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Data-Driven Insights from National-Scale Learning Analytics: How Self-Regulated Learning Mitigates Summer Learning Loss

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Abstract: Summer Learning Loss (SLL) remains a persistent educational concern. However, prior research offers limited generalizability for policy and practice due to the limited to small-scale controlled settings. This study addresses that gap by analyzing national-scale learning data from 70,677 elementary students, focusing on TALP supported self-regulated learning (SRL) during the summer of 2023 in Taiwan. Using biannual PRIORI-tbt assessments as benchmarks, we examined 6.79 million TALP learning logs to assess engagement patterns and outcomes. Results show that students who used TALP during summer outperformed non-users, with the most significant gains observed among those who engaged for two or more consecutive weeks. These findings highlight effective engagement strategies and optimal intervention timing, offering empirical support for leveraging digital SRL to mitigate SLL.

Keywords: Taiwan Adaptive Learning Platform(TALP), summer learning loss, self-regulated learning, method of moving averages, learning continuum

1. Introduction

Students who lack structured learning arrangements and support during the prolonged summer break are highly susceptible to experiencing Summer Learning Loss (SLL). This phenomenon refers to the significant academic regression due to the interruption of learning activities over the vacation period. SLL is not confined to specific countries or educational systems; instead, it is recognized as a global educational challenge, disproportionately impacting students with lower academic achievements or lower socio-economic backgrounds (Atteberry & McEachin, 2020; Baş, 2023; Kuhfeld et al., 2020). Many studies suggest that maintaining some learning activity during the summer can effectively mitigate SLL (Contesse et al., 2020). Learning management systems (LMS), in particular that provide learning experiences with feedback mechanisms and adaptive content, can enhance student engagement and persistence outside regular school terms, thereby reducing the severity of learning loss (Lynch & Kim, 2017; Liu, 2022). This effect has been validated in recent research (Kuo & Chang, 2025). Nevertheless, large-scale empirical research assessing the practical efficacy of digital autonomous learning during summer breaks remains limited. Furthermore, there is an urgent need for robust data analysis on the national-scale empirical dataset to inform educational practices and policy initiatives with data-driven insights, specifically on how guidance should be provided to students and recommendations regarding the intensity of intervention from teachers or schools (Lenhoff et al., 2020; McCombs et al., 2011).

In Taiwan, the Ministry of Education (MOE) has developed several LMS to support teaching and learning. The Taiwan Adaptive Learning Platform (TALP) with SRL functionalities is the most-adopted nationwide digital learning platform within the K-12 schools, featuring comprehensive educational content. TALP provides a curriculum-aligned question bank, video-based instructional materials, and individualized learning recommendations to fully supports SRL activities (e.g., planning, monitoring and evaluating). The TALP can also providing adaptive learning suggestions to facilitating individual students' learning proficiency,

or overcome the learning weaknesses complemented by teacher-assigned tasks. Given these affordances, TALP could be an promising platform to mitigate students' SLL .

This study aims to analyze elementary students' learning persistence, and engagement on TALP during summer breaks, using two rounds of nationwide standardized technology-based testing as benchmarks to evaluate the platform's efficacy in mitigating SLL. Specifically, the study addresses the following research questions: (1) What is the effectiveness of TALP in reducing SLL? (2) What learning patterns (persistence and engagement) effectively reduce SLL? By addressing these questions, empirical evidence and suggestions that leverage technology-assisted SRL to mitigate SLL.

2. Related works

2.1 Summer Learning Loss

Summer Learning Loss (SLL) refers to students' academic decline during summer due to the lack of structured learning. As a global issue, SLL has drawn wide attention across educational systems. Maldonado and De Witte (2022) found that SLL could reduce reading proficiency by 63–68%, math by 37–50%, and literacy by up to 67% among kindergartners. Kaffenberger (2020) projected that third-grade students may lose up to 1.5 years of learning by tenth grade. Paechter et al. (2015) and Shinwell and Defeyter (2017) confirmed the prevalence of SLL across different countries and education systems. Studies consistently show that SLL is especially severe in mathematics and contributes to widening achievement gaps (Atteberry & McEachin, 2020). Low-achieving students are most affected, showing greater declines during summer (Alexander et al., 2007; Lynch & Kim, 2017). Accordingly, this study focuses on low-performing students in mathematics to explore solutions for mitigating SLL.

