

RECONCEPTUALIZING VOCABULARY INSTRUCTION THROUGH QR CODE INTEGRATED FLASHCARDS: AN EMPIRICAL STUDY OF DIGITAL MICROLEARNING

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ABSTRACT

This study reconceptualizes mathematics learning through the integration of QR Code-based flashcards as a form of digital microlearning in the context of English as a Foreign Language (EFL) learning. Unlike conventional print-based flashcards, this medium is positioned as a multimodal, mobile-based pedagogical innovation that allows students to directly and independently acquire pronunciation, visual representations, and contextual examples of word usage. This study aims to empirically test the effectiveness of this technology-based approach in improving secondary school students' vocabulary mastery. The study employed a pre-experimental design with a one-group pre-test and post-test model involving 32 tenth-grade students at a high school in Indonesia. Data were collected through a 30-item vocabulary test that included matching, sentence completion, and translation tasks. The intervention was implemented in four learning sessions, utilizing QR code-integrated flashcards to support an interactive and self-directed learning experience within a microlearning framework. The statistical analysis results showed a significant increase in students' mean scores between the pre-test and post-test. A paired-sample t-test confirmed a statistically significant difference ($p < 0.05$), indicating that QR Code-based flashcards were effective in improving students' vocabulary mastery. These findings suggest that transforming conventional learning media into technology-mediated multimodal tools can significantly support lexical development in EFL contexts. This study contributes to strengthening the discourse on technology-based vocabulary learning by presenting empirical evidence from the context of secondary education in Indonesia and offering pedagogical implications for the development of adaptive, affordable, and sustainable digital innovations in language learning.

Keywords: QR Code-based flashcards, digital microlearning, vocabulary acquisition, EFL pedagogy, technology-based learning.

1) INTRODUCTION

Vocabulary mastery is a foundational component of English as a Foreign Language (EFL) learning because it directly shapes learners' ability to comprehend, communicate, and participate meaningfully in language activities. In secondary school contexts, limited vocabulary often becomes a major obstacle that hinders students' reading comprehension, speaking fluency, and writing development. Traditional vocabulary instruction in many classrooms

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remains dominated by memorization, textbook dependency, and teacher-centered explanation, which frequently reduces learner engagement and limits opportunities for autonomous practice. As digital technology increasingly influences educational practices, the reconceptualization of vocabulary instruction through accessible and innovative learning media has become pedagogically urgent.

Flashcards have long been recognized as an effective instructional medium for vocabulary development because they promote repetition, visual association, and recall. However, conventional flashcards are often limited to static text-image presentation and may not fully address contemporary learners' needs for interactive and multimodal learning experiences. The integration of QR (Quick Response) codes into flashcards introduces a transformative dimension by linking printed materials with digital resources such as pronunciation audio, visual explanations, and contextualized usage examples. This innovation aligns with digital microlearning, an instructional approach that delivers concise, focused learning experiences through accessible technology, often via mobile devices.

Digital microlearning emphasizes flexibility, learner autonomy, and cognitive efficiency by presenting information in small, manageable units. In vocabulary instruction, QR Code–integrated flashcards can bridge physical and digital learning spaces, allowing students to engage with vocabulary beyond classroom boundaries. Previous studies have highlighted the positive role of multimedia tools, mobile-assisted language learning, and visual strategies in vocabulary acquisition. However, limited empirical studies specifically explore QR Code–based flashcards as a structured microlearning intervention in Indonesian secondary EFL settings.

This study addresses that gap by examining whether QR Code–integrated flashcards significantly improve vocabulary mastery among tenth-grade students at MAN Palopo. By positioning flashcards not merely as memorization aids but as multimodal pedagogical tools, this research seeks to expand theoretical and practical perspectives on vocabulary learning innovation. The research question guiding this study is: To what extent do QR Code–integrated flashcards improve students' vocabulary mastery in EFL learning?

2) METHODS

This study employed a pre-experimental research design using a one-group pre-test and post-test model. This design was selected to measure students' vocabulary mastery before and after the implementation of QR Code–integrated flashcards as the instructional treatment.

