ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

ENHANCING SCIENCE VOCABULARY ACQUISITION THROUGH AUGMENTED REALITY (AR) FLASHCARDS AMONG GRADE 3 LEARNERS

Carla T. Jolampong [1], Jescel Kristine A. Mosquete [2], Jonelson C. Escandallo, PhD[3], Kristy Jane R. Muegna, PhD[4], Regine L. Generalao, MST – Math[5], Conie B. Cerna, MAEd[6], Deveyvon L. Espinosa, PhD[7]

[1]*Researcher, Institute of Teachers Education, Kapalong College of Agriculture, Sciences and Technology, Kapalong, Philippines*
[2]*Researcher, Institute of Teachers Education, Kapalong College of Agriculture, Sciences and Technology, Kapalong, Philippines*
[3]*Program Coordinator, Kapalong College of Agriculture, Sciences and Technology, Kapalong, Philippines*
[4]*Program Coordinator, Kapalong College of Agriculture, Sciences and Technology, Kapalong, Philippines*
[5]*Program Coordinator, Kapalong College of Agriculture, Sciences and Technology, Kapalong, Philippines*
[6]*Program Coordinator, Kapalong College of Agriculture, Sciences and Technology, Kapalong, Philippines*
[7]*Dean of Institute of Teachers Education, Kapalong College of Agriculture, Sciences and Technology, Kapalong, Philippines*

Article DOI: https://doi.org/10.36713/epra22506
DOI No: 10.36713/epra22506

ABSTRACT

This action research aimed to enhance the science vocabulary acquisition of Grade 3 learners through the use of Augmented Reality (AR) flashcards. Conducted at Maniki Elementary School SPED Center in Kapalong, Davao del Norte, Philippines, the study addressed the observed difficulty of students in understanding and retaining science terms, particularly in topics under Earth and Space. A total of 30 students participated in a four-week intervention that employed interactive AR flashcards with digital 3D visuals and auditory components to reinforce vocabulary learning. The intervention was carried out during the National Reading Program (NRP) period through structured 30-minute sessions integrating visual interaction and vocabulary drills. A pre-test was administered to assess baseline performance, followed by AR flashcard sessions, and concluded with a post-test to evaluate learning gains. Quantitative data were analyzed using descriptive statistics and paired-sample t-tests. The results indicated a significant improvement in students' performance, with mean scores increasing from 59.56% (low) in the pre-test to 91.33% (very high) in the post-test, t(29) = [insert t-value], $p < .001$, *Cohen's* $d = 6.89$, *indicating a large effect size. In addition, qualitative data from interviews with seven students supported the quantitative findings. Learners reported that AR flashcards made science terms easier to understand, increased engagement and confidence, and encouraged independent learning. The study concludes that AR flashcards are an effective tool for improving science vocabulary among elementary learners and recommends their continued integration into science instruction.*

KEYWORDS: *Augmented Reality (AR) Flashcards, Science Vocabulary Acquisition, Quasi-Experimental, Vocabulary Development, Elementary Science, Philippines*

INTRODUCTION

Augmented Reality (AR) is a technology that enhances the real-world environment by overlaying digital information such as images, sounds, or other data onto the user's view through devices like smartphones or AR glasses (Na'amnh et al., 2021). Broum et al. (2022) define AR by its three key features: merging real and virtual worlds, operating interactively in real-time, and being registered in 3D space. Despite these technological advancements, many Grade 3 students continue to struggle with science vocabulary acquisition, which affects their comprehension and classroom engagement. Research has highlighted the importance of explicit vocabulary instruction in helping young learners understand science terms, but many teachers face challenges in implementing effective strategies such as dialogic talk and shared reading (Kazeni, 2020; Anderson et al., 2023). Moreover, the technical nature of science vocabulary, as noted by Fitzgerald et al. (2022), poses additional difficulties for both native and non-native English speakers, further hindering their language development and content understanding.

Challenges in science vocabulary acquisition are evident globally. In Spain, Chen et al. (2020) found traditional methods ineffective, leading to the use of AR games that improved second graders' retention and motivation. In Taiwan, Tsai (2020) reported better vocabulary performance among fifth graders using AR-integrated instruction. In India, multilingual classrooms and rote learning hinder vocabulary understanding,

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

despite AR's potential (Mishra et al., 2021; Prasad & Mahajan, 2022). However, infrastructure limits its use. These studies highlight the global need for more effective science vocabulary instruction.

In the Philippines, over 35% of students show low science vocabulary skills, contributing to poor TIMSS rankings (Bernardo et al., 2023). English as the medium of instruction poses challenges, as many learners struggle with comprehension (Aruta, 2022). At Boot National High School, 57% of students had difficulty explaining science terms (Buban, 2023), highlighting the need for content literacy support. In Davao Occidental, the shift from mother tongue to English instruction led to confusion and poor retention of science vocabulary (Arevalo, 2020). These studies stress the need for vocabulary-focused interventions to improve science understanding and achievement.

In Maniki Elementary School SPED Center in the Division of Davao del Norte, classroom observations in 2023 revealed that approximately 40% of Grade 3 students struggled with understanding basic science concepts due to limited vocabulary proficiency (Arban, 2023). Teachers noted that students often failed to relate scientific terms to real-life contexts, leading to low participation and comprehension during science lessons. This challenge was linked to the continued use of traditional, text-heavy teaching methods and minimal access to interactive tools like visual aids or digital resources (Abendaño, 2023). Moreover, during the post-pandemic transition, the sudden reliance on digital learning platforms without adequate support further weakened student motivation and vocabulary acquisition in science (Yuningsih et al., 2022). Yasa et al. (2022) also found that the absence of culturally relevant examples in science instruction reduced students' ability to retain and apply key terms, emphasizing the urgent need for context-based and engaging vocabulary interventions.

