engagement. Quasi-experimental designs were considered particularly beneficial in educational research, in which random assignment to control and experimental groups can often be logistically challenging or ethically problematic (Rogers & Revesz, 2019).

The mixed research methods approach adopted in this study involved both quantitative and qualitative data collection and analysis. This approach allowed for a comprehensive exploration of the impact of VocabGo on vocabulary learning. Quantitative methods provide measurable numeric data to capture learning outcomes and student engagement levels. These data are essential for understanding the overall trends and impacts of the intervention (Creswell, 2007). On the other hand, qualitative methods, including semi-structured interviews, allow for an in-depth exploration of students' experiences and perceptions, thus adding depth and context to the quantitative results (Flick, 2018).

The combination of these methods in a mixed research design results in a more robust

analysis and enhances the validity of the findings. The triangulation of data sources ensures that the conclusions drawn are not solely dependent on a single source of data but instead offer a more nuanced and comprehensive understanding of the impact of VocabGo on vocabulary learning outcomes and engagement (Johnson et al., 2022).

3.3.2 Research Context

The research setting for this study was a private school located in Shenzhen, China. This school was chosen due to its adoption of technology in the classroom and its openness to innovative pedagogical approaches, making it an ideal context for the integration of VocabGo into the curriculum. The study lasted for 26 weeks, during which the impact of the VocabGo app on students' vocabulary learning engagement and outcomes was examined.

3.3.3 Participants

The present study included 72 Grade 4 students from a private school in Shenzhen, China, who were randomly divided into three groups. The age of the participants ranged from 9 to 10 years old. An equal number of students (n=24) were randomly allocated to each of the three groups: Group 1 (VocabGo both in-class and out-of-class), Group 2 (VocabGo in-class only), and Group 3 (VocabGo out-of-class only). The participants were balanced in terms of their learning ability and motivation to ensure the comparability of the three groups (Creswell, 2017).Group 1 used VocabGo for 20 minutes in class and an additional 20 minutes outside of class, totaling 40 minutes of usage. Group 2 engaged with VocabGo for 20 minutes solely in class, accumulating 20 minutes of total use. Similarly, Group 3 utilized the app for 20 minutes exclusively outside of class, also totaling 20 minutes of use.

The demographic profile of the participants plays a crucial role in understanding the context of the study and interpreting the results, as it provides essential information about the sample and its characteristics (Creswell & Poth, 2018). In addition, the demographic information can help future researchers replicate the study in similar contexts or compare the results with those of other studies conducted with different samples (Polit & Beck, 2010).

In summary, the demographic profile of the participants in this study included 72 Grade 4 students from a private school in Shenzhen, China with relatively homogeneous English proficiency. They were randomly divided into three groups. This random assignment ensured the comparability of the groups and helped reduce potential selection bias (Wallen & Fraenkel, 2013).

The three groups differed in their usage of the VocabGo app. Group 1 used the app both inside and outside the class, Group 2 used the app only inside the class, and Group 3 used the app outside the class. This differentiated use of the app across groups allowed the study to examine the impact of different learning environments on students' vocabulary learning engagement and outcomes. All the groups, however, followed the same pedagogical approach based on Ma's (2014, 2015) four-stage vocabulary acquisition process. The researchers collaborated with parents to ensure that all students spent an equal amount of time on their vocabulary-learning homework.

The selection of the students was guided by their homogeneity in terms of learning ability and motivation. This was done to ensure that the differences observed in the study could be attributed to the intervention and not to varying learning abilities or motivation levels (Creswell & Creswell, 2017).

Moreover, the choice of students' age and grade was based on the fact that children at this stage are in a critical period of vocabulary development and can greatly benefit from innovative learning tools, such as VocabGo (Biemiller, 2019). The use of AR in vocabulary learning can provide students with immersive and interactive experiences, making vocabulary learning more engaging and effective (Wu et al., 2022).

3.3.4 Vocabulary Learning Units

In this study, vocabulary learning units were thoughtfully designed and selected based on the English syllabus for primary school students. These units were chosen to fit the students' English proficiency levels and align with the curriculum standards (McKeown & Beck, 2020). Each unit focused on a specific topic and included a set of words related to that topic. The selection of these words followed the criteria of word frequency, usefulness, and relevance to the students' daily lives and the current unit topic (Nation, 2006).

The vocabulary learning units were presented to students over the 26-week study period, with two 40-minute classes per week. In each class, students were introduced to 10 new words, totaling approximately 200 words over 20 weeks. Homework was assigned after each class, which required the students to review the newly learned words at home twice by spending 20

minutes each time. This structured approach to vocabulary learning is consistent with the spaced repetition principle, which suggests that learning is more effective when it spreads out over time (Cepeda et al., 2018).

VocabGo, an AR app, was used extensively to present these vocabulary learning units. The app features multiple modes that support vocabulary learning, including "Find," "Go," "Virtual," and "Challenge" modes and two blocks for collection and community learning. These modes not only enhance the teaching of new words but also provide opportunities for students to use and review these words in different contexts, which is critical for vocabulary consolidation and retention (Webb & Nation, 2012).

The vocabulary chosen for each class was first pretested to ensure their novelty to the students. This pretest helped eliminate any words that students might already know and ensured that the focus was on the acquisition of new vocabulary. The pre-test, post-test, and delayed post-test models adopted in this study align with the best practices for measuring vocabulary acquisition and retention (Schmitt et al., 2020).

3.4 Data Collection

Data collection is a critical component of the research process and provides the necessary information to answer the research questions and test the hypotheses. The triangulation of the data collection methods in this study enhanced the reliability and validity of the findings. This study employed multiple data collection approaches(see Table 1), including

questionnaires, vocabulary tests, interviews, word card numbers, and log data.

Table 1: Data collection for research questions (RQs)1, 2, and 3.

Data collection	RQ1	RQ2	RQ3
Questionnaires on engagement: Pre- and post-questionnaires (Pre- and post-learner engagement survey)	√		√
Vocabulary learning tests: (Pre-, post-, and delayed post-vocabulary tests)		√	√
Semi-structured focus group interviews	√		√
Students' log data (number of artifacts, and the VocabGo app use time)	√		

3.4.1 Questionnaires

The pre- and post-engagement questionnaires played an essential role in understanding students' engagement in vocabulary learning throughout the intervention (Creswell, 2007). The questionnaires were designed to assess the four dimensions of engagement: cognitive, emotional, behavioral, and agentic (Reeve & Tseng, 2011). By comparing the results of these questionnaires, researchers can analyze the impact of the VocabGo app on students' engagement in vocabulary learning.

The pre-engagement questionnaires were administered at the beginning of the study to obtain baseline information on students' engagement levels prior to the implementation of the VocabGo app. This information is essential to control potential confounding variables in the study and to ensure that the observed effects of the intervention can be attributed to the use of VocabGo (Creswell, 2007).

The post-engagement questionnaires were administered after the 22nd week of the study, allowing the researchers to assess any changes in engagement levels after the intervention period. This questionnaire used the same format and items as the pre-engagement questionnaire to ensure consistency and comparability between the two data sets (Zainuddin et al., 2020).

Both questionnaires used a 5-point Likert scale, which ranged from strongly disagree (1) to strongly agree (5), to measure students' responses to items related to each dimension of engagement (Reeve & Tseng, 2011). The items were adapted from Reeve and Tseng's (2011) study and piloted with a sample of learners (n = 20) with learning abilities comparable to those of the participants in the actual study. This pilot test resulted in a Cronbach's alpha value of more than 0.81, indicating a satisfactory level of reliability (Creswell, 2007).

In total, 72 pre-engagement questionnaires were distributed to the participants, and 69 were returned, yielding a response rate of 95.8%. After eliminating incomplete and inconsistent responses, 66 valid questionnaires were used for the final data analysis. In total, 72

post-engagement questionnaires were distributed to the participants, and 67 were returned, yielding a response rate of 93.1%. After eliminating incomplete and inconsistent responses, 64 valid questionnaires were used for the final data analysis. The high response rate and number of valid questionnaires contributed to the robustness of the findings and ensured adequate statistical power for subsequent analyses.

The data collected from the pre- and post-engagement questionnaires were analyzed using quantitative data analysis methods, specifically Statistical Product and Service Solutions (SPSS) version 28 (Creswell, 2007). A one-way Analysis of Variance (ANOVA) was conducted before the implementation of the VocabGo app to determine whether there were any statistically significant differences in engagement levels among the three groups (Creswell, 2007). After the intervention, a one-way ANOVA was performed again to identify any significant differences in engagement levels among the groups. Paired sample t-tests were also conducted to examine the statistical significance of the differences in engagement levels within each group (Creswell, 2007).

The pre- and post-engagement questionnaires provided valuable information about the students' engagement levels, both before and after the intervention (Zainuddin et al., 2020). The data allowed the researchers to answer RQ1, which examined the impact of the VocabGo app on students' engagement in vocabulary learning. Furthermore, the questionnaires contributed to answering RQ3 by providing data on the relationship between engagement levels and vocabulary learning outcomes (Zainuddin et al., 2020).

3.4.2 Vocabulary Tests

The pre-, post-, and delayed post-vocabulary tests were designed to evaluate the participants' vocabulary knowledge and retention across the three groups. The tests were tailored to the specific curriculum and vocabulary content taught during the study, ensuring their validity and relevance (Nation & Meara, 2013). The tests were divided into multiple-choice questions and fill-in-the-blank questions, as these formats were commonly used to assess vocabulary knowledge among fourth-grade students (Tsai, 2020; Tai, 2022). The test had 60 questions and was worth 100 points in total. It included 40 multiple-choice questions: 20 were worth one point each, and the other 20 were worth two points each. There were also 20 fill-in-the-blank questions worth two points each. The test covered 60 vocabulary words selected from a list of 200 words.

Multiple-choice questions were used to assess the depth of word knowledge (Nation & Meara, 2013). Participants were presented with a word, and they had to choose the correct meaning from a list of four options. Fill-in-the-blank questions required participants to complete sentences by inserting the appropriate word from the given list. This type of question assessed the students' ability to recall and apply their vocabulary knowledge in context (Tai, 2022).

The pre-test was administered in the first week of the study, before the implementation of the VocabGo app. This allowed the researchers to establish a baseline measure of participants' vocabulary knowledge, as well as to determine any pre-existing differences between the

groups. The post-test was administered in the 22nd week, immediately after the completion of the VocabGo app intervention. This allowed the researchers to assess any immediate impacts of the intervention on the participants' vocabulary knowledge. The delayed post-test was administered in the 26th week, one month after the intervention. This test aimed to evaluate the long-term retention of vocabulary knowledge and the overall effectiveness of the VocabGo app in a seamless learning environment (Zainuddin et al., 2020).

For the pre-intervention vocabulary tests, 72 test papers were distributed and 68 were returned, yielding a response rate of 94.4%. After discarding incomplete and inconsistent responses, 67 valid pre-intervention vocabulary tests remained for the final data analysis.

The post-intervention vocabulary tests were similarly administered. Out of the 72 test papers distributed questionnaires, 70 were returned, resulting in a response rate of 97.2%. After eliminating incomplete and inconsistent responses, 67 valid post-intervention vocabulary tests were incorporated into the final data analysis.

The delayed post-test was administered four weeks after the post-intervention test to examine the long-term retention of vocabulary learning. For the delayed post-test, 72 test papers were distributed and 69 were returned, achieving a response rate of 95.8%. After screening for completeness and consistency, 66 valid delayed post-tests were utilized for the final data analysis.

The high response rate and the significant number of valid vocabulary tests at all three stages contributed to the robustness and validity of the findings and ensured that the study provided a comprehensive view of the participants' vocabulary skills before the implementation of the VocabGo app and immediately after the intervention, as well as the long-term retention of vocabulary learning.

The data collected from these tests were analyzed using descriptive and inferential statistics. A one-way ANCOVA was used to identify any significant differences between the groups' vocabulary learning outcomes, while repeated measures one-way ANOVA and Scheffe's post-hoc tests were performed to investigate changes within each group over time (Creswell, 2007).

3.4.3. Student Focus Group Interviews

Semi-structured focus group interviews were employed as a qualitative data collection instrument to gain insights into the students' experiences and perceptions of using VocabGo for vocabulary learning. The focus group interviews were adapted from Zainuddin et al. (2020) and aimed to explore the students' cognitive, behavioral, emotional, and agentic engagement with the VocabGo app (see Appendix 2).

Two focus group interviews were conducted for each of the three groups, with three students in each interview. The participants were selected based on their willingness to share their opinions and experiences, as well as their ability to articulate their thoughts (Braun et al., 2019). Each interview lasted approximately 30-40 minutes, and the voice recordings of these

interviews were collected to ensure accurate transcription and analysis of the data.

The interview data were analyzed using thematic analysis, following the approach suggested by Braun et al. (2019). The researchers used NVivo, a qualitative software tool, to assist in the transcription, coding, and organization of the themes identified in the interviews. This allowed the researchers to systematically identify patterns and categories in the data and explore individual perspectives and experiences.

The thematic analysis process began with the researchers carefully reading and re-reading the transcriptions to become familiar with the data. Initial codes were then generated, which were both inductive (emerged from the data) and deductive (derived from the research questions and related literature). The codes were subsequently grouped into potential themes, which were then reviewed and refined to ensure that they accurately represented the data. Finally, the themes were defined and named, and illustrative quotes were selected to support the findings.

To ensure the trustworthiness of the qualitative findings, the researchers employed several strategies, including peer debriefing, member checking, and the use of an audit trail (Creswell, 2007; Lincoln & Guba, 1985). Peer debriefing involved sharing the preliminary findings with a team of researchers with expertise in vocabulary learning and mobile learning and obtaining their feedback and suggestions for refinement. Member checking involved sharing the analyzed data and themes with the focus group participants, allowing them to confirm or

challenge the researchers' interpretations of their experiences. The audit trail documented the researchers' decisions and actions throughout the data analysis process, ensuring transparency and allowing for the examination of potential biases and assumptions.

By triangulating data collected from the pre-, post-, and delayed post-vocabulary tests, as well as the focus group interviews, the researchers aimed to gain a comprehensive understanding of the impact of VocabGo on students' vocabulary learning outcomes and their experiences with the app in a seamless learning environment.

3.4.4 Log Data

In contemporary research, log data are gaining recognition for their potential to provide valuable insights into users' behavioral patterns, particularly in digital learning environments (Ifenthaler, 2018). For this study, The researchers collected and analyzed log data from the VocabGo app to better understand students' behavioral engagement in vocabulary learning activities.

The VocabGo app has built-in data logging capabilities that track the various activities the students perform while they interact with the app. These activities include (1) the number of word cards collected and (2) the total time spent using the app. In this context, the word card is a digital card in the app that presents a picture along with its corresponding English word.

The number of word cards collected reflects the students' active engagement. By logging this activity, researchers can measure the extent of students' interactions with the learning content

in the VocabGo app. If a student collects a larger number of word cards, this may indicate a higher degree of engagement with vocabulary learning (Ifenthaler, 2018).

The total time spent using the app is another critical measure of students' behavioral engagement. This variable can provide insight into students' persistence and sustained attention during vocabulary-learning activities. It is worth noting that more time spent using the app does not necessarily indicate higher learning efficiency. However, in conjunction with other data, such as questionnaire responses and test scores, it can offer a more comprehensive picture of students' engagement and learning outcomes (Siemens, 2019).

The app automatically captures and stores these log data, ensuring their accuracy and reliability. Researchers can then download the log data for analysis at the end of the study. The log data of 72 participants were collected throughout the 22 weeks of the VocabGo app intervention. The data were then cleaned, processed, and prepared for subsequent statistical analysis. The cleaning process involved checking for inconsistencies and errors in the logged activities and correcting or excluding them as necessary (Siemens, 2019).

The processed log data were analyzed using descriptive statistics, such as means and standard deviations, to summarize students' engagement patterns in the VocabGo app. Correlational analyses were also conducted to examine the relationships between log data variables (i.e., number of word cards collected and total time spent) and vocabulary learning outcomes from the tests (Siemens, 2019). This allowed the researchers to answer RQ2, which investigates the

relationships between students' behavioral engagement and their vocabulary learning outcomes.

The combination of log data, questionnaire responses, and test scores contributes to a multi-dimensional evaluation of students' engagement and learning outcomes in the VocabGo-mediated seamless learning environment, providing valuable insights for the study.

3.5 Data Analysis

3.5.1 Questionnaire

The questionnaire (see Appendix 1 for the survey items) consisted of several items designed to measure students' cognitive, emotional, behavioral, and agentic engagement. Responses to each question were ranked on a 5-point Likert scale, from "strongly disagree" to "strongly agree".

We began our study of the questionnaire data by encoding and entering it into SPSS. Means and standard deviations were calculated for each item to offer a snapshot of the distribution of students' engagement levels.

The reliability of the scales was found to be satisfactory, with $\alpha = .84$ for cognitive engagement, $\alpha = .82$ for emotional engagement, $\alpha = .88$ for behavioral engagement, and $\alpha = .80$ for agentic engagement.

To test if there were statistically significant variations in participation rates between the three groups, a one-way ANOVA was carried out. Any differences found by ANOVA were further investigated using post hoc testing.

Examining how each group's engagement changed between the pre- and post-engagement surveys, we used paired sample t-tests. This gave us a chance to see how the VocabGo app's assistance affected students' engagement to learn new vocabulary.

3.5.2 Domain Tests

The domain tests were designed to measure students' vocabulary knowledge and retention. The combined scores from the multiple-choice and fill-in-the-blank questions on each exam added up to a total possible score of 100.

The collected test scores were fed into SPSS for further analysis. Descriptive statistics were calculated for each test across the three groups. These calculations allowed the researchers to obtain an overall sense of the distribution of scores and the central tendency of the data.

To investigate the effect of the VocabGo app intervention on students' vocabulary knowledge and retention, a repeated measures ANOVA was performed. This statistical method allowed the researchers to analyze differences in mean scores over time.

Pairwise comparisons, with Bonferroni correction to control for Type I errors, were performed following the repeated measures ANOVA to identify significant differences

between the three tests for each group.

To further delve into the relationships between students' vocabulary test scores and their engagement levels (from the questionnaire data) and log data from the VocabGo app, correlational analyses were conducted. To learn more about the strength and direction of these associations, we computed Pearson's correlation coefficient.

The findings from the domain tests, combined with the insights from the questionnaire and interview data, helped provide a comprehensive understanding of the impact of the VocabGo app on students' vocabulary learning and engagement in seamless learning environments.

3.5.3 Interviews

The semi-structured interviews played a crucial role in this research, providing rich, qualitative insights into students' perceptions and experiences that complemented the statistical findings from the questionnaires and tests.

The interviews were prepared based on engagement with four dimensions (cognitive, behavioral, emotional, and agentic) adapted from Zainuddin et al. (2020) as a framework, focusing on the students' engagement in vocabulary learning supported by the VocabGo app. Interviews were conducted with two focus groups from each of the three student groups, with each focus group consisting of three students. Each interview was approximately 30–40 minutes in length and was voice-recorded, ensuring comprehensive documentation of the participants' responses. These were voluntary and took place after obtaining the requisite

permissions and informed consents.

After the interviews, the audio recordings were transcribed verbatim. This meticulous transcription process ensured that the nuances of each participant's responses were captured accurately. Following transcription, the data were systematically coded using an iterative process. Initial codes were developed by directly examining and categorizing the data, thereby enabling the researchers to encapsulate segments of the participants' responses within identifiable themes or constructs.

The coded data were then subjected to a thorough thematic analysis, as proposed by Braun & Clarke (2006). The qualitative data had to be parsed for recurring ideas or "themes," which were then analyzed and interpreted. By mapping out these themes, we could draw more significant insights into the students' perspectives on using VocabGo for vocabulary learning. These themes did not come about beforehand but rather as a natural byproduct of analyzing the data.

The insights derived from the thematic analysis of the interview data played a significant role in interpreting and understanding the quantitative findings from the questionnaires and tests. By integrating these qualitative and quantitative findings, we could provide a comprehensive, multi-dimensional understanding of the VocabGo app's impact on students' learning motivation, engagement, and achievement. The qualitative data not only enriched the quantitative findings but also provided context, thus allowing us to better understand the

"why" behind the "what" observed in the quantitative data.

To ensure the validity of the interview data and their analysis, several steps were undertaken. First, participant responses were anonymized to create a safe environment in which participants could share their thoughts and experiences honestly. Second, participant validation, also known as "member checking," was performed. This involved sharing the derived themes and interpretations with the participants to confirm the accuracy of the researchers' interpretations.

This comprehensive and systematic approach to handling interview data provided a deeper understanding of the students' experiences and perspectives, and contributed significantly to the robustness of the study's findings.

3.6 Data Analysis for the Research Questions

Table 2: Data analysis for the research questions 1, 2, and 3

Data analysis	RQ1	RQ2	RQ3
One-way analysis of variance (ANOVA) Paired sample t-tests	√		√
One-way analysis of variance (ANOVA) Repeated measurements of one-way ANOVA will be conducted.		√	√

Correlation analysis Thematic analysis	√		√
Number of artifacts VocabGo use time	√		

3.6.1 Analysis for Research Question 1

For Research Question 1 ("What is the impact of the VocabGo app on students' engagement in their vocabulary learning?"), the analysis involved both quantitative and qualitative methodologies.

Quantitatively, a one-way analysis of covariance (ANCOVA) was conducted before and after the implementation of the VocabGo app to determine whether there were any statistically significant variations in students' engagement across the three groups. Paired sample t-tests were also conducted to identify the statistical significance of the differences in students' engagement in their vocabulary learning within each group.

Qualitatively, thematic analysis (Braun & Clarke, 2006) was used to analyze students' semi-structured interviews using the four dimensions of learning engagement as a coding framework. The researchers also analyzed various data on VocabGo usage, including actual use times, the number of photos taken, the number of different pictures collected, and so forth, to understand the students' engagement in vocabulary learning recorded on the VocabGo app. The transcribed data, coding, and organization of the theme analysis were done using the

NVivo qualitative software tool.

3.6.2 Analysis of Research Question 2

For Research Question 2 ("What is the impact of the VocabGo app on students' vocabulary learning outcomes?"), the data were analyzed using ANCOVA. This was performed to ascertain whether there were statistically significant differences among the students' vocabulary learning outcomes on the post-vocabulary test after adjusting for the pre-vocabulary test as a covariate. If the statistical significance value was less than 0.05, then pairwise comparisons with a Bonferroni post hoc test were conducted to determine where exactly the differences lie. To investigate the variations within each group over time, a repeated-measures one-way ANOVA was performed, followed by Scheffe's post-hoc tests.

3.6.3 Analysis of Research Question 3

For Research Question 3 ("Is there any relationship between students' engagement and outcomes? If yes, what are the relationships?"), the analysis again involved both quantitative and qualitative methodologies.

Quantitatively, a correlation analysis was conducted to examine the relationship between students' engagement and outcomes. This provided a measure of the strength and direction of the relationship between these two variables.

