



Fostering Sustainable Vocabulary Development in Fourth Graders Using Augmented Reality

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Abstract. The study investigates the effectiveness of augmented reality (AR) as a teaching medium for improving vocabulary learning among elementary school students. The research subjects comprised twenty-four students in the 4th grade of a state elementary school in Sleman Regency in Yogyakarta, Indonesia. More studies on the implementation of AR as a medium of primary school learning, especially regarding vocabulary, are still needed. This study analyzed the results of vocabulary learning in classrooms before and after the implementation of AR media. This research adopted a Quantitative approach with an experimental design. The instruments used were pre-test and post-test. The results showed that the students had 'good' vocabulary skills before being given exposure to AR [M=84.96, S.D.=10.88]. After the implementation, their vocabulary level increased and was categorized as excellent [M=89.33, S.D.=10.58]. Furthermore, a Wilcoxon test was run to investigate the effectiveness of the AR treatment. From the 'Test Statistics' result, the Asymp. Sig [2-tailed] value was 0.041 [0.041<0.05], indicating a significant difference between the two sets of vocabulary tests. Thus, the alternative hypothesis [H_a] is accepted. The study results implied that AR media effectively enhanced elementary school students' vocabulary and encouraged their involvement in daily vocabulary learning. Thus, teachers can adopt and maximize the significant use of AR in their classroom instructions.

Keywords: Augmented Reality, Learning media, English vocabulary, English for young learners (EYL), Sustainable vocabulary development

1 Introduction

In the era of digitalization, educational approaches are significantly progressing, using innovative technology to enhance the process of gathering knowledge. Using Augmented Reality (AR) in learning environments is an interesting approach that can gain interest from students in learning. It is a technology that connects 2D and 3D objects in cyberspace with the natural world in real-time [1]. It is one of the most intriguing technology developments in recent years [2]. By incorporating AR into

learning environments, teachers can provide students with exciting and interactive experiences that bridge the gap between theoretical concepts and real-world applications [3]. In addition, AR can potentially revolutionize the educational system and how things are done. AR can help improve the learning experience when studying English. AR creates a dynamic and immersive learning experience, making English vocabulary learning more pleasurable and effective [4]. AR can display 3D objects to interact with students more engagingly, and AR can help teach English vocabulary.

Several research studies show that using augmented reality (AR) in English language learning has several important advantages. AR can raise students' interest and motivation, widen their grasp of the subject matter, and boost student involvement in learning [2]. The potential of AR technology to increase the interactivity and effectiveness of English language learning for elementary school children [5]. Meanwhile, creating AR-based applications can assist students in learning English vocabulary both individually and in class [3]. Although previous research provides a better knowledge of the role of AR in English language learning, some still need to be studied further.

Although AR technology has excellent potential for application in educational settings, research on its use in primary schools has been limited and has yielded few results. This demonstrates the importance of researching and implementing innovative technology at the primary level of education. In other cases, many previous studies have researched AR technology at higher levels of education, like in universities [6], [7], [8]. Several factors, including increased access to information and research opportunities in university settings, caused this condition. Most available studies highlight the importance of prioritizing research in advanced education levels. Thus, research on AR technology in elementary schools is critical because of AR's potential to enhance the quality of learning and student engagement. This research proposed innovative and relevant learning experiences for students from an early age.

Previous research has shown that AR has a significant opportunity to enhance the learning experience and understanding of English vocabulary, most of it has been conducted in higher education settings. As a result, more studies are needed to investigate the use of AR in teaching English vocabulary at the primary school level. Thus, this study aims to evaluate the effectiveness of AR-based visual media for enhancing English vocabulary learning among elementary school students, therefore giving significant advantages to teachers as well as students in the learning process.

1.1. Vocabulary Learning in Elementary Education

Vocabulary learning is crucial in elementary school because it provides the foundation for academic achievement and the development of all skills in language. Successful vocabulary is vital for effective communication because it allows for the foundation for language learning [9]. Furthermore, when learning English language skills, vocabulary becomes the main component and essential pillar in the process of learning the English language [10]. Vocabulary is the basic foundation for learning in all aspects of the English language. Therefore, teachers need to provide sufficient vocabulary exposure to elementary school students.

Learning many words not only enhances skills in the English language but also enhances communication skills and overall academic achievement. Furthermore, Korosidou [11] states that vocabulary learning plays a crucial role in improving communication skills and helps in remembering words. Language skills are essential for students to communicate successfully and achieve academic achievement [8]. Enhancing a student's vocabulary skills can also improve the student's general academic performance [12].