Participants

The participants were 32 tenth-grade students of MAN Palopo, South Sulawesi, Indonesia. The sample was selected purposively based on classroom accessibility and the identified need for vocabulary improvement. These participants represented secondary-level EFL learners with relatively similar curricular exposure.

Research Instrument

The primary instrument was a vocabulary mastery test consisting of 30 items divided into three categories: matching words with meanings, sentence completion, and translation tasks. The instrument focused on school-related vocabulary and was designed to assess students' understanding, recognition, and practical application of vocabulary.

Procedure

The research was conducted in four stages:

- a. Pre-test: Students completed the vocabulary test prior to the intervention.
- b. Treatment: Students participated in four instructional sessions using QR Code–integrated flashcards. Each flashcard presented target vocabulary alongside scannable QR codes linking to pronunciation audio, visual support, and contextual examples.
- c. Post-test: After the treatment period, students completed the same vocabulary test.
- d. Data Analysis: Scores from the pre-test and post-test were analyzed quantitatively using descriptive statistics and paired-sample t-test analysis to determine significance.

Data Analysis Technique

Mean scores, score improvements, and significance values were calculated to determine the effectiveness of the intervention. The hypothesis criteria were established as follows: if $p < 0.05$, the alternative hypothesis (H_1) would be accepted, indicating significant improvement.

3) RESULTS

The effectiveness of QR Code–integrated flashcards was analyzed using a paired-sample t-test to compare students' vocabulary scores before and after the intervention.

Table 1. The Paired Samples Statistics of Pre-test and Post-test

	Descriptive Statistics				
	N	Minimum	Maximum	Mean	Std. Deviation
Pre test	32	50	83	60.8750	8.70576
post test	32	66	100	80.8438	10.06145
Valid N (list wise)	32				

The statistical results indicate that the mean score increased from 60.87 in the pre-test to 80.84 in the post-test, showing substantial improvement after the treatment.

Table 2. The Paired Samples Test of pre - test and post – test

Paired Samples Test								
	Paired Differences					T	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair1 1 2	-19.96875	8.56657	1.51437	-23.05733	-16.88017	-13.186	31	.000

The paired-sample t-test showed that the significance value (0.000) was lower than 0.05, indicating a statistically significant difference between pre-test and post-test scores. Thus, the alternative hypothesis (H_1) was accepted, while the null hypothesis (H_0) was rejected. These findings confirm that QR Code–integrated flashcards significantly improved students' vocabulary mastery. Overall, the sample t-test analysis demonstrates that the use of QR Code–integrated flashcards as a digital microlearning strategy was effective in enhancing vocabulary acquisition among tenth-grade students at MAN Palopo.

4) DISCUSSION

The findings of this study strongly indicate that QR Code–integrated flashcards significantly enhanced the vocabulary mastery of tenth-grade students at MAN Palopo. Based on the paired-sample t-test analysis, the significance value ($p < 0.05$) confirmed that there was a statistically significant improvement after the treatment. The increase in students' mean scores from pre-test to post-test demonstrates that QR Code–based flashcards were not merely supplementary teaching aids but functioned as effective pedagogical instruments capable of transforming vocabulary learning into a more meaningful and engaging process. This improvement occurred because students were exposed not only to printed vocabulary items but also to digital resources such as pronunciation models, visual illustrations, and contextual sentence examples that could be accessed independently through QR code scanning. Such multimodal exposure strengthened vocabulary retention, comprehension, and practical understanding.

This result supports Mayer's Cognitive Theory of Multimedia Learning (2010), which explains that students learn more effectively when information is delivered through combined verbal and visual channels rather than through isolated text alone. In this study, QR Code–integrated flashcards provided exactly this combination by connecting printed flashcards to mobile-accessed multimedia content. The presence of pronunciation audio supported listening and speaking dimensions, while visual representations and contextual examples facilitated semantic understanding. This confirms that multimedia-based vocabulary instruction can reduce students' cognitive burden by presenting vocabulary in clearer and more accessible forms. In line with Sweller's Cognitive Load Theory (2020), QR Code flashcards simplified information processing by organizing vocabulary learning into manageable microlearning units, allowing students to focus on one lexical item at a time without excessive overload.