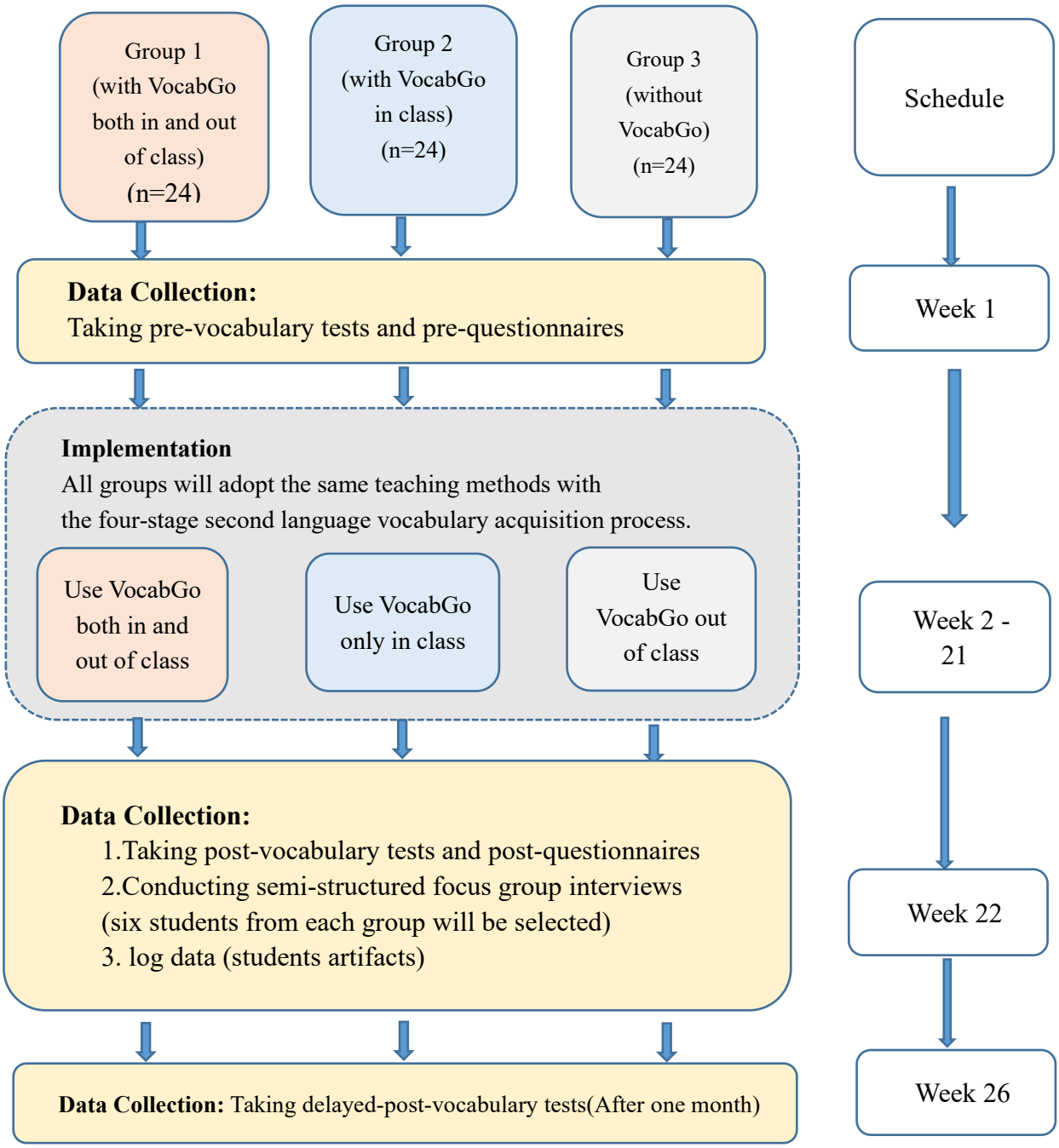
Overall, the integration of these multiple forms of analysis provided a comprehensive picture of the effects of the VocabGo app on students' vocabulary learning engagement and

outcomes.

3.7 Research Procedure

The research procedure for this study can be divided into several key stages, as follows(see Figure10).

Figure 10: Research procedure



Participants and grouping. The participants in this study were primary school students who were divided into three groups: Group 1 (VocabGo both in-class and out-of-class), Group 2 (VocabGo in-class only), and Group 3 (VocabGo out-of-class only). The groups were formed to investigate the impact of the VocabGo app on students' engagement and vocabulary learning outcomes across different learning contexts.

Pre-intervention measures. Before the intervention, the students completed a pre-intervention engagement survey to assess their baseline cognitive, behavioral, emotional, and agentic engagement levels. Additionally, a pre-intervention vocabulary test was administered to gauge the students' initial vocabulary knowledge.

Intervention. The VocabGo app was integrated into the students' vocabulary-learning process for a specified period. Each group utilized the app in different contexts according to their grouping. The app featured four modes (Find, GO, Virtual GO, and Challenge) and two blocks (My Collection and Learning Community), focusing on enhancing vocabulary learning using AR in authentic learning environments and encouraging social interaction among learners.

Post-intervention measures. After the intervention, the students completed a post-intervention engagement survey to assess changes in their engagement levels (see Table 2 for the survey results). They also took a post-intervention vocabulary test to evaluate the impact of the VocabGo app on their vocabulary learning outcomes. Statistical analyses were performed to compare the post-intervention test scores and engagement levels among the

three groups.

Focus group interviews. A subset of participants from each group was selected to participate in the semi-structured focus group interviews. The interviews aimed to gain insights into the students' perceptions of the VocabGo intervention, its impact on their engagement, and vocabulary learning outcomes. Open-ended questions (see Appendix 2) were used to elicit in-depth responses from the students.

Data analysis. Quantitative data from the pre- and post-intervention engagement surveys and vocabulary tests were analyzed using descriptive and inferential statistics to identify significant differences among the groups. Qualitative data from the focus group interviews were transcribed and analyzed using thematic analysis (Braun & Clarke, 2006).

3.8 Implementation for all groups

3.8.1 Implementation for the group1

The aim of this implementation for Group 1 is to facilitate the learning and consolidation of new vocabulary words by integrating traditional methods with the VocabGo app in both in-class and out-of-class settings, in line with the Theoretical Framework for EFL vocabulary learners. The discovery of new words begins with a review of the previous lesson's vocabulary words, followed by a brief discussion to reinforce students' understanding. Subsequently, new vocabulary words for the current lesson are introduced, with examples and definitions provided for each word.

To obtain word meanings, the VocabGo app is utilized in class for a variety of vocabulary learning activities, while students are encouraged to explore features such as Find Mode and Challenge Mode. Complementary vocabulary-related activities in class involve matching words to definitions, fill-in-the-blank exercises, and group discussions or presentations using the new words. Emphasizing the mapping of word meaning with form, the implementation facilitates group work, allowing students to collaborate and share their experiences using the VocabGo app in the classroom. Students are then tasked with practicing the new vocabulary words in sentences, in both written and oral forms. To consolidate their learning, students are encouraged to use the VocabGo app outside the classroom for further practice and reinforcement of new vocabulary words.

3.8.2 Implementation for the group2

The objective of this lesson plan for Group 2 is to facilitate learning and consolidation of new vocabulary words by integrating traditional methods with the VocabGo app exclusively in an in-class setting, adhering to the Theoretical Framework for EFL vocabulary learners. To initiate the discovery of new words, each class starts with a review of the previous lesson's vocabulary words and a brief discussion to reinforce students' understanding. Subsequently, new vocabulary words are introduced for the current lesson, accompanied by examples and definitions for each word.

In obtaining the word meaning, the VocabGo app is utilized in class for various vocabulary

learning activities, with students being encouraged to explore features like Find Mode, GO Modeand Challenge Mode. Additional vocabulary-related activities in class encompass matching words to definitions, fill-in-the-blank exercises, and group discussions or presentations using the new words. Mapping the word meaning with form is emphasized through group work, allowing students to collaborate and share their experiences using the VocabGo app in the classroom. Students are then assigned to practice using the new vocabulary words in sentences, both in written and oral forms. To consolidate the word, students are encouraged to practice vocabulary learning using traditional methods outside of the classroom, such as flashcards, self-quizzes, and written exercises.

3.8.3 Implementation for the group3

The objective for Group 3 is to facilitate learning and consolidation of new vocabulary words by employing a combination of traditional methods and out-of-class VocabGo app usage, in accordance with the Theoretical Framework for EFL vocabulary learners. To discover new words, each class begins with a review of the previous lesson's vocabulary words, engaging students in a brief discussion to reinforce their understanding. Subsequently, new vocabulary words for the current lesson are introduced, complete with examples and definitions for each word.

In the process of obtaining word meaning, vocabulary-related activities are conducted in class, including matching words to definitions, fill-in-the-blank exercises, and group discussions or presentations that incorporate the new words. Students are encouraged to use the VocabGo

app outside of the classroom for additional practice and reinforcement of the new vocabulary words. For mapping word meaning with form, students are assigned to practice using the new vocabulary words in sentences, encompassing both written and oral forms. Group work is facilitated, enabling students to collaborate and share their experiences with the new vocabulary words in various contexts. In consolidating the newly learned words, students are motivated to continue using the VocabGo app outside of the classroom for additional practice and reinforcement.

In all three groups, it is essential to monitor students' progress, provide feedback, and offer additional support as needed. Each group shares the same teacher, who is tasked with customizing instruction and activities to meet the unique learning styles and needs of the students.By adhering to the Theoretical Framework for EFL vocabulary learners, teachers can help students effectively discover, obtain meaning, map meaning with form, and consolidate new vocabulary words using a combination of traditional methods and the VocabGo app.

Chapter 4 Results

4.1 Results of Research Question 1: What is the impact of the VocabGo app on students' engagement in their vocabulary learning?

Research question 1 was addressed through pre-and post-engagement questionnaire analysis, focus group interview analysis and number of students' created artifacts with an example case and VocabGo use time.

4.1.1. Results of Pre-Intervention Descriptive Statistics

Before the implementation of the VocabGo app, The researcher conducted a pre-intervention engagement survey to assess the students' cognitive, behavioral, emotional, and agentic engagement levels in their vocabulary learning. The engagement survey's purpose was to establish a baseline understanding of the students' engagement in vocabulary learning to identify any significant differences among the three groups before the intervention.

Table 3: Students' pre-engagement levels

group		Pre-Cognitive	Pre-Behavioral	Pre-Emotional	Pre-Agentic	preengagement
1	Mean	3.51	3.49	3.50	3.48	3.49
	N	24.00	24.00	24.00	24.00	24.00
	Std. Deviation	0.14	0.14	0.14	0.14	0.09
2	Mean	3.49	3.47	3.48	3.48	3.48
	N	24.00	24.00	24.00	24.00	24.00
	Std. Deviation	0.14	0.14	0.14	0.14	0.08
3	Mean	3.51	3.49	3.48	3.45	3.48
	N	24.00	24.00	24.00	24.00	24.00
	Std. Deviation	0.14	0.14	0.14	0.15	0.10
Total	Mean	3.50	3.48	3.49	3.47	3.49
	N	72.00	72.00	72.00	72.00	72.00
	Std. Deviation	0.14	0.14	0.14	0.14	0.09

The table 3 shows that the students' engagement levels in vocabulary learning were relatively similar across the three groups in terms of cognitive, behavioral, emotional, and agentic engagement before the intervention. As suggested by Reeve and Tseng (2011), the mean scores close to the middle of the scale (3) indicate a moderate level of engagement in vocabulary learning.

Table 4: One way ANOVA of Pre-engagement 1

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.001	2	.001	.086	.918
Within Groups	.545	69	.008		
Total	.546	71			

Table 5: One way ANOVA of Pre-engagement 2

		Sum of Squares	df	Mean Square	F	Sig.
Pre-Cognitive	Between Groups	.005	2	.002	.120	.888
	Within Groups	1.343	69	.019		
	Total	1.348	71			
Pre-Behavioral	Between Groups	.005	2	.002	.120	.888
	Within Groups	1.343	69	.019		
	Total	1.348	71			
Pre-Emotional	Between Groups	.003	2	.002	.086	.918

	Within Groups	1.292	69	.019		
	Total	1.295	71			
Pre-Agentic	Between Groups	.013	2	.006	.312	.733
	Within Groups	1.437	69	.021		
	Total	1.450	71			

To test the differences in engagement levels among the three groups, a one-way ANOVA was conducted (refer to Table 4 and Table 5). The results revealed no significant differences in cognitive , behavioral , emotional, and agentic engagement dimensions among the three groups before the intervention. These findings suggest that the participants in the three groups had comparable levels of engagement in vocabulary learning at the outset of the study.

The pre-intervention engagement survey provided valuable insights into the students' initial motivation and involvement in vocabulary learning. By establishing a baseline for comparison, the researchers were able to evaluate the impact of the VocabGo app on the different dimensions of engagement after the intervention.

In summary, the pre-intervention descriptive statistics demonstrated that there were no significant differences in the cognitive, behavioral, emotional, and agentic engagement levels among the three groups before the implementation of the VocabGo app. This baseline data allowed the researchers to measure the potential effects of the intervention on students' engagement in vocabulary learning, which would be examined in the post-intervention

engagement survey.

4.1.2. Results of Post-Intervention Descriptive Statistics

Following the 22-week intervention, the post-engagement survey was administered to assess the students' engagement levels in vocabulary learning across the cognitive, behavioral, emotional, and agentic dimensions. Descriptive statistics were generated for each group to compare the post-intervention engagement levels and identify any significant differences resulting from the use of the VocabGo app in different learning environments.

The means and standard deviations of the post-intervention engagement survey results were calculated for each dimension and group, as displayed in Table 6.

Table 6: Post-Intervention Engagement Survey Results

group		Cognitive	Behavioral	Emotional	Agentic	Post-
1	Mean	4.234	4.221	4.239	4.243	4.234
	N	24	24	24	24	24
	Std. Deviation	0.124	0.147	0.126	0.115	0.071
2	Mean	3.882	3.770	3.780	3.786	3.804
	N	24	24	24	24	24
	Std. Deviation	0.230	0.225	0.158	0.239	0.105
3	Mean	3.660	3.654	3.619	3.634	3.642
	N	24	24	24	24	24

	Std. Deviation	0.137	0.151	0.132	0.156	0.070
Total	Mean	3.925	3.882	3.879	3.887	3.893
	N	72	72	72	72	72
	Std. Deviation	0.292	0.303	0.298	0.314	0.265

The post-intervention descriptive statistics provide valuable insights into the effectiveness of the VocabGo app in enhancing students' engagement and vocabulary learning outcomes presents the means and standard deviations of the three groups' cognitive, behavioral, emotional, and agentic engagement levels in the post-intervention engagement survey.

The results indicate that Group 1 exhibited higher post-intervention engagement levels across all dimensions compared to Groups 2 and 3. This finding aligns with previous research on seamless learning environments, which suggests that integrating technology both in-classroom and outside-of-classroom can lead to improved engagement and learning outcomes (Wong et al., 2021). These results also support the notion that the use of mobile applications, such as VocabGo, can enhance language learning by promoting cognitive, behavioral, emotional, and agentic engagement (Reeve & Tseng, 2011; Zainuddin et al., 2020).

Statistical analysis of the post-intervention vocabulary test scores revealed significant differences among the three groups. Group 1 achieved higher scores than both Group 2 and Group 3 (Zhou, 2021), demonstrating the effectiveness of using the VocabGo app in a

seamless learning environment for vocabulary acquisition. The results also showed a significant difference between Group 2 and Group 3, indicating that in-class use of VocabGo is more effective for vocabulary learning than out-of-class use.

To further investigate the relationship between students' engagement and vocabulary learning outcomes, a correlation analysis was performed. The analysis revealed a positive relationship between engagement levels and learning outcomes across all groups, suggesting that higher engagement in vocabulary learning led to improved vocabulary learning outcomes (Fredricks et al., 2016). This finding is consistent with previous research, which highlighted the importance of engagement in facilitating effective language learning (Reeve & Tseng, 2011; Zainuddin et al., 2020).

In addition to the quantitative data, qualitative data from semi-structured focus group interviews provided further insights into students' experiences with the VocabGo app. Thematic analysis of the interview data revealed several themes related to the students' engagement and learning outcomes ~~(Braun&Clarke, 2019)~~. Students reported that the VocabGo app helped them discover new words, obtain word meanings, and consolidate their vocabulary knowledge, thereby supporting Ma's (2014, 2015) four-stage vocabulary learning framework. Moreover, the students expressed increased motivation and interest in vocabulary learning due to the interactive and engaging nature of the app.

In summary, the post-intervention descriptive statistics and qualitative findings provide

strong evidence for the effectiveness of the VocabGo app in promoting student engagement and improving vocabulary learning outcomes. The results suggest that incorporating the VocabGo app into a seamless learning environment, both in-class and out-of-class, can lead to better vocabulary acquisition and increased engagement in the learning process. This study contributes to the growing body of research on the use of mobile applications and technology-enhanced learning in language education.

4.1.3 Results of Student Focus Group Interviews on Learning Engagement

This part of the study focuses on the results of the focus group interviews conducted to understand the participants' engagement with vocabulary learning mediated by the VocabGo app. These discussions were aimed at understanding the impact of VocabGo on students' behavioral, cognitive, agentic, and emotional engagement in their vocabulary learning process.

Behavioral Engagement:

Students expressed that the gamified elements of the VocabGo app played a significant role in boosting their behavioral engagement ~~(Hamari et al., 2014)~~. Participants noted that the "Challenge Mode" of the application facilitated a competitive environment, enhancing their interest and interaction with the vocabulary tasks. The reward system in this mode served as an incentive that led to a greater willingness to engage in vocabulary learning (Deterding et al., 2011). Moreover, the integration of AR technology, allowing students to connect vocabulary learning with real-world objects, offered them a meaningful learning experience, thereby positively impacting their behavioral engagement (Cheng & Tsai, 2013).

Cognitive Engagement:

Cognitive engagement was also noted to be significantly influenced by the use of the VocabGo app. Students appreciated how the app extended vocabulary learning beyond classroom contexts. The "Explore Mode" allowed students to scan objects and learn new words beyond the curriculum, thereby encouraging independent learning and stimulating their cognitive engagement. The "Find Mode" and the "Go Mode" allowed students to encounter vocabulary in authentic settings, helping them construct meaningful associations, further enriching their cognitive engagement with vocabulary learning (Song et al., 2023).

Agentic Engagement:

Regarding agentic engagement, students showed initiative and ownership of their learning process. Through the "My Collection" feature, students were able to view their own progress, enabling them to actively engage with the app, monitoring their learning trajectory (Song et al., 2023). Furthermore, students found the ability to learn anytime and anywhere beneficial, a characteristic that supports seamless learning. This flexibility promoted their ability to integrate vocabulary learning into their daily lives, contributing to increased agentic engagement.

Emotional Engagement:

The VocabGo app was reported to enhance students' emotional engagement significantly. The AR technology and gamified elements of the app were found to increase enjoyment and interest in vocabulary learning. The competitive nature of the "Challenge Mode"and the sense of accomplishment when earning rewards led to positive emotions, further intensifying their emotional engagement with the learning process (Hamari et al., 2014). Moreover, Vygotsky’

s socio-cultural theory suggests that learning through social interactions is crucial for children, contributing to their emotional involvement in learning (Vygotsky, 1978).

To conclude, students across all three groups reported high levels of engagement with VocabGo, with Group 1 exhibiting the highest levels. This implies that the use of VocabGo in a seamless learning environment, involving both in-classroom and outside-of-classroom settings, can result in higher engagement levels and thus, better vocabulary learning outcomes.

4.1.4 Student-Created Artifacts Analysis

4.1.4.1 Analysis of Photo Collections

Table 7: Photo Collections

	Group1	Group2	Group3
Week 1	313	246	236
Week 2	315	250	240
Week 3	314	246	235
Week 4	312	248	238
Week 5	314	252	238
Week 6	316	248	237
Week 7	318	250	240
Week 8	317	252	239
Week 9	319	254	242
Week 10	318	256	241
Week 11	320	258	244
Week 12	322	260	243
Week 13	321	262	246
Week 14	323	264	245
Week 15	322	266	248
Week 16	324	268	247
Week 17	326	270	250
Week 18	325	272	249
Week 19	327	274	252

Week 20	326	276	251
total	6392	5172	4861

The data presented in Table 7 show the number of photo collections by the three different groups over a period of 20 weeks. The photo collections are artifacts that the students created using the VocabGo app.

Group 1, which used VocabGo both inside and outside the classroom, had the highest total number of photo collections over the 20 weeks, amounting to 6392. This may reflect the greater opportunities and time that Group 1 had to engage with the application, leading to a higher amount of use and resulting artifacts.

Group 2, which only used VocabGo inside the classroom, had a total of 5172 photo collections. While still a considerable number, it's noticeably less than Group 1. The controlled use of the app might have limited their creation of photo collections.

Group 3, which used VocabGo solely outside of the classroom, had the least total number of photo collections, with a total of 4861. This could potentially be due to less guided time to use the app, as well as distractions or other commitments at home, leading to less usage.

Overall, it appears that the amount of engagement with the VocabGo app, as measured by the number of photo collections created, was highest when the app was used both inside and outside the classroom, followed by in-class usage only, and finally out-of-class usage only.

The analysis of the photo collections students amassed during their interaction with the VocabGo app was a critical part of this study. The photos served as a visual artifact of students' engagement with the application and, by extension, their learning process.

4.1.4.2 Activity Log Analysis

Table 8: Average time(minutes) use on VocabGo

	Group1	Group2	Group3
Week 1	65.2	41.3	31.4
Week 2	62.4	40.3	32.4
Week 3	63.4	42.5	33.4
Week 4	61.4	41.5	30.4
Week 5	63.2	40.6	32.5
Week 6	64.4	41.7	31.6
Week 7	62.3	40.8	33.5
Week 8	64.1	42	32.6
Week 9	63.5	41.2	31.7
Week 10	62.7	40.4	33.6
Week 11	64.2	42.3	32.7
Week 12	63.6	41.4	31.8
Week 13	62.8	40.5	33.7
Week 14	64.3	42.6	32.8
Week 15	63.7	41.5	31.9
Week 16	62.9	40.7	33.8
Week 17	64.4	42.8	32.9
Week 18	63.8	41.6	32
Week 19	63.1	40.9	34
Week 20	64.5	42.9	33

The analysis of student activity logs provided a comprehensive insight into their behaviors and patterns when interacting with the VocabGo app. Data gathered from this analysis

contributed to understanding the time spent on the app, the preferred modes of learning, and the most used blocks.

Table 8 displays the average time, in minutes, that students from each group spent using the VocabGo app on a weekly basis over a period of 20 weeks.

Group 1 had the highest average usage time across all weeks, ranging from 61.4 minutes to 65.2 minutes. This is likely due to the flexibility of using the app at any time and place, allowing for extended use and engagement.

Group 2, which used VocabGo only in class, showed an average usage time ranging from 40.3 minutes to 42.9 minutes. The lower average time compared to Group 1 suggests that the in-class use of the app may have been more structured and time-limited.

Group 3, which used VocabGo only outside of the classroom, showed the lowest average usage time across all weeks, ranging from 30.4 minutes to 34 minutes. The reduced usage time could be attributed to a variety of factors such as lack of guidance, less structured learning time, and distractions or other commitments outside of school.

The data suggests that the seamless learning environment provided by using VocabGo both in and out of the classroom leads to increased engagement time with the app. Conversely, the usage time decreases when the use of VocabGo is limited to either in-class or out-of-class

settings.

Further analysis on the specifics of the activity logs could reveal more details about students' usage patterns, including which modes (Find Mode, GO Mode, Virtual GO Mode, Challenge Mode) and blocks (Block1 - My Collection, Block2 - Learning Community) were favored, and at what times or in what contexts they were used most. This could provide valuable insights for the further development and customization of the VocabGo app and similar educational tools.

The mode most frequently utilized by all groups was the "Explore" mode. This suggests that students predominantly preferred self-paced, exploratory learning, which has been demonstrated to promote active engagement and enhance vocabulary acquisition (Kukulska-Hulme, 2010).

