LEKSIKA
Jurnal Bahasa, Sastra, dan Pengajarannya
Volume 20, Number 1, Nov 2025 – Feb 2026
https://dx.doi.org/10.30595/lks.v20i1.29160

Optimizing vocabulary mastery through augmented reality flashcards in early primary EFL learners

Nabila Shafa Fikriyyah[1], Eva Nikmatul Rabbianty[2]
[1-2] English Department, Faculty of Tarbiyah, Universitas Islam Negeri Madura

Abstract
Vocabulary mastery plays a crucial role in supporting young learners' English proficiency; however, many primary school students continue to struggle with retaining new words due to limited exposure and monotonous instructional methods. Although recent technological advancements, particularly Augmented Reality (AR) have shown, promise in enhancing learners' engagement and multisensory processing, empirical evidence on AR-based vocabulary learning for early primary EFL students remains limited. This study investigates whether there is a significant difference in vocabulary mastery between second-grade students before and after being taught using Augmented Reality (AR)-Based Flashcards at SDI Al-Munawwarah Pamekasan and determines the magnitude of the effect of this intervention on their vocabulary mastery. A quantitative approach was employed using a one-group pretest–posttest pre-experimental design involving 32 second-grade students selected through total sampling. Data were collected using a picture-based vocabulary test administered before and after the intervention, which consisted of two AR-supported learning sessions. The data were analyzed using the Wilcoxon Signed-Rank Test and effect size calculation. The findings reveal a significant improvement in students' vocabulary mastery, as indicated by an increase in the mean score from 16.81 in the pretest to 18.69 in the posttest. The Wilcoxon Signed-Rank Test shows a statistically significant difference between pretest and posttest scores ($p < .001$), accompanied by a very large effect size ($r = 0.764$). These results indicate that AR-Based Flashcards provide substantial learning benefits by offering engaging, interactive, and visually enriched input that supports vocabulary comprehension and retention. Pedagogically, AR-based instruction should be reinforced through brief consolidation tasks and differentiated scaffolding, while schools should ensure device availability, technical readiness, and teacher preparation to support effective implementation. Future research is recommended to employ comparative designs with larger samples, include delayed posttests, and examine engagement or motivation to better explain AR's long-term effects.

Keywords: *augmented reality, AR- based flashcards, vocabulary learning, young learners, primary EFL education*

Article History: Received 14 Dec 2025, Final revision 23 Jan 2026, Published 26 Jan 2026

Introduction

Vocabulary mastery is a key component of English proficiency because it enables learners to understand texts, express ideas, and participate in classroom communication (Lei & Reynolds, 2022; Li et al., 2024). Studies have consistently shown that both vocabulary breadth and depth strongly predict overall language proficiency and learners' ability to process linguistic input in meaningful contexts (Sun & Nam, 2023; Webb & Nation, 2017). However, vocabulary learning remains particularly challenging for young learners, especially when instruction relies on conventional practices such as rote memorization or static flashcards that provide limited interaction and often fail to sustain engagement (Arslan, 2024). Therefore, young learners benefit more from learning environments that offer multisensory input, clear visual support, and meaningful interaction to strengthen comprehension and retention (Graves et al., 2012). Recent studies confirm that integrating digital technology into vocabulary instruction is valuable for young learners because it increases engagement, supports multisensory processing, and improves retention. For instance, (Song et al., 2023) developed a mobile

*Corresponding author: **Nabila Shafa Fikriyyah**, Address: TBI, Fakultas Tarbiyah UIN Madura, Jl. Raya Panglegur KM.4, Pamekasan, Jawa Timur. Email address: nabilashafaa2003@gmail.com,

vocabulary-learning application (VocabGo) for lower primary students and found that interactive mobile features helped improve learners' engagement and participation during vocabulary learning activities, especially in online learning contexts. Another study also highlights that digital tools can promote vocabulary development while creating positive emotional learning experiences among young learners, showing that technology-enhanced vocabulary practice can foster both cognitive growth and affective engagement (Sadan et al., 2024). In addition, a large-scale systematic review focusing on technology-enhanced vocabulary learning (2011–2023) concludes that technology-supported instruction consistently benefits learners' vocabulary outcomes, particularly through activities that promote cognitive strategies and interactive learning, indicating that digital environments provide strong support for vocabulary learning compared to conventional methods (Zhou et al., 2024)**.** In line with studies published in *Leksika*, technology-supported instruction has also been reported to support vocabulary development and classroom learning processes in EFL contexts, reinforcing the relevance of digital media for language teaching (Daulay et al., 2024; Sabila & Salmiah, 2025). Among various forms of digital technology, Augmented Reality (AR) offers an interactive and multisensory learning experience that aligns well with young learners' vocabulary learning needs.

Augmented Reality (AR) is an interactive technology that overlays digital information such as images, sounds, and three-dimensional (3D) models onto the physical environment in real time, creating a blended experience of virtual and real elements (Amores-Valencia et al., 2022). Previous studies have shown that AR increases learners' attention, motivation, and vocabulary retention through its multisensory features, especially when implemented through AR-based flashcards that combine visual, auditory, and kinesthetic stimuli (Belda-Medina & Marrahi-Gomez, 2023; Cai et al., 2024). Research conducted in various contexts, including Indonesia, further demonstrates that AR-supported media enhance comprehension, participation, and long-term retention among early childhood and primary learners (R. W. Chen & Chan, 2019; Y. C. Chen, 2019; Hafidah et al., 2022; Makhyoun, 2024).