The use of Augmented Reality (AR) flashcards in teaching science vocabulary to Grade 3 learners addresses a key gap in primary education research. While studies like Abdullah et al. (2022), Booyoesen (2023), and Yilmaz (2021) highlight AR's benefits in science learning, few focus on its impact on vocabulary acquisition in young learners. As digital tools gained importance post-pandemic (Kellems et al., 2020), this study seeks to explore AR's potential to improve vocabulary retention and comprehension in science, offering an innovative strategy to support early science education.

Research Questions

The main objective of this quasi-experimental study was to explore and determine the effectiveness of using Augmented Reality (AR) flashcards in enhancing science vocabulary skills among Grade 3 learners. To achieve this objective, the study sought to answer the following research questions:

1. What was the level of science vocabulary acquisition among Grade 3 learners before the implementation of Augmented Reality (AR) flashcards?
2. What was the level of science vocabulary acquisition among Grade 3 learners after the implementation of Augmented Reality (AR) flashcards?
3. What was the significance of Augmented Reality (AR) flashcards in improving the science vocabulary acquisition of Grade 3 learners?
4. What insights could be drawn from the implementation of Augmented Reality (AR) flashcards regarding their effectiveness in enhancing students' science vocabulary learning?

Proposed Intervention Plan

To address the challenges in science vocabulary acquisition among Grade 3 learners, a four-week intervention using Augmented Reality (AR) flashcards was implemented, beginning with the administration of a pre-test to determine the learners' baseline performance. The intervention focused on Grade 3 Science Fourth Quarter topics under Earth and Space, with a different topic covered each week such as landforms, weather conditions, celestial objects, and natural phenomena. Conducted during the National Reading Program (NRP) time before afternoon classes, each 30-minute session included interactive AR flashcard use followed by vocabulary drills to reinforce learning. The intervention aimed to make vocabulary learning more engaging, visually stimulating, and meaningful through the use of 3D visuals, and real-time interaction with virtual content. At the end of the fourth week, a post-test was administered to assess learning gains, followed by interviews with seven students to gather insights into their experiences, motivation, and understanding throughout the intervention.

Pre-Implementation	Week 0 (Before Week 1 starts)	To determine learners' baseline performance in science vocabulary	- Administer pre-test to Grade 3 learners
Implementation	Week 1	To introduce and reinforce vocabulary on landforms	- Use AR flashcards showing 3D landforms - Conduct vocabulary drills
	Week 2	To introduce and reinforce vocabulary on weather conditions	- Use AR flashcards showing various weather conditions - Conduct vocabulary drills
	Week 3	To introduce and reinforce vocabulary on celestial objects	- Use AR flashcards showing celestial objects - Conduct vocabulary drills
	Week 4	To introduce and reinforce vocabulary on natural phenomena	- Use AR flashcards showing natural phenomena - Conduct vocabulary drills
Post-Implementation	End of Week 4	To assess learning gains and gather learner feedback	- Administer post-test - Conduct interviews with seven students about their experiences

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

RESEARCH METHODOLOGY

Research Design

This study utilized a quasi-experimental design to evaluate the impact of Augmented Reality (AR) flashcards on science vocabulary acquisition among Grade 3 learners. A quasi-experimental design was suitable for assessing changes in science vocabulary proficiency through (pre-test) and (post-test) comparisons, providing measurable insights into the effectiveness of AR flashcards as a pedagogical tool. This design aligned with the study's objective of determining whether interactive, technology-based interventions could significantly enhance vocabulary development in young science learners. Following an initial pre-test to establish (baseline) science vocabulary proficiency, students engaged with the AR flashcards intervention (over a period of four weeks). At the conclusion of the intervention, a post-test was administered to the same participants to assess any improvements in science vocabulary skills attributable to the AR flashcards (Mertens, 2019).

This methodological approach was exceptionally well-suited for the context of this action research, which focused on enhancing science vocabulary acquisition through Augmented Reality (AR) flashcards among Grade 3 learners. By integrating AR technology, the intervention aimed to engage students more deeply and make their learning experience in science both interactive and memorable. This innovative approach not only fostered greater involvement but also facilitated better retention of key scientific concepts, ultimately enriching the students' understanding of the subject.

Participants

This study employed purposive sampling, a non-probability sampling technique where participants were selected based on specific attributes aligned with the study's objectives (Nikolopoulou, 2023). Also known as judgmental sampling, this method enabled researchers to use their expertise to choose participants likely to provide meaningful insights. Using purposive sampling, the study aimed to gather a group of students with diverse levels of science vocabulary proficiency, ensuring representation of the broader population of interest. The participants in this action research will consisted of thirty (30) Grade 3 students from Maniki Central Elementary School SPED Center, enrolled in the 2023-2024 academic year. This carefully chosen sample size allowed for manageable interactions with the AR flashcards intervention, facilitating in-depth observation of students' vocabulary development in science. The study's pre-test and post-test design enabled thorough analysis of vocabulary gains attributable to the AR flashcards intervention.

Instruments of the Study

This study utilized a researcher-made questionnaire to assess the science vocabulary acquisition of Grade 3 learners in the topic Earth and Space. The questionnaire was designed to measure students' understanding of key concepts before and after the intervention using Augmented Reality (AR) flashcards. This study investigates the effectiveness of an augmented reality (AR) intervention in improving science vocabulary acquisition among Grade 3 students. The study will address the challenges highlighted in prior research regarding science vocabulary acquisition and the limitations of traditional teaching methods. The instrument used in this study is based on the work of Broum et al. (2022), who defined Augmented Reality through its key features: the merging of real and virtual worlds, interactive real-time operation, and 3D registration. This study will leverage these features to design tasks that incorporate these elements, aiming to create an engaging and effective learning environment. This approach directly tackles the challenges identified in previous research concerning science vocabulary acquisition, suggesting a potential solution to improve student learning outcomes. The use of AR offers a unique opportunity to enhance understanding through interactive and immersive experiences, potentially leading to a more significant and lasting impact on vocabulary acquisition compared to traditional methods. Further research is needed to determine the long-term effects and the optimal implementation strategies for such AR-based interventions.