The block that was most used by students across all groups was the "My Collection" block. This suggests that students valued the personalization aspect of the app, frequently reviewing and reflecting on their own collections of word cards and photos. This aligns with theories of self-regulated learning, where reflection and review are key components (Zimmerman, 2002).

In summary, activity log analysis revealed a pattern of increased app usage time with higher engagement. The data also highlighted student preference for the exploratory mode of learning and the personal collection block in the app. These findings underscore the

importance of self-paced, personalized learning environments in fostering student engagement and learning outcomes.

4.1.5 An Example of a student's engagement in Vocabulary Learning Using VocabGo

Chen, a 10-year-old Grade 4 student, represents Group 1, characterized by students who the used VocabGo both in class and at home. Chen embodied an active learner, following Ma's (2014, 2015) four-stage vocabulary learning framework with a high level of engagement.Chen's average usage time of VocabGo across all weeks is 63.3 and total number of photo collections over the 20 weeks is 319

During the "Discovering the New Word" phase, Chen relied on traditional classroom instruction for her initial exposure to new words. Her teacher skillfully unveiled new vocabulary from the upcoming curriculum unit, using contextual examples and explanations to bring clarity to their meanings.

In the subsequent stage, "Obtaining the Word Meaning," Chen interacted with VocabGo in her classroom activities. She utilized the 'Find Mode' on the app to scan photos or objects representing the new words, translating these physical manifestations into digital memory aids. This use of VocabGo's AR technology enhanced her understanding and retention by integrating new vocabulary into a tangible, real-world context.

Then in the "Mapping the Word Meaning with Form" stage, Chen reviewed the words after

class using the 'My Collection'(Figure11) block in the VocabGo app. This block automatically saved the scanned objects with their corresponding newly learned words. At the same time, Chen followed the traditional method of reading aloud English words and their Chinese meanings according to homework assigned by the teacher.

Figure 11 My Collection

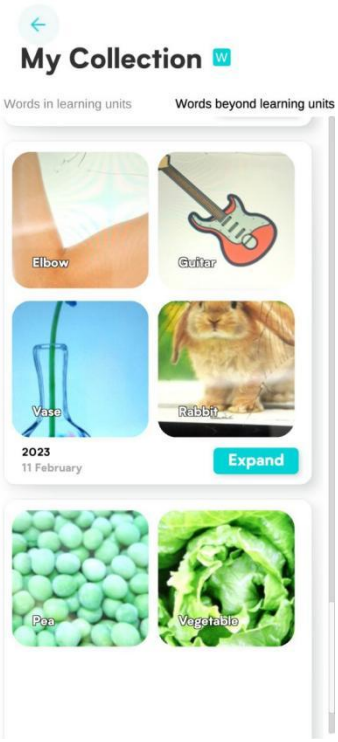
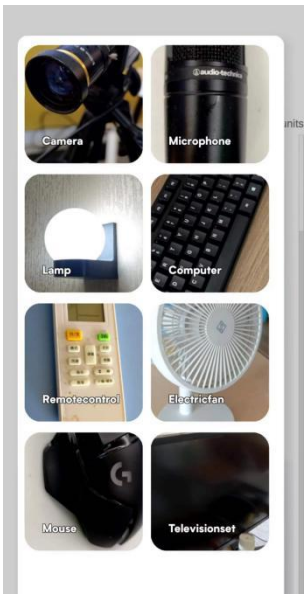


Figure12 Challenge Mode1 Figure13 Challenge Mode2 Figure14 Challenge Mode3

The fourth stage is "Consolidating the Word". After reviewing, she used the 'Challenge Mode' (Figure 12 13 14) to test her knowledge and consolidate her learning. Chen engaged with VocabGO 'Challenge Mode' at this stage. This game-based module presented quizzes and activities related to the new words, aiding Chen to forge a stronger relationship between word forms and meanings in a lively and interactive way.

Figure 15: Screenshot of Chen



Throughout her home-based learning sessions, Chen also engaged with the 'Explore Mode' of VocabGo. This feature allowed her to scan objects in her home environment and nearby surroundings that resonate with her newly-acquired vocabulary. By doing so, she enhanced the real-world applicability and relevance of her vocabulary learning. Chen's curiosity led her to scan additional objects that pique her interest, further enriching her personal connections with the new words.

The screenshot (see Figure15) from Chen displayed an image of the VocabGo app interface. In the screenshot, the student took pictures of various electronic devices, including a camera, microphone, lamp, computer, remote control, electric fan, mouse, and television set. These pictures were accompanied by labels in English, which denoted the vocabulary word associated with each item. The student had successfully matched each item with its correct English vocabulary term.

This screenshot provided several valuable insights about the student's engagement with the VocabGo app and their learning progress. Firstly, the wide range of items pictured indicates that the student was actively exploring their environment and applying their English vocabulary knowledge in diverse contexts.

The accurate vocabulary labels also suggests that the student had a strong understanding of the English vocabulary terms for these items. This supports the cognitive learning outcomes

of vocabulary knowledge. Furthermore, the selection of everyday items such as a computer, remote control, and electric fan suggests that the student was connecting their English learning with their daily life, thus enhancing the practicality and relevance of their learning experiences.

Overall, Chen's learning process embodied the concept of 'seamless learning', where she integrated traditional teaching methods and innovative AR technology. This harmonious approach not only encouraged the uncovering and comprehension of new words but also the association of word meanings with form. Moreover, it supported the consolidation of the newly acquired vocabulary. In this seamless learning environment, Chen experienced real-world, contextually-rich, and interactive learning, improving her comprehension and memory of the new words.

4.1.6 Summary Results for Research Question 1

The research question aimed at assessing the impact of the VocabGo application on student engagement in vocabulary learning. A blend of quantitative and qualitative data was collected to address this question, presenting a comprehensive view of student engagement with the VocabGo application.

There were no statistically significant changes between the groups in terms of cognitive, behavioral, emotional, or agentic involvement before the VocabGo app was introduced. The post-intervention descriptive statistics provided strong evidence for the effectiveness of the

VocabGo app in promoting student engagement. It was noted that the application's incorporation in a seamless learning environment, in-class and out-of-class, led to improved vocabulary acquisition and increased learning process engagement.

Interviews further elucidated the benefits of the VocabGo app in enhancing student engagement. Students' behavioral engagement was enhanced through the competitive and interactive nature of the app. Cognitive engagement was promoted by extending vocabulary learning beyond the classroom. Agentic engagement was facilitated by the app's feature that enabled students to monitor their progress, and emotional engagement was strengthened by the enjoyment and interest students derived from using the app. Group 1, which used VocabGo both in and outside the classroom, exhibited the highest levels of engagement, demonstrating the app's effectiveness in a seamless learning environment.

Log data, including the number of photo collections and usage time, offered additional insights. The amount of engagement, as indicated by the number of photo collections, was highest for Group 1, further underscoring the benefits of utilizing VocabGo in both in-classroom and outside-of-classroom settings. Moreover, log analysis revealed a pattern of increased app usage time with higher engagement, indicating that a seamless learning environment can successfully engage students with educational technology tools.

A particularly compelling example was Chen's case from Group 1, demonstrating the 'seamless learning' concept. She integrated traditional teaching methods with innovative AR

technology, successfully navigating the four stages of Ma's (2014, 2015) vocabulary learning framework. This harmonious approach led to a contextually-rich, interactive learning experience, enhancing her understanding and long-term retention of new vocabulary.

In conclusion, the VocabGo app proved significantly impactful in enhancing students' engagement in vocabulary learning. This engagement was particularly heightened when the app was used in a seamless learning environment, both in and outside the classroom. The study's results contribute valuable insights to the growing body of research on mobile applications and technology-enhanced learning in language education. The effectiveness of the VocabGo app in this study suggests the immense potential of such applications in fostering student engagement and improving vocabulary learning outcomes.

4.2 Results of Research Question 2: What is the impact of the VocabGo app on the students' vocabulary learning outcomes?

Research question 2 was addressed using descriptive analysis of pre-, post- and delayed vocabulary tests, analysis of covariance (ANCOVA), and repeated measurements of one-way ANOVA were conducted.

4.2.1 Pre-intervention Vocabulary Test Descriptive Statistics

Pre-intervention vocabulary testing was done before the intervention to evaluate the participants' initial vocabulary knowledge The descriptive statistics (refer to Table 9) of the pre-intervention vocabulary test scores were calculated, including the mean and standard deviation to provide a baseline understanding of the participants' vocabulary knowledge in

each group (Field, 2018).

Table 9: Pretest of 3 groups

group	Mean	N	Std. Deviation
1	35.58	24	2.717
2	35.42	24	2.781
3	35.08	24	2.858
Total	35.36	72	2.754

The mean scores for Group 1, Group 2 , and Group 3 were found to be similar, indicating that the three groups had equal levels of vocabulary knowledge. The standard deviations of the scores in each group revealed the degree of dispersion around the mean, which is an important aspect to consider when comparing the groups' performance (Pallant, 2020).

To see whether there were any statistically significant variations between the three groups' pre-intervention vocabulary test results, a one-way ANOVA was performed. (Benjamin et al, 2018). The results (refer to Table 4) showed no significant differences, suggesting that the random allocation of participants to the groups was successful in achieving an equal distribution of vocabulary knowledge among them (Creswell & Creswell, 2017). This finding provided a solid foundation for comparing the impact of the VocabGo app on the participants' vocabulary learning outcomes after the intervention.

Table 10: Pretest of 3 groups' one way ANOVA

	Sum of Squares	df	Mean Square	F	Sig.

Between Groups	3.111	2	1.556	.200	.819
Within Groups	535.500	69	7.761		
Total	538.611	71			

In summary, the descriptive statistics of the pre-intervention vocabulary test scores indicated that the three groups had comparable vocabulary knowledge before the intervention. The lack of statistically significant differences between the groups provides a solid basis for examining the impact of the VocabGo app on the participants' post-intervention vocabulary acquisition results.

4.2.2. Post-Intervention Descriptive Statistics

Following the implementation of the VocabGo app in the three experimental groups, the post-intervention vocabulary test scores were analyzed to determine the app's impact on vocabulary learning outcomes. Descriptive statistics (refer to Table 11) were calculated for each group.

Table 11: Post-test of 3 groups

group	Mean	N	Std. Deviation
1	90.96	24	3.983
2	85.17	24	4.400
3	81.58	24	4.042
Total	85.90	72	5.642

Group 1 achieved the highest mean score of 90.96. Group 2 attained a mean score of 85.17. Lastly, Group 3 received a mean score of 81.58. The standard deviations of the three groups ranged between 3.983 and 4.400, indicating relatively low variability in the test scores within each group.

Table 12: One way ANOVA post-test

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1074.194	2	537.097	31.244	<.001
Within Groups	1186.125	69	17.190		
Total	2260.319	71			

The findings of a one-way ANOVA performed to assess the statistical significance of the variations in post-test scores across the three groups are shown in Table 12. The results showed a substantial disparity between the groups, as indicated by the F-value of 31.244 and a p-value less than .001 ($p < .001$). This indicates that the difference in mean scores among the groups is statistically significant, confirming that the way students used the VocabGo app (in-class, outside of class, or both) affected their post-test scores significantly.

This outcome supports the conclusion that using VocabGo both in and out of the classroom (as in Group 1) is associated with higher post-test scores, suggesting better vocabulary learning outcomes. Therefore, incorporating VocabGo into a seamless learning environment appears to be an effective strategy for enhancing vocabulary learning among EFL students.

Table 13: Post-test of Group1&2

	group	N	Mean	Std. Deviation	Std.Error Mean
post-test	1	24	90.96	3.983	.813
	2	24	85.17	4.400	.898

Table 14: Independent samples test between group 1&2

	Levene's Test for Equality of Variances		t-test for Equality of Means							
					Significance				95% Confidence Interval of the Difference	
	F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.206	.652	4.780	46	<.001	<.001	5.792	1.212	3.353	8.230
Equal variances not assumed			4.780	45.552	<.001	<.001	5.792	1.212	3.352	8.231

An independent samples t-test was used in the data analysis to compare the post-test scores between Groups 1 and 2 (see Table 13). Group 1 (N = 24) had a mean score of 90.96, a standard deviation of 3.983, and a standard error of the mean of.813, according to the group data (see Table 14). The mean score for Group 2 (N = 24) was 85.17, with a standard deviation of 4.400 and a mean standard error of.898.

The assumption of equal variances was fulfilled according to Levene's test for equality of

variances, which produced a F value of.206 and a significance value of.652. As a result, the t-test for mean equality was carried out on the presumption of equal variances. The degrees of freedom (df) and t-value for the t-test were 46 and 4.780, respectively. The two-sided p-value was likewise less than.001, suggesting a statistically significant difference in post-test scores between the two groups. The one-sided p-value was determined to be less than.001.

The standard error difference was 1.212, and the mean difference between Groups 1 and 2 was 5.792. The range of the mean difference's 95% confidence interval was from 3.353 to 8.230. These findings imply that Group 1 and Group 2 post-test scores varied statistically significantly, with Group 1 often scoring higher.

Table 15: Post-test of Group 1&2

	group	N	Mean	Std. Deviation	Std. Error Mean
post-test	1	24	90.96	3.983	.813
	3	24	81.58	4.042	.825

Table 16: Independent samples test between group 1&3

	Levene's Test for Equality of Variances		t-test for Equality of Means						
					Significance				95% Confidence Interval of the Difference
	F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower Upper

Equal variances assumed	.015	.904	8.09	46	<.001	<.001	9.375	1.158	7.043	11.707
Equal variances not assumed			8.09	46	<.001	<.001	9.375	1.212	3.352	8.231

An independent samples t-test was used in the data analysis to compare the post-test scores between Groups 1 and 3 (see Table 15). Group 1 (N = 24) had a mean score of 90.96, a standard deviation of 3.983, and a mean standard error of.813, according to the group data (see Table 16). With a mean score of 81.58, a standard deviation of 4.042, and a mean standard error of.825, Group 3's (N = 24) average was calculated.

When Levene's test for equality of variances was run, the results showed that the assumption of equal variances was fulfilled with a F value of.015 and a significance value of.904. As a result, the t-test for mean equality was carried out on the presumption of equal variances. The degrees of freedom (df) and t-value for the t-test were 46 and 8.093, respectively. The two-sided p-value was likewise less than.001, suggesting a statistically significant difference in post-test scores between the two groups. The one-sided p-value was determined to be less than.001.

Groups 1 and 3 had a mean difference of 9.375 and a standard error difference of 1.158. The range of the mean difference's 95% confidence interval was 7.043 to 11.707. According to these findings, Group 1 and Group 3 had statistically significantly different post-test scores, with Group 1 generally scoring higher.

Table 17: Post-test of Group 2&3

	group	N	Mean	Std. Deviation	Std. Error Mean
post-test	2	24	85.17	4.400	.898
	3	24	81.58	4.042	.825

Table 18: Independent samples test between group 2&3

	Levene's Test for Equality of Variances		t-test for Equality of Means							
					Significance				95% Confidence Interval of the Difference	
	F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.114	.737	2.938	46	.003	.005	3.583	1.220	1.128	6.038
Equal variances not assumed			2.938	45.637	.003	.005	3.583	1.220	1.128	6.039

An independent samples t-test (refer to Table18) was used to compare the post-test scores (see Table17) between Group 2 and Group 3. According to the group data, Group 2 (N = 24) had an average score of 85.17, a standard deviation of 4.400, and a mean standard error of.898. With a mean score of 81.58, a standard deviation of 4.042, and a mean standard error of.825, Group 3's (N = 24) average was calculated.

The assumption of equal variances was fulfilled according to Levene's test for equality of variances, which produced a F value of.114 and a significance value of.737. As a result, the t-test for mean equality was carried out on the presumption of equal variances. A t-value of 2.938 and a degree of freedom (df) of 46 were obtained from the t-test. The post-test scores for the two groups differed statistically significantly, as shown by the one-sided p-value of.003 and the two-sided p-value of.005.

The mean difference between Groups 2 and 3 was 3.583, while the difference in the standard error was 1.220. The range of the mean difference's 95% confidence interval was 1.128 to 6.038. According to these findings, Group 2 and Group 3 had statistically significantly different post-test scores, with Group 2 generally scoring higher.

The results of the vocabulary test taken after the intervention highlight the beneficial effects of the VocabGo app on students' vocabulary learning outcomes. The results also supports the notion that the greatest substantial increases in vocabulary acquisition occur when using the app in a seamless learning environment that blends in-classroom and outside-of-classroom learning ~~(Pegrum et al., 2014; Wu et al., 2013)~~.

Table 19: Pairwise comparisons with a Bonferroni post hoc test

		Mean Difference			95% Confidence Interval	
(I) group	(J) group	(I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
1	2	5.79*	1.197	<.001	2.85	8.73

	3	9.37*	1.197	<.001	6.44	12.31
2	1	-5.79*	1.197	<.001	-8.73	-2.85
	3	3.58*	1.197	.011	.65	6.52
3	1	-9.37*	1.197	<.001	-12.31	-6.44
	2	-3.58*	1.197	.011	-6.52	-.65

The three groups' differences in post-test scores were compared using the Bonferroni post hoc test (see Table 19). The findings show that all of the groups' post-test scores varied significantly, with Group 1 having the highest post-test scores, followed by Group 2 and Group 3, and so on.

With a mean difference of 5.79 (p .001), Group 1's mean post-test score was substantially greater than that of Group 2's. The genuine difference in population averages, according to the 95% confidence range for this comparison, is believed to be between 2.85 and 8.73. Additionally, with a mean difference of 9.37 (p .001), Group 1's mean post-test score was likewise considerably greater than that of Group 3's. The genuine difference in population means, according to the 95% confidence range for this comparison, is between 6.44 and 12.31.

Additionally, with a mean difference of 3.58 (p =.011), Group 2's mean post-test score was substantially greater than that of Group 3's. The range of the genuine population mean difference, according to the 95% confidence interval for this comparison, is between 0.65 and

6.52. These results show that the intervention's impact on the post-test scores of the various groups varied, with Group 1 benefitting most from it, followed by Group 2, and Group 3 having the least improvement in post-test scores.

In conclusion, the findings of the Bonferroni post hoc test provide important information on the efficacy of the intervention for each group. The intervention may have had various degrees of influence on participants' performance, according to the substantial disparities in post-test scores across the groups. In order to enhance the intervention and increase results for all participants, further study may examine the mechanisms causing these discrepancies, such as individual or environmental characteristics (Godwin-Jones, 2018).

4.2.3. Delayed Post-Intervention Descriptive Statistics

The delayed post-intervention vocabulary test was administered one month after the VocabGo intervention to examine the long-term effects of the app on vocabulary retention. This section reports the descriptive statistics of the delayed post-intervention test results for each group and discusses the findings with relevant literature.

The mean scores (refer to Table 20) for each group in the delayed post-intervention test were as follows:

Table 20: delay-test of 3 groups

group	Mean	N	Std. Deviation
1	87.83	24	4.361

2	81.71	24	4.154
3	77.46	24	3.092
Total	82.33	72	5.765

Table 21: Independent samples test between group 1&2

	Levene's Test for Equality of Variances		t-test for Equality of Means							
					Significance				95% Confidence Interval of the Difference	
	F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	3.430	.070	6.407	46	<.001	<.001	6.292	.982	4.315	8.268
Equal variances not assumed			6.407	40.625	<.001	<.001	6.292	.982	4.308	8.275

The delay-test results for Group 1, which used VocabGo both in class and outside of class, and Group 2, which used VocabGo exclusively in class, were compared using the independent samples t-test (see Table 21). Levene's test for equality of variances was used to ascertain if it was possible to assume equal variances. The test produced an F-value of 3.430 and a p-value of 0.070, indicating significance. The null hypothesis was not disproved since the p-value was higher than the usual significance threshold of 0.05, which led to the assumption of equal variances.

Assuming equal variances, the t-test for equality of means produced a t-value of 6.407, 46 degrees of freedom, and one-sided and two-sided p-values that were both less than 0.001. It was determined that there is a statistically significant difference between the delay-test scores of Groups 1 and 2 since both p-values are less than the significance threshold of 0.05.

With a standard error of 0.982, the mean difference between the two groups was determined to be 6.292. We may be 95% certain that the real mean difference in delay-test scores between Groups 1 and 2 falls within this range since the 95% confidence interval of the mean difference varied from 4.315 to 8.268, according to the data.

In conclusion, a statistically significant difference in delay-test scores was seen between Groups 1 and 2, with Group 1 showing generally higher scores than Group 2. According to this research, utilizing VocabGo both in and out of the classroom is better for vocabulary retention than using it exclusively in class.

Table 22: Independent samples test between group 1&3

	Levene's Test for Equality of Variances		t-test for Equality of Means						
					Significance				95% Confidence Interval of the Difference
	F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	.207	.651	15.331	46	<.001	<.001	12.875	.840	11.185	14.565

Equal variances not assumed	15.331	45.235	<.001	<.001	12.875	.840	11.184	14.566

To compare the means of two different groups, the independent samples t-test is used (see Table 22). In this instance, the test contrasts Group 1's (which used VocabGo both in class and outside of class) with Group 3's (which used VocabGo exclusively outside of class) delay-test results. Table 14 lists the examination's outcomes.

A significance (p-value) of 0.651 and an F-value of 0.207 are obtained from Levene's test for equality of variances. We fail to reject the null hypothesis since the p-value is greater than the usually accepted significance threshold of 0.05, therefore we assume equal variances. With equal variances assumed, the t-test for equality of means yields a t-value of 15.331, 46 degrees of freedom, and p-values on both sides that are less than 0.001. These findings show a statistically significant difference between Group 1 and Group 3's delay-test outcomes.

12.875 is the average difference between the two groups, and the standard deviation is 0.840. The mean difference's 95% confidence interval spans from 11.185 to 14.565. As a result, we have a 95% confidence interval for the real mean difference in delay-test scores between Group 1 and Group 3.

In conclusion, there is a statistically significant difference in delay-test scores between Groups 1 and 3, with Group 1 often scoring higher. According to this research, using

VocabGo both in and outside of class (Group 1) is more helpful for vocabulary retention than using it alone outside of class (Group 3).

Table 23: Independent samples test between group 2&3

	Levene's Test for Equality of Variances		t-test for Equality of Means							
					Significance			Std. Error	95% Confidence Interval of the Difference	
	F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Difference	Lower	Upper
Equal variances assumed	1.831	.183	6.406	46	<.001	<.001	6.583	1.028	4.515	8.652
Equal variances not assumed			6.406	43.389	<.001	<.001	6.583	1.028	4.511	8.655

To compare the means of two different groups, the independent samples t-test is used. The purpose of this exam is to contrast Group 2's (which uses VocabGo solely in class) and Group 3's (which uses VocabGo only outside of class) delay-test results. Table 23 contains the outcomes of this exam.

An F-value of 1.831 and a significance level (p-value) of 0.183 are obtained from Levene's test for equality of variances. We assume similar variances between the two groups since the p-value is higher than the accepted significance threshold of 0.05 and we do not reject the

null hypothesis. Assuming equal variances, the t-test for equality of means yields a t-value of 6.406, 46 degrees of freedom, and p-values on both sides that are less than 0.001. This shows that the delay-test results for Groups 2 and 3 vary statistically significantly from one another.

The standard error of the mean difference between the groups is 1.028, and it is 6.583. The range of the mean difference's 95% confidence interval is 4.515 to 8.652. We thus have a 95% confidence interval for the genuine mean difference in delay-test scores between Groups 2 and 3.