Although Augmented Reality (AR) has been widely investigated in language learning contexts, previous studies have predominantly focused on preschool learners or upper elementary students. Research on preschool contexts highlights the role of AR in supporting basic word recognition and sensory engagement through visual and auditory stimulation (R. W. Chen & Chan, 2019; Hafidah et al., 2022). Meanwhile, studies involving upper elementary learners emphasize AR's effectiveness in enhancing vocabulary retention, motivation, and conceptual understanding through interactive and immersive learning environments (Belda-Medina & Marrahi-Gomez, 2023; Nurjanah, 2025. However, empirical evidence concerning the use of AR for early primary learners, particularly students in the lower grades of elementary school, remains limited. This gap is more evident in Islamic primary school settings, where contextual, value-based, and developmentally appropriate instructional media are essential. Relatedly, recent work in *Leksika* highlights persistent challenges in elementary TEFL contexts such as short attention spans and rapid forgetting, underscoring the need for engaging instructional support in primary classrooms (Suryanto, 2025).

Preliminary classroom observations at SDI Al-Munawwarah Pamekasan revealed that second-grade students experienced difficulties in retaining newly introduced vocabulary and showed limited engagement during English lessons conducted through conventional instructional methods. Students frequently relied on rote memorization, exhibited short attention spans, and demonstrated low

participation during vocabulary activities, such as passive repetition and minimal oral responses. Prior to the intervention, many students struggled to recall previously learned words and showed hesitation when asked to identify or pronounce vocabulary items independently.

Conceptually, this study is grounded in multimedia and multisensory learning perspectives. The Cognitive Theory of Multimedia Learning (CTML) posits that learners process verbal and visual information through partially independent channels, and learning is strengthened when both channels are meaningfully coordinated (Mayer, 2024). Similarly, Dual Coding Theory explains that vocabulary is more memorable when encoded through both verbal and nonverbal representations, leading to stronger recall and recognition (Paivio, 1991). In AR-based flashcard activities, vocabulary input is presented through 3D visual representations and pronunciation audio and is reinforced through physical interaction (scanning), which may strengthen form–meaning mapping, increase salience, and support retention. At the same time, AR environments may introduce extraneous cognitive load if not guided carefully; therefore, structured implementation is essential to ensure that engagement translates into learning (Akçayır & Akçayır, 2017).

Because these affordances align with teachers' expectations for engaging, contextual, and developmentally appropriate media, AR-based flashcards represent a promising option for enhancing both the breadth and depth of young learners' vocabulary. The media allow students to experience new words through multisensory input and playful exploration while still being manageable within a primary classroom setting. Accordingly, this study examines the effectiveness of Augmented Reality (AR)-Based Flashcards for improving second-grade students' vocabulary mastery at SDI Al-Munawwarah Pamekasan. The results are expected to contribute to the growing body of literature on technology-enhanced vocabulary learning and to provide practical insights for integrating AR into early English instruction. Thus, this study aims to 1) examine whether there is a significant difference in vocabulary mastery between second-grade students before and after being taught using Augmented Reality (AR)-Based Flashcards at primary school in Indonesia; and, 2) determine the magnitude of the effect of AR-based flashcards on students' vocabulary mastery.

Method

This section describes the methodological framework of the study, including the research design, participants, instrument, data collection procedures, and data analysis techniques used to examine the effect of Augmented Reality (AR)-Based Flashcards on young learners' vocabulary mastery.

Research Design

This study employed a quantitative approach using a pre-experimental one-group pretest–posttest design. This design was chosen for several reasons. First, the intervention was implemented in a single intact second-grade class, and the school did not permit random assignment or the creation of a separate control group, making more rigorous experimental designs impractical in this natural classroom setting (Cohen et al., 2002). Second, pre-experimental one-group pretest–posttest designs are commonly used as an initial step to obtain preliminary evidence of the effectiveness of new instructional interventions before conducting larger-scale quasi-experimental or true experimental studies (Creswell & Creswell, 2017; Thyer, 2012). Third, this design allows researchers to evaluate changes in learning outcomes within the same group by comparing pretest and posttest scores while maintaining normal instructional routines, which is particularly useful when the primary aim is to explore whether an innovation such as AR-based flashcards produces measurable improvement under

real-world teaching conditions. At the same time, the limitations of this pre-experimental design especially the absence of a control group and potential threats to internal validity are acknowledged and discussed in the Conclusion and Recommendations (Knapp, 2016). This design is commonly used to measure changes in learning outcomes before and after an intervention when random assignment is not feasible in natural classroom settings (Cohen et al., 2002). It allows researchers to identify whether improvements are associated with the treatment while maintaining normal instructional conditions. This approach is also recommended for initial investigations of instructional innovations without manipulating the learning environment (Creswell & Creswell, 2017).

