



**Development of a Web Application for Enhancing English Vocabulary Learning
Achievement among Secondary School Students Based on Spaced Repetition and Active**

Recall

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Abstract

English plays a vital role in education and communication, with vocabulary serving as a fundamental component of language learning. However, traditional memorization methods are often ineffective for long-term retention, limiting students' ability to recall and apply vocabulary effectively. To address this issue, this project developed a web application based on Spaced Repetition and Active Recall principles. The application includes vocabulary management, interactive flashcards, classroom management tools, pre- and post-test recording systems, and a learning analytics dashboard. The effectiveness of the system was evaluated using a pre-test/post-test experimental design with 40 secondary school students (20 Grade 8 students and 20 Grade 10 students). Data were analyzed using a paired-sample t-test, Cohen's d, Normalized Gain, and the Effectiveness Index (E.I.). The results showed that the mean scores of Grade 8 students increased from 68.8% to 92.3% (Normalized Gain = 0.75, E.I. = 0.7520), while Grade 10 students' mean scores increased from 53.5% to 75.3% (Normalized Gain = 0.47, E.I. = 0.4677). Statistical analysis confirmed that the post-test scores of both groups were significantly higher than their pre-test scores ($p < .001$), with a large effect size (Cohen's $d > 1.00$). These findings demonstrate that this web application effectively improves English vocabulary learning achievement and provides a digital learning tool that supports personalized learning, progress tracking, and educational assessment. Furthermore, this project aligns with Sustainable Development Goal 4 (SDG 4): Quality Education by leveraging digital technology to promote equitable access to quality education.

Keywords: Flashcards, English Vocabulary Learning, Web Application, Spaced Repetition, Active Recall, Digital Learning

Introduction

English has become a vital global language, serving as the primary medium for international communication, academic exchange, and access to digital educational resources. For Thai students, English proficiency is not only an academic

requirement but also an essential skill for higher education and future careers. Among the various components of English language learning, vocabulary knowledge forms the foundation of all language skills [1]. However, many Thai learners, particularly secondary school students who face



increasing academic demands, continue to experience difficulties in retaining English vocabulary. Conventional learning approaches often rely on rote memorization and one-time review, which are insufficient for promoting long-term memory retention [4], [6]. As a result, students frequently forget previously learned vocabulary and struggle to apply it effectively in their academic performance and daily communication.

Research in cognitive psychology has demonstrated that Spaced Repetition and Active Recall are among the most effective learning strategies for improving long-term vocabulary retention [3], [5]. These approaches encourage learners to review vocabulary at scientifically determined intervals while actively retrieving information from memory, leading to significantly higher retention than passive review. Although digital learning technologies have made these principles easier to implement, there remains a need for a flexible platform that allows teachers and learners to create and customize vocabulary sets according to their own learning objectives while also supporting systematic monitoring of students' learning progress and achievement.

Therefore, this project developed a web-based English vocabulary learning application that integrates Spaced Repetition and Active Recall with customizable vocabulary sets, interactive flashcards, and classroom management features. The application also records pre-test and post-test scores and provides a learning analytics dashboard to facilitate the evaluation of students' vocabulary achievement. The evaluation framework follows educational assessment principles that employ pre-test and post-test scores to determine learning effectiveness and instructional outcomes [2]. To validate the system's effectiveness across different

secondary education levels, this study investigates its impact on English vocabulary achievement among a representative sample of Grade 8 and Grade 10 secondary school students. Furthermore, the project supports the United Nations Sustainable Development Goal (SDG) 4: Quality Education by promoting equitable access to effective, technology-enhanced learning resources and encouraging evidence-based educational innovation.

Methodology

1) Application Design and Development

The researchers developed MyFlashcard, a web application built with HTML, CSS, and JavaScript, integrated with Firebase Cloud Firestore for real-time data storage and Firebase Authentication for user account management. The application consists of four core components: text-based and image-based flashcard systems employing spaced repetition, a multiple-choice quiz system supporting Pre-test, Post-test, and general Quiz modes, a classroom management system for teachers, and a built-in analytics dashboard that automatically computes research-oriented statistics.

2) Participants and Research Instruments

2.1) Participants were selected through purposive sampling and divided into two groups of 20 students each:

- 1) Group A: Grade 8 students (CEFR A2 level)
- 2) Group B: Grade 10 students (CEFR B1 level)

2.2) Research instruments consisted of a 20-item, four-option multiple-choice vocabulary achievement test constructed from 30 target words:

- 1) Group A used vocabulary from the Cambridge A2 Key Vocabulary List (Cambridge University Press & Assessment, 2020)



2) Group B used vocabulary from IELTS Vocabulary You Must Know (B1 level)

Both groups used the identical test for both pre-test and post-test administrations, with item order and answer choices randomized via a seeded shuffle algorithm to maintain consistency across administrations.