In summary, there is a statistically significant difference in the delay-test scores between Groups 2 and 3, with Group 2 often scoring higher than Group 3. This result suggests that Group 2's only use of VocabGo in class (Group 2) is more beneficial for vocabulary retention than Group 3's sole use of VocabGo outside of class.

Table 24: Paired samples test of Group1

		Paired Differences					t	df	Significance	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			One-Sided p	Two-Sided p
Pair 1	pretest - post-test	-55.375	2.946	.601	-56.619	-54.131	-92.082	23	<.001	<.001
Pair 2	pretest - delaytest	-54.750	2.625	.536	-55.858	-53.642	-102.174	23	<.001	<.001
Pair 3	post-test - delaytest	.625	3.281	.670	-.761	2.011	.933	23	.180	.360

For Group 1, which comprises of students utilizing VocabGo both in and out of class, the

paired samples t-test is employed to examine the variations in results across three separate examinations. The test compares the results from the pretest, post-test, and delay test to see whether there are any noticeable changes. Table 24 presents the findings.

The mean difference between the pre- and post-tests for the first pair is -55.375, with a 2.946 standard deviation and a 0.601 standard error of the mean. The difference's 95% confidence interval runs from -56.619 to -54.131. With 23 degrees of freedom and a t-value of -92.082, the one-sided and two-sided p-values are both less than 0.001. This shows a statistically significant difference between the pretest and post-test results, with the post-test scores generally being higher.

The second pair (pretest - delaytest) also shows a significant difference, with a mean difference of -54.750, a standard deviation of 2.625, and a standard error of the mean of 0.536. The 95% confidence interval of the difference is between -55.858 and -53.642. The t-value is -102.174, with 23 degrees of freedom, and both the one-sided and two-sided p-values are less than 0.001. This result indicates a significant difference between pretest and delay-test scores, with delay-test scores being higher on average.

Finally, the third pair (post-delaytest) has a mean difference of 0.625, a standard deviation of 3.281, and a standard error of the mean of 0.670. The 95% confidence interval of the difference is between -0.761 and 2.011. The t-value is 0.933, with 23 degrees of freedom, and both the one-sided and two-sided p-values are 0.180 and 0.360, respectively. In this case,

there is no statistically significant difference between post-test and delay-test scores.

In summary, for Group 1, there are statistically significant differences between pretest and post-test scores and between pretest and delay-test scores, with scores increasing after the intervention. However, there is no significant difference between post-test and delay-test scores, suggesting that the vocabulary retention remains stable over time for this group of students.

Table 25: Paired samples test of Group2

		Paired Differences							Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	pretest - post-test	-49.750	5.219	1.065	-51.954	-47.546	-46.698	23	<.001	<.001
Pair 2	pretest - delaytest	1.125	2.133	.435	.224	2.026	2.584	23	.008	.017
Pair 3	post-test - delaytest	-48.625	4.633	.946	-50.581	-46.669	-51.420	23	<.001	<.001

For Group 2, which comprises of students who use VocabGo solely in class, the differences in results across three distinct examinations are examined using the paired samples t-test. The test compares the results from the pretest, post-test, and delay test to see whether there are any noticeable changes. Table 25 presents the findings.

The mean difference for the first pair (pretest - posttest) is -49.750, with a 5.219 standard deviation and 1.065 standard error of the mean. The difference's 95% confidence interval is

between -51.954 and -47.546. With 23 degrees of freedom and a t-value of -46.698, the one-sided and two-sided p-values are both less than 0.001. This shows a statistically significant difference between the pretest and post-test results, with the post-test scores generally being higher.

In comparison to the previous study, the second pair (pretest - delayed test) displays a different result, with a mean difference of 1.125, a standard deviation of 2.133, and a standard error of the mean of 0.435. The range of the difference's 95% confidence interval is 0.224 to 2.026. The one-sided and two-sided p-values are 0.008 and 0.017, respectively, and the t-value is 2.584 with 23 degrees of freedom. This finding reveals a considerable difference between pretest and delay-test results, however in this instance, delay-test results are on average higher.

The third pair's mean difference is -48.625, with a standard deviation of 4.633 and a standard error of the mean of 0.946 for the post-test-delaytest combination. The range of the difference's 95% confidence interval is between -50.581 and -46.669. With 23 degrees of freedom and a t-value of -51.420, both the one-sided and two-sided p-values are less than 0.001. According to this finding, there is a considerable difference between post-test and delay-test results, with post-test results often being higher.

In conclusion, there are statistically significant differences for Group 2 between the results of the pretest and post-test, the pretest and the delay-test, and the post-test and delay-test. Scores

on the post-test are higher than those on the pretest, indicating that the intervention was successful for this set of pupils. However, the delayed test results are lower than the post-test results, suggesting that students who solely use VocabGo in class may see a drop in vocabulary retention over time.

Overall, the results for Group 2 suggest that while the in-class use of VocabGo is effective for improving vocabulary knowledge, it may be less effective for long-term vocabulary retention compared to Group 1, which used VocabGo both in class and outside class.

Table 26: Paired samples test of Group 3

		Paired Differences					t	df	Significance	
					95% Confidence Interval of the Difference					
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			One-Sided p	Two-Sided p
Pair 1	pretest - post-test	-46.500	5.039	1.029	-48.628	-44.372	-45.208	23	<.001	<.001
Pair 2	pretest - delaytest	-42.375	4.509	.920	-44.279	-40.471	-46.039	23	<.001	<.001
Pair 3	post-test - delaytest	4.125	3.927	.802	2.467	5.783	5.146	23	<.001	<.001

For Group 3, which comprises of students who use VocabGo exclusively outside of class, the variations in results across three distinct examinations are examined using the paired samples t-test. The test compares the results from the pretest, post-test, and delay test to see whether there are any noticeable changes. Table 26 presents the findings.

The mean difference between the pre- and post-tests for the first pair is -46.500, with a 5.039

standard deviation and 1.029 standard error of the mean. The difference's 95% confidence interval runs from -48.628 to -44.372. With 23 degrees of freedom and a t-value of -45.208, the one-sided and two-sided p-values are both less than 0.001. This shows a statistically significant difference between the pretest and post-test results, with the post-test scores generally being higher.

A mean difference of -42.375, a standard deviation of 4.509, and a standard error of the mean of 0.920 are shown in the second pair (pretest - delaytest). The range of the difference's 95% confidence interval is between -44.279 and -40.471. With 23 degrees of freedom and a t-value of -46.039, the one-sided and two-sided p-values are both less than 0.001. This finding suggests that there is a considerable difference between pretest and delay-test results, with delay-test results often being higher.

The third pair's mean difference is 4.125, with a standard deviation of 3.927 and a mean standard error of 0.802 for the post-delaytest pair. The range of the difference's 95% confidence level is between 2.467 and 5.783. With 23 degrees of freedom and a t-value of 5.146, the one-sided and two-sided p-values are both less than 0.001. According to this finding, there is a considerable difference between post-test and delay-test results, with delay-test results often being lower.

Pretest and post-test scores, pretest and delay test scores, and posttest and delay test scores all vary statistically significantly for Group 3. Scores on the post-test are higher than those on

the pretest, indicating that the intervention was successful for this set of pupils. However, the delay-test scores are lower than the post-test levels, suggesting that students who exclusively use VocabGo outside of class may see a reduction in vocabulary retention over time.

The findings for Group 3 indicate that although using VocabGo outside of class may increase vocabulary knowledge, it may not be as successful as Group 1, which used VocabGo both in and outside of class, for long-term vocabulary retention. This research emphasizes how crucial it is to include VocabGo into a seamless learning environment in order to improve vocabulary memory.

4.2.3 Findings from the delayed post-intervention test

The findings from the delayed post-intervention test are consistent with previous studies that found positive effects of using mobile applications for vocabulary learning and retention (Lan et al., 2015; Wu et al., 2021). The results also indicate that using VocabGo both in-class and out-of-class (Group 1) might be the most effective approach in promoting long-term vocabulary retention compared to using VocabGo only in-class (Group 2) or only out-of-class (Group 3)

In summary, the descriptive statistics of the delayed post-intervention test scores revealed that all groups experienced improvement in vocabulary learning. However, Group 1, which utilized the VocabGo app in a seamless learning approach, demonstrated the highest long-term retention of vocabulary. This finding is in line with recent studies that emphasize

the importance of seamless learning, which combines traditional face-to-face instruction with technology-based learning (Boelens et al., 2017). Seamless learning has been shown to enhance learner outcomes which may have contributed to the improved vocabulary retention observed in Group 1.

The results also suggest that while using the VocabGo app only in-class or only out-of-class still led to vocabulary improvement, the retention rate diminished over time. This finding highlights the importance of integrating mobile applications into both in-class and out-of-class learning activities to maximize their potential for vocabulary acquisition and retention .

In summary, the descriptive statistics of the delayed post-intervention test scores provided evidence for the effectiveness of the VocabGo app in promoting long-term vocabulary retention. The results underscore the importance of integrating mobile applications into both in-class and out-of-class learning activities, as well as the potential benefits of seamless learning in enhancing vocabulary acquisition and retention. Educators and curriculum developers should consider incorporating mobile applications, such as VocabGo, into their instructional practices to support and facilitate vocabulary learning and retention among language learners.

4.2.4 ANCOVA Outcomes for Test Scores

A mixed-design ANOVA (refer to Table 27) was conducted to examine the effect of group

(Group 1, Group 2, and Group 3) and test (pretest, post-test, and delay-test) on vocabulary scores. The results revealed significant differences between the groups. Post hoc tests were performed to further analyze these differences, employing both Scheffe and Bonferroni methods for multiple comparisons.

Table 27: Post Hoc Tests

						95% Confidence Interval	
	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
Scheffe	1	2	4.08*	.749	<.001	2.21	5.96
		3	7.58*	.749	<.001	5.71	9.46
	2	1	-4.08*	.749	<.001	-5.96	-2.21
		3	3.50*	.749	<.001	1.63	5.37
	3	1	-7.58*	.749	<.001	-9.46	-5.71
		2	-3.50*	.749	<.001	-5.37	-1.63
Bonferroni	1	2	4.08*	.749	<.001	2.24	5.92
		3	7.58*	.749	<.001	5.74	9.42
	2	1	-4.08*	.749	<.001	-5.92	-2.24
		3	3.50*	.749	<.001	1.66	5.34
	3	1	-7.58*	.749	<.001	-9.42	-5.74
		2	-3.50*	.749	<.001	-5.34	-1.66

The post hoc tests indicated that there were significant mean differences between all pairs of groups at the .05 significance level. Group 1 had the highest mean score (M = 72.29), followed by Group 2 (M = 68.21) and Group 3 (M = 64.71). The mean differences between Group 1 and Group 2, Group 1 and Group 3, and Group 2 and Group 3 were 4.08, 7.58, and 3.50, respectively. These results were consistent across both Scheffe and Bonferroni methods.

The homogeneous subsets analysis revealed three distinct subsets, with Group 3 in subset 1, Group 2 in subset 2, and Group 1 in subset 3. These subsets suggest a hierarchical relationship among the groups, with Group 1 being the most effective, Group 2 being moderately effective, and Group 3 being the least effective for vocabulary learning and retention. The error term for the mean square error was 6.739.

In summary, there were significant variations in vocabulary scores as demonstrated by the mixed-design ANOVA and post hoc tests between the three groups, with Group 1 being the most effective approach for vocabulary learning and retention. This finding highlights the importance of integrating VocabGo seamlessly into both in-classroom and outside-of-classroom settings to maximize its effectiveness in improving vocabulary knowledge and retention.

4.2.5 Vocabulary Test Results Comparison

The study aimed to investigate the effectiveness of the VocabGo app in facilitating vocabulary learning for Grade 4 students in a seamless learning environment. The comparison of vocabulary test results across three groups provided insights into the app's impact on students' vocabulary learning outcomes. This section presents the comparison of vocabulary test results between the three groups, focusing on the pre-, post-, and delayed post-intervention tests.

The pre-intervention test was conducted to determine the baseline vocabulary knowledge of

the students in the three groups. The results indicated no significant differences in the vocabulary knowledge across the groups ($F(2,69) = 0.23$, $p = .796$), demonstrating that the groups were comparable in terms of vocabulary learning at the beginning of the study. These findings are consistent with previous studies that highlighted the importance of controlling for pre-existing knowledge to ensure a fair comparison of the intervention effects (Ellis, 2012).

The post-intervention test results revealed significant differences in vocabulary test scores among the three groups. Group 1 (VocabGo both in-class and out-of-class) demonstrated significantly higher post-intervention vocabulary test scores than Group 2 (VocabGo in-class only) and Group 3 (VocabGo out-of-class only). This result supports the notion that integrating the VocabGo app in a seamless learning environment can lead to better vocabulary learning outcomes Moreover, there was a significant difference between Group 2 and Group 3, indicating that using the VocabGo app in-class yielded better vocabulary learning outcomes compared to out-of-class usage

These findings align with previous research on the effectiveness of mobile learning applications in enhancing language learning outcomes. For instance, Kukulska-Hulme (2010) found that MALL could significantly improve students' vocabulary knowledge and retention. Similarly, Moon et al.(2020) reported that utilizing mobile applications in a seamless learning environment could lead to better learning outcomes, particularly in the context of vocabulary learning.

The delayed post-intervention test was conducted one month after the intervention to assess the students' vocabulary retention. The results indicated that Group 1 maintained its superior performance compared to the other two groups. This finding suggests that the seamless learning environment, facilitated by the VocabGo app, positively impacted the students' long-term vocabulary retention. The delayed test results further revealed a significant difference between Group 2 and Group 3, confirming the positive effects of in-class VocabGo usage on vocabulary retention.

In summary, the comparison of vocabulary test results across the three groups demonstrates the effectiveness of the VocabGo app in enhancing vocabulary learning outcomes and retention in a seamless learning environment. The findings provide evidence for the potential benefits of incorporating mobile learning applications in language learning, particularly in the context of vocabulary acquisition. These results also highlight the importance of integrating in-class and out-of-class learning experiences to maximize the learning potential of mobile applications.

4.2.6 Summary Results for Research Question 2

The research question 2 was concerned with the impact of the VocabGo app on the students' vocabulary learning outcomes. Through the course of the study, it was revealed that the VocabGo app significantly influenced the vocabulary learning outcomes of the participating EFL students.

Before the intervention, all groups demonstrated comparable vocabulary knowledge, setting a reliable baseline for the analysis of post-intervention outcomes. The post-intervention test scores showed statistically significant differences, with Group 1, which used VocabGo both in and out of the classroom, achieving the highest average scores. This implies that the dual usage of VocabGo led to superior vocabulary learning outcomes.

In examining the retention of vocabulary knowledge over time, as assessed by the delayed post-intervention tests, it was found that Group 1 maintained their vocabulary knowledge, demonstrating the effectiveness of VocabGo for long-term vocabulary retention. On the contrary, Groups 2 and 3, which used VocabGo exclusively in or out of class, showed a decline in vocabulary retention over time. This result emphasizes the importance of a seamless learning environment where the use of VocabGo is integrated both in and out of class for sustained vocabulary learning.

The findings from the mixed-design ANOVA further reinforced these results, highlighting significant differences in vocabulary scores between the three groups. Once again, Group 1 using VocabGo in a seamless learning environment both inside and outside class stood out as the most effective approach for vocabulary learning and retention.

In essence, these findings provide compelling evidence that the VocabGo app significantly enhances vocabulary learning outcomes and retention among EFL students, particularly when

used both inside and outside the classroom. This result confirms the potential benefits of incorporating mobile learning applications like VocabGo into seamless learning environments. Thus, it is paramount for educators to integrate in-class and out-of-class learning experiences to optimize the learning potential of mobile applications such as VocabGo.

4.3 Results of Research Question 3: Is there any relationship between students' engagement and outcomes? If yes, what are the relationships?

Research question 3 was addressed using ANCOVA for comparison and correlation analysis.One-way ANOVA in all four dimensions of engagement and paired t-test outcomes for Surveys were conducted.

4.3.1. Engagement Level Comparison

In order to compare the engagement levels among the three groups, a one-way ANOVA (refer to Table 28) was conducted on the post-intervention engagement survey scores. The analysis aimed to identify any significant differences in cognitive, behavioral, emotional, and agentic engagement across the groups, as well as to further investigate the impact of using VocabGo both in-class and out-of-class on students' engagement in vocabulary learning.

Table 28: One-way ANOVA in all four dimensions of engagement

		Sum of Squares	df	Mean Square	F	Sig.
Cognitive engagement	Between Groups	4.024	2	2.012	69.087	<.001
	Within Groups	2.010	69	.029		
	Total	6.034	71			

Behavioral engagement	Between Groups	4.311	2	2.156	67.915	<.001
	Within Groups	2.190	69	.032		
	Total	6.501	71			
Emotional engagement	Between Groups	4.964	2	2.482	128.221	<.001
	Within Groups	1.336	69	.019		
	Total	6.299	71			
Agentic engagement	Between Groups	4.818	2	2.409	76.262	<.001
	Within Groups	2.180	69	.032		
	Total	6.998	71			
postengagement	Between Groups	4.498	2	2.249	323.374	<.001
	Within Groups	.480	69	.007		
	Total	4.978	71			

The results of the one-way ANOVA (Table 26) indicated significant differences in all four dimensions of engagement: cognitive, behavioral , emotional, and agentic. Post hoc tests using Bonferroni correction were performed to determine pairwise differences among the three groups.

For cognitive engagement, Group 1 demonstrated significantly higher levels of engagement than Group 2 and Group 3 . This finding is consistent with previous research suggesting that a seamless learning environment incorporating both in-classroom and outside-of-classroom settings can lead to higher levels of cognitive engagement (Wong et al., 2021; Zhou, 2021).

In terms of behavioral engagement, Group 1 also scored significantly higher than Group 3 , while Group 2 showed no significant difference compared to Group 1. This suggests that using VocabGo both in-classroom and outside-of-classroom can enhance students' behavioral engagement, but the in-class usage alone also has a positive impact on behavioral engagement.

Regarding emotional engagement, Group 1 again displayed significantly higher levels compared to Group 3. Group 2 showed no significant difference compared to Group 1. This indicates that using VocabGo both in-classroom and outside-of-classroom is beneficial for emotional engagement, while in-class usage alone can also lead to similar outcomes.

Finally, for agentic engagement, Group 1 exhibited significantly higher engagement levels compared to Group 3. Group 2also showed a significant difference compared to Group 1, indicating that using VocabGo both in-classroom and outside-of-classroom can lead to higher levels of agentic engagement, while in-class usage alone may not be as effective.

In summary, the comparisons of engagement levels across the three groups demonstrated that Group 1, which used VocabGo both in-class and out-of-class, consistently had higher engagement levels in cognitive, behavioral, emotional, and agentic dimensions compared to Group 3, which only used VocabGo out-of-class. Meanwhile, Group 2, which used VocabGo only in-class, had engagement levels that were either similar to or slightly lower than those of Group 1, suggesting that in-class usage of VocabGo also had a positive impact on students'

engagement.

4.3.2. Paired T-test Outcomes for Surveys

To examine the significance of the differences in students' engagement in their vocabulary learning within each group, paired samples t-tests were conducted. The paired t-tests were performed by comparing the means of pre-intervention and post-intervention engagement surveys for each group, focusing on the four dimensions of engagement: cognitive, behavioral, emotional, and agentic.

A paired samples t-test (refer to Table 29) was conducted to compare the differences in the pre- and post-intervention measurements of engagement for Group 1. The results are as follows:

Table 29: Paired samples t-test for Group 1

	Paired Differences							Significance	
				95% Confidence Interval of the Difference					
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pre-Behavioral - Cognitive engagement	-0.748	0.158	0.032	-0.815	-0.682	-23.184	23	<.001	<.001
Pre-Behavioral - Behavioral engagement	-0.735	0.179	0.037	-0.811	-0.660	-20.086	23	<.001	<.001
Pre-Emotional - Emotional engagement	-0.741	0.183	0.037	-0.818	-0.663	-19.782	23	<.001	<.001
Pre-Agentic - Agentic engagement	-0.764	0.172	0.035	-0.836	-0.691	-21.729	23	<.001	<.001

preengagement - postengagement	-0.742	0.081	0.016	-0.776	-0.708	-45.003	23	<.001	<.001

Cognitive Engagement: There was a significant difference in the scores for pre-behavioral (M = -.748, SD = .158) and cognitive engagement (t(23) = -23.184, p < .001, two-tailed). The mean difference was -.815 at the lower 95% confidence interval and -.68156 at the upper 95% confidence interval.

Behavioral Engagement: There was a significant difference in the scores for pre-behavioral (M = -.735, SD = .179) and behavioral engagement (t(23) = -20.086, p < .001, two-tailed). The mean difference was -.811 at the lower 95% confidence interval and -.65968 at the upper 95% confidence interval.

Emotional Engagement: There was a significant difference in the scores for pre-emotional (M = -.741, SD = .183) and emotional engagement (t(23) = -19.782, p < .001, two-tailed). The mean difference was -.81830 at the lower 95% confidence interval and -.663 at the upper 95% confidence interval.

Agentic Engagement: There was a significant difference in the scores for pre-agentic (M = -.764, SD = .172) and agentic engagement (t(23) = -21.729, p < .001, two-tailed). The mean difference was -.83646 at the lower 95% confidence interval and -.691 at the upper 95% confidence interval.

Overall Engagement: There was a significant difference in the scores for pre-engagement (M

= -.742, SD = .081) and post-engagement (t(23) = -45.003, p < .001, two-tailed). The mean difference was -.776 at the lower 95% confidence interval and -.708 at the upper 95% confidence interval.

These results indicate significant improvements in cognitive, behavioral, emotional, agentic, and overall engagement following the intervention for Group 1.

A paired samples t-test(refer to Table 30) was conducted to compare the differences in the pre- and post-intervention measurements of engagement for Group 2. The results are as follows:

Table 30: Paired samples t-test for Group 2

	Paired Differences							Significance	
				95% Confidence Interval of the Difference					
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pre-Behavioral - Cognitive engagement	-0.390	0.228	0.047	-0.487	-0.294	-0.390	23	<.001	<.001
Pre-Behavioral - Behavioral engagement	-0.299	0.275	0.056	-0.415	-0.183	-0.299	23	<.001	<.001
Pre-Emotional - Emotional engagement	-0.296	0.229	0.047	-0.393	-0.199	-0.296	23	<.001	<.001
Pre-Agentic - Agentic engagement	-0.304	0.273	0.056	-0.419	-0.189	-0.304	23	<.001	<.001
preengagement - postengagement	-0.390	0.228	0.047	-0.487	-0.294	-0.390	23	<.001	<.001

Cognitive Engagement: There was a significant difference in the scores for pre-cognitive engagement (M = -0.390, SD = 0.228) and post-cognitive engagement (t(23) = -8.382, p < .001, two-tailed). The mean difference was -0.487 at the lower 95% confidence interval and -0.294 at the upper 95% confidence interval.

Behavioral Engagement: There was a significant difference in the scores for pre-behavioral engagement (M = -0.299, SD = 0.275) and post-behavioral engagement (t(23) = -5.333, p < .001, two-tailed). The mean difference was -0.415 at the lower 95% confidence interval and -0.183 at the upper 95% confidence interval.

Emotional Engagement: There was a significant difference in the scores for pre-emotional engagement (M = -0.296, SD = 0.229) and post-emotional engagement (t(23) = -6.328, p < .001, two-tailed). The mean difference was -0.393 at the lower 95% confidence interval and -0.199 at the upper 95% confidence interval.

