

Effects of Taiwan Adaptive Learning Platform Engagement and Self-Regulated Learning on Mathematics Achievement among Low-Achieving Elementary Students

Bor-Chen Kuo ^a, Jui-Chih Hsin ^{a*} and Chia-Hua Lin ^a

^a*Graduate Institute of Educational Information and Measurement, National Taichung University of Education, Taichung, Taiwan*

*cms108102@gm.ntcu.edu.tw

Abstract

Adaptive learning technologies are increasingly used to support personalized learning; however, evidence regarding their effectiveness for low-achieving students in remedial education contexts and the underlying self-regulated learning (SRL) mechanisms remains limited. Drawing on SRL theory, this study examined whether SRL mediates the relationship between engagement with a Taiwan adaptive learning platform (TALP) and mathematics achievement among low-achieving upper elementary students. Participants were 1,805 Grade 5 and Grade 6 students in Taiwan who received after-school remedial mathematics instruction supported by the TALP. Platform engagement was derived from system usage records, SRL was measured using a validated questionnaire, and mathematics achievement was assessed using a growth-based computerized test. Results indicated that platform engagement was positively associated with both SRL and mathematics achievement, and SRL was positively associated with mathematics achievement. A significant indirect effect through SRL indicated a partial mediation pattern. These findings highlight SRL as an important mechanism linking Taiwan adaptive learning platform engagement to learning outcomes in remedial education contexts.

Keywords: Self-regulated learning; adaptive learning; remedial teaching; mathematics achievement; mediation effect

1. Introduction

Recent advances in adaptive learning technologies (ALTs) have spurred the adoption of digital platforms offering personalized learning pathways. While effective for general populations (VanLehn, 2011), the cognitive-behavioral mechanisms through which ALTs support underachieving students in remedial contexts remain under-explored. In such settings, access to technology alone does not guarantee gains; Self-regulated learning (SRL)—the capacity to set goals, monitor progress, and adjust strategies—acts as a critical bridge between digital environments and academic outcomes (Panadero, 2017; Zimmerman, 2002). For low-achieving students, deficits in internal regulation often hinder their ability to benefit from instructional supports (Dignath & Büttner, 2008). From an SRL perspective, ALTs provide external regulatory scaffolding through diagnostic feedback and personalized sequences, which may compensate for limited internal regulation and facilitate its development (Winne & Hadwin, 2010). Although prior research suggests that SRL may mediate the link between platform engagement and achievement (Lin et al., 2025), empirical evidence in remedial contexts is scarce. This study examines upper elementary students in Taiwan using the Taiwan Adaptive Learning Platform (TALP)—a knowledge-map-based system—to investigate the mediating role of SRL in remedial mathematics instruction. We propose the following hypotheses:

- H1. TALP engagement is positively associated with mathematics achievement.
- H2. TALP engagement is positively associated with students' SRL.
- H3. SRL is positively associated with mathematics achievement.

- H4. SRL is associated with the relationship between TALP engagement and mathematics achievement.

2. Method

2.1 Participants

This study analyzed 1,805 upper elementary students (Grade 5, N= 923 ; Grade 6, N= 882) participating in Taiwan's national remedial mathematics program via the TALP platform in 2022. The analytic sample was restricted to students with complete data across three key areas: (1) remedial mathematics growth test scores, (2) digital platform usage logs, and (3) SRL questionnaire responses. This ensured a robust dataset for structural equation modeling (SEM). Data were anonymized and processed in compliance with institutional ethics standards for secondary educational data analysis.

2.2 Instruments

2.2.1 Taiwan adaptive learning platform

The Taiwan Adaptive Learning Platform (TALP), developed by the Ministry of Education, is an AI-driven diagnostic and adaptive system for K-12 education. It integrates diverse resources, including instructional videos, dynamic assessments, and game-based modules. Based on assessment performance, TALP generates individualized diagnostic reports and automated personalized learning pathways tailored to specific knowledge gaps. Students with divergent mastery profiles are guided through distinct, node-based learning sequences.

In this study, platform engagement was operationalized as total time spent on TALP, reflecting students' exposure to the adaptive learning environment. During the remedial period, students followed a learning cycle aligned with self-regulated learning (SRL). Diagnostic assessments and personalized pathways supported goal setting, while videos and practice facilitated strategy selection. Feedback and progress indicators enabled monitoring, and adaptive recommendations supported adjustment. Together, these features position TALP as external regulatory scaffolding that supports SRL processes.