Elementary school students have a variety of obstacles when learning English vocabulary, including difficulties with understanding words, a lack of student engagement, and inadequate facilities [13]. Other challenges include struggles with grammar, pronunciation, understanding connotations, and translating words [14]. Additional obstacles are frequently impacted by a need for more motivation to learn English [15]. These obstacles highlight the importance of engaging in activities and technology-based tools to develop all aspects of vocabulary for students.

1.2 Augmented Reality in Education

Augmented Reality (AR) in education uses smartphones and tablets to show digital images, sound, and text in the real world to enhance learning. Furthermore, AR uses text, images, music, and video to enhance real-world experiences [16]. AR is significant because it provides public objects with digital information and communication [17].

AR can be used in many different areas of education, from science and math to language and the arts. The technology makes interactions with the material more dynamic and exciting. Furthermore, Binhomran and Altalhab [2] state that using AR in education can change how to teach and learn. Furthermore, using AR-based learning materials based on the Cybernetic Learning Framework can also help deaf students get better at spatial awareness [18].

1.3 Augmented Reality in Education

Studies indicate that Augmented Reality (AR) has a significant impact on improving student engagement and motivation. In line with Palmeira et al. [19], they highlighted the potential of immersive AR in enhancing vocabulary learning and said that AR can improve engagement and motivation. Research conducted by Pena and Yugopuspito [12], also showed that Augmented Reality positively affected the relationship between motivation and achievement in learning English vocabulary. In addition, according to Nováková et al. [20], the optimal benefits for education can be achieved by focusing on the quality of AR content, its level of engagement, and the integration of multimedia elements, including audio and visual components.

Moreover, the research from Carrión-Robles et al. [6] investigated using AR on the Assembler Edu platform [<https://id.edu.assemblerworld.com/>] to inspire writing in an online EFL program in Ecuador. Assembler Edu is an internet-based AR platform facilitating English language acquisition through 3D models. The study discovered that including interactive 3D AR can efficiently enhance vocabulary and support the development of writing skills [12]. A study by Agata et al. [5] demonstrates the advantageous effect of AR on students' English language proficiency, which is vocabulary. In addition, a study by [21] highlights the beneficial effects of using

innovative learning methods to enhance elementary school students' English language skills and vocabulary knowledge through AR technology in language learning.

AR has the potential to enhance vocabulary learning and student engagement, and it has implications for improving language proficiency in specific domains [22]. In line with Sadikin and Martyani [9], the impact of using AR technology in EFL classrooms for teaching vocabulary showcases its potential to enhance language learning experiences and motivate young learners to engage actively in acquiring English vocabulary. Furthermore, Korosidou [11] argued AR applications have a positive impact on very young learners' motivation and proficiency in alphabet and vocabulary learning.

In conclusion, the literature analyzed indicates the rising corpus of research on using AR technology in language learning, especially vocabulary learning. The results demonstrate the potential of AR to improve students' motivation, engagement, and performance in vocabulary acquisition and retention, providing valuable insights for language teachers and researchers.

1.4 Theoretical Framework

Technology and direct instruction are important aspects of vocabulary learning [23]. Learning activities, including reading and listening, can contribute to the accidental learning of vocabulary [24]. Students of English as a foreign language use a variety of strategies, including practice and metacognitive strategies, to enhance their vocabulary, but they also have challenges with motivation and environment [25]. It suggests that software be used as a tool in teaching the English language to enhance vocabulary learning [26].

Several theories have supported the use of multimedia technology in the context of English language learning. This theory becomes an important basis for enhancing student comprehension by optimizing the presentation of knowledge. Two theories in Multimedia Learning by Mayer [27] were adopted in this study: [1] the Modality Principle Theory and [2] the Multimedia Principle Theory. According to the Modality Principle Theory, students learn knowledge more effectively when given with a combination of pictures and sound rather than when given with pictures and printed material [27]. Meanwhile, in the Multimedia Principle Theory, individuals have a higher learning ability when given words and pictures than when given words alone. Richard Mayer's approach offers a practical framework on how to enhance sustainable vocabulary learning by effectively designing multimedia materials. Those components are included and integrated in Augmented Reality (AR). Thus, this study proposed AR as a learning media to teach vocabulary at the primary level.

2 Methodology

The following section provides a detailed research methodology adopted by the researchers to gather data. This section addresses the discussion relating to research design, setting, participants, data collection procedure, and data analysis.

2.1 Research Design

A quantitative research method was adopted to investigate the research objective regarding the significance of Augmented Reality (AR) in enhancing elementary school students' vocabulary learning. In addition, this research used an experimental design involving two sets of tests, pre-test and post-test. An experimental design was chosen to identify the significance of students' vocabulary learning outcomes after getting exposed to AR technology in the learning process. Thus, Cohen et al. [28] argued that experimental research design is a form of research that aims to determine the impact of specific treatments on specific groups. Specifically, the researchers focused on studying a single group, known as a one-group pre-test-post-test experimental design. Thus, this study adopted a quasi-experimental design with a nonequivalent pre-test and post-test design [29], [30].