3) Data Collection Procedure

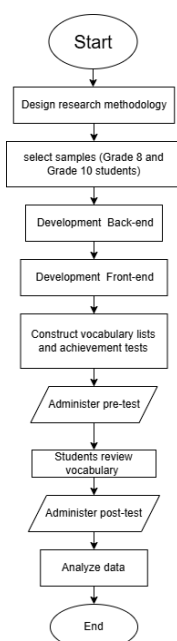
Pre-test — both groups completed the vocabulary test prior to intervention

Intervention period — students used MyFlashcard's spaced repetition system to review vocabulary for 3 days

Post-test — students completed the identical test following the intervention period

4) Data Analysis

Data were analyzed separately for each group using descriptive statistics (mean, SD), paired-sample t-tests, Cohen's d effect size, normalized gain ($\langle g \rangle$), and the Effectiveness Index (E.I.) following Kitrakarn and Pattiyathane (2002). Prior to the t-test, the normality assumption of the score differences (Post — Pre) was verified using the Shapiro-Wilk test.



Picture 1 Flowchart

Results and Discussion

1) Group A Results (Grade 8)

Table 1 Descriptive statistics of pre-test and post-test scores, Group A (n = 20)

Measure	Mean(%)	S.D.
Pre-test	68.75	25.75
Post-test	92.25	13.33
Mean Gain	+23.50	21.47

Table 2 Statistical analysis of Group A

Statistic	Value	Interpretation
Shapiro-Wilk(difference)	W = 0.905, p = .052	Approximately normal
t-test(df=19)	t = 4.90, p < .001	Significant at .05
Cohen's d	1.10	Large effect
Normalized Gain $\langle g \rangle$	0.75	High
Effectiveness Index (E.I.)	0.752	Passes 0.50 criterion

Group A's post-test scores were significantly higher than pre-test scores ($t(19) = 4.90, p < .001$), with a large effect size (Cohen's d = 1.10) and a high normalized gain ($\langle g \rangle = 0.75$), consistent with an Effectiveness Index that passed the 0.50 threshold (E.I. = 0.752).

2) Group B Results (Grade 10)

Table 3 Descriptive statistics of pre-test and post-test scores, Group B (n = 20)

Measure	Mean (%)	S.D.
Pre-test	53.50	21.71



Post-test	75.25	16.42
Mean Gain	+21.75	20.28

Table 4 Statistical analysis of Group B

Statistic	Value	Interpretation
Shapiro-Wilk (differences)	W = 0.969, p = .733	Normal
t-test (df = 19)	t = 4.80, p < .001	Significant at .05
Cohen's d	1.07	Large effect
Normalized Gain $\langle g \rangle$	0.47	Medium
Effectiveness Index (E.I.)	0.468	Below 0.50 criterion

Group B's post-test scores were also significantly higher than pre-test scores ($t(19) = 4.80, p < .001$), with a similarly large effect size (Cohen's $d = 1.07$). However, the normalized gain fell in the medium range ($\langle g \rangle = 0.47$), and the Effectiveness Index did not meet the 0.50 threshold (E.I. = 0.468).

3) Between-Group Comparison

Table 5 Comparative summary of Group A and Group B

Metric	Group A (Grade 8)	Group B (Grade 10)
Pre-test Mean (%)	68.75	53.50
Post-test Mean (%)	92.25	75.25
Mean Gain (%)	+23.50	+21.75
Cohen's d	1.10	1.07
Normalized Gain $\langle g \rangle$	0.75 (High)	0.47 (Medium)
E.I.	0.752 (Pass)	0.468 (Fail)

Although the raw mean gains were similar between groups (+23.50% vs. +21.75%), Group A showed a substantially higher normalized gain and Effectiveness Index than Group B. This is attributable to Group A's lower pre-test baseline, which allowed greater room for improvement, whereas Group B began from a higher baseline and studied more complex B1-level vocabulary, resulting in a lower proportion of realized potential gain.

4) Discussion

The findings support both research hypotheses, demonstrating that MyFlashcard significantly improved English vocabulary achievement at both the lower- and upper-secondary levels. These results align with Sirait et al. (2024), who reported comparable outcomes among junior high school students ($t = 4.716, p < .05$), and with Saksittanupab (2024) and Vibulphol et al. (2025), who documented the benefits of spaced repetition among Thai learners.

Notably, Group A outperformed Group B in terms of normalized gain and Effectiveness Index, which may be explained by a ceiling-effect phenomenon: groups with lower baseline scores inherently have greater room for improvement. This finding suggests that the effectiveness of vocabulary-review tools should be interpreted in conjunction with learners' baseline proficiency, rather than through raw score gains alone.

Several limitations should be noted, including the absence of a control group (one-group design), a limited intervention period (4 days) that may be insufficient to assess long-term retention, and a relatively small sample size ($n = 20$ per group) drawn from a single school.



Conclusions

This study developed MyFlashcard, a web-based application integrating spaced repetition with active recall to enhance English vocabulary achievement, and evaluated it with 20 Grade 8 and 20 Grade 10 Thai students over a 4-day intervention period. Both groups showed statistically significant improvement ($p < .001$) with large effect sizes (Cohen's $d > 1.0$). Grade 8 achieved a high normalized gain ($\langle g \rangle = 0.75$, E.I. = 0.752), while Grade 10 achieved a medium gain ($\langle g \rangle = 0.47$, E.I. = 0.468), reflecting their higher baseline proficiency.

These findings confirm that spaced repetition and active recall are effective for Thai secondary students across proficiency levels, and demonstrate that MyFlashcard is a practical, classroom-ready tool for vocabulary instruction and learning analytics. Future studies should extend the intervention period and sample size to assess long-term retention.

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