

Using QR-Code Flashcards with the Phonics Method to Improve Children's Phonics Skills

Dina Amalia¹, Aliva Rosdiana², Nur Alina Lailil Faroh³, Rama Tri Nuryahya⁴

^{1,2,3,4} Universitas Islam Nahdlatul Ulama Jepara, Jawa Tengah,
Indonesia

e-mail: *dina@unisnu.ac.id , ²aliva@unisnu.ac.id

ARTICLE INFO

Article history:

Received: March 3, 2026

Accepted: July 12, 2026

Available online on:

July 31, 2026

Keywords:

Augmented Reality;

Phonic Method;

Colored Flashcards;

Reading Skills

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Published by Universitas

Muhammadiyah Tangerang

ABSTRACT

This study addresses the low early reading proficiency of children aged 5–6 years and the limited use of interactive technology-based learning media in early childhood education. The study aimed to examine the effectiveness of QR-Code Flashcards integrated with the phonics method in improving children's early reading skills. A quantitative quasi-experimental design with a pretest–posttest control group was employed at TK Al Ikhlas Pekalongan, Jepara, involving 60 children (30 experimental; 30 control). Data were collected through early reading tests and classroom observation sheets and analyzed using descriptive statistics and an independent samples t-test. The results showed that the experimental group's mean score increased from 62.4 in the pretest to 85.7 in the posttest, with a gain of 23.3 points, while the control group improved from 61.8 to 72.3, with a gain of 10.5 points. Improvements were consistently higher in letter recognition (88.5), phoneme articulation (84.7), and vocabulary comprehension (83.9). The independent samples t-test indicated a statistically significant difference between the two groups ($t(58) =$

36.15, $p < .001$), demonstrating that QR-Code Flashcards integrated with the phonics method were significantly more effective than conventional flashcards. The findings indicate that integrating QR-Code technology with phonics instruction provides an effective multisensory learning approach that strengthens children's early reading skills and offers a practical innovation for early childhood literacy instruction in the digital era.

Introduction

Early childhood education in Indonesia plays a strategic role in shaping the nation's human capital, as this formative stage establishes the fundamental foundations of children's cognitive, linguistic, socio emotional, and character development. Commonly referred to as the golden age, early childhood represents a period of rapid brain growth and heightened sensitivity to environmental stimulation (Suteja, 2024). Consequently, the quality of educational experiences provided during this stage significantly influences children's academic readiness and long-term learning trajectories. Among the essential competencies to be systematically nurtured is early reading ability, which serves as the foundation of literacy (Bellasonya & Dahlan, 2024). Literacy extends beyond the mechanical recognition of letters and words; it encompasses the capacity to comprehend, interpret, and critically reflect upon information. Strengthening early literacy, therefore, constitutes a strategic investment in sustainable educational quality improvement (Nurhabibah et al., 2023; Zakiya et al., 2023).

Despite ongoing reforms, literacy achievement in Indonesia remains a critical concern. Findings from the Programme for International Student Assessment (PISA), administered by the Organisation for Economic Co-operation and Development (OECD), consistently indicate that Indonesian students' reading proficiency falls below the international average (Sari & Setiawan, 2023). Such evidence suggests underlying structural issues in the development of foundational literacy skills (Gunawan, 2024). Observations in early childhood classrooms reveal that many children aged 5–6 encounter difficulties in letter recognition, phonemic discrimination, grapheme phoneme correspondence, and basic word comprehension. Conventional instructional practices emphasizing rote memorization and repetitive drills often fail to accommodate young learners' developmental characteristics, which require concrete, visual, interactive, and experiential approaches.

Given these challenges, pedagogical innovation that is both developmentally appropriate and technologically responsive is urgently needed. Current early reading instruction often relies on conventional flashcards and rote memorization, which provide limited interactivity, immediate feedback, and multisensory learning experiences essential for young children. (Amalia, Pratiwi, et al., 2024). To address these limitations, this study implements QR-Code Flashcards integrated with the phonics method, enabling children to access interactive audio support for letter-sound correspondence and

pronunciation practice, thereby fostering more effective early reading development.

