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Modeling the Relationships Among Platform Usage, Gamified Engagement, and Math Achievement

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Abstract: This study examines the impact of gamified learning by analyzing how students' use of the Taiwan Adaptive Learning Platform (TALP) and their engagement in the integrated gamified system, TALP Hero Rising, relate to mathematics achievement. System usage records were collected from 2,190 students in grades 4 to 6 across 20 cities in Taiwan between July and December 2024. Results indicated that greater use of TALP was positively associated with higher engagement in the gamified environment and directly related to improved mathematics achievement. Mediation analysis further indicated that engagement in TALP Hero Rising partially mediated the relationship between TALP usage and students' mathematics achievement.

Keywords: gamification, learning analytics, structural equation modeling

1. Introduction

Gamified learning has been extensively examined across K–12, higher education, and professional training contexts, with prior studies consistently highlighting its potential to enhance learners' motivation and learning performance (Basit et al., 2021; Dahri et al., 2025; Shen et al., 2024; Smirani & Yamani, 2024). Empirical research has demonstrated that gamified learning can effectively enhance students' academic performance and engagement in online learning environments (Mustafa et al., 2023). More specifically, gamification elements such as points, badges, and leaderboards have been shown to promote learners' academic achievement and strengthen their engagement in learning activities (Tay et al., 2022; Zaric et al., 2021) Furthermore, integrating gamification mechanisms into learning management systems (LMSs) has been found to support sustained learner engagement and long-term learning outcomes (Yuliana & Palumian, 2023).

The Taiwan Adaptive Learning Platform (TALP) is a nationwide digital learning system that provides curriculum-aligned learning resources across multiple subject, including Chinese, English, mathematics, science, and core competencies, spanning elementary to university levels. Learners interact with TALP by watching instructional videos, completing assessments, and submitting assignments, either independently or under teacher guidance. To further incentivize learning behaviors, TALP is integrated with a gamified platform, TALP Hero Rising, in which students earn virtual coins upon completing learning tasks and can exchange these rewards for in-game items.

Despite the growing body of research on gamified learning, previous studies have primarily focused on single game-based learning platforms and relied heavily on self-reported questionnaire data (Dehghanzadeh et al., 2024; Vrcelj et al., 2023). To address these limitations, the present study utilizes large-scale usage records collected from TALP and TALP Hero Rising across 20 counties and cities in Taiwan to examine whether engagement in TALP Hero Rising mediates the relationship between TALP usage and students' mathematics achievement, as illustrated in Figure 3.

2. Methods

2.1 Participants and data collection

System usage records were collected from TALP and TALP Hero Rising from July 1 and December 31, 2024, involving 2,190 students in grades 4 to 6 across 20 counties and cities in Taiwan. Table 1 and Table 2 show the breakdown by grade and region, respectively.

Table 1. *Distribution of participant by grade*

Grade Level	Grade 4	Grade 5	Grade 6	Total
Sample Size	650	737	803	2,190

Table 2. *Distribution of participant by region*

Region	North	Central	South	East	Offshore	Total
Sample Size	315	489	1,328	50	8	2,190

2.2 Indicators

2.2.1 TALP

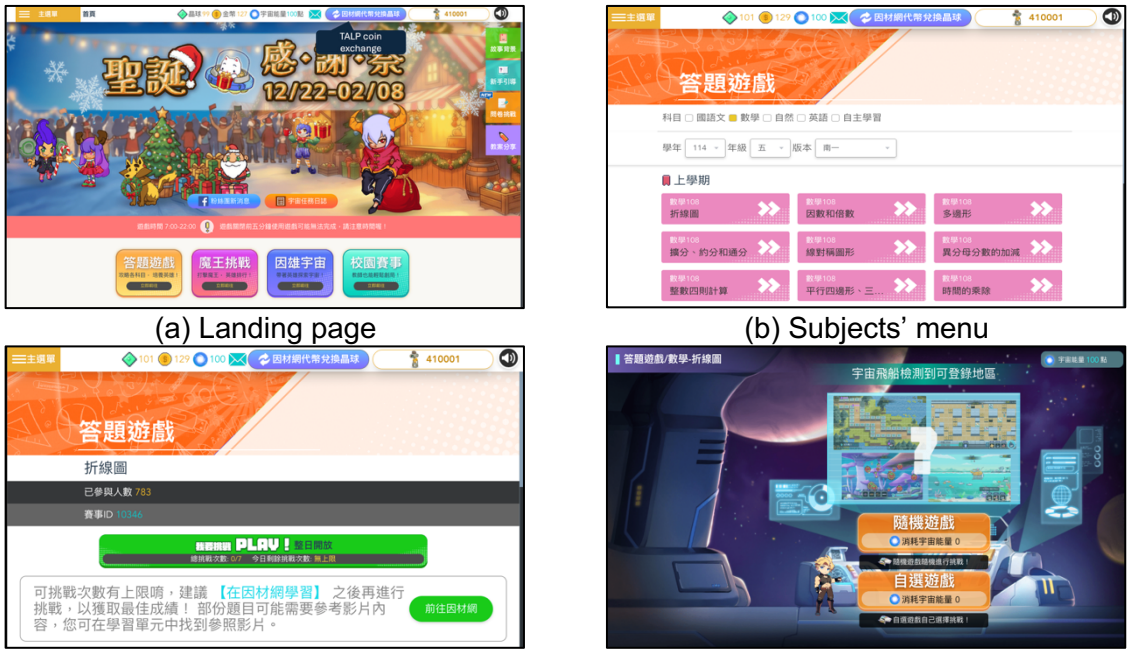
Students' use of the TALP was operationalized using four log-based duration indicators, labeled T1 through T4, derived from system records, reflecting the amount of time students spent engaging in video learning, practice, and assessment activities. The TALP instructional video interface is shown in Figure 1. Detailed definitions of each indicator are provided in Table 3.

