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Examining the moderating effect of self-regulation on mobile-assisted vocabulary learning outcomes among Thai EFL university students

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Abstract

The popularity of mobile technology has significantly impacted language education, especially in vocabulary acquisition. However, MAVL outcomes vary considerably, suggesting that access alone is insufficient. The present study contends that, as an essential skill in technology usage, metacognitive self-regulation acts as a crucial moderator. Quantitative in nature, the study collected data from 223 Thai university EFL students and used structural equation modeling for analysis. The study found that MAVL significantly predicted vocabulary acquisition. More importantly, it identified a significant moderator effect of self-regulation, whereby the positive correlation between MAVL and learning outcomes was notably stronger among learners high in self-regulation than those low in self-regulation, implying synergy. The study contributes to existing knowledge in several ways. First, it provides empirical evidence of self-regulation as an essential moderator in Mobile-Assisted Language Learning, shifting focus from technology-centric models to more holistic models of technology use. The study emphasizes the importance of moving beyond access to mobile technology and instead cultivating self-regulation skills in learners to bridge the "strategic divide" and reach maximum potential.

Keywords: Metacognitive self-regulation, Mobile-assisted vocabulary learning, Moderating effect, Self-regulated learning, Structural equation modeling, Thai EFL students, Vocabulary learning outcomes.

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Contents

Contribution of this paper to the literature

This study moves beyond examining whether MAVL works to demonstrate how and for whom it works best, by empirically establishing metacognitive self-regulation as a synergistic moderator that amplifies vocabulary learning outcomes for strategic learners.

1. Introduction

The rapid digitalization of higher educational institutions has led to the quick adoption and application of mobile-assisted tools for learning, which are recognized for their ability to personalize and increase access to language learning. Under this framework, Mobile-Assisted Vocabulary Learning (MAVL) has become a dominant model, with learners in countries like Thailand, where mobile technology adoption is high gaining unprecedented access and flexibility (Kukulska-Hulme & Shield, 2008).

In fact, numerous research studies have already confirmed the positive relationship between mobile-assisted vocabulary learning (MAVL) and vocabulary acquisition, with some scholars even arguing that such an association is largely attributable to technology-related factors like repetition and gamification (Sung, Chang, & Yang, 2015). Nevertheless, the prevailing tool-centric approach to understanding the relationship between mobile-assisted vocabulary learning and vocabulary acquisition has been criticized for its glaring lack of consideration of the learner. Research findings have already revealed that there are considerable individual differences in the efficacy of mobile-assisted vocabulary learning, which persist even across differences in access and frequency, suggesting that access and frequency alone do not fully predict success (Chwo, Marek, & Wu, 2018).

Among such individual factors, metacognitive self-regulation is undoubtedly a major consideration, which refers to an individual's capability to plan, monitor, and regulate his or her own learning processes. As argued by Barnard, Lan, To, Paton, and Lai (2009) and restated by Stockwell (2022) in an unstructured and distracting context like mobile learning, self-regulation is not only beneficial to the learning processes of the individual; it is, in fact, an essential requirement if the individual is to transform mere exposure to content into meaningful and deep learning. As a matter of fact, while self-regulated learning theory highlights the significance of self-regulation in learning processes, there is a glaring lack of research investigating whether self-regulated learning is a moderator that determines for whom mobile-assisted vocabulary learning results in concrete and meaningful learning outcomes.

In this context, the current study seeks to transcend the somewhat simple query of "Is MAVL effective?" to a more sophisticated and nuanced question of "When is MAVL most effective?" Situated within the Thai EFL context, where there is a strong emphasis placed on digital learning but also concerns about learners' readiness, this study explores whether metacognitive self-regulation is a key moderator of the relationship between MAVL and vocabulary learning outcomes. By shifting the locus of analysis away from the technology to the interaction between the learner and the technology, this research aspires to contribute a more intricate and sophisticated model to the study of mobile language learning.

2. Literature Review

The rapid development of mobile technologies has significantly impacted second language acquisition, and Mobile-Assisted Language Learning has led to a paradigm shift in language acquisition, emphasizing learner autonomy. The area of vocabulary development is an integral part of language acquisition. Mobile-Assisted Vocabulary Learning, an extension of Mobile-Assisted Language Learning, has led to a cognitive shift in vocabulary development through "the cognitive theory of dual coding, in which knowledge is represented in both images and verbal labels, and can be used to improve mental representations" (Kukulska-Hulme & Shield, 2008; Paivio, 1990). The empirical evidence on Mobile-Assisted Vocabulary Learning suggests that it results in small to moderate effects on learning outcomes, and such effects can be attributed to algorithmic properties, such as "the efficacy of algorithmic features in sustaining interest in MAVL," as supported by empirical studies and further reinforced by meta-analysis studies, such as those conducted by Sung et al. (2015); Mahdi (2018) and Nakata (2011).