Participants

The participants were 32 second-grade students of SDI Al-Munawwarah Pamekasan, who were included as the single intact group required for a pre-experimental one-group pretest–posttest design. Because this design does not involve random assignment or a comparison group, all students in the target class were selected through total population sampling, a technique appropriate when the population is limited and all members meet the inclusion criteria for receiving the same instructional treatment (Statistics, 2020). The students were at a similar stage of English vocabulary development and suitable for learning through interactive and visually supported media. To determine the students' initial English vocabulary level, a picture-based vocabulary pretest was administered prior to the intervention. The pretest results indicated that the students demonstrated a relatively homogeneous level of English vocabulary mastery, as reflected in the pretest scores (M = 16.81, Min = 8, Max = 20). These results suggest that the participants were at a comparable stage of English vocabulary development at the beginning of the study and therefore suitable for examining the effect of the instructional treatment. All participants were considered appropriate for learning through interactive and visually supported media due to their age and developmental stage as early primary learners. Only students who completed both the pretest and posttest were included in the final analysis. The study was conducted with school approval and classroom supervision.

Research Ethics

Ethical safeguards were applied throughout this study because the participants were minors. The researchers' institution (UIN Madura) does not have a formal Institutional Review Board (IRB) or ethics committee; therefore, the study protocol was reviewed through the institutional *Seminar Proposal* process prior to data collection. Site permission was obtained through an official letter issued to the school principal (Letter No**.** B-1158/In.38/FT/TL.00/03/2025), and classroom-level permission was granted by the homeroom teacher. Because the participants were children, parental/guardian informed consent was obtained prior to data collection, and student assent was secured using age-appropriate explanations. Participation was voluntary, and students were informed that they could withdraw at any time without penalty. The intervention consisted of low-risk instructional activities aligned with regular classroom learning and was conducted under teacher supervision. To ensure anonymity and confidentiality, no identifying information was recorded; students were assigned codes, results were reported only in aggregate, and the dataset was stored securely and accessed only by the researchers for research purposes.

Instrument

The instrument consisted of a 20-item picture-based vocabulary test administered as a pretest and posttest. Each test measured students' understanding of animal-related vocabulary through multiple-choice items. Different but parallel visual prompts were used in the posttest to reduce memorization bias. Each correct response received a score of one. The validity of the test was examined using the

Pearson Product Moment correlation, while reliability was assessed using Cronbach's Alpha, both of which confirmed that the instrument consistently measured vocabulary mastery (DeVellis & Thorpe, 2021).

Data Collection Procedures

Data were collected through three stages: pretest, treatment, and posttest. During the pretest stage, students individually completed a picture-based vocabulary test to measure their initial vocabulary mastery prior to the intervention. The overall procedure of data collection is presented in Figure 1, which illustrates the sequence of activities conducted throughout the study, including the pretest, the implementation of Augmented Reality (AR)-Based Flashcards across two instructional sessions, and the posttest administration.

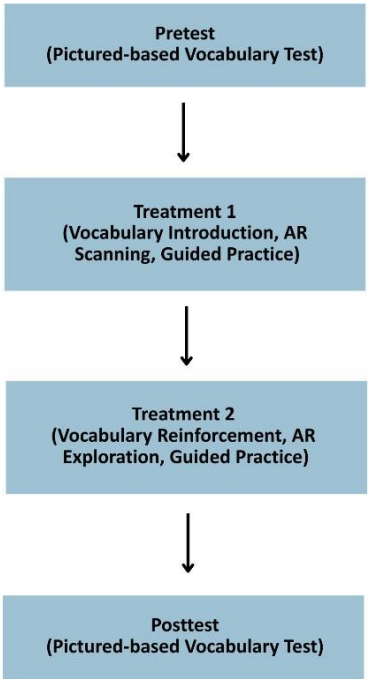

Figure 1. Flowchart of Data Collection Procedures

This figure illustrates the sequence of data collection stages, including the pretest, AR-based instructional sessions, and posttest.

The treatment consisted of two learning sessions using Augmented Reality-Based Flashcards. During the treatment phase, students were introduced to English vocabulary using Augmented Reality (AR)-Based Flashcards. The learning activities were conducted in the classroom using mobile devices provided by the researcher and the school. Each flashcard contained a printed image marker representing the target vocabulary items. When scanned with mobile devices, the flashcards displayed 3D animations, pronunciation audio, and visual cues that supported multisensory learning by engaging learners' visual, auditory, and kinesthetic channels, thereby facilitating vocabulary comprehension and retention among young learners (Graves et al., 2012; Hafidah et al., 2022). Each session included vocabulary introduction, AR exploration, and guided practice. Students were guided to observe the objects, listen to the pronunciation, and repeat the vocabulary items aloud during the activity. After the treatment, the posttest was administered under similar conditions to the pretest.

To provide a concrete illustration of the classroom implementation, Figure 2 shows a student scanning an AR-based flashcard during the vocabulary learning activity. During each instructional session, students were guided to observe the 3D objects, listen to the correct pronunciation, and repeat the vocabulary items aloud. Guided practice was incorporated to ensure that students actively interacted with the AR content rather than passively observing it.

Figure 2. Students scanning Augmented Reality-Based Flashcards during the vocabulary learning activity

After the completion of the treatment sessions, the posttest was administered under conditions similar to those of the pretest to assess students' vocabulary mastery following the intervention.

Data Analysis

The test data were analyzed using SPSS version 25. Descriptive statistics were used to summarize students' pretest and posttest scores. Normality was examined using the Shapiro–Wilk test, which is suitable for small sample sizes (Mishra et al., 2019). Because the data were not normally distributed ($p < .05$), the Wilcoxon Signed-Rank Test was employed to examine whether significant differences existed between the pretest and posttest scores at $\alpha = .05$. Effect size was calculated using the rank-based formula $r = Z/\sqrt{N}$ to determine the magnitude of improvement (Coe et al., 2025). Validity and reliability analyses were conducted to ensure the test consistently measured vocabulary mastery.