2.2 Setting

A state elementary school located in the Sleman Regency within the province of Yogyakarta, Indonesia, was designated as the research setting. The selection of this particular elementary school was based on the rationale that it represents a typical educational setting in the region, allowing for a comprehensive understanding of the challenges faced by students in accessing current and innovative teaching media for vocabulary learning. Furthermore, English vocabulary learning has yet to be explored through the utilization of Augmented Reality technology. In addition, this research was carried out during the even semester of the academic year 2023/2024.

2.3 Participant

This study involved twenty-four fourth-grade students aged between ten and eleven years. The students exhibited low to medium levels of proficiency in the English language. A total of twenty-four students were taken as samples in this study [N=24]. They were gathered as one group, the treatment group, and given exposure to augmented reality technology as the learning media to learn English, especially vocabulary. Regarding the research ethical issue, as the research subjects were young learners, some procedures were conducted by the researchers. The researchers involved a classroom teacher to inform the students' parents about the research plans. The parents were requested to give an unwritten consent allowing the students to be involved as the research participants. Eventually, all parents agreed.

2.4 Treatment and Data Collection Procedure

Prior to implementing the treatment, several preparations were conducted. First, the researchers, together with the teacher, designed a lesson plan based on the chosen lesson topic, which was 'vehicles.' Then, learning materials integrating the use of Augmented Reality (AR) technology were designed. The researchers made use of 'Assembler Edu Software' to design AR-based learning media. Fifteen vocabularies on vehicles, categorized into three: land, air, and water vehicles, were created. Finally, tests were also made to evaluate the students' understanding of the lesson, specifically their vocabulary skills before and after the treatment. The tests comprised a total of fifteen questions, ten multiple-choice and 5 fill in blank questions adopted from the English course book for grade 4.

This study was conducted in one-and-a-half-month duration during the even semester of the academic year 2023/2024. A pre-test was conducted in one meeting prior to the implementation. Afterwards, the treatments were conducted in four consecutive weeks. Finally, a post-test was given at the end of the implementation to investigate the effectiveness of the treatment. In total, the research was conducted in six meetings.

After obtaining the pre-test results, the researchers provided vocabulary exposures related to a vehicle, along with the pronunciation and the meaning. Later, the

Table 1. The range category

Level	Category
88.5 - 100	Excellent
76.7 – 88.45	Good
64.85 – 76.6	Fair
53 – 64.75	Poor

researchers introduced the AR technology to the students so that they could understand the lesson better. The students were grouped and assisted by the researchers in demonstrating the use of AR in learning the vocabulary being taught. During the process, the students could interact with the contents, such as seeing the moving image, hearing the pronunciation, and understanding the meaning. Finally, the post-test was given to the students to observe the students' vocabulary knowledge before and after the use of AR.

3 Result and Discussion

3.1 Students' Vocabulary Level Before and After the Treatment

This section presents the results collected from students' pre-tests and post-tests. To evaluate the effectiveness of Augmented Reality (AR) treatments on student vocabulary learning, a pre-test was used to assess their initial vocabulary level. In addition, a post-test was used to measure the progress and improvement after treatment. In order to be able to draw a conclusion from the research results, the following range category was used:

The results from the pre-test and post-test were as follows:

Based on the data in Table 2, the result revealed that the twenty-four fourth-grade students had a 'good' score on the vocabulary test before getting treatment using Augmented Reality (AR). This is shown by the average score of 84.96 [$M=84.96$,

Table 2. The pre-test and the post-test results

Descriptive Statistics						
	N	Min	Max	Mean	Std. Deviation	Category
Pre_ Test	24	53.00	100.00	84.96	10.88	Good
Post_ Test	24	60.00	100.00	89.33	10.58	Excellent
Valid N [listwise]	24					

In interpreting the results of the normality test, the Sig. values were observed. The data are considered normal if the Sig. value is higher than 0.05 [Sig. > 0.05]. As presented in the table above, from the output of the normality test, the Sig. value of the pre-test data was 0.03 [$0.03 < 0.05$], while the Sig. value of the post-test data was 0.001 [$0.001 < 0.05$]. The Sig. values from both tests were lower than 0.05. After operating the Shapiro-Wilk test analysis, it can be inferred that the data resulting from both tests were not normally distributed. This means that the data do not meet the requirements for proceeding to the parametric paired sample t-test analysis. Therefore, the Wilcoxon test was run to identify the impact of the implementation of Augmented Reality on the students' vocabulary learning.