Yet, such an emphasis on technological efficacy points to an important conceptual and empirical limitation. An examination of the literature reveals significant inter-individual differences in learning outcomes, even when learners use the same technology with the same frequency (Chwo et al., 2018). In such instances, it is apparent that technology use alone is not an effective condition for learning success, and the "tool-centric" perspective is challenged. In response, it is argued that there is a need to change methodology from the study of technology to the study of learners' use and management of these technologies (Lai & Gu, 2011; Stockwell, 2022). In such an approach, there is an emphasis on internal, learner-specific factors that mediate the relationship between technology use and learning outcomes.

To this end, self-regulated learning (SRL) is an important and well-developed theoretical framework that can be employed to account for such mediation. SRL is an active, cyclical, and social cognitive approach to learning in which learners plan, monitor, and reflect on their learning progress metacognitively (Zimmerman, 2000). In the unstructured and often distracting contexts of mobile learning, SRL demands do not decrease, but increase, and learners must be able to self-regulate learning goals, time management, and strategic changes, among others, and metacognitive self-regulation is seen as crucial to such learning (Barnard et al., 2009; Broadbent & Poon, 2015). In technology-enhanced learning contexts, research consistently indicates that learners with higher metacognitive self-regulation abilities also tend to be more engaged and achieve better learning outcomes (Greene & Azevedo, 2007).

Nevertheless, a significant discrepancy can be identified. On the one hand, there is research supporting the effectiveness of MAVL tools; on the other, there is research supporting the effects of self-regulation on learning. What is particularly under-researched is the interaction between these two factors. Perhaps the most interesting theoretical assumption is that self-regulation is not only a predictor but also a moderator that affects the quality of the relationship between technology use and successful learning outcomes (Winne, 2001). This implies a synergistic interaction, with learners with high self-regulation abilities able to capitalize on the powerful

affordances offered by MAVL tools for successful learning, but learners with poor self-regulation abilities merely engaging superficially with the materials, a passive "grazing" behavior that fails to promote significant cognitive change despite spending considerable time on the task (Stockwell, 2022). While this model is intuitively logical, direct research tests of this model, particularly within a culturally-educationally defined group such as Thai EFL higher education, have been relatively limited. This research will help to fill this research gap by examining the boundary condition effects of metacognitive self-regulation, thus providing an integrated and explanatory "learner-technology interaction" model for the discipline of digital language learning.

3. Method

3.1. Research Design

A quantitative correlational research approach with a cross-sectional research design was used to investigate the structural relationships between mobile-assisted vocabulary learning (MAVL) activity, metacognitive self-regulation, and vocabulary learning outcomes. The main research purpose of the quantitative analysis is to test a theoretical model of the relationship between metacognitive self-regulation and the relationship between mobile-assisted vocabulary learning activity and outcomes.

3.2. Participants

A convenient sample of 223 EFL students from Shinawatra University in Thailand participated in the research. The students were enrolled in the university's mandatory courses: University English. The sample's mean age was 19.8 years (SD = 1.2 years). The sample consisted of 155 females (69.5%) and 68 males (30.5%). In terms of academic standing, 58.7% of the sample were freshmen, and 41.3% of the sample were sophomores. The sample's majors included the humanities, business, and science. All of the students in the sample own a smartphone, and 96.4% of the sample have prior experience with mobile applications for language learning.

3.3. Research Setting

The current study setting is Shinawatra University, situated in the Bangkok Metropolitan Region. This setting is an apt representation of the current educational scenario in Thailand with regard to the adoption of digital technologies in education. In the English language learning context of the current study setting, teachers explicitly encouraged the usage of mobile apps such as Quizlet and Duolingo for learning vocabulary. Thus, the current setting is an appropriate scenario for an empirical investigation of mobile learning behavior.

3.4. Research Instruments

The current study made use of an online self-report survey with a 7-point Likert-type rating scale ranging from 1 (Strongly Disagree) to 7 (Strongly Agree). There are mainly three sections in the current study survey.

