International Research Journal of Multidisciplinary Scope (IRJMS), 2026; 7(1): 634-647 IRJMS

Original Article | ISSN (O): 2582-631X DOI: 10.47857/irjms.2026.v07i01.08146

Self-Regulated Learning, Grit, and English Proficiency: A Structural Equation Modeling Study of University Students in Taiwan

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Abstract

This study tests the directional relation between self-regulated learning (SRL), grit, and English proficiency among Taiwanese university students. A total of 452 students from three institutions completed measures of SRL strategies, grit, classroom engagement, teacher motivation, and self-perceived English proficiency. Using structural equation modeling, two competing models: Model A (grit → SRL → English) and Model B (SRL → grit → English), each including a direct path to English proficiency. Model comparison using global fit and information-theoretic criteria favored Model B. In the preferred model, SRL was positively associated with grit ($\beta = 0.25$, $p < 0.001$) and English proficiency ($\beta = 0.25$, $p < 0.001$), whereas the path from grit to English proficiency was non-significant ($\beta = -0.06$, ns). An extended model that added engagement and teacher motivation as predictors of grit achieved adequate fit but yielded no additional significant paths once SRL was included, underscoring the primacy of strategic learning behaviors over external supports. Findings suggest that perseverance develops as a consequence of effective self-regulation rather than its antecedent, and that language confidence is better explained by goal setting, planning, and monitoring. The study also illustrates how structural equation modeling can adjudicate between competing theoretical accounts through information-theoretic model selection. Practically, results support integrating explicit SRL training into English instruction and treating grit as an emergent outcome of sustained regulatory practice.

Keywords: English Proficiency, Grit, Self-Regulated Learning, Structural Equation Modeling, University Students.

Introduction

In recent years, Taiwan has intensified its efforts to become a bilingual nation, recognizing the strategic role of English in global competitiveness, talent mobility, and national development (1). While policy initiatives such as the Blueprint for Bilingual 2030, launched by Taiwan's National Development Council, outlines a comprehensive plan to strengthen English education across all levels from K–12 to higher education (2). Universities have responded with curriculum reforms, English-medium instruction (EMI), and increased emphasis on communicative competence (3). Yet, challenges remain: while some students thrive, others continue to struggle with motivation, confidence, and sustained effort in learning English (4). These discrepancies suggest that beyond structural access, individual psychological and behavioral factors play a critical role in shaping language learning outcomes (5). Hence, these challenges highlight the need not only for educational reform, but also for rigorous mathematical modeling of the psychological and behavioral factors that shape language learning outcomes.

Against this backdrop, the present study uses structural equation modeling (SEM) to adjudicate between two theoretically opposed accounts of the self-regulated learning (SRL) – grit relationship. More specifically, this study focuses on three such factors: SRL, grit, and classroom motivation; and investigates how they contribute to university students' self-perceived English proficiency. From a modeling perspective, understanding the directional and mediating relationships among these variables enables more precise predictive and explanatory frameworks. SEM, a method grounded in linear algebra and statistical theory, offers a rigorous approach to test such pathways (6). This study addresses the bidirectionality problem between SRL and grit by specifying and comparing two alternatives (SEMs. Using model fit indices and information-theoretic criteria (such as AIC, BIC), evaluation to which directional pathway offers greater explanatory power. In doing so, the

(Received 11th September 2025; Accepted 21st December 2025; Published 19th January 2026)

study contributes both to mathematics education research and to the methodological advancement of SEM in applied interdisciplinary contexts. Within the mathematics education and applied statistics domains, this kind of research bridges psychometric analysis and educational policy by modeling latent constructs that are central to language learning (7). It also contributes to the ongoing refinement of measurement models and pathway testing in behavioral data analysis.

Overall, the current study aims to inform both instructional practice and future quantitative modeling in the field of English education. From a mathematical standpoint, these objectives can be represented as alternative SEMs, allowing for formal comparison of competing pathways. Structural equations, path coefficients, and information-theoretic indices (AIC, BIC) are employed to test bidirectional hypotheses between SRL and grit. To explore these dynamics, the present study addresses the following objectives: First, to compare two directional structural models and determine whether grit predicts SRL, or vice versa, in relation to English proficiency; Second, to examine whether teacher motivation and classroom engagement predict grit when added to the structural pathway; Third, to identify the most consistent and statistically significant predictors of university students' English proficiency within the model.