Table 1. ***Range of Mean Percentage***

Range of Mean	Descriptive Level	Interpretation
91-100	Very High	The learner demonstrated outstanding science vocabulary knowledge.
76-90	High	The learner demonstrated a very satisfactory understanding of science vocabulary.
61-75	Average	The learner demonstrated a satisfactory understanding of science vocabulary.
51-60	Low	The learner demonstrated a fairly satisfactory understanding of science vocabulary.
0-50	Very Low	The learner did not meet the expected level of science vocabulary acquisition.

Procedure

To gather the necessary data for this research, the following steps were undertaken. First, the researchers will sought permission from the school principal to conduct the study and allow the participation of Grade 3 learners. After securing approval, a pre-test was administered to assess students' initial science vocabulary proficiency in the topic Earth and Space. The pre-test included 30 multiple-choice questions, serving as a baseline for measuring vocabulary acquisition.

Following the pre-test, a four-week intervention was implemented, during which students engaged with Augmented Reality (AR) flashcards designed to enhance science vocabulary learning. The intervention took place during the National Reading Program (NRP) time before afternoon classes and focused on different Grade 3 Fourth Quarter Earth and Space topics each week such as landforms, weather conditions, celestial objects, and natural phenomena. Each 30-minute session featured AR flashcard use followed by vocabulary drills, allowing students to interact with 3D visuals, and real-time virtual content.

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

At the end of the intervention, a post-test using the same format as the pre-test was administered to evaluate improvements in science vocabulary proficiency. The data from both tests were collected, tabulated, and analyzed to determine the effectiveness of AR flashcards as an instructional tool for enhancing science vocabulary acquisition among Grade 3 learners.

Data Analysis

The data gathered in this study was analyzed using statistical tools to accurately interpret students' science vocabulary acquisition before and after the intervention.

Mean. The mean, or average, was computed by dividing the total scores of students in both the pre-test and post-test by the total number of participants. This was used to determine the level of science vocabulary proficiency of Grade 3 learners before and after the implementation of Augmented Reality (AR) flashcards as an intervention to enhance vocabulary acquisition.

Standard Deviation. Standard deviation indicated the level of variation within a set of values. A lower standard deviation suggested that the scores were closely clustered around the mean, while a higher standard deviation indicated more variability (Field, 2013).

Paired T-Test. Also known as a dependent t-test, this statistical method was used to compare the means and standard deviations of two related groups (Gleichmann, 2020). In this study, the paired t-test assessed whether there was a significant difference in students' science vocabulary scores before and after the intervention. By comparing pre-test and post-test scores, this test helped determine whether any observed improvement in vocabulary acquisition was due to the AR flashcards or merely a result of random variation.

Cohen's d. This statistical measure quantified the effect size between two groups in terms of standard deviation units, providing insight into the strength of the intervention's impact (Cohen, 1988). In this study, Cohen's d was used to assess the effectiveness of AR flashcards in improving students' science vocabulary skills. By calculating the effect size between pre-test and post-test scores, the study measured not only the significance of the improvement but also its practical importance in enhancing students' vocabulary retention.

In Qualitative data were gathered through observations, open-ended survey responses, and short interviews with students and teachers. These were analyzed using the following qualitative methods:

Coding. The researchers used an open coding process to examine student responses and written outputs. Initial codes were assigned to meaningful units of data that reflected aspects of writing performance such as organization, coherence, and clarity. Codes were derived directly from the data and grouped into broader categories.

Data Reduction. After coding, the data were reduced by grouping similar codes together, allowing for clearer patterns and categories to emerge. This step facilitated the identification of the most relevant and recurring elements in students' writing that demonstrated improvement or challenges.

Thematic analysis. A thematic analysis was conducted to identify emerging themes from the clustered codes. Responses that shared similar thoughts and ideas were grouped under the same category, and a theme was assigned to each category. For credibility, these themes were reviewed and validated by experts in writing pedagogy to ensure.

In this study, standard deviation was analyzed to examine the consistency of students' vocabulary improvements. A decrease in standard deviation from pre-test to post-test would suggest that the intervention not only helped enhance science vocabulary but also reduced differences in vocabulary proficiency among students, ensuring more uniform improvement.

Ethical Considerations

Observing ethical standards was crucial when exploring science vocabulary acquisition through augmented reality (AR). Key ethical principles in this study included respecting participants' autonomy by allowing voluntary engagement with AR tools without coercion. The study adhered to beneficence and non-maleficence, ensuring that AR technology benefited learners without causing harm, whether physical or psychological. Justice was also prioritized, guaranteeing equal access to AR learning tools and avoiding biases that could disadvantage groups based on socio-economic status, race, or geographic location. Informed consent was integral to the research process, with participants fully briefed on the purpose, risks, and potential benefits of the study.

Furthermore, confidentiality and data protection were maintained by safeguarding participants' personal and educational data, ensuring it was exclusively used for research purposes. Integrity was also prioritized, avoiding deceptive practices and misrepresentation of AR's effectiveness while transparently addressing potential conflicts of interest. By adhering to these ethical principles, the study promoted fairness, trust, and accountability, striving for knowledge and truth in assessing AR's potential for enhancing science vocabulary acquisition.