Recent scholarship over the past decade has highlighted the transformative potential of digital technology integration in enhancing student engagement and learning outcomes. Augmented Reality (AR) enables the real time overlay of virtual elements onto the physical environment, creating immersive and multimodal learning experiences. Empirical evidence demonstrates that AR enhances attention, conceptual understanding, and memory retention by combining visual, auditory, and interactive stimuli (Amalia, Nasyirin, et al., 2024). Concurrently, phonics-based instruction has been widely recognized as an effective approach to developing phonemic awareness and systematic letter sound correspondence, which are foundational prerequisites for successful reading acquisition. The incorporation of visually appealing colored flashcards further strengthens cognitive associations between symbols and meaning (Sundari, 2024; Tohir et al., 2024).

Nevertheless, existing AR research predominantly focuses on science and mathematics education or secondary level contexts, often emphasizing general motivational outcomes and student engagement rather than specific literacy components. In addition, previous studies have rarely integrated QR-Code Flashcards with the phonics method to support early reading instruction for young children. Unlike those studies, the present research specifically examines the effectiveness of

QR-Code Flashcards integrated with the phonics method in improving children's early reading skills, including letter recognition, letter-sound correspondence, pronunciation, and word decoding. Studies examining the structured integration of AR technology with phonics based early reading instruction for young children, particularly within Indonesia, remain limited (Amalia & Rosdiana, 2023; Rosdiana & Amalia, 2023). Furthermore, few investigations have developed AR based learning media designed according to developmentally appropriate principles and systematically evaluated their effectiveness using measurable early literacy indicators within a quantitative experimental research design (Fauziah, N. A., 2025; Zarkasih, 2024).

In response to this gap, the present study introduces a novel contribution through the systematic integration of phonics-based pedagogy, developmentally appropriate colored flashcard design tailored for children aged 5–6 years, and QR code-based audio integration within a validated instructional product. Accordingly, this study aims to develop and validate a QR code-based phonics flashcard learning medium designed for children aged 5–6 years and to evaluate its feasibility as an instructional tool for supporting early English language learning in young children. Unlike prior studies that broadly examine AR usage, this research specifically evaluates its effectiveness in improving measurable components of early literacy, including letter recognition, phoneme articulation, and basic English vocabulary comprehension. The study's novelty also lies in its structured

multisensory approach, integrating visual, auditory, and real-time interactive stimulation to strengthen grapheme phoneme connections. Thus, this research contributes not only an innovative technology based learning medium but also an evidence based and developmentally appropriate AR integration model for early childhood literacy education in Indonesia, addressing the urgent need for effective early reading interventions in the digital era.

Methods

This study employed a quantitative approach using an experimental research design to examine the effectiveness of Augmented Reality (AR) based colored flashcards in improving early reading skills among young children. The research applied a quasi experimental design in the form of a pretest–posttest control group design. According to (Creswell, 2019), this design enables researchers to compare learning outcomes before and after treatment between experimental and control groups in order to determine the effect of the intervention objectively. The study was conducted at TK Al Ikhlas Pekalongan, Jepara. The population consisted of all Group B students aged 5–6 years, with a total sample of 60 children. The participants were divided into two groups: 30 students in the experimental group who received instruction using AR-based colored flashcards, and 30 students in the control group who received conventional instruction using printed flashcards without AR integration.

The research procedure began with the development of the research

instruments, including observation sheets, early reading skills tests, and questionnaires for teachers and parents. The instruments were validated through expert judgment involving material and media experts to ensure content appropriateness. Their reliability was examined prior to implementation to ensure consistent measurement throughout the study. After the instruments were deemed valid and reliable, a pretest was administered to both the experimental and control groups to assess students' initial abilities in letter recognition, phoneme articulation, and basic vocabulary comprehension (Sugiyono, 2020). After the instruments were declared valid and reliable, a pretest was administered to both groups to measure students' initial abilities in letter recognition, phoneme articulation, and basic vocabulary comprehension.