Results and Discussion

This section presents the main findings of the study regarding the effect of Augmented Reality-Based Flashcards on students' vocabulary mastery. The results are described in a logical sequence, starting with the descriptive outcomes, followed by inferential findings, and concluding with a thematic interpretation aligned with existing literature. The discussion then elaborates on these findings by interpreting the results, explaining possible contributing factors, and contextualizing the outcomes within the learning setting and relevant theoretical perspectives.

Results

This subsection reports the quantitative outcomes of the intervention. It begins with descriptive statistics to show the direction and pattern of score changes, followed by inferential testing and effect size estimation to determine the significance and magnitude of improvement.

Improvement of Students' Vocabulary Mastery

The descriptive analysis indicated a clear improvement in students' vocabulary mastery after the implementation of AR-based flashcards. Table 1 presents the descriptive statistics of students' vocabulary scores before and after the AR-Based Flashcard intervention.

Table 1. Descriptive Statistics of Students' Vocabulary Scores

Test	N	Minimum	Maximum	Mean	SD	Median
Pretest	32	8	20	16.81	2.79	18.00
Posttest	32	13	20	18.69	2.32	20.00

As shown in Table 1, the posttest mean score was higher than the pretest mean score. The mean score increased from M = 16.81 (SD = 2.79) in the pretest to M = 18.69 (SD = 2.32) in the posttest. In addition, the median score increased from 18.00 to 20.00, suggesting that more students achieved near-maximum performance after the intervention. The score range also shifted upward from 8–20 (pretest) to 13–20 (posttest), indicating overall improvement and more consistent achievement among learners. Prior to inferential analysis, a Shapiro–Wilk normality test was conducted to examine the distribution of the data. The results indicated that the vocabulary scores were not normally distributed ($p < .05$). Therefore, a non-parametric statistical test was applied. A Wilcoxon Signed-Rank Test was conducted to determine whether the difference between pretest and posttest scores was statistically significant. The results revealed a statistically significant improvement in students' vocabulary mastery after the intervention ($Z = -4.324$, $p < .001$). This finding indicates a significant difference in vocabulary mastery before and after the use of AR-Based Flashcards. This result suggests that the AR-Based Flashcards intervention was associated with meaningful vocabulary gains among the participants. This significant gain can be theoretically explained through multimedia and multisensory learning principles, which suggest that vocabulary retention is strengthened when verbal and visual input are integrated and processed through multiple channels (Mayer, 2024; Paivio, 1991). In the AR-based sessions, learners encountered repeated form–meaning mapping via 3D visual representations and pronunciation audio, supported by physical interaction when scanning the flashcards. Such multimodal exposure can increase salience and noticing of new lexical items, reduce ambiguity in meaning, and strengthen memory traces through dual coding and repeated retrieval practice. Moreover, because early primary learners benefit from concrete referents and engaging activities, the interactive AR features may have sustained attention and promoted active rehearsal, which are key mechanisms for vocabulary consolidation and recall.

Strength of the AR-Based Flashcards Intervention

In addition to statistical significance, it is important to examine the practical magnitude of the observed improvement. To determine the magnitude of the intervention's impact, the effect size of the Wilcoxon test was calculated, as presented in Table 2.

Table 2. Effect Size of AR-based Flashcards on Vocabulary Mastery

Statistic	Value
Z-score (Wilcoxon)	-4.324
Asymp. Sig. (2-tailed)	p < .001
N (Participants)	32
Effect Size (r)	0.764
Interpretation	Very Large Effect

Table 2 shows the magnitude of the intervention's effect on students' vocabulary mastery, the effect size of the Wilcoxon Signed-Rank Test was calculated ($r = Z/\sqrt{n}$). As shown in Table 2, the Wilcoxon Signed-Rank Test yielded a significant result ($Z = -4.324$, $p < .001$, two-tailed) with a very large effect size ($r = 0.764$), indicating that the improvement was not only statistically significant but also substantial in magnitude.

According to (Cohen et al., 2002) and (Coe et al., 2025) guidelines for interpreting effect sizes in educational research, an *r* value of approximately 0.1 represents a small effect, 0.3 a medium effect, and 0.5 or higher a large effect. The obtained value of *r = 0.764* in this study therefore indicates a very large practical effect, suggesting that the use of AR-Based Flashcards had a substantial impact on students' vocabulary mastery. This magnitude of effect demonstrates that the intervention not only produced statistically significant gains but also yielded a meaningful educational improvement in learners' vocabulary outcomes.

Beyond quantifying the magnitude of change, a very large effect size also implies that the intervention likely created learning conditions that supported improvement for most learners rather than benefiting only a small subset. From a theoretical perspective, AR-Based Flashcards may produce a strong impact because they reinforce core mechanisms of early vocabulary acquisition, particularly salient form–meaning mapping, repeated multimodal exposure, and active rehearsal. The integration of 3D visualization and pronunciation audio, combined with physical interaction through scanning and repetition, aligns with multimedia learning and dual coding principles, which predict stronger retention when learners encode information through coordinated visual and verbal channels (Mayer, 2024; Paivio, 1991). Moreover, the interactive features of AR can sustain attention and reduce monotony, factors that are especially influential for early primary learners who benefit from concrete referents and engaging learning tasks. As a result, the large effect may reflect not only improved recognition of target vocabulary but also stronger initial lexical representations that become easier to retrieve during assessment.