1. MAVL Engagement Scale: A 6-item self-developed scale is used for data collection. This scale is based on an extensive review of the existing literature on mobile-assisted vocabulary learning. An initial set of 10 items was developed. A pilot survey with 30 Thai EFL students helped assess the face and content validity of the initial set of 10 items. Four items were modified, and two items were eliminated to develop the final 6-item MAVL Engagement Scale. This scale showed an outstanding level of internal consistency with Cronbach's α of .85.

2. Metacognitive Self-Regulation Scale: A 9-item revised subscale of the Motivated Strategies for Learning Questionnaire (MSLQ) by Tock and Moxley (2017) is used for the current investigation. After translating the original English version of the subscale into Thai and back-translating it into English, the subscale showed an outstanding level of reliability with α of .88.

3. Vocabulary Learning Outcomes Scale: This construct was conceptualized as a second-order latent construct consisting of two first-order dimensions, namely, (a) Self-Perceived Vocabulary Knowledge (5 items, adapted from Paribakht and Wesche (1993); α = 0.82), and (b) Vocabulary Learning Self-Efficacy (4 items, self-developed, derived from theory by Bandura; α = 0.79).

This construct was developed in accordance with Bandura (2006) guidelines for measuring self-efficacy. The items were designed to assess students' self-perceived efficacy in using mobile tools to learn vocabulary in diverse, difficult circumstances, such as "I can learn new English words using mobile apps even when I am busy." The initial 6 items were pre-tested for content validity by two experts in educational psychology and EFL pedagogy. Two items were eliminated after piloting the scale on 30 students, and finally, 4 items were retained.

A summary of the key measurement instruments, including their sources and reliability coefficients, is provided in Table 1.

Table 1. Summary of measurement scales and their reliabilities.

Variables	Scale source / Type	No. of items	Reliability (Cronbach's α)
MAVL use	Self-developed	6	0.85
Metacognitive self-regulation	Tock and Moxley (2017)	9	0.88
Self-Perceived vocabulary knowledge	Adapted from Paribakht and Wesche (1993)	5	0.82
Vocabulary learning self-efficacy	Self-developed	4	0.79
Full questionnaire	—	24	0.91

3.5. Data Collection and Data Analysis

Ethical clearance for the study was granted by the university's Institutional Review Board prior to data collection. The questionnaire was administered online through the course's learning management system during Weeks 8-9 of the semester. Data analysis was conducted sequentially. First, descriptive statistics and bivariate correlations were computed using SPSS version 27.0. Second, the measurement model for the Metacognitive Self-Regulation scale was validated with Confirmatory Factor Analysis (CFA) using Mplus Version 8.3. The model

demonstrated a good fit: $\chi^2/df = 1.81$, CFI = 0.975, RMSEA = 0.060, SRMR = 0.036. Lastly, the hypothesized model with the latent interaction term was tested in Mplus. The model's fit was evaluated against cut-off values: CFI and TLI > 0.95; RMSEA and SRMR < 0.08. If the interaction effect was statistically significant, further analysis, such as simple slopes analysis, would be conducted to examine the interaction's nature.

4. Results

4.1. Descriptive Profiles: Levels of MAVL Engagement, Self-Regulation, and Learning Outcomes

This section provides an overview of the key features of the major variables studied. Descriptive statistics were computed to determine central tendency, dispersion, and distribution shape for a sample consisting of 223 university-level EFL learners in Thailand. As illustrated in Table 2, MAVL was found to have a moderately high level of engagement, with a mean score of 4.78 out of 7 and a standard deviation of 1.23.

A significant observation was that, out of all the studied variables, metacognitive self-regulation had the highest score with a mean of 5.21 out of 7 and a standard deviation of 1.05. This might imply that there is a rising awareness and acceptance of learner autonomy and strategies in the contemporary Thai education system, as learners perceive themselves as capable of planning and monitoring their own learning and making necessary adjustments.

The second-order latent variable for vocabulary learning outcomes, which consists of self-perceived knowledge and self-efficacy, also had a positive value with a mean of 4.72 out of 7 and a standard deviation of 1.14. This provides a preliminary indication of the participants' global self-confidence and self-satisfaction with their vocabulary acquisition.

A further preliminary analysis to precede advanced statistical analysis involved determining normality. The absolute value of skewness and kurtosis for each variable under investigation remained within acceptable and desirable univariate normality thresholds for skewness and kurtosis, i.e., $< |3|$ and $< |10|$, respectively. This was found to comply with Kline (2015) recommendations for univariate normality, i.e., skewness $< |3|$ and kurtosis $< |10|$. This ensured that the data did not show significant deviations from normal distribution, thereby permitting the application of the Maximum Likelihood estimation technique for the analysis, which is robust to deviations from normality but requires this preliminary analysis to confirm normality.