RESULTS AND DISCUSSION

This section presents the findings based on the research questions. Quantitative data from the pre- and post-tests measured Grade 3 learners' science vocabulary acquisition before and after the AR flashcard intervention. Descriptive statistics, including frequency, percentage, and mean, were used to assess performance. The discussion begins with learners' baseline data prior to the intervention.

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

Research Question No. 1: What was the level of science vocabulary acquisition among Grade 3 learners before the implementation of Augmented Reality (AR) flashcards?
To address this objective, a researcher-made assessment tool was used to determine the science vocabulary acquisition level of students prior to the use of AR flashcards. The assessment was composed of 30 multiple choice items. Shown in Table 2 were the frequency of the scores of the students before the implementation of the intervention.

Table 2. ***Frequency of the total Scores in Pre-test***

Pre-test Scores	*Frequency*	*Percentage*
15	1	3.3%
16	4	13.3%
17	9	30.0%
18	6	20.0%
19	5	16.7%
20	4	13.3%
21	1	3.3%
Total	30	100%
Average Percentage Score (%)		**59.56%**
Standard Deviation		**1.48**
Description		**Low**

Presented in Table 2 are the results of the pre-test, indicating the science vocabulary acquisition levels of 30 students before the implementation of the intervention. The average percentage score was 59.56%, with a standard deviation of 1.48, reflecting low performance by the students in the pre-test. The highest score was 21, achieved by 1 student, while the lowest score was 15, also achieved by 1 student. The most frequent score was 17, with a frequency of 9. In the pre-test, no student achieved a high score. The distribution indicates that the majority of students struggled to perform well in the science vocabulary test, reflecting weak prior knowledge and limited mastery of subject-specific terms.

The results highlight a common academic challenge in science vocabulary acquisition among elementary learners. The diagnostic test revealed gaps in understanding key topics like landforms, weather, and natural phenomena, with students struggling to define terms, match visuals, and distinguish related concepts. This aligns with Anderson et al. (2023), who found that limited exposure to science-specific vocabulary leads to confusion and weak expression of scientific ideas. Fitzgerald et al. (2022) also noted that the abstract nature of science terms poses difficulties, especially for students from non-STEM or linguistically diverse backgrounds. In the Philippines, Aruta (2022) reported that limited vocabulary knowledge correlates with low science literacy, affecting comprehension, performance, and classroom engagement.

Given the depth and importance of science vocabulary in shaping conceptual understanding, a contextualized and engaging intervention became necessary. The integration of Augmented Reality (AR) flashcards in vocabulary instruction provided a visually rich and interactive platform for learners. This approach enhanced comprehension by allowing students to see and hear the word in action, connect it to real-world visuals, and develop deeper memory retention. Through such digital tools, learners were more likely to overcome the limitations posed by traditional rote memorization and develop stronger foundations in science learning. Thus, targeted vocabulary-building interventions such as AR flashcards were essential in supporting learners' academic growth and long-term scientific literacy.

Research Question No. 2: What was the level of science vocabulary acquisition among Grade 3 learners after the implementation of Augmented Reality (AR) flashcards?
After a four-week intervention using Augmented Reality Flashcards specifically designed to present and reinforce science terms through interactive visual and auditory representations, a post-test was administered. Shown in Table 3 are the results of the post-test, indicating the learners' level of science vocabulary acquisition following the AR Flashcards intervention.

Table 3. ***Frequency of the total Scores in Post-test***

Post-test Scores	*Frequency*	*Percentage*
23	1	3.3%
24	3	10.0%
25	5	16.7%
26	3	10.0%
27	2	6.7%
28	4	13.3%
29	2	6.7%
30	10	33.3%

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

Total	30	100%
Average Percentage Score (%)		**91.33%**
Standard Deviation		**2.37**
Description		**Very High**

Presented in Table 3 are the results of the post-test, indicating the science vocabulary acquisition levels of 30 students after the implementation of the Augmented Reality (AR) Flashcards intervention. The average percentage score was 91.33%, with a standard deviation of 2.37, reflecting very high performance among the students. The highest score was 30, achieved by 10 students, while the lowest score was 23, achieved by 1 student. The most frequent score was 30, with a frequency of 10, indicating that a significant portion of the class achieved perfect scores. Compared to the pre-test, these results revealed a substantial improvement in students' understanding and retention of science vocabulary. This suggests that the AR flashcards played a critical role in enhancing their ability to identify scientific terms, understand science-related concepts, and accurately match definitions with the appropriate vocabulary.

The results demonstrated a substantial upward shift in student performance, as almost all learners scored well above 80%, suggesting that they developed a stronger grasp of science vocabulary after being exposed to the AR flashcards. Compared to the pre-intervention data where scores were concentrated in the lower range and no student attained a perfect score, the post-test scores reflected not only improved comprehension but also enhanced retention and application of learned terms.

The significant increase in post-test scores supports Kellems et al. (2020), who emphasized AR's role in enhancing learning through immersive, multi-sensory experiences. By allowing learners to see, hear, and interact with science terms, AR made learning more engaging and meaningful. Tyson (2021) also found that students using AR outperformed those using traditional flashcards and reported higher motivation and satisfaction—reflected in the increased enthusiasm and confidence of the Grade 3 learners in this study. Similarly, Korosidou (2024) found that AR flashcards improved vocabulary retention among young children through 3D visuals and real-time interaction. The overall improvement in post-test scores showed AR's positive impact on all learners, helping bridge performance gaps and support diverse learning needs.

The contextual and interactive features of AR made scientific vocabulary more engaging and meaningful. By providing real-life simulations such as 3D models and auditory cues students were immersed in dynamic learning experiences that promoted better comprehension and retention. The notable improvements in scores and participation confirm that integrating AR technology into instruction is not only effective but also transformative. The significant gains from pre- to post-test scores provided concrete evidence of their impact, reinforcing the value of integrating innovative technologies in classroom instruction to support meaningful and long-lasting learning.