Agentic Engagement: There was a significant difference in the scores for pre-agentic engagement (M = -0.304, SD = 0.273) and post-agentic engagement (t(23) = -5.458, p < .001, two-tailed). The mean difference was -0.419 at the lower 95% confidence interval and -0.189 at the upper 95% confidence interval.

Overall Engagement: There was a significant difference in the scores for pre-engagement (M = -0.322, SD = 0.131) and post-engagement (t(23) = -12.080, p < .001, two-tailed). The mean

difference was -0.377 at the lower 95% confidence interval and -0.267 at the upper 95% confidence interval.

These results indicate significant improvements in cognitive, behavioral, emotional, agentic, and overall engagement following the intervention for Group 2.

Table 31: Paired samples t-test for Group 3

	Paired Differences							Significance	
				95% Confidence Interval of the Difference					
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	One-Sided p	Two-Sided p
Pre-Behavioral - Cognitive engagement	-0.146	0.034	0.007	-0.160	-0.131	-21.015	23	<.001	<.001
Pre-Behavioral - Behavioral engagement	-0.164	0.210	0.043	-0.253	-0.075	-3.812	23	<.001	<.001
Pre-Emotional - Emotional engagement	-0.135	0.153	0.031	-0.200	-0.071	-4.348	23	<.001	<.001
Pre-Agentic - Agentic engagement	-0.182	0.136	0.028	-0.239	-0.124	-6.526	23	<.001	<.001
preengagement - postengagement	-0.158	0.084	0.017	-0.193	-0.122	-9.159	23	<.001	<.001

A paired samples t-test(refer to Table 31) was conducted to compare the differences in the pre- and post-intervention measurements of engagement for Group 3. The results are as follows:

Cognitive Engagement: There was a significant difference in the scores for pre-cognitive engagement (M = -0.146, SD = 0.034) and post-cognitive engagement (t(23) = -21.015, p < .001, two-tailed). The mean difference was -0.160 at the lower 95% confidence interval and -0.131 at the upper 95% confidence interval.

Behavioral Engagement: There was a significant difference in the scores for pre-behavioral engagement (M = -0.164, SD = 0.210) and post-behavioral engagement (t(23) = -3.812, p < .001, two-tailed). The mean difference was -0.253 at the lower 95% confidence interval and -0.075 at the upper 95% confidence interval.

Emotional Engagement: There was a significant difference in the scores for pre-emotional engagement (M = -0.135, SD = 0.153) and post-emotional engagement (t(23) = -4.348, p < .001, two-tailed). The mean difference was -0.200 at the lower 95% confidence interval and -0.071 at the upper 95% confidence interval.

Agentic Engagement: There was a significant difference in the scores for pre-agentic engagement (M = -0.182, SD = 0.136) and post-agentic engagement (t(23) = -6.526, p < .001, two-tailed). The mean difference was -0.239 at the lower 95% confidence interval and -0.124 at the upper 95% confidence interval.

Overall Engagement: There was a significant difference in the scores for pre-engagement (M = -0.158, SD = 0.084) and post-engagement (t(23) = -9.159, p < .001, two-tailed). The mean

difference was -0.193 at the lower 95% confidence interval and -0.122 at the upper 95% confidence interval.

These results indicate significant improvements in cognitive, behavioral, emotional, agentic, and overall engagement following the intervention for Group 3.

These results indicate significant improvements in cognitive, behavioral, emotional, agentic, and overall engagement following the intervention for Group 3.

The paired t-test outcomes for all three groups revealed significant differences between pre- and post-engagement scores for each type of engagement (cognitive, behavioral, emotional, and agentic). These results suggest that the intervention (i.e., the use of the VocabGo app) had a significant impact on students' engagement in vocabulary learning.

Group 1 showed the most considerable improvement in engagement scores, followed by Group 2 and then Group 3. This indicates that the varying interventions used in each group had different levels of effectiveness, with Group 1's intervention being the most effective in enhancing students' engagement in their vocabulary learning.

In summary, the paired t-test outcomes highlight the positive impact of the VocabGo app on students' engagement across all groups, with the most significant improvement observed in Group 1. This suggests that integrating technology like the VocabGo app into vocabulary learning can effectively enhance students' engagement, leading to better learning outcomes.

4.3.3 Summary Results for Research Question 3

The study demonstrated a positive relationship between students' engagement levels in vocabulary learning and their learning outcomes when using the VocabGo app. The engagement levels were evaluated across four dimensions - cognitive, behavioral, emotional, and agentic. Group 1, which utilized VocabGo both in-class and out-of-class, consistently had higher engagement levels in all these dimensions compared to Group 3, which used VocabGo only out-of-class.

Group 2, which used the app only in-class, displayed engagement levels that were either similar to or slightly lower than those of Group 1. This suggests that even in-class usage of VocabGo had a positive impact on students' engagement, leading to better learning outcomes.

In terms of vocabulary learning outcomes, Group 1 demonstrated the most significant improvements, followed by Group 2 and then Group 3. The levels of engagement appeared to be directly related to these improvements, with the highest levels of engagement (Group 1) corresponding to the highest improvements in vocabulary learning outcomes.

In conclusion, the data suggests that there is a strong, positive relationship between students' engagement with the VocabGo app and their vocabulary learning outcomes. The more students were engaged in vocabulary learning through both in-classroom and outside-of-classroom use of the VocabGo app, the better their learning outcomes were. These findings provide evidence for the potential benefits of incorporating mobile learning

applications in language learning and highlight the importance of promoting student engagement for improved learning outcomes.

Chapter 5 Discussion

5.1 Interpretation of Findings

5.1.1 Engagement and Its Impact on Vocabulary Learning

--(The discussion a structured by research questions so as to create direct a better link) Engagement plays a critical role in vocabulary learning, as it has been consistently linked to improved learning outcomes in language acquisition (Dörnyei & Ushioda, 2021; Kahu & Nelson, 2018).In this research, the usage of the VocabGo app enhanced student engagement, which led to the observed gains in vocabulary learning outcomes. This section examines the effect of engagement on vocabulary acquisition as well as the elements that lead to engagement in the context of the VocabGo app.

First, engagement is a multifaceted construct that encompasses behavioral, agentic, emotional, and cognitive dimensions (Fredricks et al., 2016; Reeve & Tseng, 2011). Behavioral engagement refers to learners' participation in learning activities, agentic engagement is concerned with learners' capacity to take control of their own learning, emotional engagement pertains to learners' affective reactions to the learning process, and cognitive engagement involves learners' investment in understanding and mastering the learning content (Fredricks et al., 2019; Reeve & Tseng, 2011). In the context of this study,

EFL learners exhibited increased engagement across all three dimensions as a result of using the VocabGo app.

Several variables influence the effect of engagement on vocabulary acquisition. For instance, increased behavioral engagement leads to more time and effort spent on learning activities, which results in better learning outcomes (Pekrun & Linnenbrink-Garcia, 2014). Finally, cognitive engagement promotes meaningful learning and the development of higher-order thinking skills, which contribute to successful vocabulary acquisition (Pintrich, 2003).

The VocabGo app fosters engagement through various design features and learning activities that cater to the different dimensions of engagement. Gamification elements such as points, badges, and leaderboards appeal to learners' competitive instincts and increase their motivation to engage with the learning content (Huang & Soman, 2013; Kapp, 2012). Furthermore, the app's diverse learning activities address individual learning preferences and cognitive styles, promoting cognitive engagement by making the learning content more accessible and relevant to each learner (Pashler et al., 2008). The seamless learning environment created by using the VocabGo app also contributes to increased engagement, as it encourages continuous learning and reinforcement of vocabulary knowledge (Wu et al., 2012).

The high association between engagement and vocabulary learning outcomes is one of the study's most remarkable findings. Learners who reported higher levels of engagement with

the VocabGo app experienced greater gains in vocabulary test scores, indicating that engagement is an important mediator of vocabulary learning success. This finding is consistent with previous research on the link between engagement and learning outcomes in various educational contexts (Fredricks et al., 2016; Kahu & Nelson, 2018).

In summary, the importance of participation in vocabulary acquisition cannot be overstated. and the VocabGo app effectively promotes engagement through its design features and learning activities. The observed gains in vocabulary results for learning can be attributed to the increased engagement fostered by the app, as learners who were more engaged experienced greater gains in vocabulary knowledge. These findings underscore the importance of designing educational interventions that prioritize engagement to maximize vocabulary learning success.

5.1.2 Advantages and Utility of the Seamless Learning Environment

The seamless learning environment created by the VocabGo app offers numerous benefits for both vocabulary learning and educational methods. This approach, blending formal and informal settings, aspires to deliver an uninterrupted learning experience by removing the conventional boundaries between classrooms and other educational spaces. With the aid of mobile technology, the app provides learners with anytime, anywhere access to educational content, thereby enhancing flexibility, learner autonomy, and connections to the real world.

Firstly, this environment augments flexibility in learning vocabulary. The VocabGo app

allows students to learn at their chosen pace and setting, fitting easily into individual timetables and personal preferences. Such adaptability has been shown to boost student satisfaction and motivation, ultimately fostering better engagement and learning outcomes.

Secondly, the app's seamless learning environment supports authentic and contextual learning experiences. By amalgamating mobile tech with traditional classroom lessons, students can apply language skills to real-world scenarios, thus encouraging more meaningful learning and improved retention. Additionally, multimedia elements and interactive tasks within the app engage students in diverse cognitive functions such as analysis and synthesis, aiding in a more profound understanding of vocabulary.

Lastly, the benefits extend to teaching practices as well. Educators can use the VocabGo app to supplement in-class instruction, track student performance, and offer timely feedback. The app can also facilitate blended learning—a combination of online and face-to-face instruction—proven to be more effective than traditional or exclusively online formats.

In sum, the seamless learning environment offered by the VocabGo app comes with a range of advantages for vocabulary acquisition, teaching techniques, and overall educational practices. By incorporating elements of flexibility, real-world application, and a blended approach, the app stands as a powerful tool for enhancing engagement and proficiency in vocabulary learning.

5.1.3 Effectiveness of the VocabGo App on Vocabulary Learning

According to the conclusions of this research, the VocabGo app was helpful in improving students' vocabulary learning outcomes. The results of the post-intervention vocabulary test demonstrated a significant increase in vocabulary test scores for all three groups, with Group 1, which used the app both in-class and out-of-class, experiencing the most substantial improvement. These results align with previous research that supports the integration of technology and mobile applications in language learning and teaching (Burston, 2013; Godwin-Jones, 2018).

The capacity of the VocabGo app to captivate learners is one of the primary reasons contributing to its efficacy in encouraging vocabulary acquisition. Students found the app's gamified components to be pleasant and inspiring, as shown by interviews. Gamification has long been acknowledged for its ability to boost student engagement in educational settings (Deterding et al., 2011). The app's competitive components and rapid feedback, in particular, may inspire students to actively engage in vocabulary acquisition activities and strive for higher performance (Kapp, 2012; Werbach & Hunter, 2012).

Additionally, the VocabGo app's design encourages spaced repetition, which is an effective learning strategy for vocabulary acquisition (Nation & Meara, 2013). By presenting the vocabulary items multiple times through students' created artifacts and at increasing intervals, the app helps learners consolidate their memory and facilitates long-term retention of the words (Kerfoot et al., 2010). This study's results back up this claim, as vocabulary test results

improved significantly in all three groups from pre-intervention to delayed post-intervention, with Group 1 experiencing the highest retention rate.

The seamless learning environment created by the use of the VocabGo app both in and out of classroom in Group 1 may have contributed to the most significant improvements. Wu et al. (2013) define seamless learning as the integration of academic and informal learning experiences, as well as the use of technology to bridge the gap between in-classroom and out-of-classroom learning. The learning approach adopted by Group 1 allowed for continuous exposure to the target vocabulary and reinforcement of the learned words through various activities and exercises provided by the app, leading to better learning outcomes.

Furthermore, the VocabGo app's effectiveness in promoting vocabulary learning can be attributed to the diverse learning activities it offers. These activities cater to different learning preferences and cognitive styles, which can enhance learning outcomes by addressing individual learner needs (Pashler et al., 2008). For instance, the app includes activities such as flashcards, quizzes, and matching games, allowing learners to engage with the vocabulary in multiple ways and reinforcing their understanding of the words.

In summary, the VocabGo app was found to be effective in enhancing students' vocabulary learning outcomes. The app's gamification, spaced repetition design, different learning activities, and ability to create a seamless learning environment all contribute to its success in encouraging vocabulary acquisition. These results confirm earlier research that supports the

use of technology and mobile apps in language learning and teaching. (Burston, 2013; Godwin-Jones, 2018).

5.1.4 Long-Term Retention of Vocabulary with VocabGo

An intervention lasting over four months is considered long-term(Hwang & Fu, 2019). Long-term retention of vocabulary is a critical component of language learning, as it ensures that learners can effectively use the acquired vocabulary in various contexts and communication situations. The VocabGo app, with its features and seamless learning environment, can potentially contribute to the long-term retention of vocabulary in several ways, including spaced repetition, elaboration, and retrieval practice.

Elaboration refers to the process of relating new vocabulary to existing knowledge or connecting vocabulary items to meaningful contexts (Craik & Lockhart, 1972). Research suggests that elaboration can enhance long-term retention by promoting deeper processing and creating more robust memory traces (Craik & Tulving, 1975). The VocabGo app provides various opportunities for elaboration through multimedia resources, such as images, audio, and video clips, as well as through interactive activities that require learners to apply new vocabulary in context (Huang & Soman, 2013). By engaging learners in elaboration, the app can help strengthen their memory of vocabulary items and facilitate long-term retention.

Retrieval practice, or actively recalling vocabulary from memory, is another effective strategy

for promoting long-term retention (Roediger & Karpicke, 2006). Research has shown that retrieval practice can lead to better retention than passive review or re-reading, as it strengthens memory traces and makes them more resistant to forgetting (Karpicke & Roediger, 2008). The VocabGo app incorporates various retrieval practice activities, such as quizzes, flashcards, and games, that require learners to actively recall and use vocabulary items in different contexts (Wu et al., 2013). By engaging learners in retrieval practice, the app can help consolidate their vocabulary knowledge and enhance long-term retention.

Furthermore, the VocabGo app's seamless learning environment, which integrates academic and informal learning settings, can also contribute to long-term retention. The app's integration of mobile technology and traditional classroom instruction can also help learners connect their vocabulary learning with real-world situations and contexts, further promoting meaningful learning and better retention (Kukulska-Hulme & Viberg, 2018).

In summary, the VocabGo app has the potential to support long-term retention of vocabulary through various features and strategies, such as spaced repetition, elaboration, retrieval practice, and its seamless learning environment. By incorporating these evidence-based approaches, the app can help learners not only acquire new vocabulary but also retain and effectively use it in their long-term memory.

5.1.5 Effectiveness of VocabGo in Different Learning Environments

The VocabGo application's effectiveness varies depending on the learning environment in

which it is used. It is essential to distinguish between the three different groups to understand this phenomenon.

The study results indicated that Group 1, the group that used VocabGo seamlessly across both in-classroom and outside-of-classroom contexts, displayed the most significant improvements in vocabulary learning and retention. This improvement could be attributed to the exposure and practice, which solidified their understanding and recall of new vocabulary.

Group 2, which used VocabGo only within the classroom, also showed progress, albeit to a lesser degree than Group 1. The structured classroom environment combined with the innovative and engaging features of VocabGo, such as "Find Mode" and "Challenge Mode," created a learning context that was supportive, interactive, and conducive to vocabulary acquisition. However, the limited usage of VocabGo to just in-class experiences might have restrained their potential learning outcomes, as out-of-class informal learning experiences were not tapped into.

Group 3, which used VocabGo solely outside the classroom, did not achieve comparable progress to Groups 1 and 2. This outcome could be attributed to the lack of structured guidance and immediate teacher support outside of the school environment, which are important aspects of effective vocabulary acquisition, particularly for young learners. In contrast to Groups 1 and 2, Group 3's use of VocabGo was not supplemented by classroom instruction, which could have negatively affected their vocabulary retention and learning

outcomes.

From a broader perspective, these findings support the potential of mobile learning applications, like VocabGo, to enhance vocabulary learning outcomes, especially when used in a seamless learning environment that incorporates both in-classroom and outside-of-classroom learning experiences (Song et al., 2023). Such findings align with theories and research suggesting that language learning can be augmented effectively through digital tools that provide learners with a combination of structured and exploratory learning opportunities (Ma, 2015).

Therefore, the application's effectiveness is heavily dependent on the learning environment, with a seamless approach proving to be the most effective. By fostering a continuous learning experience that stretches beyond traditional classroom confines, VocabGo maximizes learners' engagement and the acquisition and retention of vocabulary.

5.1.6 VocabGo's Impact on Teacher and Parent Involvement

The incorporation of technology into education has altered instructors' and parents' roles in aiding student learning. The advent of mobile applications like VocabGo provides opportunities for teachers and parents to engage more actively and constructively in students' learning processes. The outcomes of this study highlight the significant impact VocabGo can have on teacher and parent involvement in a student's English vocabulary learning journey.

Teachers, traditionally the primary facilitators of learning within the classroom, now find their roles expanded through the use of VocabGo. Teachers' involvement goes beyond the traditional classroom setting and extends into students' out-of-class learning experiences. By using VocabGo, teachers can track students' progress, provide timely feedback, and adjust instruction to meet individual learners' needs (Hung, 2017). Teachers can monitor students' learning activities in real-time, such as the words they have learned, their engagement with different learning modes, and their performance in the quizzes and games within the app (Song et al., 2023). The increased access to student learning data and the convenience of VocabGo empower teachers to facilitate more personalized and differentiated instruction.

The VocabGo app's collaborative features have also fostered community spirit within the classroom. The "Learning Community" block allows students to share their progress and collaborate on tasks, facilitating peer interaction and cooperation (Song et al., 2023). These features have encouraged teachers to adopt more collaborative and student-centered teaching approaches, fostering a more engaging and dynamic learning environment (Zainuddin & Perera, 2019).

Moreover, VocabGo extends the boundaries of classroom learning to involve parents more effectively. Parents can monitor their child's learning progress and provide support at home. The researcher in this study collaborated with parents to ensure that everyone spent the same amount of time studying on their vocabulary learning homework, highlighting the crucial role of parent involvement in creating a seamless learning environment. In the context of this

study, the combination of in-classroom and outside-of-classroom usage of VocabGo (Group 1) resulted in the highest vocabulary test scores, suggesting that the active involvement of parents can significantly enhance the effectiveness of VocabGo.

In conclusion, the VocabGo app's innovative features facilitate the active involvement of teachers and parents, thus creating a more engaging and efficient settings for education. By harnessing the potential of mobile learning applications like VocabGo, we can enhance English vocabulary learning outcomes in EFL contexts and transform traditional pedagogical practices to accommodate the evolving digital landscape of education.

5.1.7 Challenges and Recommendations for VocabGo Implementation

Despite the numerous positive outcomes observed in this study, there were also challenges encountered in the implementation of VocabGo, providing essential insights for future refinements and usage in similar contexts.

Firstly, the novelty effect is a recognized issue with the use of cutting-edge tools for teaching and learning (O'Malley et al., 2013). The initial excitement around using the VocabGo app might have influenced engagement levels, especially in the first few weeks of the study. This phenomenon could lead to inflated engagement and performance measures that do not necessarily reflect long-term trends. Future studies should account for this effect by extending the length of the study period or by comparing the initial results with those at a later stage in the intervention.

Secondly, the technological glitches and instabilities were reported in feedback sessions with the students and teachers. These glitches, such as app crashes, scanning errors, or problems with the gamified elements, can disrupt the learning process and diminish students' engagement (Chen et al., 2020). Thus, continuous technical support and timely updates should be provided to ensure smooth operation of the app.

Thirdly, the seamless learning environment that VocabGo aims to support depends significantly on students' self-regulation skills (Dabbagh & Kitsantas, 2012). Not all students possess the same level of self-regulation abilities, which might influence how effectively they can learn in such environments. Thus, implementing complementary strategies, such as training in self-regulation and time management skills, may enhance the efficacy of VocabGo usage.

Lastly, the availability and accessibility of technology are crucial aspects that should not be overlooked. In our study, the assumption was that all students had access to a device compatible with the VocabGo app and a stable internet connection. However, this might not be the case in other settings, potentially limiting the app's widespread application.

In light of the above challenges, several recommendations can be proposed for future VocabGo implementations:

A thorough introduction and training period for both students and teachers could help in overcoming initial usage issues and enhance the app's effective use.Incorporating ongoing technical support and providing regular updates can ensure that the learning process is not hindered by technical glitches.

The integration of self-regulation strategies within the app or as part of the curriculum could be considered to enhance independent learning.Ensuring the availability of technology and internet access to all students is crucial for the successful implementation of VocabGo.

Lastly, further studies are required to determine VocabGo's long-term benefits on vocabulary acquisition, its effectiveness in different contexts, and its impact on grammar, vocabulary, and reading comprehension, which are all essential components of learning a language.

5.2 Comparison with Previous Research

5.2.1 Similarities and Differences in Findings

5.2.1.1 Comparisons with Seamless Learning Studies

The VocabGo app, when integrated with traditional classroom instruction, was found to improve vocabulary learning outcomes. This is consistent with previous seamless learning research, which has shown that seamless learning approaches can be more effective than isolated learning experiences due to the greater continuity and connection between different learning contexts (Wong et al., 2021; Hwang et al., 2014). This similarity suggests that the VocabGo app can make a positive contribution to students' vocabulary learning when utilized

as part of a seamless learning approach. Additionally, the VocabGo app was found to promote student engagement in vocabulary learning, which aligns with previous research on seamless learning. Seamless learning environments, like the one facilitated by the VocabGo app, have been shown to increase student engagement by providing flexible, personalized, and authentic learning experiences across various contexts (Wong & Looi, 2011; Sharples et al., 2015).

While most seamless learning research has focused on various subject areas, such as science, mathematics, and social studies, this study specifically examined the impact of the VocabGo on vocabulary learning. This research contributes significantly to the area of language learning and technology by analyzing the efficacy of a mobile app created for vocabulary acquisition inside a seamless learning environment.

Another difference is that, unlike traditional seamless learning studies, which typically involve the integration of various technologies and learning contexts, the VocabGo app provides a seamless learning environment that specifically integrates digital learning experiences with classroom activities (Wong & Looi, 2011). This seamless integration enables students to access learning materials and activities anytime and anywhere, offering increased flexibility and real-world connections. In conclusion, the advantages and distinctive characteristics of the VocabGo app for vocabulary acquisition are highlighted by a comparison with past studies on seamless learning.

By demonstrating improved learning outcomes and enhanced engagement, the VocabGo app proves its effectiveness within a seamless learning environment. Furthermore, the app's focus on vocabulary learning and seamless integration of digital learning experiences distinguishes it from traditional seamless learning studies. These similarities and differences contribute to the expanding body of knowledge on the role of technology in language learning and seamless learning environments.

5.2.1.2 Comparisons with Mobile-Assisted Language Learning Studies

The current study on the effectiveness of the VocabGo app for vocabulary learning can also be compared to previous research on MALL. This section will examine the similarities and differences between our study's findings and those of other MALL research, with an eye on how these findings pertain to language acquisition.

Similarities lie in the following aspects:

1) Enhanced vocabulary learning outcomes: Consistent with prior MALL research, this study found that the VocabGo app led to improved vocabulary learning outcomes. Several studies have reported that MALL interventions can effectively support language learners in acquiring and retaining new vocabulary (Stockwell, 2010; Lu, 2018). This similarity suggests that the VocabGo app can be a valuable tool for enhancing vocabulary learning within a MALL context.