2.2 Self- regulated learning

Self-Regulated Learning (SRL) is widely regarded as an effective strategy for addressing SLL. Structured SRL fosters knowledge acquisition and problem-solving among K–12 students (Lee & Chang, 2024), particularly in digital environments where adaptive tools promote motivation and persistence (Majumdar et al., 2023). Intensive SRL during summer has been shown to reduce math learning loss in low-achieving students (Baş, 2023; Kuhfeld et al., 2020). Online math platforms, when paired with proper scaffolding, can further enhance engagement (Lynch & Kim, 2017).

Since 2020, Taiwan's Ministry of Education has administered the national PRIORI-tbt assessments in May (Screening test) and December (Progress Test) to evaluate student proficiency in Mandarin, math, and English (MOE, 2023). These assessments help identify struggling students and track summer learning outcomes. To support SRL, the MOE also developed the Taiwan Adaptive Learning Platform (TALP), now serving over 2.8 million users (Kuo et al., 2023). TALP offers personalized learning pathways and real-time diagnostics to support precision interventions (Liu, 2022). Analyzing students' summer TALP usage and their PRIORI-tbt results offers valuable insights into how technology-assistant SRL can help mitigate SLL and bridge research gaps.

3. Methodology

3.1 Dataset and data pre-processing

This study analyzed data from 70,677 elementary students identified as low-achievers in mathematics based on the Screening test. The national representative sample covers schools across Taiwan. Among them, 9,393 used TALP during summer, while 61,284 did not.

From February to August 2023, we collected 6,786,993 TALP math learning records, including 6,131,658 video logs and 655,335 practice logs. The top 1% of outliers and incomplete or missing records were removed. All data were anonymized to ensure student privacy.

3.2 Learning Features

To examine the relationship between summer learning behaviors and outcomes, three dimensions were extracted from log data: learning persistence, learning intensity, and learning outcomes.

- **Learning Persistence**: Measured by consecutive and cumulative learning weeks. The former refers to the longest streak of uninterrupted weekly usage; the latter captures total usage weeks.
- **Learning Patterns**: Defined by students' total weekly learning activities (including video views and practice exercises) and video viewing durations.
- **Learning Outcomes**: Students who passed the Progress test, after failing the Screening test, were classified as “Pass”; otherwise, they were labeled as “Fail.”

4. Accessibility

4.1 The effects of using TALP on reducing SLL

Table 1 shows that students who used TALP during summer had higher passing rates on the December Progress Test than those who did not, regardless of TALP usage during the school term. Students who never used TALP had the lowest passing rate (34.14%), highlighting the impact of TALP-supported learning. These findings support prior research on the benefits of structured or self-regulated learning (SRL) in preventing academic decline during long breaks (Baş, 2023; Lynch & Kim, 2017).

Table 1. *Comparison of Progress Test Passing Rates Between TALP Users and Non-Users During Summe*

Use or not during semester (Feb.- June)	Use or not during summer vacation (July-Aug.)	*n*	Passing Rate
No	Yes	2,761	41.94%
Yes	Yes	3,594	39.24%
Yes	No	3,038	35.02%
No	No	61,284	34.14

4.2 Identifying Optimal Summer Learning Patterns: Continuous vs. Cumulative TALP Usage

To evaluate how different usage patterns affect learning outcomes, we analyzed both cumulative and continuous weekly engagement. As shown in Table 2, students with four or more cumulative usage weeks had the highest pass rate (41.00%), aligning with findings that greater learning time improves performance (Kuo & Chang, 2025). However, for continuous use, the highest pass rate (42.17%) was among students who engaged for exactly two consecutive weeks, outperforming those with shorter or longer durations. Notably, pass rates declined to 34.94% for those with four or more continuous weeks, possibly due to learning fatigue (Son & Simon, 2012). These results suggest that moderate, structured engagement, specifically, two consecutive weeks of TALP use, may be the most effective and sustainable summer strategy for underperforming students.