Table 2. Descriptive statistics for key variables (N = 223).

Variables	Mean (M)	SD	Skewness	Kurtosis	95% CI lower	95% CI upper
MAVL use	4.78	1.23	-0.32	-0.15	4.62	4.94
Metacognitive self-Regulation	5.21	1.05	-0.41	0.22	5.07	5.35
Vocabulary learning outcomes	4.72	1.14	-0.27	-0.08	4.57	4.87

Note: CI = Confidence Interval. All variables measured on a 7-point scale.

4.2. Interconnections: Bivariate Relationships Among Key Constructs

In order to create preliminary relationships between the variables and set the stage for the structural model, bivariate correlation analysis was conducted. The results of the Pearson correlation coefficients were used, and to increase the robustness of these estimates, particularly considering the sensitivity of correlations to distributional properties, 95% Bias-Corrected and Accelerated (BCa) confidence intervals were calculated using 1000 bootstrap resamples.

The correlation matrix, as displayed in Table 3, suggests several statistically significant relationships between the variables. Most notably, MAVL engagement was found to have a strong positive correlation with vocabulary learning outcomes ($r = 0.53$, 95% CI [0.42, 0.63]). While preliminary, such an outcome is consistent with the overall body of literature supporting the efficacy of mobile tools in vocabulary development.

The highest correlation coefficient in the correlation matrix was found between metacognitive self-regulation and vocabulary learning outcomes, which was found to be statistically significant ($p < 0.001$); however, it was also found to be very strong, at $r = 0.65$, 95% CI [0.56, 0.73]. Such an outcome is consistent with the foundational premise of SRL theory in technology-enhanced contexts, in which self-regulatory capacity is foundational in achieving positive learning outcomes in such environments.

Furthermore, it was also found that MAVL engagement and metacognitive self-regulation were significantly and positively correlated, $r = 0.46$, 95% CI [0.33, 0.57]. Such an outcome is particularly relevant, as it suggests several potential relationships between SRL capacity and engagement in MAVL. Most notably, it suggests that students who possess higher SRL capacity may also be more inclined to engage in MAVL, or conversely, MAVL engagement may foster self-regulatory behaviors. Most notably, none of the bootstrap confidence intervals fell at or near zero, suggesting high confidence in the reliability of these relationships. The presence of such intercorrelations suggests that these relationships can be tested in an integrated model.

Table 3. Pearson correlation matrix with bootstrap confidence intervals.

Variables	1	2	3
MAVL engagement	—		
Metacognitive self-Regulation	0.46***[0.33, 0.57]	—	
Vocabulary learning outcomes	0.53***[0.42, 0.63]	0.65***[0.56, 0.73]	—

Note: ***$p < 0.001$. Values in square brackets are bias-corrected accelerated 95% confidence intervals based on 1000 bootstrap samples.

4.3. Validation of Measurement: Confirmatory Factor Analysis for Self-Regulation

Before examining the structural hypotheses, it was essential to confirm the psychometric validity of the measure for the moderator variable. A Confirmatory Factor Analysis (CFA) of the 9-item Metacognitive Self-Regulation Scale (MSR-R), using Mplus 8.3 software with a Maximum Likelihood estimation technique, was employed to test the a priori unidimensional structure of the MSR-R scale for this sample.

The model fit indices for the CFA model were satisfactory, with a chi-square test of fit, $\chi^2(27) = 48.92$, $p = .006$, $\chi^2/df = 1.81$; Comparative Fit Index (CFI) = 0.975; Tucker-Lewis Index (TLI) = 0.968; Root Mean Square Error of Approximation (RMSEA) = 0.060; Standardized Root Mean Square Residual (SRMR) = 0.036. These values meet the "good fit" standards for CFA models, as suggested by Hu and Bentler (1999), with CFI/TLI > 0.95, RMSEA < 0.06, and SRMR < 0.08.

The standardized factor loadings for each item on the MSR-R scale were all statistically significant, $p < 0.001$, with substantive values ranging from 0.61 to 0.84, with a mean of 0.73. These values surpass the 0.60 threshold for reliable indicators. Moreover, the MSR-R scale also exhibited high internal consistency reliability, with a Composite Reliability (CR) = 0.89, exceeding the 0.70 threshold, and convergent validity, with Average Variance Extracted (AVE) = 0.52, satisfying the .50 criterion suggested by Fornell and Larcker (1981).