Table 4. The Wilcoxon test result

Ranks				
		N	Mean Rank	Sum of Ranks
Pre_Test	Negative Ranks	4 ^a	9.75	39.00
Post_Test	Positive Ranks	14 ^b	9.43	132.00
	Ties	6 ^c		
	Total	24		
a. Post_Test < Pre_Test				
b. Post_Test > Pre_Test				
c. Post_Test = Pre_Test				

The next step was running the Wilcoxon test to identify the significant level of the difference between pre-test and post-test results from integrating Augmented Reality (AR) on students' ability to learn English vocabulary. The first result of the Wilcoxon test is the result of 'Ranks' [Table 4]. The positive rankings or the positive difference between the pre-test and post-test values are of particular interest. There were fourteen positive data [$N=14^b$] demonstrating improved English vocabulary learning outcomes among fourteen students after the treatment.

Table 5. The test statistic result

Level	Category
	Post_Test – Pre_Test
Z	-2.041 ^b
Asymp.Sig. [2-tailed]	.041
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

Moreover, based on the 'Test Statistics' [Table 5], the Asymp. Sig [2-tailed] value was 0.041, which is less than 0.05 [$0.041 < 0.05$]. It shows that there is a significant

difference between the pre-test and post-test scores of English vocabularies learning after the implementation of Augmented Reality. From the results, it can be concluded that the alternative hypothesis is accepted ['Ha is accepted']. Therefore, the utilization of Augmented Reality has an impact on English vocabulary learning among fourth-grade elementary school students. The results of this study suggest that Augmented Reality can be used as an alternative learning media for learning English vocabulary.

This study highlights the notable results from the conducted tests, showing that implementing Augmented Reality (AR) is highly effective in improving elementary school students' vocabulary learning. Previous studies have demonstrated that AR technology significantly promotes innovative vocabulary learning approaches. This is achieved by the potential ability of AR to enhance vocabulary learning and provide engaging language learning experiences [33]. In the context of young learners, this learning ambiance should be able to be provided by the teachers to maximize the learning results. This technological integration allows the teachers to provide such innovative and engaging learning experiences to teach foreign language skills. Thus, AR technology plays a crucial role in classroom instruction enhancing language learning and student engagement [34]. According to Korosidou [11] study, using advanced AR technology in foreign language learning contexts offers valuable insights to enhance engagement, understanding, and memories of language abilities among young learners through interactive and immersive learning experiences.

In addition, previous research has shown that AR instruction significantly enhances students' English vocabulary learning outcomes compared to standard multimedia teaching approaches [21]. Thus, Rozi et al. [35] highlighted the significance of integrating innovative AR technology into language learning in elementary schools to improve learning results and enhance student engagement. Consistent with Rozi et al. [3] asserted the significance of using advanced learning tools, such as augmented reality (AR) technology, to enhance students' vocabulary learning and language mastery. Therefore, AR technology has significantly improved students' comprehension of English vocabulary

4 Conclusions

The research investigates the effectiveness of augmented reality (AR) as an educational tool aimed at improving vocabulary learning among elementary school students. Conducted in a public elementary school in Sleman Regency, Yogyakarta, Indonesia, the study involved a sample of twenty-four fourth-grade students. Initial assessments indicated that these students possessed good vocabulary skills before being introduced to AR technology. Subsequent to the intervention, their vocabulary level significantly improved and was classified as excellent. Furthermore, a Wilcoxon signed-rank test was run to statistically validate these results, confirming the significant positive impact of the AR intervention. This statistical analysis supported the alternative hypothesis [Ha], reinforcing the conclusion that AR technology is highly effective in enhancing vocabulary learning among elementary school students. The implications of this research are far-reaching. It underscores the potential of AR technology to revolutionize vocabulary learning by making it more interactive and

engaging. The study suggests that AR can be an effective tool for teachers seeking to improve language skills in young learners, providing a more immersive and engaging learning experience.

The limitation of this study is that the sample size is small, which only involved one treatment group, and limited to one primary school in Sleman Regency in Yogyakarta, Indonesia. Thus, the results may not be generalized for a wider population. Future research should explore the broader integration of AR in primary education settings. Specifically, it should investigate how AR can be systematically incorporated into various subjects and curricula to enhance overall learning outcomes. Additionally, it would be beneficial to study the long-term effects of AR on student engagement and retention of vocabulary. Further investigations could also examine how AR can be customized to meet the diverse needs of students, including those with different learning styles and abilities. Moreover, expanding the sample size and including a diverse range of schools from different regions could provide more generalizable results.

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