2.2.2 Self-regulated learning integrated questionnaire

SRL was measured using the Self-Regulated Learning Integrated Questionnaire (SRLIQ), an instrument validated for large-scale digital learning and the TALP context (Kuo & Chang, 2025). The SRLIQ assesses four domains: cognitive, behavioral, motivational/affective, and technology-supported regulation. Prior research confirmed its robust psychometric properties with a Comparative Fit Index (CFI) of 0.982, ensuring precise alignment between the measure of self-regulation and the adaptive scaffolding features of the platform.

2.2.3 Growth-Based Mathematics Achievement Assessment

Mathematics achievement was measured via the Priori-tbt, a standardized digital assessment tailored for remedial contexts (Kuo & Chang, 2025). The system employs a bi-annual cycle: a screening test in May (threshold < 70) for program enrollment, and a growth test in December to evaluate progress. In this study, the December growth test scores served as the primary outcome measure, representing academic performance following sustained TALP engagement and remedial intervention.

2.3 Data analysis and Study Procedure

This longitudinal study tracked 1,805 upper elementary students (Grade 5, n = 923; Grade 6, n = 882) through a national remedial mathematics program in Taiwan. The procedure followed a structured timeline: Initial Screening (May): Students completed the Priori-tbt screening test; those scoring below 70 were enrolled in remedial instruction. Adaptive Intervention (May–October): Students engaged in after-school remedial sessions supported by TALP, involving diagnostic assessments, self-paced video learning, and iterative practice. System logs captured granular platform engagement data. SRL Assessment (October–December): Following sustained intervention, students completed the

SRLIQ to evaluate their self-regulated learning processes. Growth Assessment (December): Mathematics achievement was measured using the Puri-tbt growth test.

2.4 Descriptive Statistics and Learning Gains

Students' mathematics scores increased from the May screening test to the December growth test. The mean score on the screening test was $M = 66.34$ ($SD = 14.58$), whereas the mean score on the growth test was $M = 85.38$ ($SD = 7.62$). A paired-samples t -test indicated that this increase was statistically significant, $t(1804) = 58.87$, $p < .001$, with a large effect size (Cohen's $d = 1.36$). These results indicate that students' mathematics performance improved significantly over the study period. Based on these findings, subsequent analyses further examined the role of SRL and digital learning behaviors in explaining students' learning outcomes.

2.5 Structural Equation Modeling Results

The mediation structural equation model indicated an acceptable fit to the data (CFI = .959, IFI = .959, NNFI = .952, RMSEA = .064). Standardized path coefficients showed that platform engagement was positively associated with SRL ($\beta = .237$, $p < .001$). In turn, SRL was positively associated with mathematics achievement ($\beta = .331$, $p < .001$). Platform engagement also had a significant direct association with mathematics achievement ($\beta = .348$, $p < .001$), as shown in Figure 3.

In addition, the results indicated a significant indirect effect of TALP engagement on mathematics achievement through SRL ($\beta = .078$, $p < .001$), supporting that SRL functioned as a partial mediator in the relationship between TALP engagement and mathematics achievement. Although the indirect effect was relatively small, it indicates that SRL represents one of multiple pathways through which platform engagement is associated with learning outcomes in complex educational settings.

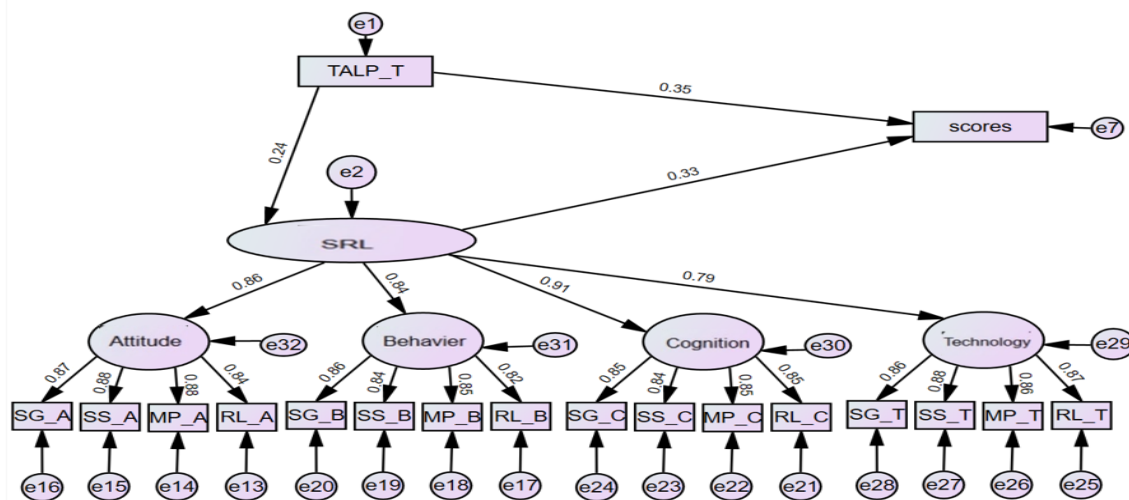


Figure 3. Structural equation model of platform engagement, self-regulated learning, and mathematics achievement.