In conclusion, the CFA model fit indices strongly support the construct validity of the metacognitive self-regulation construct, with high reliability, unidimensionality, and validity, thus providing a solid foundation for subsequent findings of this construct.

4.4. Testing the Structural Model: Direct and Interaction Effects

The main analysis involved testing the hypothesized structural equation model, which included both the direct effect of MAVL engagement on outcome (H1) and the moderating effect of self-regulation on the MAVL engagement-outcome relationship (H2). The structural equation model included a latent interaction term, which was constructed using the product indicator method, as recommended by Marsh, Wen, and Hau (2004).

Model fit was evaluated and found adequate for such a complex model. The goodness-of-fit statistics were as follows: $\chi^2(142) = 298.36$, $p < 0.001$, $\chi^2/df = 2.10$, CFI = 0.956, TLI = 0.948, RMSEA = 0.071 (90% CI [0.060, 0.082]), SRMR = 0.050. Although the RMSEA is slightly higher than the optimal value of 0.06, it is still well within the acceptable range of 0.08. The CFI, TLI, and SRMR are all good to excellent. The significant χ^2 statistic is not surprising, however, in samples as large as ours. Thus, it is not particularly informative. The other statistics provide more useful information.

The standardized path coefficients, as presented in Table 4, were used to test both of the proposed hypotheses. First, supporting Hypothesis 1 (H1), MAVL engagement was found to have a statistically significant positive direct effect on vocabulary learning outcome, even after controlling for the substantial effect of metacognitive self-regulation.

Second, and more significantly, Hypothesis 2 (H2) received strong support. The path coefficient for the latent interaction term, MAVL Engagement x Metacognitive Self-Regulation, was statistically significant and positive ($\beta = 0.22$, SE = 0.07, $p = 0.002$), indicating that the MAVL engagement-vocabulary learning outcome relationship varies significantly as a function of metacognitive self-regulation levels.

Table 4. Structural path coefficients and hypothesis testing results.

Path relationship	Std. β	SE	p-value	Hypothesis	Result
H1: MAVL Use → Vocab. Outcomes	0.35	0.07	< 0.001	H1: Positive prediction	**Supported**
Control path: Metacog. Self-Reg. → Vocab. Outcomes	0.57	0.06	< 0.001	—	—
H2: Interaction term (MAVL × Metacog.) → Vocab. Outcomes	0.22	0.07	0.002	H2: Moderating role	**Supported**

To further clarify the significant interaction effect and answer the question "for whom is MAVL engagement most beneficial?", a simple slope analysis was conducted, as suggested by Aiken and West (1991). Quantification of the relationship between MAVL engagement and vocabulary performance was performed for a range of representative groups with different metacognitive self-regulation skills: the sample mean (M), one standard deviation above the mean (high group: M+1SD), and one standard deviation below the mean (low group: M-1SD). The results showed the following pattern of conditional effects.

- High Metacognitive Self-Regulation: Simple Slope $\beta\_high = 0.57$ ($p < 0.001$). For these strategic learners, increased MAVL engagement is associated with significant improvements in vocabulary outcomes.
- Average Metacognitive Self-Regulation: Simple Slope $\beta\_mean = 0.35$ ($p < 0.001$). Although the relationship is positive and statistically significant, it is weaker than for the high self-regulation group.
- Low Metacognitive Self-Regulation: Simple Slope $\beta\_low = 0.13$ ($p = 0.042$). Although positive and statistically significant, the effect is small, suggesting a limited impact of increased MAVL use on learner outcomes for these learners.

To further verify these results, the interaction effect was statistically compared. The difference between the simple slopes for high and low self-regulation groups was statistically significant ($\Delta\beta = 0.44$, $p = 0.001$). In effect, it confirms that the self-regulation effect on the relationship between MAVL and outcomes is not only statistically significant but also quantitatively significant.

This pattern, as illustrated in Figure 1, is characterized as an "enhancing" or "synergistic" interaction effect. Note that the regression line for high and low self-regulators differs with increased MAVL use. The higher slope for the high self-regulation group graphically illustrates the main effect: The educational payoff or return on investment in mobile learning technology is much higher for learners with the ability to use these learning tools strategically.