Figure 1. Instructional video interface of the TALP.

2.2.2 TALP Hero Rising

TALP Hero Rising is a gamified system integrated with the TALP, in which students earn virtual coins upon completing learning activities in TALP and subsequently use these coins within the game environment. TALP Hero Rising provides a variety of game genres, including action, puzzle, shooting/combat, and strategy or casual games. The system requires students to first complete quiz tasks, which award stamina or attack power, thereby enabling them to challenges within the game environment. TALP Hero Rising was operationalized using three log-based behavioral indicators (G1–G3), reflecting their game participation through system usage and reward-related activities across TALP and TALP Hero Rising. Detailed definitions of each indicator are provided in Table 3. Among these indicators, the exchange of coins represents students' active participation in the reward

system of the game. By exchanging earned coins for in-game supplies, students can enhance their abilities to complete missions more effectively or achieve higher scores.



(a) Landing page (b) Subjects' menu

(c) Leading to TALP's instructional videos (d) Game selection

Figure 2. The interface of TALP Hero Rising.

2.2.3 Project for Implementation of Remedial Instruction Technology-Based Testing

The Project for Implementation of Remedial Instruction Technology-Based Testing (Priori-tbt) is a nationwide assessment administered twice a year in Taiwan as part of the national remedial instruction program, targeting students in grades 1 to 8. In this study, students' mathematics scores from the screening test in May 2024 and the growth test in December 2024.

Screening test (ST) is typically administered between May and June to identify students with lower academic achievement in core subjects, including Chinese, English, and mathematics, and was used in this study to indicate students' prior mathematics achievement. Growth test (GT) is usually administered between November and December to evaluate students' academic growth following remedial instruction and was used in this study to represent students' mathematics learning progress.

Table 3. *Variables and indicators in the model*

Variables	Indicators	Abr.	Description
TALP	Video Watching	T1	Total hours' time of lecture video watching by students.
	Exercises	T2	Total hours' time students spend on lecture exercises.
	Dynamic Assessment	T3	Total hours' time students spend on unit assessment.
	Diagnostic Assessment	T4	Total hours' time students spend on diagnostic assessment.
Hero Rising	Game Playing	G1	Total hours' time of playing TALP Hero Rising by students.
	Login Times	G2	Total number of login TALP Hero Rising by students.
	Exchange Coins Times	G3	The number of times students exchanged coins for supplies in TALP Hero Rising.

Priori-tbt	Screening Test	ST	The test administered in May 2024.
	Growth Test	GT	The test administered in December 2024.

2.3 Data Analysis

Structural Equation Modeling (SEM) was employed to examine the hypothesized direct and indirect relationships among TALP usage, engagement in TALP Hero Rising, and students' mathematics achievement. SEM is a robust analytical approach that allows for the simultaneous estimation of multiple structural relationships and direct and indirect effects among observed variables. All analyses were conducted using SPSS AMOS.

3. Results

3.1 Descriptive Statistics

Means and standard deviations of all study variables are presented in Table 4. The descriptive statistics indicate adequate variability in engagement behaviors and mathematics achievement for subsequent structural analyses. Pearson correlation analysis was performed to examine the linear associations among the observed variables in Table 5. The results were consistent with theoretical expectations, showing moderate correlations within constructs (e.g., video watching and exercises, r = 0.52) and lower correlations across different constructs. All coefficients remained below 0.60, indicating no multicollinearity concerns.