Table 2. *Comparison of Cumulative and Continuous TALP Usage During Summer and Their Effects on Students' Progress Test Passing Rates*

Usage Type	Weeks	*n*	Passing Rate
No use	-	61,284	34.14%
Cumulated use	1 week	3,117	34.74%
	2 weeks	1,635	39.69%
	3 weeks	956	40.69%
	4+ weeks	3,685	41.00%
Continuous Use	1 week	5,865	37.02%
	2 weeks	3,008	42.17%
	3 weeks	437	39.55%
	4 weeks	83	34.94%

4.3 Comparison of Learning Intensity Between Passing and Non-Passing Students

Building on the finding that two consecutive weeks of TALP use may be optimal, we applied a two-week moving average to students' school-term learning frequencies (Feb–Jun) to smooth out activity spikes (Majumdar et al., 2023). Weekly summer learning volumes were normalized by this baseline. A relative increase of 10% was marked as +0.1, while equal activity was marked as 0. We then compared normalized learning volumes between students who passed the December Progress Test and those who did not, visualized through a heatmap (Figure 1). Each cell reflects the weekly difference in learning intensity between the two groups—for example, +0.35 indicates the passing group have 35% more learning behaviors than the non-passing group.

Results (Figure 1) show the passing group consistently exhibited higher summer engagement during the weekdays and the weekends in August, particularly during mid-August. This suggests deliberate use of TALP and implies that mid-summer may be a key period for teacher-led interventions. Overall, sustained summer learning is linked to greater academic recovery, affirming TALP's role in mitigating SLL.

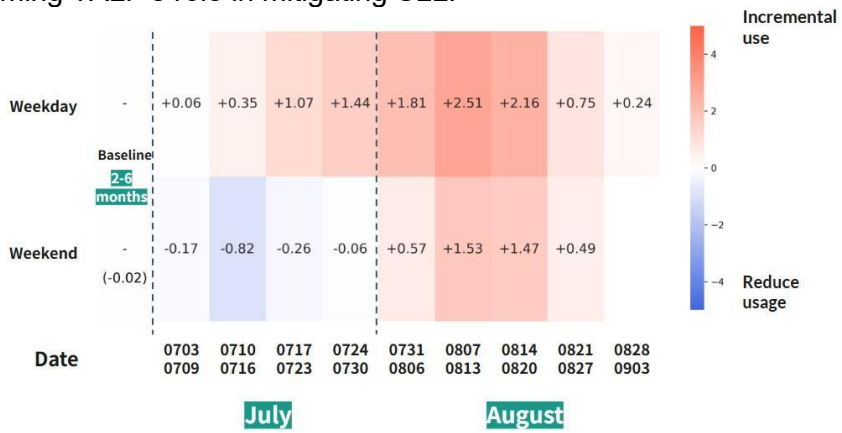

Figure 1. Weekly Differences in Summer Learning Intensity Between Passing and Non-Passing Students Based on a Two-Week Moving Averages

5. Conclusion and limitations

This study analyzed national-scale data from 70,677 low-achieving elementary students to evaluate the effectiveness of the Taiwan Adaptive Learning Platform (TALP) in mitigating summer mathematics learning loss. Students who used TALP during July–August showed significantly higher pass rates on the December Progress Test, confirming its positive impact. Notably, the most effective engagement pattern was two consecutive weeks of use, particularly in mid-August, suggesting an optimal window for targeted interventions. These findings offer practical insights for designing structured, data-informed digital learning

strategies. Specifically, aligning TALP with PRIORI-tbt diagnostics enables actionable, assessment-based support during breaks, helping sustain learning continuity and reduce disparities. This study has limitations, including its focus on mathematics and the use of cross-sectional rather than longitudinal data. Future research should explore broader subjects and long-term effects to strengthen policy and instructional applications with solid data-driven insights to students' SRL for addressing summer learning loss.

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