Research Question No. 3: What was the significance of Augmented Reality (AR) flashcards in improving the science vocabulary acquisition of Grade 3 learners?
Significant Difference Between the Pre-test and Post-test Scores

Table 4. Significant Difference between Pre-test and Post-test Scores

Paired Samples T-Test									
			statistic	**df**	**P**	**Mean difference**	**SE difference**		**Effect Size**
Pre-Test	**Post-Test**	**Student's t**	37.8	29.0	<.001	9.53	0.252	Cohen's d	6.89

A total of 30 students participated in this study, wherein their science vocabulary acquisition was assessed both before and after the implementation of the Augmented Reality (AR) flashcards intervention. As presented in Table 4, a paired samples t-test was conducted to determine whether there was a statistically significant difference in the students' performance between the pre-test and post-test, $t(29) = 37.8$, $p < .001$. The p-value was less than 0.001, far below the conventional alpha level of $\alpha = 0.05$, which led to the rejection of the null hypothesis. This confirms that the improvement observed after the intervention was not due to chance, but rather a true and measurable outcome of the applied AR flashcards. This confirms that there is a statistically significant difference between the pre-test and post-test scores.

Additionally, the effect size, measured by Cohen's d, was calculated to be 6.89, indicating a very large effect. This suggested that the improvement in scores after the AR flashcard intervention was not only statistically significant but also practically meaningful in terms of its impact on learners' vocabulary performance.

These findings suggest that the intervention created a dramatic shift in learning outcomes. The interactive features, 3D models, real-time audio-visual feedback, and contextual representations provided by AR flashcards helped learners go beyond rote memorization. Instead, they engaged in deeper learning, wherein they could visualize, manipulate, and internalize complex scientific terms in a way that aligned with their developmental stage and cognitive capacity. This aligns with constructivist theories of learning, which advocate that learners construct knowledge more effectively when they interact with content in a meaningful and contextualized manner.

The statistical results support broader educational literature that champions technology-enhanced learning environments. For instance, Kellems et al. (2020) and Korosidou (2024) found that AR applications led to better academic performance and

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

increased retention in vocabulary-based subjects. The current study affirms these findings and contributes to the growing body of local evidence suggesting that AR is a viable, scalable, and effective strategy for improving foundational literacy in science, especially among elementary learners.

Similarly, Anderson et al. (2023) and Fitzgerald et al. (2022) showed that technology-driven interventions effectively address language barriers in science education by providing multisensory learning opportunities. This study corroborates those insights, demonstrating that AR flashcards can bridge vocabulary gaps and foster deeper understanding in early science education.

Furthermore, the findings align with research by Tyson (2021) and Abdullah et al. (2022), who demonstrated that integrating AR tools in classroom instruction boosts student engagement and achievement in science vocabulary. This study reinforces these results and adds to the evidence supporting AR as an innovative method to enhance science learning for young students.

In summary, the results of the paired samples t-test clearly demonstrate that the use of AR flashcards resulted in a substantial and statistically significant improvement in science vocabulary acquisition. The large mean score increase and remarkable effect size strongly support the intervention's success. These findings highlight the potential of AR to revolutionize vocabulary instruction in science and suggest that educators and policymakers should consider adopting AR-based tools as part of the curriculum to foster engaged, meaningful, and high-impact learning experiences in primary education.

Research Question No. 4: What insights could be drawn from the implementation of Augmented Reality (AR) flashcards regarding their effectiveness in enhancing students' science vocabulary learning?

To answer this research question, in-depth interviews discussion was conducted with the selected participants. Probing questions were used to explore their observations and personal experiences regarding the impact of Augmented Reality (AR) flashcards in enhancing science vocabulary acquisition among Grade 3 learners. The major themes and corresponding sample statements for research question number 2 were summarized in Table 4. Participants openly shared their insights on how the intervention influenced students' vocabulary understanding, engagement, and retention. Their responses reflected both their direct experiences with the learners and their observations of how AR flashcards supported the development of science-related vocabulary in a more interactive and meaningful way. From the answers of the participants, five major themes emerged: (1) Tool for Conceptual Understanding, (2) Enhancing Learning Engagement and Enjoyment, (3) Fostering Independent and Self-initiated Learning, (4) Boosting Learning Confidence, (5) Incorporating Interactive Learning Strategies

Table 5. ***Insights on the Impact of Augmented Reality (AR) to enhance the vocabulary in Science among Grade 3 Students***

Emerging Themes	Supporting Statements
Tool for Conceptual Understanding	✓ "*I saw that science words are really important so I can better understand nature, my environment, and space. Because of the pictures and sounds, the meaning of the words became clear. I can understand the class topics better.*" — IDI-01 ✓ *"I like learning science vocabulary because I can use it when I answer questions from the teacher. It really helps improve my scores during quizzes."* — IDI-04 ✓ *"I understood that science vocabulary or words are important so it is easier for me to understand the lesson. If you are familiar with the words, it is easier to understand the teacher and our tests."* — IDI-05 ✓ *"I saw that science words are important to help me understand our science topics in the 4th quarter. I do not get confused anymore because I know what they look like and remember their definitions."* — IDI-06
Enhancing Learning Engagement and Enjoyment	✓ *"I liked learning because of the AR, it is really exciting. Every time we use the flash-cards, I am happy because it feels like we're just playing. Class is not boring anymore."* — IDI-01 ✓ *"I was happy and always excited whenever we study using AR. It is fun and feels like a game."* — IDI-02 ✓ *"I liked it because AR Flashcards are interactive. It felt like I was playing, but I was already learning. I do not get bored studying science because it is fun."* — IDI-03 ✓ *"I do not have a hard time learning anymore because AR is really fun. It's not like before when I easily got tired because science was hard. Now, I remember the words more easily."* — IDI-06 ✓ *"I am always excited because we get to read many new words and see colorful pictures. I enjoy learning more now because it is fun."* — IDI-07
Fostering Independent and Self-initiated Learning	✓ *"I tried downloading the AR app on my mom's phone at home because I wanted to keep learning. I was really excited to see more information."* — IDI-01 ✓ *"I now practice the words more often at home. I even made my own flashcards using paper and I drew pictures too."* — IDI-03