Table 4. *Means and standard deviations*

Variables	M	SD
Video Watching	6.90	3.40
Exercises	6.64	2.13
Dynamic Assessment	2.42	3.03
Diagnostic Assessment	9.40	6.22
Game Playing	7.62	1.38
Login Times	25.13	28.56
Exchange Coins Times	3.26	5.01
Screening Test	62.02	16.91
Growth Test	75.20	17.43

Table 5. *Pearson correlation coefficient*

	Video watching	Exercises	Dynamic Assessment	Diagnostic Assessment	Game playing	Login Times	Exchange Coins Times	Screening Test	Growth Test
Video watching	1	0.520**	0.303**	0.332**	0.078**	0.139**	0.048*	0.023	0.107**
Exercises	0.520**	1	0.363**	0.303**	0.114**	0.150**	0.187**	0.034	0.100**
Dynamic Assessment	0.303**	0.363**	1	0.260**	0.142**	0.140**	0.120**	0.167**	0.236**
Diagnostic Assessment	0.332**	0.303**	0.260**	1	0.04	0.039	0.028	0.049*	0.116**
Game playing	0.078**	0.114**	0.142**	0.04	1	0.558**	0.215**	0.077**	0.096**
Login Times	0.139**	0.150**	0.140**	0.039	0.558**	1	0.381**	0.051*	0.078**
Exchange Coins Times	0.048*	0.187**	0.120**	0.028	0.215**	0.381**	1	0.049*	0.073**
Screening Test	0.023	0.034	0.167**	0.049*	0.077**	0.051*	0.049*	1	0.588**
Growth Test	0.107**	0.100**	0.236**	0.116**	0.096**	0.078**	0.073**	0.588**	1

Note. *p < .05. **p < .01

3.2 Model fit assessment and path analysis

Figure 3 illustrates the hypothesized structural relationships examined in this study. The model conceptualizes how students' usage of the TALP platform influences their engagement in TALP Hero Rising, which in turn contributes to their mathematics achievement.

The chi-square test yielded a significant result (χ^2 = 309.181, df =27). The GFI was 0.97 and the CFI was 0.925, both exceeding the recommended threshold of 0.90. The TLI was 0.90, indicating acceptable model fit. The RMSEA was 0.069 and the SRMR was 0.05, both within commonly accepted range (RMSEA < 0.08, SRMR < 0.05), suggesting that the proposed model demonstrated an adequate fit to the data. Figure 3 also presents the standardized path coefficients of the structural model, indicating which relationships were statistically significant at the 95% confidence level (p < 0.05). The mediated effected showed in Table 6, supporting the role of engagement in TALP Hero Rising as a meaningful mechanism linking TALP usage to mathematics achievement.

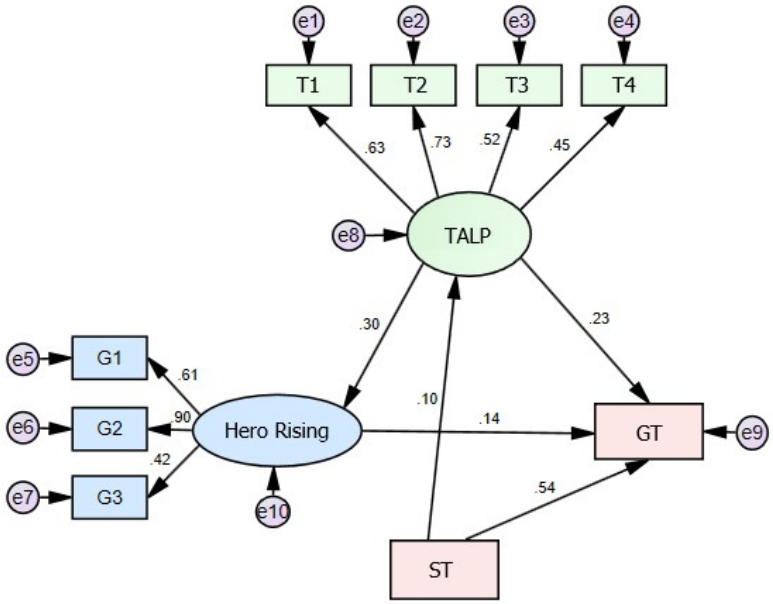


Figure 3. The Elements of the structural model of current study

Table 6. *Analysis of mediated effect*

Effect	Path	Effect values
Mediated effect	TALP → Hero Rising → GT	0.042
	ST→ TALP → GT	0.023

4. Discussion and Conclusions

This study examined the integration of an adaptive learning platform with a gamified system and explored how students' engagement across these environments relates to their academic achievement. Drawing on large-scale usage records from TALP and TALP Hero Rising, the findings suggest a partial mediation effect, indicating that engagement in the gamified environment acts as a catalyst, while TALP usage remains the primary contributor to learning outcomes. The reward mechanism (G3) serves as a bridge linking students' learning efforts in TALP with goal-oriented activities in TALP Hero Rising.

Taken together, these findings suggest that gamification should be designed as a complementary mechanism rather than a standalone intervention. Integrating reward-based systems with adaptive learning platforms can help sustain students' engagement and reinforce their learning behaviors. For educators, combining learning tasks with gamified incentives may enhance students' persistence and participation. For researchers, aligning

game mechanics with learning objectives is essential to ensure that engagement meaningfully supports academic. Although the observed effect sizes were modest, they remain practically meaningful for supporting student engagement and informing the design of gamified learning environments.

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