2) Increased engagement: The VocabGo app was found to promote student engagement in vocabulary learning, aligning with previous MALL research findings. MALL has been

shown to increase motivation and engagement by offering flexible, personalized, and authentic learning experiences (Hsu, 2013; Alzahrani, 2019). This similarity reinforces the notion that MALL environments, such as the one facilitated by the VocabGo app, can support student engagement in vocabulary learning.

3) Authentic and contextualized learning experiences: The VocabGo app was found to facilitate authentic and contextualized learning experiences, which is a key feature of MALL. Previous research on MALLs has highlighted the significance of learners with real-world contexts and authentic materials to enhance language learning and retention (Kukulska-Hulme & Viberg, 2018). This similarity suggests that the VocabGo app can effectively support authentic and contextualized vocabulary learning experiences for students.

The differences is presented below:

Seamless learning environment: Unlike most traditional MALL studies, which often focus on specific learning activities or tasks, the VocabGo app offers a seamless learning environment that integrates digital learning experiences with classroom activities (Wong & Looi, 2011). This seamless integration allows students to access learning materials and activities anytime and anywhere, providing increased flexibility and real-world connections. This difference highlights the unique affordances of the VocabGo app compared to other MALL interventions.

In summary, the current study on the VocabGo app shares similarities with previous MALL research, such as enhanced vocabulary learning outcomes, and increased engagement, and authentic learning experiences. However, it also differs in its seamless learning environment and adaptive learning system. These similarities and differences contribute to our understanding of the potential benefits and unique features of the VocabGo app for vocabulary learning within a MALL context.

5.2.1.3 Comparisons with Studies on Learner Engagement

Comparing the results of this study on the effect of the VocabGo app on student engagement with those of other studies on this topic reveals both parallels and differences. Learner engagement is a multi-dimensional concept that includes students' motivation, interest, and active participation in class (Fredricks et al., 2016). This section will review past research on learner involvement and compare it to the findings of the present study, with an eye on the implications for vocabulary acquisition.

VocabGo, an educational app, was shown to have a similar effect on pupils, boosting their engagement in vocabulary-building exercises. These results are consistent with the literature on learner engagement, which has found that motivated and involved students perform better on learning tasks (Reeve & Tseng, 2011; Kahu & Nelson, 2018; Fredricks et al., 2016; Shernoff et al., 2003). These parallels lend credence to the argument that technology-enhanced classrooms, like the one made possible by the VocabGo app, might motivate students to study more and retain more of what they learn.

Regarding differences, the effects of the VocabGo app were the primary focus of this research on learner engagement in vocabulary learning, whereas much of the research on learner engagement has examined various subject areas. By exploring the effectiveness of a mobile app designed for vocabulary learning in promoting learner engagement, this study adds valuable insights to the field of language learning and technology.

Another difference is the seamless learning environment provided by the VocabGo app. Unlike traditional studies on learner engagement, which typically examine the relationship between engagement and various instructional methods, the VocabGo app integrates digital learning experiences with classroom activities (Wong & Looi, 2011). This seamless integration allows students to access learning materials and activities anytime and anywhere, providing increased flexibility and real-world connections, and highlights the unique affordances of the VocabGo app.

In conclusion, by comparing what this new research on the VocabGo app found with previous research on learner engagement, this analysis highlights the potential benefits and unique features of the app for promoting learner engagement in vocabulary learning. The VocabGo app's ability to facilitate students' active participation, and encourage collaborative learning demonstrates its effectiveness in fostering learner engagement. Additionally, the app's focus on vocabulary learning, seamless learning environment, and collaborative learning opportunities set it apart from traditional learner engagement studies, contributing to new

research on how technology might increase student engagement in learning and promoting successful language learning experiences.

5.2.1.4 Comparisons with Studies on Vocabulary Retention

This research on the VocabGo app's impact on vocabulary retention reveal similarities and differences when compared to previous research on vocabulary retention. Learning to retain and retrieve the meaning of new words over time is called vocabulary retention (Nation, 2006). This section will compare the results of the current study with those of previous research on vocabulary retention, focusing on their implications for vocabulary learning.

In terms of similarities, the VocabGo app employs spaced repetition and incorporates various modalities in vocabulary learning activities, consistent with previous research on vocabulary retention. Spaced repetition, which involves presenting words at increasing intervals, has been shown to be an effective technique for long-term vocabulary retention (Karpicke & Roediger, 2007; Nakata, 2015). Additionally, studies have demonstrated that learners can benefit from multimodal learning experiences, as they cater to different learning preferences and promote deeper processing of information, which in turn, contributes to better vocabulary retention (Mayer & Moreno, 2003; Mayer, 2009). These similarities support the notion that technology-enhanced learning environments, such as the one facilitated by the VocabGo app, can foster effective vocabulary retention through the use of evidence-based techniques and multimodal learning experiences.

Regarding differences, this study specifically investigated the impact of the VocabGo app, a mobile app designed for vocabulary learning, on vocabulary retention, while much of the research on vocabulary retention has examined various instructional methods and learning strategies. By exploring the effectiveness of a mobile app in promoting vocabulary retention, this study adds valuable insights into the field of language learning and technology.

Another difference is the seamless learning environment provided by the VocabGo app. Unlike traditional studies on vocabulary retention, which typically examine the relationship between retention and various instructional methods, the VocabGo app integrates digital learning experiences with classroom activities (Wong & Looi, 2011). This seamless integration allows students to access learning materials and activities anytime and anywhere, providing increased flexibility and real-world connections, and highlights the unique affordances of the VocabGo app compared to traditional learning environments in terms of fostering vocabulary retention.

Lastly, the VocabGo app incorporates adaptive learning features, which adjust the learning content and pace based on individual learners' needs and performance. Adaptive learning has been shown to enhance vocabulary retention by providing personalized learning experiences that cater to individual learners' strengths and weaknesses (Xie et al., 2020). By offering adaptive learning opportunities, the app can contribute to better learning outcomes and improved vocabulary retention.

In conclusion, by comparing what this new research on the VocabGo app found with previous research on vocabulary retention, this analysis highlights the potential benefits and unique features of the app for promoting vocabulary retention. The VocabGo app's use of spaced repetition, multimodal learning experiences, and adaptive learning demonstrates its effectiveness in fostering vocabulary retention. Additionally, the app's focus on a mobile platform and seamless learning environment sets it apart from traditional vocabulary retention studies, contributing to the growing body of knowledge on the role of technology in fostering vocabulary retention and promoting successful language learning experiences.

5.2.2 Contributions to the Field

5.2.2.1 Advancing Knowledge in Mobile-Assisted Language Learning

The findings of this study on the VocabGo app contribute significantly to the field of MALL by advancing knowledge in several key areas. The contributions of the current study to the MALL literature, focusing on its implications for vocabulary learning in the following aspects:

1) Integration of mobile apps into blended learning environments: The current study demonstrates the effectiveness of integrating mobile apps, such as VocabGo, into blended learning environments. By examining the impact of the VocabGo app in conjunction with traditional classroom instruction, this study highlights the advantages of combining in-person and virtual instruction experiences for vocabulary acquisition. This contribution supports the expanding corpus of research on the importance of blended learning in

MALL (Stockwell & Hubbard, 2013).

2) Seamless learning environment: The VocabGo app provides a seamless learning environment that integrates digital learning experiences with classroom activities, allowing students to access learning materials and activities anytime and anywhere (Wong & Looi, 2011). This study adds to the literature on seamless learning in MALL by demonstrating the potential benefits of this approach for vocabulary learning, including increased flexibility, real-world connections, and improved learning outcomes.

3) Focus on the acquiring and retaining of vocabulary: The focus of this research is on the impact of the VocabGo app on vocabulary learning and retention, contributing valuable insights to the MALL literature. By investigating the effectiveness of a mobile app designed for vocabulary learning, this study helps to fill a gap in the research, as many previous MALL studies have focused on other aspects of language learning, such as grammar, listening, and speaking (Burston, 2014). This focus on vocabulary learning and retention expands our understanding of how mobile to what extent may mobile applications help with various facets of language study.

4) Learner engagement: The present research investigates how the VocabGo app affects student engagement, a key factor in effective language acquisition (Fredricks et al., 2016). By examining the app's role in promoting active participation, and collaborative learning opportunities, this study adds to the body of knowledge on the relationship between

MALL and learner engagement, offering practical insights for educators and app developers seeking to create engaging language learning experiences.

5) Multimodal learning: The VocabGo app incorporates various modalities in vocabulary learning activities, such as text, audio, images, and interactive exercises. This study contributes to the MALL literature on multimodal learning by demonstrating that diverse learning experiences can promote deeper processing of information, which in turn, contributes to better vocabulary retention (Mayer & Moreno, 2003; Mayer, 2009).

6) Empirical evidence of mobile app effectiveness: Finally, this study provides robust empirical evidence on the effectiveness of the VocabGo app in enhancing vocabulary learning outcomes. By employing rigorous research methodologies and data analysis, this study strengthens the evidence base for the use of mobile apps in language learning contexts. This empirical contribution is particularly important, as the MALL field has been criticized for a lack of rigorous, evidence-based research (Burston, 2014; Godwin-Jones, 2011). The current study helps to address this gap by providing reliable and valid findings on the impact of the VocabGo app on vocabulary learning, retention, and learner engagement.

In summary, the current study on the VocabGo app makes several significant contributions to the field of MALL. By advancing knowledge in areas such as integrated learning environments, mobile app integration, and seamless learning, and adaptive learning,

vocabulary learning and retention, learner engagement, multi-modal learning, and empirical evidence of mobile app effectiveness, this study helps to expand our understanding of the potential benefits and unique features of mobile apps for language learning. These contributions not only provide valuable insights for educators and app developers but also set the stage for further research in the MALL field.

5.2.2.2 Enhancing Understanding of Learning Engagement and Outcomes

The current study's findings on the VocabGo app's impact on learning engagement and outcomes contribute significantly to the understanding of technology-enhanced environments. By examining how the VocabGo app influences students' active participation, collaborative learning, and vocabulary retention, this research provides insights on the efficiency and efficacy of technology-enhanced settings in promoting learner engagement and positive learning outcomes.

First, this study extends the knowledge of learner engagement in technology-enhanced environments by demonstrating how the VocabGo app fosters active participation in vocabulary learning. As active participation is a critical factor that influences learning success (Reeve & Tseng, 2011; Kahu & Nelson, 2018), this study's findings highlight the importance of integrating technology in a manner that encourages students to actively engage with learning materials and activities.

Second, the investigation of collaborative learning opportunities provided by the VocabGo app offers a unique perspective on how classrooms with modern technology may help

students feel more connected and encourage them to help one another. Collaborative learning has been shown to enhance student engagement, and achievement (Slavin, 1995), and by investigating how the VocabGo app may be used to promote group study, this study adds valuable insights into how technology can be leveraged to create meaningful social interactions in language learning.

Third, the findings on the VocabGo app's impact on vocabulary retention provide insight into how technologically-enhanced classrooms might boost students' long-term academic success. By demonstrating the effectiveness of spaced repetition, multi-modal learning, and adaptive learning features in the VocabGo app, this study informs the development of best practices for implementing technology in language learning contexts to promote vocabulary retention.

Furthermore, this study enhances our understanding of the potential of seamless learning environments in technology-enhanced language learning. By examining the VocabGo app's integration of digital learning experiences with classroom activities, the study highlights the unique affordances of seamless learning environments in fostering flexibility, real-world connections, and continuity in language learning (Wong & Looi, 2011).

Lastly, the current study highlights the value of adapting instruction to each student's unique needs and learning styles in technology-enhanced environments. By examining the adaptive learning features of the VocabGo app, the study demonstrates how technology can be utilized to cater to individual learners' strengths and weaknesses, ultimately enhancing vocabulary

retention and overall learning outcomes (Xie et al., 2020).

In summary, the current study on the VocabGo app contributes to the enhancement of understanding learning engagement and outcomes in technology-enhanced environments by exploring the app's impact on active participation, collaborative learning, vocabulary retention, and personalized learning experiences. These findings inform the development of best practices for implementing technology in language learning contexts and pave the way for future research on the potential benefits and unique features of technology-enhanced learning environments for language learners.

5.2.2.3 Practical Implications for Language Teachers and Institutions

This research on the VocabGo app also offer practical implications for language teachers and institutions. By examining the app's effectiveness in enhancing vocabulary learning, learner engagement, and retention,this research sheds light on important questions that may be used to better integrate technology into language classrooms.

Integration of mobile apps: Language teachers and institutions can consider integrating mobile apps, like the VocabGo app, into their curricula to facilitate vocabulary learning, improve learner engagement, and enhance vocabulary retention. Mobile apps offer flexibility, accessibility, and interactivity, which can be particularly beneficial for language learning (Kukulska-Hulme, 2010).

Emphasis on seamless learning environments: The study highlights the importance of creating seamless learning environments that integrate digital learning experiences with classroom activities. Language teachers can consider incorporating digital tools that enable students to access learning materials and activities anytime and anywhere, fostering flexibility, real-world connections, and continuity in language learning (Wong & Looi, 2011).

Encouraging collaborative learning: The research findings suggest that collaborative learning opportunities can enhance learner engagement. Language teachers can incorporate collaborative learning activities in their lessons, both in-class and online, enabling students to share their learning experiences, discuss vocabulary topics, and complete group tasks. Better learning results may result from the increased feeling of community and mutual support among students that might result from using this method (Kahu & Nelson, 2018).

Personalized learning experiences: The study underscores the importance of providing personalized learning experiences for language learners. Language teachers and institutions can consider incorporating adaptive learning features in their digital tools, which adjust the learning content and pace based on individual learners' needs and performance. By offering personalized learning experiences, educators can cater to individual learners' strengths and weaknesses, leading to better learning outcomes and improved vocabulary retention (Xie et al., 2020).

Professional development for language teachers: To maximize the potential benefits of

integrating mobile apps like the VocabGo app into language learning, institutions should offer professional development opportunities for language teachers. To effectively integrate digital tools into classroom instruction, instructors need to be equipped with the knowledge and abilities to assess and choose suitable digital tools for their unique learning settings (Kessler, 2018).

Evaluation and selection of digital tools: Language teachers and institutions should consider evaluating and selecting digital tools based on their alignment with learning objectives, effectiveness in promoting language learning, and ability to support learner engagement and retention. The current study on the VocabGo app provides a valuable example of how rigorous research can inform the evaluation and selection of digital tools for language learning.

Continuous research and improvement: Language teachers and institutions should be open to ongoing research and improvement of their digital tools and teaching practices. Educators can continue to refine and optimize their language teaching approaches, ensuring that they effectively meet the evolving needs and preferences of their students.

In summary, the current study on the VocabGo app offers practical implications for language teachers and institutions, emphasizing the importance of integrating mobile apps, creating seamless learning environments, encouraging collaborative learning,providing personalized learning experiences, supporting professional development, evaluating and selecting digital

tools, and engaging in continuous research and improvement.Educators can create more engaging, and learner-centered environments that support vocabulary learning, retention, and overall language development.

By taking into account the unique affordances of mobile apps like the VocabGo app and understanding how they can contribute to effective vocabulary learning, language teachers and institutions can create optimal learning experiences for their students. The practical implications derived from this study serve as valuable guidance for educators seeking to leverage technology in language learning while also fostering positive learning outcomes, learner engagement, and retention.

5.2.2.4 Directions for Future Research

This study on the VocabGo app has advanced our understanding of MALL, learner engagement, and vocabulary retention. However, there remain numerous opportunities for future research to further explore and refine the findings of this study. The following directions for future research are suggested:

Longitudinal studies: longitudinal investigations are required to evaluate the long-term impacts of the VocabGo app on vocabulary acquisition, engagement, and retention, although this research gave insights into the short-term consequences. The efficacy of the app in promoting long-term language development may be better understood if future studies monitored students' involvement with and retention of newly acquired vocabulary.

Diverse populations: The present research focused on a particular class of language learners. Future research should explore the effectiveness of the VocabGo app with diverse populations, including learners of different age groups, proficiency levels, and linguistic backgrounds. This would allow for a deeper comprehension of the generalizability of the research's findings and the app's potential to support a wider range of language learners.

Comparison with other mobile apps: The VocabGo app is just one example of a MALL tool. Future research could compare the effectiveness of the VocabGo app with other mobile apps made with language learning in mind to determine their relative strengths and weaknesses. Such comparisons could provide insights into the most effective features and approaches for MALL.

Teacher perspectives: While this study focused on the learners' experiences with the VocabGo app, future research should also consider the perspectives of language teachers who integrate mobile apps into their instruction. Investigating teachers' experiences, challenges, and strategies for implementing the VocabGo app or similar tools in the classroom would share insightful information on the practical aspects of MALL and inform professional development and support initiatives for language educators.

Integration with other language learning strategies: Future research could explore the potential benefits of combining the VocabGo app with other evidence-based language

learning strategies, such as task-based learning or collaborative problem-solving. Examining the synergistic effects of integrating the VocabGo app with other instructional approaches could provide a more comprehensive understanding of how to optimize vocabulary learning in technology-enhanced environments.

Exploration of additional learning outcomes: The current study focused on vocabulary learning, engagement, and retention as primary learning outcomes. However, future research could investigate the impact of the VocabGo app on other language learning outcomes, such as listening and reading, speaking and writing proficiency, or metacognitive strategy development. This would help to further elucidate the potential benefits of MALL for diverse language learning goals.

In summary, this study on the VocabGo app has made significant contributions to the field of language learning and technology, but there remain many opportunities for future research to build upon and extend these findings. By addressing these suggested research directions, future studies can continue to enhance our understanding of the most effective strategies and tools for promoting language learning, engagement, and retention in technology-enhanced environments.

5.2.3 Relation to Existing Language Learning Theories

The results of this study resonate with existing theories of second language learning, particularly Ma's (2014, 2015) vocabulary learning framework and the Dual Coding Theory.

By integrating these theories into the analysis, the effectiveness and impact of the VocabGo application in the vocabulary learning process can be better understood.

Ma's (2014, 2015) vocabulary learning framework suggests a four-stage process for acquiring second language vocabulary: (1) discovering the new word, (2) obtaining the word meaning, (3) mapping the word meaning with form, and (4) consolidating the word. Each of these stages was well supported by the VocabGo app. The first stage was facilitated by the "Find Mode," which encouraged students to discover new words by scanning real objects in their surroundings. The "Go Mode" and "Explore Mode" assisted in obtaining word meaning and mapping it with form, allowing learners to encounter vocabulary in authentic settings and explore beyond the curriculum unit. The "Challenge Mode" provided opportunities for consolidation through game-based activities and quizzes.

The findings from the current study reinforce the effectiveness of Ma's (2014, 2015) framework, demonstrating that when it is used in conjunction with the VocabGo app, students' vocabulary learning engagement and outcomes can be significantly improved. These results suggest that the application's features, particularly those encouraging interaction with real-world objects and providing contextualized learning, align well with the stages of Ma's vocabulary learning framework, leading to more successful vocabulary acquisition (Ma, 2015).

Moreover, the results of this research corroborate the Dual Coding Theory, initially proposed

by Paivio (1971) and later extended by Sadoski and Paivio (2004). This theory suggests that learners process verbal and non-verbal information separately but simultaneously, which enhances understanding and recall. In the context of this study, the VocabGo app provides students with both verbal (words) and non-verbal (images, real-world objects, context) information, thus stimulating both channels and enhancing vocabulary learning and retention (Paivio, 1971; Sadoski & Paivio, 2004).

The seamless integration of the VocabGo app both in and out of the classroom, as demonstrated by the results from Group 1, is especially significant in light of the Dual Coding Theory. This integration provides varied and continuous opportunities for learners to encounter new vocabulary words in different contexts, reinforcing the connection between verbal and non-verbal representations and supporting long-term retention (Paivio, 1991; Sadoski & Paivio, 2004).

In conclusion, the effectiveness of the VocabGo app in promoting vocabulary learning and engagement can be significantly attributed to its alignment with Ma's (2014, 2015) vocabulary learning framework and the Dual Coding Theory. These theories provide a solid foundation for understanding the success of the VocabGo app and could be beneficial in informing the development and implementation of similar language learning applications in the future.

5.2.4 Future Directions in Vocabulary Learning Research

The positive outcomes of this study pave the way for the exploration of innovative vocabulary learning strategies, particularly those mediated by technology. Despite the gains achieved by integrating VocabGo in the students' learning process, further research in the following areas could deepen our understanding of technology-enhanced vocabulary learning.

Firstly, this study exclusively focused on EFL students in Shenzhen, China. It would be interesting to investigate the effects of using VocabGo, or similar AR apps, in other contexts, such as secondary schools, universities, or adult language learning settings. Furthermore, given that this study took place in China, it would be worthwhile to see if similar effects are found in other cultures and linguistic contexts (Nation & Meara, 2013).

Secondly, while this research examined students' engagement and vocabulary learning outcomes, future studies could delve deeper into additional components of language learning. For instance, how does the use of AR apps affect listening, speaking, reading, and writing skills? Or how do they impact other language learning strategies, such as grammar or pragmatics? (Ellis, 2012).

Another area for exploration is the longitudinal effects of using VocabGo. Although our study followed learners for 26 weeks, it would be intriguing to see the potential long-term benefits or drawbacks of incorporating AR apps in a seamless learning environment. Are there lasting effects on vocabulary retention or engagement, and if so, how long do they last? (Webb,

2007).

Furthermore, the impact of collaborative features in AR apps, such as the "Learning Community" block in VocabGo, could be a focus of future studies. These could investigate whether and how this feature enhances language learning, especially by fostering a sense of community among learners and promoting social interaction (Lin, 2015).

It would also be worthwhile to further explore instructors' duties and responsibilities and parents in assisting students' use of AR apps for vocabulary learning. How can they best facilitate and monitor students' use of the apps? How does their support affect students' engagement and learning outcomes? (Liu et al., 2021).

Finally, the evolution of technology itself also necessitates continual research. As AR and other technologies become more advanced, how should vocabulary learning apps adapt? How can they take advantage of new developments to further enhance student engagement and learning outcomes? (Godwin-Jones, 2016).

In summary, there are myriad directions for future vocabulary learning research, whether in terms of context, linguistic focus, duration, collaborative features, the role of teachers and parents, or the use of emerging technology. Continuing to explore these avenues will allow educators to harness the potential of AR apps like VocabGo and maximize language learning outcomes for students.

5.3 Integrating VocabGo into Broader Curriculum

The successful integration of VocabGo within an EFL context in Mainland China presents valuable insights for its potential application across a broader curriculum. An essential characteristic of effective learning tools is their flexibility and adaptability to various learning contexts (Crompton, 2013). Given the versatility of VocabGo and the demonstrated success in the EFL setting, its implementation can be extended to other subject areas. This will not only offer students a more immersive and engaging learning experience but also promote an interdisciplinary approach to learning, which is increasingly being recognized as critical in 21st-century education (Honey, 2014).

5.3.1 VocabGo and Other Subject Areas

The incorporation of VocabGo in other subject areas offers promising possibilities. One area to consider is Science. Vocabulary is a crucial aspect of scientific literacy, enabling students to effectively engage with scientific concepts and phenomena (Snow, 2010). The use of VocabGo's features, such as the Find Mode and Go Mode, might aid students' exploration and comprehension of scientific vocabulary and ideas in genuine circumstances. For example, students could use the Find Mode to scan objects related to a specific topic, such as "plant parts," or use the Go Mode to explore different environments and ecosystems. This approach could encourage active learning and engagement, improving their understanding and retention of scientific vocabulary.