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

Boosting Learning Confidence	✓ *"I read my notebook every afternoon because I enjoy studying science. I think I like learning science even more now."* — IDI-05 ✓ *"I started reading science books because I want to learn more. I enjoy reading additional science words."* — IDI-06 ✓ *"I practice at home by drawing landforms and labeling them. I like it because it helps me understand easily."* — IDI-07 ✓ *"Before, spelling was hard for me. But because I understood and remembered the words from the AR flashcards, I can now answer more easily."* — IDI-01 ✓ *"I am no longer afraid to read in class because I already know the words. Whenever the teacher asks us in class, I can easily answer now."* — IDI-02 ✓ *"Spelling is not hard for me anymore because I always see the correct spelling in the AR flashcards. I can understand quickly now."* — IDI-03 ✓ *"I used to have a hard time pronouncing the words, but now I know how because our teacher helped us while showing the AR flashcards. It's easier to understand and remember."* — IDI-04 ✓ *"I now raise my hand and answer in class because I'm already familiar with the words. I'm no longer shy in class when the teacher asks questions."* — IDI-05 ✓ *"I am no longer afraid to read in class because I am confident now when explaining the meaning of science words. I enjoy reading in front of my classmates."* — IDI-07
Incorporating Interactive Learning Strategies	✓ *"It would be better if there were AR games so that learning would be more fun. I want to play more games while learning."* — IDI-01 ✓ *"If there were mini-games, we would enjoy class more. It wouldn't be boring if there were games."* — IDI-05 ✓ *"If the AR had quizzes added, it would be better. We could answer and practice the science words more."* — IDI-06 ✓ *"I would love it if there were AR flashcards about other topics in science. I still want to learn topics from the previous quarters or even flashcards for other subjects too."* — IDI-07

In the study, the integration of Augmented Reality (AR) flashcards was found to be effective in improving science vocabulary acquisition among Grade 3 learners. The first emerging theme was AR as a tool for conceptual understanding. One of the biggest challenges young learners face in science is grasping abstract and unfamiliar terms. With the use of AR flashcards, these abstract concepts became more concrete and relatable. Learners were able to visually connect scientific vocabulary with real-life images, objects, and scenarios through AR simulations, enabling them to better understand terms that would otherwise be difficult to comprehend through text alone. For instance, when presented with the word "evaporation," students could see a visual representation of water transforming into vapor. This visual feedback provided by AR reduced cognitive load and made comprehension more manageable, particularly for young learners who are still developing their abstract thinking skills. This finding is supported by Altmeyer et al. (2020), who emphasized that AR-enhanced activities reduce mental strain and promote deeper conceptual learning through immediate visual cues.

The second theme that emerged was enhancing learning engagement and enjoyment. The immersive and interactive features of AR naturally captured the interest and attention of the students. Compared to traditional flashcards or textbook-based vocabulary drills, the AR flashcards were dynamic and playful, which led to increased enthusiasm and motivation to participate in lessons. Students eagerly anticipated each activity and showed visible excitement as they interacted with animated content and audio-visual elements. This aligns with Wang (2022), who found that interactive AR environments stimulate curiosity and turn science lessons into enjoyable experiences, especially in content-heavy subjects like physics and general science. This increased enjoyment created a more positive learning atmosphere, encouraging active participation and sustained attention during class discussions.

The third theme was fostering independent and self-initiated learning. A noteworthy observation was that learners began taking initiative to study science vocabulary even outside classroom hours. The novelty and fun factor of AR made students more eager to explore the terms on their own or with peers. Some students expressed a desire to revisit the flashcards during break times or after class, demonstrating a heightened sense of responsibility and curiosity in learning. This behavior reflects what Tyson (2021) highlighted in his study that AR tools can spark exploratory learning and foster long-term retention through repeated and self-directed interactions.

The fourth theme identified was boosting learning confidence. As students were repeatedly exposed to interactive content with both visuals and auditory support, they gradually improved in spelling, pronunciation, and understanding of science terms. This repetition, combined with multisensory feedback, helped reinforce learning and gave students a stronger command over the vocabulary. They began to participate more actively in class recitations and group activities, showing greater confidence in using scientific terms correctly. This outcome supports the findings of Suhendah and Prazna (2023), who stated that AR

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

fosters a supportive and motivating environment where learners feel more competent and assured in their academic abilities.

Finally, the fifth theme was incorporating interactive learning strategies. The use of 3D models, animations, and simulations through AR provided students with engaging hands-on experiences that made learning more meaningful. Unlike passive learning strategies, AR required learners to manipulate objects, observe cause-and-effect relationships, and engage in trial-and-error exploration. These physical interactions with content helped deepen cognitive processing and understanding. According to Lampropoulos et al. (2022), such interactivity enhances knowledge construction, especially in complex subjects like science, where learners benefit from seeing how abstract terms play out in real-world contexts.