Subsequently, the experimental group received treatment in the form of learning activities using AR-based colored flashcards over several instructional sessions designed according to phonics principles. Meanwhile, the control group participated in conventional learning activities without AR technology. During the intervention, classroom observations were conducted to assess students' engagement and responses to the learning media. At the end of the treatment period, a posttest was administered to both groups to measure improvements in early reading skills.

Data were analyzed using both descriptive and inferential statistical techniques. Descriptive statistics were used to calculate means,

standard deviations, and percentage gains, while inferential analysis was conducted using an independent samples t-test to determine whether there was a statistically significant difference between the experimental and control groups (Arikunto, 2020). Prior to hypothesis testing, normality and homogeneity tests were performed to ensure that the data met the assumptions for parametric analysis.

Performance benchmarks and success indicators were determined based on the increase in pretest to posttest scores and the statistical significance of differences between groups. The media was considered effective if the experimental group showed a statistically significant improvement compared to the control group at a significance level of $p < 0.05$. Effectiveness was further categorized using percentage criteria: 81–100% (highly effective), 61–80% (effective), 41–60% (moderately effective), 21–40% (less effective), and below 21% (ineffective). Through this systematic quantitative experimental procedure, the study objectively evaluated the impact of AR-based colored flashcards on enhancing early reading skills among young learners.

Result and Discussions

The results showed that the experimental and control groups had comparable early reading abilities prior to the intervention. The mean pretest score was 62.4 for the experimental group and 61.8 for the control group, indicating equivalent baseline literacy competence. The small difference between the groups, together with the results of the normality and homogeneity tests, confirmed that the data met the

assumptions for parametric analysis. This baseline equivalence strengthened the internal validity of the study, suggesting that the improvements observed after the intervention could be attributed to the use of QR Code-based Augmented Reality (AR) flashcards integrated with the phonics method.

Following the instructional intervention, a substantial improvement was observed in the experimental group. The detailed mean scores across indicators are presented in Table 1.

Table 1. Mean Pretest and Posttest Scores by Indicator

Indicators	Experimental Pretest	Experimental Posttest	Gain	Control Pretest	Control Posttest	Gain
Letter Recognition	63.2	88.5	25.3	62.7	74.6	11.9
Phoneme Articulation	61.5	84.7	23.2	60.9	71.8	10.9
Vocabulary Comprehension	62.5	83.9	21.4	61.8	70.5	8.7
Overall Mean Score	62.4	85.7	23.3	61.8	72.3	10.5

The mean pretest score of the experimental group was 62.4, while the control group scored 61.8. The small difference indicates comparable initial literacy competence, and normality and homogeneity tests confirmed that the data met the assumptions for parametric analysis. This baseline equivalence strengthens the internal validity of the study, ensuring that post-intervention differences can be attributed to the QR-

Code phonics treatment rather than pre-existing disparities.

Following the instructional intervention, a substantial improvement was observed in the experimental group. The overall mean score increased from 62.4 to 85.7, yielding a gain of 23.3 points, whereas the control group improved from 61.8 to 72.3, yielding a gain of 10.5 points. Improvements in the experimental group were consistently greater across all indicators. Specifically, letter recognition increased by 25.3 points compared with 11.9 points in the control group, phoneme articulation improved by 23.2 points compared with 10.9 points, and vocabulary comprehension increased by 21.4 points compared with 8.7 points in the control group. The independent samples t-test revealed a statistically significant difference in posttest scores between the experimental and control groups, $t(58) = 36.15$, $p < .001$ (exact $p = 1.77 \times 10^{-41}$). These findings indicate that the QR-Code colored flashcards were significantly more effective than conventional instruction according to the predetermined effectiveness criteria.