Note. TALP_T: total time spent on the TALP; SRL: questionnaire score measured by the SRLIQ; scores: mathematics achievement based on the growth test administered via the Puri-tbt platform; SG: setting goals; SS: selecting strategies; MP: monitoring progress; RL: reflecting on learning; SG_A: setting goals in the affective domain

3. Discussion and Conclusion

3.1 Contributions and Implications

This study offers three key contributions: (1) it targets underachieving students in remedial contexts, a population often underrepresented in ALT research; (2) it identifies SRL as a critical psychological mechanism linking digital engagement to achievement; and (3) it leverages large-scale, real-world data to enhance ecological validity. Theoretically, our

findings support the role of ALTs as external regulatory scaffolding (Winne & Hadwin, 2010), where personalized pathways compensate for internal regulation deficits in low-achieving learners. Practically, the results emphasize that while "time-on-task" is beneficial, fostering SRL processes (e.g., goal setting and reflective regulation) is essential for maximizing the efficacy of adaptive systems.

3.2 Limitations and Future Directions

The study's observational nature precludes causal claims, and the modest mediation effect suggests other contributing factors like prior achievement. In addition, the absence of a control group limits the ability to isolate the specific contribution of TALP from other components of remedial instruction. Additionally, the aggregate measure of total time-on-task lacks behavioral granularity. Future research should employ longitudinal or cross-lagged designs to capture potential reciprocal relationships between SRL and achievement. Incorporating fine-grained behavioral logs—such as navigation patterns and revision cycles—will further clarify which specific interactions best scaffold self-regulation for struggling learners.

Acknowledgements

This study was successfully completed with heartfelt gratitude to 'The Digital Learning Enhancement Plan for Grades 1–12 Students' and 'Taiwan Adaptive Learning Platform' supported by the Ministry of Education, Taiwan, for their invaluable data and support. Academic papers published using this data represent solely the views of the author and do not reflect the opinions, perspectives, or positions of the Ministry of Education. The author assumes full responsibility for any related matters.

Funding

This study is supported by the National Science and Technology Council of Taiwan under grant number NSTC 112-2410-H-142 -017 -MY3.

References

- Clarebout, G., Horz, H., Schnotz, W., & Elen, J. (2010). The relation between self-regulation and the embedding of support in learning environments. *Educational Technology Research and Development*, 58(5), 573-587.
- Dignath, C., & Büttner, G. (2008). Components of fostering self-regulated learning among students. A meta-analysis on intervention studies at primary and secondary school level. *Metacognition and learning*, 3(3), 231-264.
- Kuo, B. C., & Chang, F. T. Y. (2025). Development and application of a self-regulated learning questionnaire in the large-scale digital learning context. *Education and Information Technologies*, 30, 16463–16486.
- Labuhn, A. S., Zimmerman, B. J., & Hasselhorn, M. (2010). Enhancing students' self-regulation and mathematics performance: The influence of feedback and self-evaluative standards. *Metacognition and learning*, 5(2), 173-194.
- Lin, C. H., Kuo, B. C., & Chang, F. T. Y. (2025). The impact of Taiwan adaptive learning platform (TALP) on self-regulated learning and mathematics achievement. *Educational Psychology*, 1-22.
- Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. *Frontiers in psychology*, 8, 422.
- Van Schoors, R., Elen, J., Raes, A., & Depaepe, F. (2021). An overview of 25 years of research on digital personalised learning in primary and secondary education: A systematic review of conceptual and methodological trends. *British Journal of Educational Technology*, 52(5), 1798-1822.
- VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational psychologist*, 46(4), 197-221.
- Winne, P. H., & Hadwin, A. F. (2010). Self-regulated learning and socio-cognitive theory. *International encyclopedia of education*, 503-508.
- Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In *Handbook of self-regulation* (pp. 13-39). Academic press.
- Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into practice*, 41(2), 64-70.