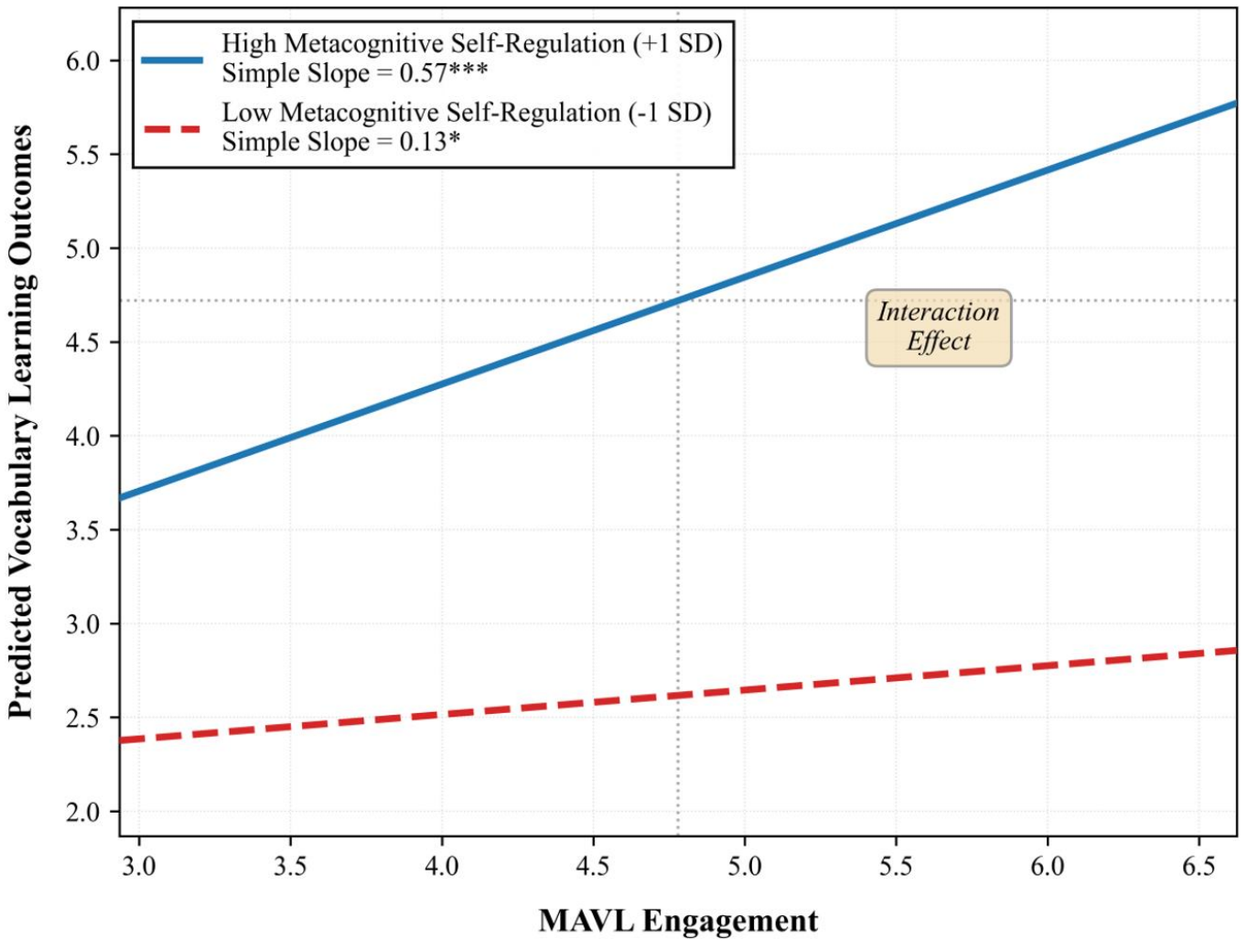

Figure 1. Visualization of the moderating effect: The relationship between MAVL engagement and vocabulary outcomes at high vs. low levels of metacognitive self-regulation.

Note: The figure shows two regression lines, one for High Self-Regulation (solid line) and one for Low Self-Regulation (Dashed line). The simple slope for the high self-regulation group ($\beta = 0.57$***) and for the low self-regulation group ($\beta = 0.13$*) were both statistically significant. The divergence of the two regression lines at higher levels of MAVL engagement suggests a significant interaction effect. *$p < 0.05$, ***$p < 0.01$.

5. Discussion

The major objective of this study was to transcend the simplistic evaluation of MAVL tool effectiveness by exploring circumstances where MAVL tool effectiveness is maximized. More specifically, this study examined the moderating impact of metacognitive self-regulation on the association between MAVL tool engagement and vocabulary outcomes for Thai EFL university students. Quantitative findings provide clear and complex implications, supporting direct and interactive effects. The next section provides an interpretation of these findings in relation to established theory, as well as their implications, limitations, and possibilities for future research.