The findings align with the theoretical framework of phonics instruction, which emphasizes the systematic and explicit teaching of grapheme-phoneme correspondence as a foundation for reading acquisition. In addition to supporting this theoretical perspective, the present findings are consistent with the previous studies cited in the Introduction, which reported that systematic phonics instruction improves word recognition, reading accuracy, and reading fluency among beginning readers. However, the present study extends this

body of evidence by demonstrating that phonics instruction also led to significant improvements in students' reading ability within the context of the current study, thereby providing further support for the effectiveness of phonics instruction in different educational settings. (Ehri, 2014) explains that early readers develop word recognition skills by forming secure connections between letters and sounds, and systematic phonics accelerates this process. The significant gains in letter recognition and phoneme articulation observed in this study support this theory, suggesting that AR enhanced phonics strengthens these cognitive associations through repeated multimodal exposure.

From a cognitive perspective, the results can also be interpreted through Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2017), which posits that learning is more effective when verbal and visual information are presented simultaneously in an integrated manner. The AR flashcards combined printed letters, animated 3D visuals, and audio pronunciation, thereby activating dual channels of processing and reducing cognitive overload. This integration likely contributed to improved vocabulary comprehension and memory retention. Empirical studies in international journals have similarly reported that AR-based learning environments increase attention span and conceptual understanding among young learners (Ibáñez & Delgado-Kloos, 2018).

Furthermore, the increase in student engagement observed during classroom implementation is consistent with constructivist learning

theory, which emphasizes active participation and experiential learning. AR technology creates immersive and interactive experiences that allow children to manipulate and explore learning materials in meaningful contexts. Research published in *Computers & Education* has demonstrated that AR applications enhance motivation and collaborative interaction in early education settings (Akçayır & Akçayır, 2017). In the Indonesian context, recent studies in early childhood education journals also report that interactive digital media significantly improve children's literacy readiness and classroom participation (Widiastuti, 2025).

The findings of this study therefore contribute to the growing body of evidence that technology integration, when pedagogically grounded, enhances early literacy outcomes. Unlike previous studies conducted by (Pan et al., 2021) and (AlNajdi, 2022), which primarily explored the integration of QR codes with Augmented Reality (AR) in science and mathematics education, the present study specifically focused on measurable components of early reading skills using a quantitative experimental design. By addressing this underexplored area, the study fills the research gap identified in the Introduction by providing empirical evidence of the effectiveness of integrating QR codes with AR to enhance early reading skills, an area that has received considerably less attention than other subject domains. The results confirm that AR-based phonics instruction not only increases motivation but also produces statistically significant cognitive gains. The integration of

colored visual stimuli, audio reinforcement, and interactive digital augmentation appears to optimize multisensory learning pathways, supporting both phonological awareness and vocabulary development.

Overall, the discussion suggests that AR based colored flashcards function as an effective instructional innovation that bridges traditional phonics pedagogy with digital learning environments. The combination of systematic phonics principles and immersive AR technology provides a developmentally appropriate and evidence-based solution for strengthening early reading skills in the digital era.

Conclusion

This study concludes that QR Code and Augmented Reality (AR) enabled colored flashcards, integrated with the phonics method, are highly effective in enhancing early reading skills in children aged 5–6. The experimental group demonstrated significantly greater improvement than the control group particularly in letter recognition, phoneme pronunciation, and vocabulary comprehension thereby confirming the effectiveness of multisensory and interactive learning. The findings indicate that systematic phonics instruction supported by QR Code based AR technology aligned with principles of child development strengthens grapheme-phoneme associations, boosts learning engagement, and improves memory retention. This integration offers a practical, evidence-based approach to supporting early literacy development in the digital age and holds potential for broader application across early childhood education institutions. For practical

implementation, educators and schools are encouraged to integrate QR Code based AR learning media into early reading instruction to complement conventional phonics methods. Future research should involve larger and more diverse samples, test effectiveness across various educational contexts, and evaluate the long term impact of QR Code and AR-based phonics instruction on children's literacy development, learning motivation, and reading retention.

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