Furthermore, the findings align with constructivist learning theory, particularly Vygotsky's concept of scaffolding and learner autonomy. QR Code–integrated flashcards encouraged students to actively construct meaning through self-directed exploration rather than relying solely on teacher-centered explanation. Students could repeatedly scan codes, review pronunciation, and revisit contextual materials based on their individual learning pace. This process reflects digital microlearning principles, where knowledge is delivered in small, focused, and flexible segments that enhance independent learning. The intervention therefore shifted vocabulary learning from passive memorization to active discovery. This is particularly important for EFL learners, who

often struggle with vocabulary retention when learning is restricted to translation and rote memorization.

The results of this study are also consistent with previous empirical studies on flashcards and technology-enhanced language learning. Studies by Amiruddin and Razaq (2022), Matrutty and Que (2021), and Saputra et al. (2023) similarly found that flashcards and digital vocabulary tools improved vocabulary acquisition, motivation, and classroom engagement. However, this study expands prior research by specifically integrating QR code technology within flashcard pedagogy and framing it through digital microlearning. Unlike traditional flashcards, which primarily support recognition and repetition, QR Code–integrated flashcards extend learning into multimodal and mobile-assisted dimensions. This innovation is particularly relevant in Indonesian educational contexts where smartphone accessibility is increasing, yet sophisticated educational technology may remain limited. QR codes represent a low-cost, practical, and scalable innovation that teachers can implement without requiring expensive infrastructure.

From a practical perspective, this study suggests that QR Code–integrated flashcards can serve as an adaptive and sustainable instructional strategy for vocabulary teaching in secondary schools. Teachers can design vocabulary materials that combine conventional classroom methods with technology-enhanced independent practice, thereby increasing student motivation and extending learning beyond school hours. The approach is especially beneficial for vocabulary categories requiring pronunciation accuracy and contextual understanding, such as school-related vocabulary, daily expressions, and academic word lists. Moreover, because QR code technology is simple and accessible, it may help bridge educational gaps between traditional pedagogy and 21st-century digital literacy demands.

Despite these positive findings, several limitations should be acknowledged. The use of a pre-experimental one-group design without a control group limits the ability to compare QR Code–integrated flashcards with other instructional methods. Additionally, the relatively small sample size of 32 students restricts broader generalization. The intervention also focused primarily on school-related vocabulary, meaning that effectiveness across broader lexical domains remains unexplored. Therefore, future studies are recommended to employ quasi-experimental or mixed-method designs involving larger and more diverse participant groups, different educational levels, and broader vocabulary categories. Further research may also investigate students' perceptions,

motivation levels, and long-term retention to provide a more comprehensive understanding of QR Code-based vocabulary instruction.

5) CONCLUSION

This study concludes that the implementation of QR Code-integrated flashcards was effective in significantly improving the vocabulary mastery of tenth-grade students at MAN Palopo. The statistical evidence from the paired-sample t-test confirmed that students' post-test performance was substantially better than their pre-test results, demonstrating that the use of digital microlearning tools can positively influence lexical development. By combining visual flashcards with QR-linked digital resources, this instructional approach enhanced not only vocabulary recognition but also pronunciation awareness, contextual understanding, and learner autonomy.

In broader pedagogical terms, this research reconceptualizes traditional flashcards as technology-enhanced multimodal tools capable of supporting contemporary EFL instruction. QR Code-integrated flashcards offer an affordable, accessible, and sustainable innovation for vocabulary teaching, particularly in educational contexts with limited resources but increasing smartphone accessibility. Future research is recommended to involve larger participant groups, control groups, and broader vocabulary categories to strengthen generalizability and expand understanding of technology-based vocabulary instruction.

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