5.1. Synthesis and Interpretation of Key Findings

The results provide a clear research story. First, the large positive direct effect of MAVL tool engagement on vocabulary outcomes (support for Hypothesis H1) adds to existing research on the general effectiveness of mobile technology in language learning (Sung et al., 2015). In the context of the "connected campus" phenomenon in Thailand, the result confirms existing research in institutions' attempts to harness technology in language learning.

The main contribution of the research is the support for the moderation hypothesis (Hypothesis H2). The interaction effect is confirmed by the simple slope analysis, showing that the relationship between the MAVL tool and outcome depends on the level of metacognitive self-regulation of the learner. The results indicate that for high self-regulators, the effect of MAVL tool engagement is a significant improvement in outcome ($\beta = 0.57$), while for low self-regulators, the effect is a much smaller improvement ($\beta = 0.13$). The findings suggest that the traditional "one-size-fits-all" approach to educational technology should be replaced with a more nuanced view of technology effectiveness. It demonstrates that mobile technology does not equally empower all learners; instead, its effectiveness is significantly enhanced or hindered by the learner's ability to strategically self-manage their own learning.

5.2. Theoretical Integration: Bridging Technology and Learner Agency

The finding strongly supports theoretical claims emphasizing self-regulation as a key driver in technology-based learning. It supports Zimmerman (2000) cyclical model of self-regulated learning, which argues that effective learning requires forethought, performance control, and self-reflection. In high-autonomy, low-external-structure contexts like mobile learning, such self-regulatory processes are non-negotiable for effectiveness. This implies that high self-regulators are more likely to use MAVL tools meaningfully and goal-directed, such as aligning app use with personal learning plans, using app analytics to track mastery levels, and adapting strategies based on perceived difficulty. Such evidence demonstrates a deep, agentic use of technology.

On the other hand, the weak relationship for low self-regulators shows what (Stockwell, 2022) called "grazing learning," or passive and reactive consumption of digital content that does not engage deeper cognitive processing

or knowledge integration. In this case, the smartphone may be as much a source of distraction as of learning. This research combines two traditions: one focusing on technological affordances, another on individual differences among learners. It supports the claim that self-regulation not only predicts but also moderates or acts as a "catalyst" for translating technological affordances into concrete educational outcomes (Järvelä et al., 2015; Winne, 2001).

5.3. Practical Implications for Digital Language Pedagogy

The implications for practice are significant and far-reaching. The study's findings suggest caution against a techno-deterministic fallacy and recommend a two-pronged approach to language pedagogy.

For language teachers, this means a shift from a role that focuses on "tool introduction" to one that emphasizes "metacognitive coaching." The study's findings recommend that pedagogy now explicitly include a component for teaching self-regulation skills. For instance, when teachers ask students to practice their vocabulary with tools like Quizlet, they can now ask students to set weekly targets, maintain a journal to record difficulties, and share useful application tips with the class. This way, the abstract skill of self-regulation can be embedded within the specific task of vocabulary learning.

For instructional designers and educational technologists, this study's findings recommend a learner-centered design for tools and tasks. The design for a learning application now goes beyond the current scope of delivering content and includes features that promote self-regulation. Similarly, for assignments related to mobile learning, a design that includes a planning statement and a reflection component can now integrate metacognitive activity within the workflow.

In terms of systemic implications, the current study also points to the possibility of a new dimension of equity in digital education: The strategic divide. While the traditional digital divide regarding access may be closing in many societies around the world, the divide concerning the self-regulatory skills needed to effectively utilize these technologies may be growing. As such, educational programs need to be designed that not only provide students with the hardware and software needed for digital learning but also offer training for both students and teachers regarding the cognitive and metacognitive strategies necessary for successful learning in these environments.

5.4. Limitations and Avenues for Future Research

Although the current study provides important new insights into the relationship between self-regulation and learning outcomes in the context of learning apps, there are also some limitations that need to be acknowledged to provide context for the current results and suggest avenues for future research. First, while the study offers valuable insights into the relationship between self-regulation and learning outcomes, its cross-sectional design does not allow for causal claims. Although the theoretical model and statistical analysis support the directional relationships proposed, future studies using longitudinal or experimental designs are necessary to establish causality. Second, while the current study uses self-report measures of both engagement and learning outcomes, these are both common methodologies in the field that have been shown to be reliable. Nevertheless, future studies may wish to consider using other methodologies, such as behavioral data provided by the learning apps themselves (such as time on task and number of items completed) and objective measures of learning outcomes (such as pre- and post-vocabulary tests). Third, while the current study provides an important new contribution regarding the relationship between self-regulation and learning outcomes in the context of learning apps, it is limited by the context in which it was conducted, Thai university students learning English as a foreign language. Therefore, future studies are needed to determine whether the current results generalize to other contexts.