CONCLUSION

The research study aimed to enhance science vocabulary acquisition among Grade 3 learners through the use of Augmented Reality (AR) flashcards. Prior to the intervention, learners demonstrated low proficiency in science vocabulary as reflected in the pre-test scores ranging from 15 to 21, with an average percentage score of 59.56%. Learners particularly struggled in identifying landforms, understanding weather conditions, recognizing natural phenomena, and matching scientific terms with their correct definitions. After the implementation of the AR flashcards, a notable improvement was observed. Post-test scores ranged from 23 to 30, with an average percentage score of 91.33%, indicating very high proficiency. The learners showed substantial gains in all targeted science vocabulary areas.

Statistical analysis using the paired t-test confirmed a significant difference between the pre-test and post-test scores $t = (29) = 37.8$, $p < .001$, with a large effect size (Cohen's $d = 6.89$), affirming the effectiveness of AR flashcards in enhancing science vocabulary acquisition. The standard deviation also decreased, suggesting more consistent improvement among the learners.

Qualitative findings from the interviews supported the quantitative data, revealing that the use of AR flashcards enhanced learners' conceptual understanding, increased motivation and engagement, fostered independent study habits, boosted learning confidence, and encouraged interactive learning. Students expressed enthusiasm toward AR-enhanced lessons, noted clearer understanding of science terms, and reported greater confidence in participating during class discussions and assessments.

In addition to the quantitative results, qualitative feedback from the learners offered meaningful insights into their experiences with the intervention. Students shared that the use of Augmented Reality (AR) flashcards made learning science vocabulary more exciting, engaging, and easier to understand. They reported that the interactive nature of the AR technology allowed them to visualize scientific concepts more clearly, which enhanced their comprehension and retention of terms related to landforms, weather conditions, and natural phenomena. Learners also expressed increased confidence when participating in class discussions and assessments, attributing this improvement to the clearer and more immersive explanations provided by the AR flashcards. These findings highlight that technology-enhanced strategies not only support academic improvement but also positively influence learner motivation, engagement, and confidence.

Based on the results and conclusions of this study, the following recommendations are proposed. First, the integration of AR flashcards is recommended as a regular supplementary tool in science instruction, especially in topics that require conceptual visualization. Its immersive and interactive features make it particularly effective for young learners who benefit from concrete representations of abstract ideas.

Second, incorporating AR technology across other subject areas could further enhance learning outcomes. Given the positive impact on vocabulary acquisition in science, future applications may include AR-based tools for language, mathematics, or social studies instruction to support diverse learning needs.

Third, while learners found AR flashcards enjoyable, feedback also suggested the inclusion of follow-up activities such as vocabulary games, quizzes, and reflection tasks to reinforce learning and assess individual understanding. A combination of interactive technology and traditional tasks can provide a balanced and comprehensive learning experience.

Fourth, to ensure effective implementation, teachers should receive training and support in utilizing AR tools. Professional development programs focused on integrating AR into lesson planning and classroom instruction will help educators maximize the strategy's impact on student learning.

Lastly, future researchers are encouraged to replicate this study in various educational settings and with different age groups to validate and extend the findings. Exploring long-term effects and combining AR with other innovative strategies may yield even greater educational benefits. Including student voices in the design and refinement of instructional technologies should remain a priority, as their perspectives are vital in creating learner-centered approaches that truly resonate.

RECOMMENDATION

Based on the findings of this study, it is strongly recommended that educators integrate Augmented Reality (AR) flashcards into science instruction, particularly at the elementary level, to effectively support and enhance vocabulary development. The significant improvement in learners' science vocabulary acquisition, as demonstrated in both quantitative and qualitative data, highlights the potential of AR as a transformative educational tool. AR provides visual, auditory, and interactive features that support learners' comprehension and retention of scientific terms. This tool can help make abstract or unfamiliar science concepts more concrete and engaging for young learners. Teachers are encouraged to explore AR-based strategies to improve student motivation and classroom participation. Incorporating AR into teaching may lead to more meaningful and effective science learning experiences in elementary education.