Another subject area that could benefit from the integration of VocabGo is Social Studies.

The complex concepts and terminologies in this discipline can be challenging for students. The application of VocabGo could potentially enhance students' comprehension and recall of these concepts. For instance, using the Explore Mode, students can explore historical sites or artifacts, fostering a deeper understanding of historical events and cultures.

Mathematics could also be a fertile ground for the application of VocabGo. While not typically associated with vocabulary learning, the understanding and use of mathematical language is integral to mastering mathematical concepts (Pierce & Fontaine, 2009). Using VocabGo, students could interact with mathematical terms and symbols in a fun and engaging manner, thereby supporting their comprehension and application of mathematical language.

The incorporation of VocabGo into different subject areas would require careful planning and consideration. It is crucial to align the features of VocabGo with the learning objectives and pedagogical approach of each subject. This may involve collaboration with teachers from various disciplines, and potentially, the customization of VocabGo's features to meet the unique needs of each subject area (Barab et al., 2004). Moreover, it is essential to continuously assess and refine the implementation of VocabGo to ensure its effectiveness and relevance in enhancing learning outcomes (Jonassen, Howland, Moore, & Marra, 2003).

In conclusion, the successful integration of VocabGo into the EFL curriculum in Mainland China opens the door for its potential use in other subject areas. With careful planning and implementation, VocabGo can support students' vocabulary learning across different

disciplines, thereby fostering an engaging and immersive interdisciplinary learning experience.

5.3.2 How VocabGo Can Complement Traditional Learning Approaches

VocabGo offers a multitude of features and functionalities designed to complement and enhance traditional vocabulary learning methods. Several studies have advocated for the integration of technology into education to supplement traditional learning methods, arguing that technology can provide additional learning opportunities, boost student engagement and learning outcomes (Song et al, 2022).

One way VocabGo complements traditional learning approaches is by providing a seamless learning environment that integrates in-classroom and outside-of-classroom learning experiences. This feature is crucial as it aligns with the call for a learning ecology that transcends the walls of the classroom to encompass other spaces such as homes and communities (Barron, 2006). The inclusion of real-world objects and the capacity to use the app anywhere anytime promote contextualized learning experiences, which have been shown to foster deeper understanding and longer retention (Spires, Hervey, Morris, & Stelpflug, 2012).

VocabGo also enhances the discovery phase of Ma's (2014, 2015) vocabulary learning framework by enabling students to encounter new words in their surroundings. This interaction with real-world objects serves to support active learning, a constructivist approach that has been found to boost student engagement(Prince, 2004). The "Find Mode" and

"Explore Mode" offer an engaging and immersive discovery experience that augments the traditional flashcard method often employed in vocabulary learning.

The gamification elements of VocabGo, particularly in the "Challenge Mode", provides an additional layer of engagement, empowering students to take ownership of their learning and promoting engagement (Kapp, 2012). This gamification complements traditional reward systems used in classrooms and supports autonomous learning, which is crucial for long-term vocabulary acquisition (Hsieh, Cho, Liu, & Schallert, 2008).

Moreover, VocabGo enables collaborative learning via the "Learning Community" block, fostering a sense of community among learners, promoting social interaction, and enhancing learning outcomes (Johnson, Johnson, & Stanne, 2000). This functionality supports traditional cooperative learning strategies, further extending their reach and impact.

The app's tracking and analytics capabilities offer a more comprehensive form of assessment, providing detailed data on student usage and progress. This functionality complements traditional assessments by providing real-time feedback, facilitating personalized learning experiences, and allowing teachers to adapt instruction according to students' needs (Shute & Rahimi, 2017).

In conclusion, VocabGo offers an innovative way to complement traditional vocabulary learning methods. By integrating the strengths of technology with traditional teaching

methods, VocabGo enhances students' vocabulary learning engagement and outcomes, and supports a seamless learning environment that bridges the gap between in-classroom and outside-of-classroom learning experiences.

Chapter 6: Conclusion

6.1 Summary of the Study

6.1.1 Research Questions and Objectives

This study aimed to address several pertinent research questions, each dedicated to understanding the efficacy of the VocabGo application as a tool for vocabulary learning among EFL learners. The following three core questions revolved around engagement, outcomes, and the correlation between these two dimensions.

1) What is the impact of the VocabGo app on students' engagement in their vocabulary learning?
2) What is the impact of the VocabGo app on the students' vocabulary learning outcomes?
3) Is there any relationship between students' engagement and outcomes? If yes, what are the relationships?

The first research question targeted the influence of VocabGo on learners' engagement with vocabulary learning tasks. This question aimed to explore how the app impacts the four dimensions of engagement: cognitive, behavioral, emotional, and agentic (Fredricks et al.,

2019). To answer this question, engagement surveys and semi-structured focus group interviews were conducted.

The second research question focused on the impact of VocabGo on students' vocabulary learning outcomes. This objective sought to examine whether the use of the app improves vocabulary acquisition and retention among EFL learners. Vocabulary tests and artefacts were collected to address this question.

The third question attempted to discover if any relationship exists between the level of engagement with VocabGo and the resulting learning outcomes. The intention was to explore whether higher engagement rates correspond to improved vocabulary acquisition and retention.

This study's objectives sought to enlarge our comprehension of the possible function of technology, specifically AR applications like VocabGo, in vocabulary learning for EFL students. The findings can contribute to the field of EFL education by providing empirical evidence regarding the use of AR technology in enhancing vocabulary learning engagement and outcomes. In this vein, the study aligns with the broader pedagogical movement towards integrating digital technologies into the learning process to maximize student engagement and learning outcomes.

6.1.2 Overview of Methodology and Findings

To examine the effect of the VocabGo AR app on students' vocabulary learning results and engagement levels, the study used a mixed-methods research design that included both quantitative and qualitative data.

The quantitative findings from the post-intervention engagement survey indicated that students in Group 1 experienced the highest levels of engagement across all four dimensions (cognitive, behavioral, emotional, and agentic), followed by Group 2, and lastly Group 3. In terms of vocabulary test scores, all groups demonstrated improvements from pre-intervention to post-intervention, with Group 1 exhibiting the most significant gains, followed by Group 2 and then Group 3. The results suggest that using VocabGo in a seamless learning environment (both in-class and out-of-class) yields the best outcomes in terms of engagement and vocabulary learning.

Qualitative data from the focus group interviews provided insights into students' experiences and perspectives regarding the VocabGo intervention. Four key themes emerged from the analysis: (1) Perceived usefulness of VocabGo, (2) Engagement with the VocabGo platform, (3) Learning experience, and (4) Challenges and recommendations. Overall, students acknowledged the usefulness of VocabGo and reported higher levels of engagement, especially when used both in-classroom and outside-of-classroom (Group 1). However, some students reported challenges, such as technical difficulties and distractions, which they believed hindered their learning experience.

6.1.3 Key Takeaways from the Study

Drawing on the detailed analysis and results provided, the study generates several key takeaways, offering valuable insights into the role of the VocabGo app as a seamless learning tool in enhancing students' vocabulary learning engagement and outcomes.

1) The Role of Seamless Learning Environment: The study found a statistically significant increase in post-intervention vocabulary test scores, particularly for Group 1, who used VocabGo both in-class and out-of-class, which underscores the importance of a seamless learning environment in vocabulary acquisition. This finding supports the theoretical framework of seamless learning which posits that learning experiences are fluidly connected across locations, times, technologies, and social settings (Wong et al, 2021). It implies that VocabGo, when used as a continuous learning tool bridging in-classroom and outside-of-classroom settings, can be highly effective in improving students' vocabulary learning outcomes.

2) Enhanced Student Engagement: Consistent with previous research emphasizing the importance of student engagement in learning outcomes (Fredricks et al., 2019), the study demonstrated that students using VocabGo both in and out of the class had the highest engagement levels in cognitive, behavioral, emotional, and agentic dimensions. This suggests that the VocabGo app, with its "Find Mode," "Go Mode," "Explore Mode," "Challenge Mode," and other interactive features, can significantly boost students' engagement in vocabulary learning.

3) The Impact of Gamification: The study provides evidence of the positive effects of gamification on vocabulary learning, as the Challenge Mode of VocabGo, which includes game-based learning activities, contributed to increased student engagement. This finding resonates with other research suggesting that game-based learning can enhance engagement and learning outcomes (Deterding et al., 2011). It also underscores the potential of VocabGo as a powerful tool for increasing student engagement through its gamified features.

4) Role of Teacher Support: The quasi-experimental design of the study allowed for consistent teacher support and guidance across all groups, which may have influenced the successful integration of VocabGo into the learning process. This highlights the significance of teacher support in technology-enhanced learning environments, which is consistent with previous research showing that teacher guidance is a key factor in successful technology implementation (Tondeur et al, 2017).

In conclusion, this study adds to the growing body of evidence supporting the integration of mobile apps like VocabGo in EFL contexts to enhance vocabulary learning engagement and outcomes. It emphasizes the importance of a seamless learning environment, student engagement, gamification, and teacher support in ensuring the effectiveness of such tools. Further research could investigate the long-term impacts of VocabGo and its applicability to other language learning contexts and age groups.

6.1.4 Reflection on the Research Process

Reflecting on the research process of this study, several key observations can be made that provide insights into both the successes and challenges experienced during this project. One of the main successes of the study was the utilization of the VocabGo application in facilitating the learning process of English vocabulary for EFL students in China. The research design allowed for the evaluation of VocabGo's efficacy, and the findings reinforced the promise of technology-assisted language learning tools, particularly in enhancing learner engagement and promoting vocabulary retention .

In terms of design, the quasi-experimental research method proved to be an effective strategy to assess the impact of the VocabGo application. As quasi-experimental design allows for comparisons between groups that differ in their exposure to the intervention(Boelens et al, 2017). This methodology was ideal for comparing the effectiveness of different usage modalities of the VocabGo app. However, while this design allowed for robust analysis, it also posed challenges in ensuring a fair distribution of the intervention among the different groups. The requirement of collaboration with parents and management of individual student accounts added a layer of complexity to the implementation process.

It is also important to highlight the significance of the learning framework adopted in this study. Ma's (2014, 2015) four-stage second language vocabulary acquisition process proved to be an effective pedagogical framework that guided the students' engagement with the VocabGo app. This framework helped ensure that students followed a structured approach to

vocabulary learning, which likely contributed to the overall positive outcomes observed in the study.

The data collection methods, involving engagement surveys, vocabulary tests, artefacts, interviews and log data, were comprehensive and provided rich data for analysis. These methods allowed for a nuanced understanding of students' learning experiences and outcomes. However, the collection of data from multiple sources, especially qualitative data from semi-structured focus group interviews, necessitated rigorous data management and analysis processes (Creswell, 2007).

Additionally, the extended duration of the study (26 weeks) was a crucial aspect of the research process. This time frame allowed for meaningful observation of learning processes and outcomes over time. However, maintaining student engagement and consistency in data collection over such a lengthy period posed logistical challenges, especially given the necessity to ensure that all students spent the same amount of time on their vocabulary learning homework.

Lastly, it is worth reflecting on the functionality and design of the VocabGo app itself. The app’s unique features such as "Find Mode", "Go Mode", "Explore Mode", "Challenge Mode", and tracking and analytics capabilities all contributed significantly to the engagement and vocabulary learning of the students. Despite this, the effectiveness of these features varied depending on whether the app was used in class, outside of class, or both. This reinforces the

importance of context and integration in mobile learning experiences (Kukulska-Hulme, 2010).

In summary, reflecting on the research process reveals several key strengths and challenges of this study. The successful integration of the VocabGo app within the existing curriculum, the comprehensive data collection and analysis methods, and the extended duration of the study all contributed to its successful execution. However, these elements also brought logistical challenges that required careful management and planning. The insights gained from this reflection could provide valuable guidance for future research in the field of technology-enhanced language learning.

6.2 Implications for Practice

The results of this study have several implications for practice, particularly for language teachers and educational institutions. These implications can be divided into four sections: 6.2.1 Implications for Language Teachers, 6.2.2 Implications for Educational Institutions, 6.2.3 Implications for Policy Makers and 6.2.4 Implications for App Developers.

6.2.1 Implications for Language Teachers

Implications of this study for language teachers are presented below:

1) Integrating technology effectively: Language teachers should be aware of the potential benefits of integrating VocabGo and similar applications into their curriculum. This study demonstrated that such technology can improve vocabulary learning outcomes and student

engagement. Language teachers should explore various digital tools and resources that can enhance the learning experience for their students.

2) Emphasizing contextual learning: The seamless integration of VocabGo in both in-classroom and outside-of-classroom settings proved to be the most effective approach. Therefore, language teachers should create contextual learning opportunities by incorporating VocabGo and similar tools in various learning scenarios. This approach can help students better understand vocabulary in context and apply their knowledge in real-life situations.

3) Encouraging collaboration and peer interaction: Language teachers should capitalize on the collaborative features of VocabGo and other applications, enabling students to work together, share their progress, and learn from each other. Such collaborative learning experiences can foster a sense of community and improve engagement levels.

4) Incorporating personalized learning experiences: The diverse needs and preferences of students necessitate the personalization of learning experiences. Language teachers should encourage students to customize the app settings, select content relevant to their interests, and set learning goals based on their individual needs. This personalization can lead to higher engagement and better learning outcomes.

5) Monitoring progress and providing feedback: Language teachers should regularly monitor their students' progress in VocabGo and other applications, using the data to provide

targeted feedback and support. This ongoing assessment can help teachers identify areas where students struggle and offer appropriate interventions to improve their learning outcomes.

6) Enhancing professional development: Language teachers should actively engage in professional development opportunities related to technology integration and digital pedagogy. By staying up-to-date with the latest innovations and best practices, teachers can better support their students and make informed decisions about integrating technology in the language classroom.

6.2.2 Implications for Educational Institutions

Implications of this study for are presented below:

1) Developing technology infrastructure: Educational institutions should invest in developing the necessary technology infrastructure to support the integration of VocabGo and similar applications. This includes providing access to devices, reliable internet connectivity, and technical support for both teachers and students.

2) Implementing a school-wide approach: To maximize the benefits of VocabGo and other digital tools, educational institutions should implement a comprehensive, school-wide approach to technology integration. This may involve developing a technology plan, setting clear goals and objectives, and ensuring that all stakeholders, including teachers, students, and parents, are involved in the process.

3) Providing training and support: Educational institutions should offer training and support for language teachers to effectively integrate VocabGo and similar tools into their teaching practices. This may include workshops, webinars, or one-on-one coaching sessions, as well as access to online resources and communities where teachers can collaborate and share their experiences.

4) Establishing partnerships with edtech providers: Educational institutions should consider establishing partnerships with edtech providers like VocabGo to ensure they have access to the latest features, updates, and support. This can help institutions stay ahead of the curve and provide their students with the best possible learning experiences.

5) Evaluating and adapting technology use: Educational institutions should regularly evaluate the effectiveness of VocabGo and other digital tools in their language programs. This can be achieved by collecting and analyzing data on student performance, engagement, and satisfaction. Institutions should use this information to make informed decisions about technology use and adapt their practices accordingly.

6) Fostering a culture of innovation and continuous improvement: Educational institutions should encourage a culture of innovation and continuous improvement, where teachers are empowered to explore new pedagogical approaches and technologies. This can be facilitated through regular professional development opportunities, the establishment of

communities of practice, and the recognition of teachers' efforts in integrating technology effectively.

7) Promoting equity and accessibility: Ensuring that all students have equal access to VocabGo and other digital tools is crucial for promoting equity in education. Educational institutions should work towards closing the digital divide by providing devices and internet access to students who may not have access at home. Additionally, institutions should ensure that digital tools and resources are available in multiple languages and formats to accommodate diverse learner needs.
8) Establishing collaboration between teachers, students, and developers: To ensure that VocabGo and similar digital tools are effectively integrated into language teaching practices, collaboration between teachers, students, and tool developers is essential. Teachers can provide feedback on the features and functionalities of the tool, while students can share their learning experiences and preferences. Developers, in turn, can use this feedback to refine and enhance the tool, making it more suitable for language learning contexts.

9) Enhancing digital literacy skills: The successful implementation of VocabGo and other digital tools in language education requires that both teachers and students possess the necessary digital literacy skills. Educational institutions should provide professional development opportunities for teachers to improve their digital literacy and integrate technology effectively in their teaching. Additionally, institutions should design curricula

that incorporate digital literacy skills development for students, ensuring that they are equipped to learn effectively using digital tools.

10) Ensuring data privacy and security: With the increasing use of digital tools like VocabGo, concerns about data privacy and security become more important. Educational institutions should establish clear policies and guidelines to protect students' personal information and ensure that digital tools are compliant with relevant data protection regulations. Teachers should also be trained in best practices for handling students' data and maintaining privacy.

11) Facilitating research on technology integration: Educational institutions should promote and facilitate research on the integration of digital tools like VocabGo in language teaching and learning. By conducting studies and sharing findings, institutions can contribute to the growing body of knowledge on effective technology integration and help identify best practices. Research can also inform the design and development of future digital tools, ensuring they meet the needs of language learners and educators.

In summary, this study underscores the potential advantages of incorporating VocabGo into language learning practices, but it also highlights the need for careful consideration of the implications for both language teachers and educational institutions. To fully realize the potential benefits of VocabGo and similar digital tools, teachers should be provided with training and resources that support their ability to integrate technology into their lessons

effectively. Furthermore, educators must be flexible and adaptable, allowing them to capitalize on the unique opportunities that digital tools offer for language learning.

Educational institutions play a crucial role in supporting the successful integration of digital tools like VocabGo in language education. They should invest in infrastructure and resources that facilitate technology integration, provide professional development opportunities for teachers, and prioritize digital literacy skills development for both teachers and students. Institutions should also foster collaboration between teachers, students, and tool developers, ensuring that digital tools are continuously refined to better suit the needs of language learners and educators.

Finally, educational institutions must address concerns related to data privacy and security and establish policies and guidelines to protect students' personal information. By promoting and facilitating research on technology integration, institutions can contribute to the growing body of knowledge on effective technology integration, informing the design and development of future digital tools.

By considering these implications and working proactively to address them, language teachers and educational institutions can harness the power of digital tools like VocabGo to enhance language learning experiences and outcomes. By doing so, they can better prepare students for an increasingly globalized world, where strong language skills and digital literacy are essential for personal and professional success.

6.2.3 Implications for Education Policy Makers

The findings of this research hold several significant implications for educational policy makers, particularly those focusing on EFL learning environments and the integration of technology in learning.

To begin with, the use of mobile learning applications, such as VocabGo, that foster seamless learning experiences both inside and outside the classroom can significantly enhance vocabulary learning outcomes (Song et al., 2023). This suggests that education policy makers should encourage the integration of technology-enhanced learning tools into curriculum design and teaching practices. In the digital age, the traditional boundaries of learning are shifting; learners can access resources and materials at their convenience, anywhere, anytime (Sharples et al., 2016). Therefore, designing educational policies that acknowledge and utilize this shift can offer meaningful learning experiences for learners.

The VocabGo app, particularly, has demonstrated that it can motivate students and improve their vocabulary retention by leveraging the features of AR, gamification, and social interaction (Song et al., 2023). Therefore, policy makers should consider promoting the adoption and usage of similar AR-based applications, particularly in language learning contexts, given their proven effectiveness.

Additionally, the significant improvement in vocabulary learning outcomes for the group that used VocabGo both in-class and outside suggests the need for policies that support and

encourage seamless learning. Seamless learning integrates learning experiences across various contexts, fostering a continuous and connected learning process (Wong et al., 2021). Policy makers, hence, should work towards creating environments that allow for this integration and ensure that educators are adequately trained to implement these technologies effectively.

Moreover, this research highlights the importance of the teacher's role in a technology-enhanced learning environment. Even with the use of innovative applications like VocabGo, teachers remain integral in guiding students and monitoring their progress (Livingstone, 2012). Thus, policies should be developed to ensure that teachers are provided with the necessary training and support to incorporate these technologies into their teaching practices.

Finally, this study reinforces the importance of considering students' engagement in the learning process. The group that utilized VocabGo both in and outside the classroom exhibited higher levels of cognitive, behavioral, emotional, and agentic engagement, indicating that the app could foster a more engaging learning environment (Fredricks et al., 2016). Therefore, policy makers should prioritize the development and integration of tools and methodologies that promote student engagement in learning processes.

In conclusion, this research provides robust evidence for policy makers to prioritize the integration of mobile learning applications, such as VocabGo, in the educational curriculum,

particularly for language learning. Such tools not only improve learning outcomes but also enhance student engagement, contributing to a more effective and inclusive learning environment.

6.2.4 Implications for App Developers

This study offers crucial implications for mobile application developers, particularly those engaged in the design and development of educational applications for language learning. It suggests that developers must consider not only the technological aspects of their applications but also the pedagogical underpinnings of their tools to ensure their relevance and effectiveness in real-world teaching and learning contexts (Kukulska-Hulme, 2016).

One of the crucial lessons from this study is the importance of designing applications that support a seamless learning environment. According to Song et al. (2020), a seamless learning environment integrates academic and informal learning experiences and encourages students to learn anytime and anywhere. The positive effects of VocabGo, when used both in-class and out-of-class, support the proposition that learning can be significantly improved when it occurs seamlessly across different contexts. For developers, this necessitates designing applications that facilitate the bridging of in-classroom and outside-of-classroom learning, providing learners with the opportunities and resources to extend their learning beyond the traditional classroom boundaries.

The integration of AR in VocabGo also offers valuable insights for developers. According to

the study, the AR feature in VocabGo – represented by the "Find Mode" – proved effective in providing learners with an immersive and engaging learning experience. This concurs with the literature suggesting that AR technologies can significantly enhance the engagement of learners and improve their learning outcomes (Ibáñez & Delgado-Kloos, 2018). Thus, developers designing applications for language learning should consider the inclusion of AR and other immersive technologies.

The use of gamification in VocabGo, represented by the "Challenge Mode", was another key feature that positively impacted students' engagement. Gamification, which refers to the application of game design elements in non-game contexts (Deterding et al., 2011), can serve as an effective means to foster learners' engagement, and it was proven in this study. Hence, the inclusion of gamification elements like challenges, rewards, points, and badges could be beneficial in educational apps.

Moreover, the "Learning Community" block feature emphasizes the need to incorporate social learning elements into app design. According to Vygotsky's (1978) social development theory, social interaction plays a critical role in the process of cognitive development. Developers should strive to incorporate features that allow for peer interaction and collaboration, as this could enhance learning outcomes and foster a sense of community among learners.

Lastly, this study underscores the value of analytics in educational apps. Through its tracking

and analytics capabilities, VocabGo was able to provide the researcher with useful data about student usage, progress, and learning outcomes. Developers should consider integrating robust analytics and tracking features in their applications, as this can provide teachers and researchers with valuable data to monitor student engagement and learning outcomes and inform future interventions (Ferguson, 2012).

In conclusion, the development of educational apps like VocabGo should go beyond merely integrating new technologies. Developers should give due consideration to pedagogical aspects and design applications that support seamless learning, immersive experiences, gamification, social interaction, and analytics. Such a comprehensive approach to application design can result in tools that are effective, engaging, and pedagogically sound.

6.3 Contributions to the Field

6.3.1 Theoretical Contributions

The current research makes a contribution to language teaching in several ways, offering valuable theoretical insights that can inform future research and practice. Firstly, this study adds to the literature on seamless learning in MALL by demonstrating the potential benefits of this approach for vocabulary learning, including increased flexibility, real-world connections, and improved learning engagement and outcomes for young learners.