Distribution of Score Changes

Beyond group-level statistics, individual score changes were examined to show how students responded to the intervention. To further illustrate the pattern of individual student improvement, Table 3 presents the distribution of score changes between the pretest and posttest.

Table 3. Distribution of Score Changes between Pretest and Posttest

Score Change Category	Number of Students (N)	Percentage (%)
Increased	24	75%
No Change	8	25%
Decreased	0	0%
Total	32	100%

As shown in Table 3, most students demonstrated improvement after the intervention (24 students, 75%), while 8 students (25%) showed no change and none experienced a decrease (0%). This pattern is consistent with the Wilcoxon signed-rank output (positive ranks = 24, ties = 8, negative ranks = 0), indicating that no students obtained lower posttest scores than pretest scores. The absence of score decreases suggests that the AR-based sessions provided supportive input and practice conditions that did not disadvantage learners, which is consistent with the role of visual and auditory scaffolding in facilitating form–meaning connections for young learners. From a learning mechanism perspective, repeated multimodal exposure (visual 3D cues, auditory pronunciation, and physical interaction) may have increased noticing and supported memory consolidation through active rehearsal and retrieval attempts, making vocabulary items easier to recognize during assessment (Mayer, 2024; Paivio, 1991).

The unchanged scores may reflect a ceiling effect among students who already performed near the maximum score on the pretest, leaving limited room for measurable improvement on a 20-item test. In addition, individual differences in attention span and learning pace may have contributed to stable scores for some learners, particularly given the relatively short duration of the intervention. This result implies that while AR-Based Flashcards broadly support vocabulary learning, some students may require extended exposure or additional consolidation tasks (e.g., guided oral recall, matching activities, or simple sentence use) to translate engagement into measurable gains.

Discussion

This subsection interprets the statistical findings by explaining why AR-Based Flashcards may have supported vocabulary gains among early primary learners. The discussion focuses on plausible learning mechanisms (e.g., multisensory input and engagement), relates the results to previous studies, and considers the influence of the Islamic primary school context on implementation.

Vocabulary Mastery Improvement Supported by Learner Engagement through AR-Based Flashcards

This subsection discusses learner engagement as a plausible mechanism underlying the vocabulary gains observed after the AR-based intervention.

The statistically significant improvement in students' vocabulary mastery and the very large effect size identified in the Results suggest that the use of AR-Based Flashcards was highly effective in supporting vocabulary learning. To interpret these findings, learner engagement is discussed as a contributing factor during the AR-based instructional process. Although learner motivation was not measured as an independent variable, the improvement in vocabulary scores may be interpreted as an indication that students were more actively involved in the learning process. These interpretations provide insight into how the observed statistical gains were achieved during the AR-based instructional process.

In addition, the very large effect size obtained in this study suggests that the AR-based flashcards did not merely provide a small incremental advantage but created learning conditions that strongly supported rapid vocabulary growth for many learners. For early primary students, vocabulary learning often depends on repeated exposure, clear form–meaning mapping, and opportunities to rehearse pronunciation and recognition in a concrete manner. AR-based flashcards may intensify these conditions by combining visual salience through three-dimensional representations, auditory modeling through pronunciation audio, and immediate action through scanning and repetition. The convergence

of these features may make vocabulary input more noticeable, memorable, and easier to retrieve, which helps explain why the improvement was substantial even within a relatively short instructional period.

During the AR-based learning sessions, students engaged in hands-on activities by scanning flashcards, observing three-dimensional visual representations, listening to pronunciation audio, and repeating vocabulary items aloud. These activities required students' active participation and sustained attention, which differ from conventional vocabulary instruction that often relies on memorization and limited interaction. Increased engagement through multisensory interaction may have supported repeated exposure to target vocabulary, thereby contributing to improved vocabulary mastery.

This interpretation aligns with theories of multisensory and multimedia learning, which suggest that learning is more effective when verbal and visual information are presented together, enabling learners to form stronger mental representations of new vocabulary (Mayer, 2024; Paivio, 1991). In the context of early primary learners, who benefit from concrete visual input and hands-on interaction, the AR-based flashcards provided an instructional environment that was well suited to their cognitive and developmental characteristics.

The improvement observed can also be interpreted in terms of vocabulary breadth and early vocabulary depth development. While the assessment primarily measured correct recognition and recall of target vocabulary items, AR-based flashcards may have supported not only learners' ability to remember word forms but also their ability to associate words with concrete referents through vivid visual cues and repeated pronunciation input. Such repeated multimodal exposure can strengthen initial lexical representations, making it easier for learners to retrieve words during assessment. Moreover, repeated scanning and consistent multimodal cues may have encouraged frequent retrieval attempts, which are known to support stronger memory consolidation compared to passive repetition alone.