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

REFERENCES

1. *Abendaño, D. O., Arellano, M. A. G., Allawan, J. M., Lemindog, B. R., & Cagape, W. E. (2023). Multivariate analysis on curriculum viability, teaching competence, and effective instruction: Davao region teachers in focus. International Journal of Research Publications, 127(1). https://doi.org/10.47119/ijrp1001271620235093*
2. *Anderson, B. E., Wright, T. S., & Gotwals, A. W. (2023). Teachers' vocabulary talk in early-elementary science instruction. Journal of Literacy Research, 55(1), 75-100. https://doi.org/10.1177/1086296x231163117*
3. *Anderson, J., Smith, L., & Brown, T. (2023). Addressing vocabulary challenges in elementary science: The role of technology. Journal of Language and Science Education, 15(1), 33–49.*
4. *Arban, P. A. (2023). strengthening science vocabulary of grade 10 students in post-pandemic learning through project scivoc. Proceedings of the International Conference on Education, 9(2), 12–16. https://doi.org/10.17501.24246700.2023.9202*
5. *Arevalo, L. G. (2020). Vocabulary enhancement: Learning science terms through word wall activities. International Journal of Innovative Research and Advanced Studies (UIJIR), 7(6), 576–580. https://uijir.com/wp-content/uploads/2020/08/UIJIR-JUNE20-120.pdf*
6. *Aruta, J. J. B. R. (2022). Science literacy promotes energy conservation behaviors in Filipino youth via climate change knowledge efficacy: Evidence from PISA 2018. Australian Journal of Environmental Education, 39(1), 55-66. https://doi.org/10.1017/aee.2022.10*
7. *Altmeyer, K., Kapp, S., Thees, M., Strzys, M. P., Kuckertz, M., & Kuhn, J. (2020). The use of augmented reality to foster conceptual knowledge acquisition in STEM laboratory courses – Theoretical background and empirical results. British Journal of Educational Technology, 51(3), 611–628. https://doi.org/10.1111/bjet.12900*
8. *Bernardo, A. B. I., Cordel, M. O., Calleja, M. O., Teves, J. M. M., Yap, S. A., & Chua, U. C. (2023). Profiling low-proficiency science students in the Philippines using machine learning. Humanities and Social Sciences Communications, 10(1). https://doi.org/10.1057/s41599-023-01705-y*
9. *Broum, T., Hořejší, P., Malaga, M., & Grzona, P. (2022). Competencies of industrial engineers for implementing augmented reality metadata systems. Sustainability, 15(1), 130. https://doi.org/10.3390/su15010130*
10. *Buban, A. (2023). Difficulties in learning science: Basis for intervention. ResearchGate. https://www.researchgate.net/publication/374949882_DIFFICULTIES_IN_LEARNING_SCIENCE_BASIS_FOR_INTERVENTION*
11. *Chen, C.-H., Huang, C.-Y., & Chou, Y.-W. (2020). Developing a game-based learning system with augmented reality for elementary school students: Learning effectiveness, motivation, and flow experience. Applied Sciences, 10(18), 6420. https://doi.org/10.3390/app10186420*
12. *Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences (2nd ed.). Lawrence Erlbaum Associates. https://doi.org/10.4324/9780203771587*
13. *Field, A. (2013). Discovering statistics using IBM SPSS statistics (4th ed.). Sage. https://doi.org/10.4236/ajcm.2017.71002*
14. *Fitzgerald, J., Relyea, J. E., & Elmore, J. (2022). Academic vocabulary volume in elementary grades disciplinary textbooks. Journal of Educational Psychology, 114(6), 1257-1276. https://doi.org/10.1037/edu0000735*
15. *Gleichmann, N. (2020). Paired vs Unpaired T-Test: Differences, Assumptions and Hypotheses. Informatics From Technology Networks. https://www.technologynetworks.com/informatics/articles/paired-vs-unpaired-t-test-differences-assumptions-and-hypotheses-330826*
16. *Kazeni, M. (2020). Strategies used by grade four educators to decode science terminology: A case study. Perspectives in Education, 38(1), 197-210. https://doi.org/10.18820/2519593x/pie.v38i1.14*
17. *Kellems, R. O., Charlton, C. T., Kversøy, K. S., & Gyori, M. (2020). Exploring the use of virtual characters (avatars), live animation, and augmented reality to teach social skills to individuals with autism. Multimodal Technologies and Interaction, 4(3), 48. https://doi.org/10.3390/mti4030048*
18. *Korosidou, E. (2024). The effects of augmented reality on very young learners' motivation and learning of the alphabet and vocabulary. Digital, 4(1), 195–214. https://doi.org/10.3390/digital4010010*
19. *Lampropoulos, G., Keramopoulos, E., Diamantaras, K., & Evangelidis, G. (2022). Augmented reality and gamification in education: A systematic literature review of research, applications, and empirical studies. Applied Sciences, 12(1), 198. https://doi.org/10.3390/app12010198*
20. *Mertens, D. M. (2019). Research and evaluation in education and psychology: Integrating diversity with quantitative, qualitative, and mixed methods (5th ed.). SAGE Publications.*
21. *Mishra, L., Gupta, T., & Shree, A. (2021). Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. International Journal of Educational Research Open, 1, 100012. https://doi.org/10.1016/j.ijedro.2020.100012*
22. *Na'amnh, S., Husti, I., & Daróczi, M. (2021). Implementing augmented reality as an Industry 4.0 application to simplify the busbar bending process during the COVID-19 pandemic. Transactions of FAMENA, 45(3), 115–125. https://doi.org/10.21278/tof.453026921*
23. *Nikolopoulou, K. (2023). What is purposive sampling? Scribbr. https://www.scribbr.com/methodology/purposive-sampling/*
24. *Prasad, V., & Mahajan, R. (2022). Enhancing learning outcomes through AR-based science learning: A study in Indian primary schools. Education and Information Technologies, 27(4), 4789–4805. https://doi.org/10.1007/s10639-021-10702-0*
25. *Suhendah, S., & Prazna, A. (2023). Integrating augmented reality into middle school science education: Effects on students' motivation and perceived competence. Journal of Science Education and Technology, 32(1), 123–135. https://doi.org/10.1007/s10956-022-09999-8*
26. *Tsai, C.-C. (2020). The effects of augmented reality to motivation and performance in EFL vocabulary learning. International Journal of Instruction, 13(4), 987–1000. https://doi.org/10.29333/iji.2020.13460a*
27. *Tyson, M. (2021). Impact of augmented reality on vocabulary acquisition and retention. Issues and Trends in Learning Technologies, 9(1). https://doi.org/10.2458/azu_itlt_v9i1_tyson*
28. *Wang, Y. (2022). Effects of augmented reality-based game-like learning systems on students' learning performance, motivation, and satisfaction. Interactive Learning Environments, 30(6), 1–15. https://doi.org/10.1080/10494820.2020.1722713*
29. *Yasa, I. M. W., Wijaya, I. K. W. B., Indrawan, I. P. E., Muliani, N. M., & Darmayanti, N. W. S. (2022). The implementation profile of the science literacy movement in elementary schools. Jurnal Ilmiah Sekolah Dasar, 6(2), 319-330. https://doi.org/10.23887/jisd.v6i2.45174*

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 11| Issue: 6| June 2025|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2025: 8.691 || ISI Value: 1.188

30. *Yuningsih, W., Permanasari, A., & Permana, I. (2022). Multimedia development of science learning based on science literacy on the theme of lightning. Journal of Science Education and Practice, 4(2), 69-84. https://doi.org/10.33751/jsep.v3i2.1722*