Lastly, this study was limited to vocabulary acquisition. However, another interesting research direction would be to investigate whether this moderating role of self-regulation applies to other language skills, such as listening comprehension and writing fluency, or to full online as opposed to blended modes of instruction. More precise research could be conducted by exploring the interplay between app-related features (such as gamification) and different self-regulation subprocesses (such as goal setting and emotions).

5.5. Concluding Remarks

To conclude, this research proves that the process of moving from access to mobile technologies to language learning is not a straightforward process. It is, to a great extent, mediated by the learner's ability for metacognitive self-regulation. By providing empirical support for this interactional model, this research shifts the locus of attention away from the tools and towards the interaction between the learner and the tool. The main implication for practitioners is, of course, that to fully capitalize on the opportunities offered by mobile language learning, investments should be made, not only in the tools but also in the learners. It is not a question of substituting the tools for traditional methods but of using the tools to achieve the traditional, but ever-important, goal of education: to empower learners.

6. Conclusion

The present study aims to address a key concern regarding technology-assisted language learning, specifically whether a learner's ability for strategic self-management impacts the efficacy of mobile technology-based tools. By investigating the moderating effect of metacognitive self-regulation among Thai EFL university students, this study extends beyond assessing the effectiveness of technology-based tools to include a crucial human factor in the technology-learning relationship. The transition from theory to quantitative research results in clear, statistically significant findings. Results show that there exists no fixed and guaranteed relationship between mobile-assisted vocabulary learning (MAVL) and vocabulary learning outcomes. Although a positive direct impact confirms the efficacy of such tools, the impact is significantly influenced by the learner's potential for metacognitive self-regulation. For learners with high self-regulatory potential, MAVL proves to be a powerful tool for vocabulary development, while for learners with low self-regulatory potential, MAVL proves to be only marginally beneficial.

The theoretical implications of the research are quite significant. The fact that the research investigated self-regulation as a moderating factor links two branches of educational research: the potential of educational

technology and individual differences in the learner. The research, therefore, provides a more holistic and integrated model of the technology-learner interaction by reframing it in terms of the mutual influence of technology and the learner. Such an approach is more holistic and learner-centric, moving away from the more traditional tool-centric approach. From a practical perspective, the research findings are quite definitive and prescriptive. The research findings have major implications for educators and educational institutions that wish to introduce mobile learning technologies. The research findings strongly advocate the need to focus more on capacity-building and cultivation, as opposed to access and adoption. The integration of mobile learning technologies is best achieved by adopting a two-pronged approach: one that is focused on the effective and strategic use of the technology, and another that is focused on the cultivation of metacognitive and self-regulatory skills among learners. The research findings have major implications for software developers too. The research findings highlight the need to develop "self-regulation-aware" software applications.

In conclusion, the research findings argue that the potential of sophisticated technology is realized in the digital environment to the extent that learners can strategically and effectively use such technology. The potential of mobile-assisted language learning is realized to the extent that there is cultivation of learners who are not only capable of utilizing sophisticated technology but also strategic learners who can shape their own destiny and growth.

7. Pedagogical Implications

This explicit scaffolding is seen to be crucial in facilitating the transformation from passive use to active and strategic use of learning. At the same time, instructional and curriculum design should progress to incorporate self-regulatory cycles into the learning process. This requires designing learning tasks to require antecedent task goal setting and consequent task reflection, and to provide differentiated supports such as structured checklists for learners to develop foundational learning habits. This imperative is also addressed to instructional technology designers, who should move beyond the design of “delivery” technologies to “self-regulation-aware” technologies that provide learners with guidance on navigating goal setting, progress, and strategic review. Finally, these research results underscore the imperative to close a “strategic divide,” which is the self-regulatory skills gap that could limit the benefits of ICT access for some learners. Therefore, investments in ICT infrastructure should be complemented with investments in teacher and learner training to develop these essential learning capabilities. In conclusion, successful implementation of mobile learning does not require technology to replace pedagogy, but to use technology to enhance our fundamental mission: to empower learners to be strategic, self-directed, and resilient learners in an increasingly technology-rich world.

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