Previous studies have also reported that interactive digital media can enhance learner engagement by increasing interest and reducing classroom monotony, which in turn supports vocabulary acquisition (Belda-Medina & Marrahi-Gomez, 2023; Zhang et al., 2025). Consistent with this explanation, studies published in *Leksika* also report that technology-mediated tools can support EFL learning processes and strengthen learners' language development, suggesting that digital affordances may contribute to engagement and learning gains when embedded in classroom instruction (Daulay et al., 2024; Sabila & Salmiah, 2025)**.** These findings are consistent with more recent research showing that Augmented Reality (AR) can promote deeper involvement during vocabulary learning activities by allowing learners to manipulate virtual objects, receive immediate multimodal cues, and connect lexical items to concrete referents. For example, (Topu et al., 2024) found that preschool children who learned vocabulary through AR-based activities demonstrated significantly higher vocabulary gains and more positive attitudes than those who used traditional flashcards. Similarly, (Korosidou, 2024) reported that very young learners who experienced AR-supported vocabulary tasks showed greater motivation and stronger word retention, suggesting that AR can effectively scaffold early lexical development.

The results of the present study align closely with these findings, as indicated by the significant improvement and very large effect size observed among the participating second-grade students. The

engagement generated through AR-based flashcards particularly through 3D visualization, pronunciation audio, and interactive exploration may have contributed to repeated and meaningful exposure to target vocabulary, similar to the mechanisms identified in previous research. However, while earlier studies focused primarily on preschool or early childhood learners, the present study extends these findings to early primary students in an Islamic school context, demonstrating that AR can also be effective for learners who are transitioning to more structured academic tasks.

Furthermore, the distribution of score changes reported in the Results indicates that the majority of students benefited from the AR-based intervention, with no students experiencing a decline in performance. This pattern is consistent with (Korosidou, 2024) observation that AR provides visual and auditory scaffolding that supports learners across different proficiency levels. The fact that 75% of students showed improvement suggests that AR-based flashcards may help minimize performance gaps by offering multisensory cues that support comprehension, recall, and confidence in vocabulary learning.

Although most students improved, 25% showed no change. This may be explained by a ceiling effect, as some students already achieved high pretest scores (maximum score = 20), leaving limited room for measurable improvement. Another explanation is that young learners differ in attention span and learning pace; some may require longer exposure or additional practice sessions to translate engagement into measurable score gains. This finding suggests that AR-based flashcards are broadly beneficial but should be complemented with differentiated support for learners who need more repetition or guided scaffolding.

In classroom practice, AR-Based Flashcards can be used flexibly to support different learner needs. Fast learners may be given enrichment tasks such as making simple sentences or short paragraphs using the target vocabulary to deepen their understanding. Meanwhile, slow learners may benefit from repeated scanning, guided pronunciation practice, and teacher-led repetition to strengthen recall and comprehension.

Despite the strong positive impact, AR-Based Flashcards may also present limitations. Young learners can experience cognitive overload when they focus more on attractive 3D animations than on the vocabulary itself, especially without clear guidance, which may reduce attention to form–meaning connections (Akçayır & Akçayır, 2017). This concern has been noted in AR/XR learning research, which warns that highly stimulating environments can increase extraneous cognitive load when not well structured. In addition, AR may be influenced by a novelty effect: students' early excitement can decrease over time if AR is not combined with varied learning activities. Research on immersive learning suggests that novelty can shape attention and learning outcomes, so structured guidance and task variety are needed to maintain effectiveness (Miguel-Alonso et al., 2024).

Therefore, while AR-Based Flashcards are generally effective for improving vocabulary mastery, their effectiveness depends on how the technology is embedded within instruction. AR tends to be most beneficial when teachers provide clear learning objectives, regulate interaction time, and integrate AR use with consolidation activities such as oral recall, matching exercises, or short sentence production. Without such mediation, AR interaction may remain superficial and fail to translate engagement into durable learning gains.

Vocabulary Mastery Improvement within an Islamic Primary School Context

This subsection discusses how the institutional and pedagogical characteristics of an Islamic primary school may have shaped the implementation and effectiveness of AR-Based Flashcards.

The improvement in students' vocabulary mastery observed in this study can also be understood in relation to the instructional context in which the AR-based intervention was implemented. The statistically significant improvement and the very large effect size reported in the Results section indicate that the AR-Based Flashcards were effective within the specific institutional context of an Islamic primary school.

Islamic primary schools generally emphasize structured classroom management, teacher guidance, and value-based education, which influence how instructional media are selected and implemented. In this study, AR-Based Flashcards were integrated as a supplementary instructional medium within a controlled and teacher-guided learning environment. This structured implementation allowed students to interact with digital learning materials in a focused manner while maintaining classroom discipline and instructional order.

The controlled use of AR ensured that the technology functioned as an instructional support tool rather than a source of distraction. As a result, the vocabulary mastery improvement identified in the Results reflects not only the effectiveness of the instructional media but also its compatibility with existing classroom practices and institutional expectations in the Islamic school setting.

At the same time, this contextual advantage suggests that the effectiveness of AR-based flashcards may be influenced by institutional and pedagogical conditions. In less structured environments or classrooms with limited teacher monitoring, AR may be more prone to distraction or novelty-driven use. Therefore, the strong outcomes observed in this study should be interpreted in relation to the alignment between technological affordances, classroom management practices, and institutional values.