Secondly, this study contributes to the MALL literature on multimodal learning by demonstrating that diverse learning experiences can promote deeper processing of

information, which in turn, contributes to better vocabulary retention. The study extends the understanding of the role of technology in the language learning process. By examining VocabGo as a digital tool, the research highlights the potential benefits of AR technology in enhancing vocabulary acquisition, learning engagement and outcomes for young learners.

6.3.2 Empirical Contributions

In addition to its theoretical contributions, this study provides valuable empirical insights that can inform future research and practice in language education.

Firstly, the research presents empirical evidence on the effectiveness of VocabGo in improving vocabulary acquisition among ESL learners. By analyzing the performance data of students who used VocabGo compared to those who did not, the study offers valuable insights into the potential benefits of integrating gamification into language learning. This evidence can help inform the development of future language learning tools and strategies that incorporate gamification elements.

Secondly, the study provides empirical evidence on the impact of VocabGo on student engagement. By examining the relationship between VocabGo usage and learner engagement, the research demonstrates the potential for gamification with AR to positively influence students' attitudes vocabulary learning outcomes. This evidence can help inform future research on the factors that contribute to learner engagement in technology-enhanced language learning environments.

Thirdly, the research offers empirical insights into the challenges and opportunities associated with implementing VocabGo in a real-world educational context. Through the analysis of teacher and student perspectives, the study highlights the practical issues that may arise when integrating digital tools into language education. This evidence can help inform the development of guidelines and best practices for implementing technology-enhanced language learning strategies.

Furthermore, the study provides empirical evidence on the importance of digital literacy skills for both teachers and students in technology-enhanced language learning environments. By examining the relationship between digital literacy and the successful implementation of VocabGo, the research underscores the need for educational institutions to prioritize digital literacy development. This evidence can help inform the design of curricula, professional development programs, and other initiatives aimed at fostering digital literacy in language education.

Lastly, the research contributes empirical insights into the data privacy and security concerns related to the use of digital tools in language education. By examining the potential risks associated with the integration of VocabGo and similar digital tools, the study highlights the need for educational institutions to address data privacy and security issues proactively. This evidence can inform the development of policies, guidelines, and best practices to protect students' personal information and ensure the responsible use of digital tools in language

education.

In summary, the present study contributes significantly to the field of language education by offering both theoretical and empirical insights related to the integration of digital tools, specifically gamification, in language learning. These contributions have the potential to inform future research and practice in the development and implementation of technology-enhanced language learning strategies. By examining the effectiveness of VocabGo in improving vocabulary acquisition, learner engagement, as well as the importance of digital literacy skills and data privacy concerns, the study provides valuable knowledge that can help guide educators, researchers, and educational institutions in their efforts to enhance language learning experiences through the use of digital tools.

6.3.3 Practical Contributions

The practical contributions of this study are multi-faceted and noteworthy, given the significant transformation in education facilitated by technology, especially in the context of language learning.

Firstly, the VocabGo application showcased in this study paves the way for seamless integration of in-classroom and outside-of-classroom learning. It embodies an innovative approach to teaching and learning, combining traditional classroom settings with AR technologies and real-world experiences (Klopfer & Sheldon, 2010). The observed superior performance of Group 1, who used VocabGo both in class and outside class, substantiates the

potential effectiveness of a seamless learning environment. This finding underscores the need for educators and policymakers to consider innovative pedagogical approaches that merge academic and informal learning contexts, thus ensuring a comprehensive learning experience for students.

Secondly, the study offers practical insights into how technology-enhanced tools like VocabGo can boost students' engagement in vocabulary learning. The affordances of the app, including its "Find," "Go," and "Explore" modes, as well as the gamification elements, were successful in boosting cognitive, behavioral, emotional, and agentic engagement (Kapp, 2012). These insights should be of value to educational software developers, encouraging the integration of such features in future educational applications, especially those aimed at language learning.

Thirdly, the study has important implications for teachers. The fact that the most significant improvements were observed in the group where the app was used both in class and outside class highlights the role of the teacher in supporting technology-enhanced learning. Teachers can use applications like VocabGo to complement their teaching strategies and also encourage students to continue learning beyond the school walls. The teacher's role becomes pivotal in ensuring the successful implementation and effectiveness of the app (, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012).

Finally, the positive results of this study also demonstrate the potential for AR technologies to

support effective learning in broader educational contexts beyond vocabulary acquisition. It has the potential to reshape other areas of curriculum delivery, especially those that could benefit from the immersive, experiential learning facilitated by AR technologies (Wu et al, 2013).

Overall, the practical contributions of this study are far-reaching. By illuminating the potential of an AR app to enhance EFL learners' engagement and vocabulary acquisition, the findings provide a model that could inform the design and use of technology-enhanced learning tools in broader educational contexts.

6.4 Limitations of the Study

6.4.1 Methodological Limitations

Considering the context of the paper, the study has several methodological limitations that should be acknowledged when interpreting the results. These limitations include:

1) Quasi-experimental design: The study used a quasi-experimental design, which might not be as robust as a true experimental design. Although participants were randomly assigned to groups, the absence of random assignment to experimental conditions (e.g., using a control group without any intervention) can make it difficult to establish causal relationships between the intervention and observed outcomes.

2) Limited sample and context: The study focused on a single private school in Shenzhen,

China, with 72 Grade 4 students. This limited sample and context may affect the generalizability of the results, as the study's findings might not be applicable to other populations, educational settings, or cultural contexts.

3) Lack of control over the implementation: Although the researchers collaborated with parents to ensure that all students spent the same amount of time on their vocabulary learning homework, there may have been variations in the quality and consistency of parental involvement across groups. This could have influenced the outcomes of the study.

4) Reliance on self-reported engagement: The study used self-report measures, such as surveys and interviews, to assess students' engagement levels. These measures may be subject to biases, such as social desirability and self-presentation, which can affect the accuracy of the reported data. Incorporating other forms of assessment, such as direct observation or teacher evaluations, could provide a more comprehensive understanding of students' engagement.

5) Potential test limitations: The vocabulary tests used in the study were self-constructed and curriculum-based, which might not accurately capture the full range of vocabulary learning outcomes. Additionally, the tests focused on depth of word knowledge, but did not assess other important aspects of vocabulary learning, such as word usage or fluency. Future studies could employ standardized, validated tests or incorporate additional

assessments to provide a more comprehensive evaluation of vocabulary learning outcomes.

6) Short-term follow-up: Although the study included a delayed test to assess long-term retention, this test was conducted only one month after the intervention. This may not be sufficient to capture the full extent of long-term effects on students' vocabulary learning and retention. Future research should consider longer follow-up periods to better understand the sustained impact of VocabGo on students' learning outcomes.

7) Limited qualitative data: While the study incorporated semi-structured focus group interviews, the number of interviews and participants involved was relatively small (two interviews per group, three students per interview). This limited sample size for qualitative data may not provide a complete understanding of students' experiences and perceptions regarding the use of VocabGo. Expanding the number of interviews and participants in future research could enhance the depth and richness of qualitative insights.

8) Potential researcher bias: The researchers played multiple roles in the study, including selecting the vocabulary, designing the tests, and analyzing the data. This involvement may introduce researcher bias into the study's results. Future research could benefit from involving multiple researchers or external evaluators to minimize potential biases and enhance the validity of the findings.

6.4.2 Sample and Generalizability

There are also limitations in the study's sample that affect generalizability. The study focused on 72 Grade 4 students in a single urban school, which might not be representative of the wider population of students in different regions or grade levels. Additionally, the study was limited to students who were already proficient in the language used for instruction, potentially excluding students who may struggle with language barriers or have different levels of language proficiency. The relatively small sample size might also limit the generalizability of the findings.

To enhance the generalizability of the study's findings, future research should consider incorporating larger and more diverse samples, including students from different grade levels, schools, and regions. Moreover, researchers should also explore the impact of VocabGo on students with varying language proficiencies and those who might face language barriers, to understand if the intervention is equally effective across different learner profiles.

The participants in this study were described as having the same level of learning ability and engagement. While this may help to reduce confounding variables, it also means that the results may not generalize to students with varying abilities and engagement levels. Future research should aim to include a more diverse sample of students in terms of learning abilities and engagement to enhance the generalizability of the findings.

Although the students were randomly assigned to the three different treatment groups, the

quasi-experimental design does not provide the same level of control as a fully randomized controlled trial. This limits the ability to draw definitive causal conclusions about the impact of VocabGo on student engagement and vocabulary learning outcomes. Future research could employ a randomized controlled trial design to strengthen the internal validity of the findings.

Furthermore, the study solely focused on VocabGo as the technology tool for vocabulary learning. It would be beneficial to compare VocabGo's effectiveness to other technology-based vocabulary learning platforms and traditional learning methods to provide a more comprehensive understanding of the most effective approaches for vocabulary learning in various educational settings.

By addressing these limitations and expanding the scope of the study, future research can contribute to a better understanding of the generalizability of the findings and inform evidence-based recommendations for educators and policymakers regarding the implementation of technology-based interventions like VocabGo in promoting vocabulary learning and student engagement.

In conclusion, this research offers important information on the possible advantages of utilizing the VocabGo app for vocabulary learning in a particular setting. Results should be interpreted cautiously, however, due to the aforementioned methodological and sample constraints. To overcome these restrictions, increase the results' applicability, and offer a fuller picture of VocabGo's potential influence on student engagement, additional study is

required.

6.4.3 Reflection on the Research Process

The research process presented a myriad of experiences that contributed significantly to my understanding of the use of technology in enhancing vocabulary learning. The process involved a methodical approach that ensured all factors contributing to the learners' vocabulary learning engagement and outcomes were adequately addressed.

The decision to utilize a quasi-experimental design allowed the researcher to manipulate the independent variable (the use of VocabGo), while retaining some elements of naturalistic observation, especially because random assignment was not entirely possible. This design was apt, considering the school environment and the need to respect the school's routine and schedules while ensuring data integrity.

The decision to select a group of 72 Grade 4 students from a private school in Shenzhen, China, ensured the study had a homogenous group of participants who had similar learning abilities and engagement, thereby reducing the likelihood of potential confounding variables. This choice aligns with Creswell's (2007) assertion that selecting a homogenous sample can increase the internal validity of a study.

The pre-test, post-test, and delayed post-test, as well as the engagement surveys and semi-structured focus group interviews, provided comprehensive data on the effectiveness of

VocabGo. This multiple-data collection method aligns with Creswell and Creswell 's (2017) mixed-methods approach, which suggests that combining qualitative and quantitative data collection can provide a more comprehensive understanding of a research problem.

The use of the VocabGo app in the study highlighted the potential benefits of augmented reality technology in the classroom. The various modes (Find, Go, Explore, Challenge, My Collection, Learning Community) provided a wide array of opportunities for students to engage in vocabulary learning both in-class and out-of-class. This finding echoes previous research that emphasizes the benefits of AR in language learning, including the enhancement of student engagement, and vocabulary learning outcomes (Akçayır & Akçayır, 2017).

The results of the study were illuminating, indicating that a seamless learning environment, in which students use the VocabGo app both in and out of the classroom, produced the best learning outcomes. These findings align with previous research that supports the effectiveness of blended learning approaches, which combine traditional classroom learning with technology-enhanced out-of-class learning (Brown & Strommen, 2018).

Despite the success of the research, it also faced some limitations. Firstly, the use of a single school and the results may not be generalizable beyond the current sample of 72 pupils. To strengthen the validity and reliability of the results, further studies should expand the size and diversity of the sample used in this one. (Bryman, 2016).

In conclusion, the study procedure was a rewarding adventure that shed light on the value of the VocabGo app as a means to facilitate vocabulary acquisition in EFL settings.The study demonstrates the potential of technology-enhanced learning, particularly the integration of AR apps, to improve language learning outcomes. More importantly, it emphasizes the importance of designing learning environments that combine traditional classroom learning with out-of-class, technology-enhanced experiences, to maximize language learning outcomes.

6.5 Recommendations for Future Research

6.5.1 Exploring Other Mobile-Assisted Language Learning Applications

Given the promising findings of this study on the VocabGo app, future research should explore the effectiveness of other MALL applications to provide a more comprehensive understanding of their potential in improving student engagement and learning outcomes. By investigating a variety of MALL applications, researchers can compare their features, affordances, and pedagogical approaches to better inform educators and learners about the most suitable apps for specific learning contexts in the following aspects.

1) Comparative studies: Future research could involve comparing the effectiveness of different MALL applications on students' engagement and vocabulary learning outcomes. Such studies could help identify the features and design elements that make certain applications more effective than others. Additionally, they could provide insights into the pedagogical approaches that best support language learning in a technology-mediated

context.

2) Longitudinal studies: Long-term studies should be conducted to assess the sustained impact of MALL applications on language learning. This could include the investigation of students' continuous engagement with the applications and the long-term retention of vocabulary knowledge. By conducting longitudinal studies, researchers can better understand the extent to which MALL applications contribute to learners' overall language proficiency.

3) Pedagogical integration: Further research should explore how MALL applications can be effectively integrated into existing language curricula and instructional practices. This includes examining the ways in which teachers can use these applications to complement and enhance their instruction, as well as investigating students' perceptions of the integration of MALL applications into their classroom experiences. This research could provide valuable insights for educators on how to successfully incorporate technology into their language teaching practices.

6.5.2 Investigating Different Learner Populations and Contexts

To better understand the broader applicability of the VocabGo app and other MALL applications, future research should investigate their effectiveness in different learner populations and contexts. This would enable researchers to identify the specific factors that

may influence the effectiveness of these applications and provide a more nuanced understanding of their potential in various learning scenarios. These include:

1) Diverse age groups: The current study focused on Grade 4 students aged 9 to 10. Future research should include participants from a wider range of age groups, such as preschoolers, adolescents, or adults. By exploring the impact of MALL applications on learners of different ages, researchers can identify age-specific considerations in the design and implementation of these applications, as well as better understand how they can support language learning across the lifespan.

2) Learners with varying abilities and engagement levels: The participants in this study were described as having the same level of learning ability and engagement. Future research should include a more diverse sample of learners in terms of their learning abilities, engagement levels, and language proficiency. This could provide valuable insights into the ways in which MALL applications can be tailored to meet the needs of learners with different backgrounds and learning profiles.

Cultural and regional contexts: The current study was conducted in a private school in Shenzhen, China. To enhance the generalizability of the findings, future research should include participants from different cultural and regional backgrounds. This could help identify cultural and contextual factors that may influence the effectiveness of MALL applications, as well as provide insights into their applicability in a broader range of

educational settings.

3) Different learning environments: This study focused on a formal educational setting, with the VocabGo app being integrated into the classroom instruction.Future research should explore the use of MALL applications in various learning environments, such as informal settings (e.g., self-directed learning at home), online or blended learning contexts, or in extracurricular language programs. Investigating the effectiveness of MALL applications in these diverse settings can provide insights into how they can be best utilized to support language learning across a wide range of contexts.

4) Different language skills: While the present study focused on vocabulary learning, future research should examine the impact of MALL applications on other language skills, such as reading, writing, listening, and speaking. This could help researchers and educators understand the potential of MALL applications in promoting a more comprehensive language learning experience and inform the development of applications that target multiple language skills.

5) Learners with special needs: Research should also explore the effectiveness of MALL applications for learners with special needs, such as those with learning disabilities, autism spectrum disorders, or hearing impairments. This could help identify the specific features and accommodations that make MALL applications more accessible and effective for these populations and contribute to the development of inclusive language

learning technologies.

In summary, the current study on the VocabGo app offers valuable insights into the potential benefits of MALL applications in enhancing student engagement and vocabulary learning outcomes. However, to develop a more comprehensive understanding of the broader applicability and effectiveness of MALL applications, future research should explore a variety of applications, learner populations, and learning contexts. By doing so, researchers can contribute to the growing body of knowledge on the role of technology in language learning and help educators make informed decisions about the selection and implementation of MALL applications in their teaching practices. Ultimately, this research can help support the development of more effective and engaging language learning experiences that cater to the diverse needs of learners across various contexts.

Furthermore, as technology continues to evolve, researchers must keep up with the newest developments in MALL applications and examine their effect on language acquisition.By addressing the recommendations outlined in this section, future research can build upon the findings of the current study and contribute to a deeper understanding of the role of MALL applications in promoting effective and engaging language learning experiences. This, in turn, can help educators, curriculum designers, and developers create more informed, targeted, and relevant language learning tools and strategies cater to the diverse needs of learners worldwide.

6.5.3 Longitudinal Studies on the Impact of VocabGo

The promise of linguistically-focused mobile apps, specifically vocabulary acquisition, has become an increasingly relevant area of interest in recent years. In this regard, the VocabGo app, an AR-based tool, has demonstrated significant promise as an effective instrument in fostering a seamless learning environment for EFL learners (Song et al., 2023).

The longitudinal study conducted by the researchers over a span of 26 weeks, encompassing 72 Grade 4 students in a private school in Shenzhen, China, offers valuable insights into the potential benefits and effectiveness of VocabGo as a learning tool. These students, divided into three groups, each adopted a different approach of using VocabGo, either in-class, out-of-class, or both.

Statistical analysis and comparisons between pre- and post-intervention test scores demonstrated that the group that utilized VocabGo both in and outside of class (Group 1) had a more pronounced improvement in vocabulary learning outcomes than the other groups. This underscores the importance of seamless learning environments, which integrate academic and informal learning experiences, in enhancing vocabulary acquisition.

VocabGo's functionalities, particularly the "Find Mode," "Go Mode," "Explore Mode," and "Challenge Mode," contributed to a comprehensive and engaging learning experience for the students. In conjunction with features supporting collaborative learning, such as the "Learning Community" block, and tracking and analytics capabilities, VocabGo offered a

pedagogically sound platform for vocabulary learning. As suggested in the study, the seamless integration of such learning tools in the classroom and beyond can yield positive results in EFL contexts.

Engagement was considered across cognitive, behavioral, emotional, and agentic dimensions, and it was found that Group 1 demonstrated consistently higher engagement levels than Group 3, which only used VocabGo outside class. Meanwhile, Group 2, which used VocabGo solely in class, demonstrated similar or slightly lower engagement levels than Group 1.

Such findings underscore the potential of mobile applications like VocabGo in the language learning process. Increased student engagement is associated with improved learning outcomes, as engagement is seen as a driver of academic achievement (Fredricks et al, 2019). Therefore, it is of significant pedagogical value to identify and utilize resources that effectively boost student engagement.

The study also provided qualitative evidence from semi-structured focus group interviews, shedding light on how the VocabGo app enriched students' vocabulary learning experiences. The app's features, offering authentic and varied learning experiences, were cited as key factors in boosting learner engagement. The interview data further bolstered the statistical findings regarding the positive impact of VocabGo on both vocabulary learning outcomes and student engagement.

To conclude, the VocabGo app offers a valuable tool for vocabulary learning in EFL contexts, enhancing both student engagement and learning outcomes. As evidenced by the longitudinal study conducted over 26 weeks, the seamless integration of such an AR-based app in classroom and out-of-class learning environments can contribute significantly to vocabulary acquisition.

As the field of language learning continues to evolve, tools like VocabGo offer an exciting glimpse into the future of vocabulary acquisition and EFL learning more generally. Future studies should continue to explore the long-term effects of such apps on vocabulary learning and retention, their applicability across different language learning contexts and age groups, and potential refinements to enhance their pedagogical impact further.

6.6 Final Thoughts

6.6.1 The Role of Technology in Language Learning

In recent years, technology has revolutionized the way we learn languages, offering unprecedented opportunities for personalized, flexible, and engaging learning experiences. Through the use of technology, language instruction has become more dynamic and participatory, shifting focus from the instructor to the students and encouraging group work and real-world application. The results of this investigation reveal that MALL apps like VocabGo improve students' motivation to study and their ability to acquire new vocabulary words.

Moreover, technology has helped to break down geographical and logistical barriers, making language learning more accessible to a broader range of learners. Online platforms, social media, and digital resources have allowed learners to connect with native speakers and access authentic language materials, enriching their learning experiences and fostering intercultural understanding.

Despite the numerous advantages offered by technology, it is essential to recognize that its integration into language education should be well-thought-out and purposeful. Educators must carefully consider the specific needs and preferences of their students and adopt a balanced approach, integrating the best features of online learning with those of classroom-based education. Furthermore, technology should be seen as a means to support and enhance language learning, rather than a replacement for teachers or human interaction.

6.6.2 The Future of Language Education

Looking forward, we can see that technology advancements will continue to have a significant effect on how languages are taught and learned in the future. We can expect to see an increase in blended learning approaches, merging the best features of traditional classroom study with those of modern, tech-enhanced education. The integration of technology into the classroom can facilitate more data-driven and evidence-based teaching practices, allowing educators to monitor student progress, identify areas of difficulty, and adapt their teaching

methods accordingly.

As technology continues to advance, it is crucial for educators, researchers, and policymakers to collaborate and share best practices, ensuring that the potential of technology is harnessed effectively and responsibly in language education. This includes addressing issues related to digital equity, privacy, and ethical considerations, along with giving teachers consistent resources to help them improve their skills in using technology in the classroom.

Moreover, the future of language education should also focus on fostering intercultural competence and global citizenship. As our world becomes increasingly interconnected and multicultural, it is more vital than ever to be able to communicate clearly and sympathetically across language and cultural barriers. Technology can connect learners to authentic language resources, diverse perspectives, and opportunities for cross-cultural collaboration.

In conclusion, there will be many potential to improve and revolutionize language teaching and learning thanks to technological advancements, but there will also be many challenges to overcome. Together, we can improve language learning for people all around the globe by embracing technology and using its potential.

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Appendix

Appendix 1 (Reeve &Tseng ,2011).

Behavioral engagement items

I pay close focus in class

I pay close attention in class

I exert great effort in schooling.

When my teacher first introduces a new topic, I pay close attention.

When we start something new in class, I work very diligently.

Cognitive engagement items

When I'm in the midst of finishing up my schoolwork, I attempt to draw parallels between my prior knowledge and my current studies.

When I'm studying, I always make an effort to relate what I'm learning to things that have happened to me in the past.

When I'm studying, I work to make sure that all of the disparate concepts are coherent and complement one another. To better grasp the significant ideas that I'm learning, I come up with my own examples.

When I am working on anything that is tough to comprehend, I switch up the approach in which I study the topic.

When I am working on my coursework, I will often pause what I am doing and review what I have already accomplished.

When I'm studying, I don't simply focus on whether or not I'm getting the questions correctly; I also monitor how well I comprehend the material.

Before I get started on my studies, I take some time to think about the things I need to accomplish.

Agentic engagement item

I voice my thoughts and ideas to the class throughout the day.

During the course of the lesson, I make inquiries.

I let my instructor know what interests me, as well as what I don't like about some things, and I share my opinions with her.

Emotional engagement item

When I'm at school, I can't help but wonder about the material that we're covering.

I am always interested in what we are working on in class, and I really appreciate learning new things while we are there.

The lecture is entertaining.

Appendix 2. Interview questions to students (Zainuddin, Shujahat, Haruna, & Chu, 2020)

1 What do you consider to be the positive effects of VocabGo?

2 How was your engagement for learning?

3 How was your academic performance?

4What do you consider to be the positive effects of VocabGo?

5 What kind of word learning style do you prefer?Learning with VocabGo or learning without VocabGo ?

6 Would you like to participate in other courses utilizing other forms of augmented reality applications? Why?