Previous research has emphasized the importance of contextual compatibility when integrating educational technologies into faith-based or value-oriented school environments (Deani & Widodo, 2020; Madkur & Albantani, 2017). In addition, evidence from *Leksika* indicates that elementary TEFL contexts commonly face constraints related to learner attention and classroom engagement, implying that structured pedagogical mediation is crucial when introducing any instructional innovation in primary settings (Suryanto, 2025)**.** In line with these perspectives, the present findings suggest that AR-Based Flashcards can be effectively implemented in Islamic primary schools when their use is aligned with pedagogical practices and institutional values. Therefore, the improvement in vocabulary mastery observed in this study can be interpreted as an outcome of both the instructional features of AR-based flashcards and their appropriate contextual implementation.

Conclusion

This study examined the effect of Augmented Reality (AR)-Based Flashcards on second-grade students' vocabulary mastery at SDI Al-Munawwarah Pamekasan. The results demonstrated a statistically significant difference in students' vocabulary mastery before and after the implementation of AR-Based Flashcards. In addition, the intervention produced a very large effect size, indicating that AR-Based Flashcards had a substantial impact on students' vocabulary learning outcomes. These findings suggest that AR-Based Flashcards can function as an effective instructional medium for improving vocabulary mastery among early primary EFL learners. The significant improvement

observed highlights the potential of integrating interactive and visually supported learning tools into vocabulary instruction at the primary level. The discussion further indicates that the observed learning gains may be supported by increased learner engagement during the AR-based instructional process and by the contextual suitability of the intervention within an Islamic primary school setting. Although learner engagement and contextual factors were not examined as independent variables, they provide plausible explanations for how the AR-based intervention contributed to improved vocabulary mastery in this study. Despite these positive results, this study has several limitations. The use of a one-group pretest–posttest design without a control group and the relatively small sample size limit the generalizability of the findings. Future research is therefore recommended to employ comparative research designs, larger samples, and additional instruments to further investigate the effectiveness of AR-based vocabulary instruction in diverse educational contexts.

Based on the findings, several practical recommendations can be proposed for teachers and schools implementing AR-Based Flashcards in early primary vocabulary instruction. Teachers are encouraged to integrate AR activities with structured follow-up tasks, such as short oral drills, sentence construction, or simple writing exercises, to reinforce form–meaning connections and promote deeper vocabulary use. In addition, differentiated instructional strategies should be applied to accommodate diverse learning needs, for example by providing enrichment tasks for fast learners and repeated guided practice for students who require more scaffolding. Schools are also advised to ensure adequate device availability, technical readiness, and teacher training to support smooth classroom implementation. Finally, future studies may explore students' engagement levels, motivation, and long-term retention outcomes more explicitly to provide a more comprehensive understanding of how AR-based media influences vocabulary development over time.

References

Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*, *20*, 1–11. https://doi.org/10.1016/j.edurev.2016.11.002

Amores-Valencia, A., Burgos, D., & Branch-Bedoya, J. W. (2022). Influence of motivation and academic performance in the use of Augmented Reality in education. A systematic review. *Frontiers in Psychology*, *13*, 1011409. https://doi.org/10.3389/fpsyg.2022.1011409

Arslan, K. (2024). Teaching English Vocabulary: Innovative Methods. *Contemporary Research In Language and Linguistics (ISSN: 2980-2253)*, *2*(1). https://doi.org/10.62601/crll.v2i1.26

Belda-Medina, J., & Marrahi-Gomez, V. (2023). The Impact of Augmented Reality (AR) on Vocabulary Acquisition and Student Motivation. *Electronics*, *12*(3), 749. https://doi.org/10.3390/electronics12030749

Cai, S., Wang, X., & Chiang, F.-K. (2014). A case study of Augmented Reality simulation system application in a chemistry course. *Computers in Human Behavior*, *37*, 31–40. https://doi.org/10.1016/j.chb.2014.04.018

Chen, R. W., & Chan, K. K. (2019). Using Augmented Reality Flashcards to Learn Vocabulary in Early Childhood Education. *Journal of Educational Computing Research*, *57*(7), 1812–1831. https://doi.org/10.1177/0735633119854028

Chen, Y. C. (2019). Effect of Mobile Augmented Reality on Learning Performance. *Motivation, and Math Anxiety in a Math*. https://doi.org/10.1177/0735633119854036

Coe, R., Waring, M., Hedges, L. V., & Ashley, L. D. (2025). *Research methods and methodologies in education*. SAGE Publications Limited.

Cohen, L., Manion, L., & Morrison, K. (2002). *Research Methods in Education* (0 ed.). Routledge. https://doi.org/10.4324/9780203224342

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Daulay, S. H., Nabila, A., & Nasution, U. A. (2024). The effect of ICT use on the classroom management in English teaching. *Leksika: Jurnal Bahasa, Sastra Dan Pengajarannya*, *18*(1), 24–35. https://doi.org/10.30595/lks.v18i1.19718

Deani, A., & Widodo, P. (2020). Active Learning in Teaching English for Young Learners. *ICCoLLiC 2020: Proceedings of the First International Conference on Communication, Language, Literature, and Culture, ICCoLLiC 2020, 8-9 September 2020, Surakarta, Central Java, Indonesia*, 115.

DeVellis, R. F., & Thorpe, C. T. (2021). *Scale development: Theory and applications*. Sage publications.

Graves, M. F., August, D., & Mancilla-Martinez, J. (2012). *Teaching vocabulary to English language learners*. Teachers College Press.

Hafidah, R., Yusuf, M., & Subagya, S. (2022). Using Augmented Reality Flashcards To Improve English Vocabulary Mastery For Children Aged 4-5 Years. *ThufuLA: Jurnal Inovasi Pendidikan Guru Raudhatul Athfal*, *10*(2), 271. https://doi.org/10.21043/thufula.v10i2.17159

Knapp, T. R. (2016). Why Is the One-Group Pretest–Posttest Design Still Used? *Clinical Nursing Research*, *25*(5), 467–472. https://doi.org/10.1177/1054773816666280

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

Lei, Y., & Reynolds, B. L. (2022). Learning English vocabulary from word cards: A research synthesis. *Frontiers in Psychology*, *13*, 984211. https://doi.org/10.3389/fpsyg.2022.984211

Li, Z., Li, J. Z., Zhang, X., & Reynolds, B. L. (2024). Mastery of listening and reading vocabulary levels in relation to CEFR: Insights into student admissions and English as a medium of instruction. *Languages*, *9*(7), 239. https://doi.org/10.3390/languages9070239

Madkur, A., & Albantani, A. M. (2017). Instilling islamic values in foreign language teaching: An Indonesian context. *International Conference on Education in Muslim Society (ICEMS 2017)*, 97–103. https://www.atlantis-press.com/proceedings/icems-17/25895133

Makhyoun, W. M. (2024). Object-Modeling Augmented Reality-Based Cards for Developing Preschoolers' Vocabulary Knowledge and Retention. 239), 2(*125*, ههههههههه ههههههه ههه ههه–260. https://doi.org/10.21608/maed.2024.373414

Mayer, R. E. (2024). The Past, Present, and Future of the Cognitive Theory of Multimedia Learning. *Educational Psychology Review*, *36*(1), 8. https://doi.org/10.1007/s10648-023-09842-1

Miguel-Alonso, I., Checa, D., Guillen-Sanz, H., & Bustillo, A. (2024). Evaluation of the novelty effect in immersive Virtual Reality learning experiences. *Virtual Reality*, *28*(1), 27. https://doi.org/10.1007/s10055-023-00926-5

Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., & Keshri, A. (2019). Descriptive statistics and normality tests for statistical data. *Annals of Cardiac Anaesthesia*, *22*(1), 67–72. https://doi.org/10.4103/aca.ACA_157_18

Nurjanah, A. (2025). The Impact of Augmented Reality (Ar) on Vocabulary Acquisition in Elementary School Students. *International Journal of Pedagogy and Teacher Education*, *9*(1), 16–29. https://doi.org/10.20961/ijpte.v9i1.97639

Paivio, A. (1991). Dual coding theory: Retrospect and current status. *Canadian Journal of Psychology/Revue Canadienne de Psychologie*, *45*(3), 255.

Sabila, F. P., & Salmiah, M. (2025). Improving EFL students' vocabulary acquisition: A phenomenological study on the use of the "DuoCards" mobile application. *Leksika: Jurnal Bahasa, Sastra Dan Pengajarannya*, *19*(2), 76–87. https://doi.org/10.30595/lks.v19i2.26360

Sadan, M., Lipka, O., & Katzir, T. (2024). Students' emotional experiences and learning outcomes during digital vocabulary instruction: Comparing struggling and typical third grade readers. *Computer Assisted Language Learning*, 1–30. https://doi.org/10.1080/09588221.2024.2382452

Song, Y., Wen, Y., Yang, Y., & Cao, J. (2023). Developing a 'Virtual Go mode' on a mobile app to enhance primary students' vocabulary learning engagement: An exploratory study. *Innovation in Language Learning and Teaching*, *17*(2), 354–363. https://doi.org/10.1080/17501229.2022.2047693

Statistics, L. (2020). Wilcoxon signed rank test. *Retrieved From*.

Sun, T., & Nam, H. (2023). Variations in Vocabulary Depth Among Second Language Learners with Comparable Vocabulary Breadths: An Empirical Investigation. *Journal of Psycholinguistic Research*, *52*(6), 2473–2498. https://doi.org/10.1007/s10936-023-10009-w

Suryanto, J. (2025). Navigating the challenges of TEFL in resource-limited elementary school: Insights from Yogyakarta. *Leksika: Jurnal Bahasa, Sastra Dan Pengajarannya*, *19*(1), 46–55. https://doi.org/10.30595/lks.v19i1.25802

Thyer, B. A. (2012). Pre-experimental research designs. *Quasi-Experimental Research Designs*, 29–76. https://doi.org/10.1093/acprof:oso/9780195387384.003.0002

Topu, F. B., Yilmaz, R. M., & Tulgar, A. T. (2024). The effects of using augmented reality on vocabulary learning and attitude of pre-school children in English education. *Education and Information Technologies*, *29*(10), 11733–11764. https://doi.org/10.1007/s10639-023-12284-5

Webb, S., & Nation, P. (2017). *How vocabulary is learned*. Oxford University Press.

Zhang, M. M., Hashim, H., & Yunus, M. M. (2025). Analyzing and comparing augmented reality and virtual reality assisted vocabulary learning: A systematic review. *Frontiers in Virtual Reality*, *6*, 1522380. https://doi.org/10.3389/frvir.2025.1522380

Zhou, K., Jin, F., Li, W., Song, Z., Huang, X., & Lin, C.-H. (2024). The design of technology-enhanced vocabulary learning: A systematic review. *Education and Information Technologies*. https://doi.org/10.1007/s10639-023-12423-y