Theoretical Development - Chicken or Egg? Directionality Debate between Grit and SRL

The relationship between grit and SRL has sparked growing scholarly interest, particularly in understanding which construct precedes the other. Grit, defined as sustained perseverance and passion for long-term goals (8), which has been widely celebrated as a driver of academic success (9). However, some researchers argue that grit may in fact be a product of underlying learning behaviors, especially those associated with SRL, such as planning, monitoring, and goal setting (10, 11). This raises the classic "chicken-and-egg" question: *does a gritty disposition lead student to self-regulate*, or *do self-regulatory habits cultivate grit over time?*

Theoretically, SRL is grounded in social-cognitive models of learning (12), wherein strategic actions, rather than traits, are central to performance. Learners who effectively regulate their cognitive and motivational processes may eventually build resilience and tenacity (13, 14); two pillars of grit, as a byproduct of their learning experience (15). Empirically, recent longitudinal and mediation studies suggest that SRL can predict grit more reliably than the reverse (16). This supports a shift in conceptual thinking: *grit may not be the engine*, *but the outcome of sustained regulatory engagement*. Thus, this study tests two competing models to clarify directionality.

Grit as Predictor vs. Grit as Outcome: Competing Models

A central theoretical issue concerns the **directionality** of the relationship between SRL and grit. Does grit, as a dispositional trait, predict the adoption of regulatory behaviors, or does SRL, as a strategic process, give rise to grit over time? From a modeling perspective, this debate can be represented as two alternative SEMs. Model A specifies grit as a precursor to SRL (Equation [1]), whereas Model B reverses the path, with SRL predicting grit (Equation [2]). Each model can be expressed in structural form as:

$$\text{Model A: SRL} = \beta_1\,\text{Grit} + \varepsilon_1,\ \text{English} = \beta_2\,\text{SRL} + \beta_3\,\text{Grit} + \varepsilon_2 \quad [1]$$

$$\text{Model B: Grit} = \gamma_1\,\text{SRL} + \varepsilon_3,\ \text{English} = \gamma_2\,\text{Grit} + \gamma_3\,\text{SRL} + \varepsilon_4 \quad [2]$$

Wherein SRL = self-regulated learning, Grit = perseverance and passion for long-term goals, English = perceived English proficiency, β and γ are standardized path coefficients, and ε are error terms. Comparing these two systems highlights the bidirectionality problem not only as a conceptual debate but also as a computational challenge, solvable through information-theoretic model selection (AIC, BIC).

Figure 1 shows the first structural model (Model A) which posits grit as a precursor to SRL, hypothesizing that persistent students naturally adopt regulatory behaviors. This view aligns with trait-based interpretations of motivation, where internal perseverance drives behaviors such as planning, goal setting, and reflective learning (17). In other words, this conceptual model hypothesizes that students' grit (i.e., perseverance and long-term commitment) influences their SRL behaviors, which in turn enhance their perceived English proficiency. The model reflects a trait-driven perspective, positioning grit as the

initiating factor in the learning process. If valid, this would suggest that personality strength is the primary force shaping strategic learning behaviors and ultimately, language confidence.

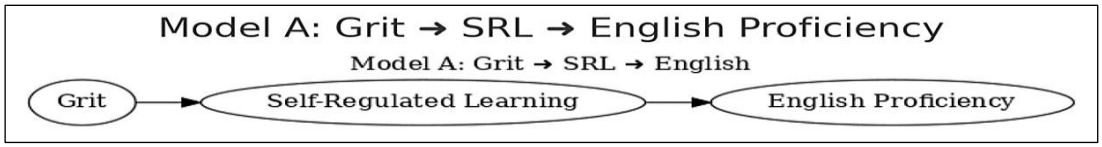

Figure 1: Model A: Grit as a Precursor to Self-Regulated Learning and English Proficiency

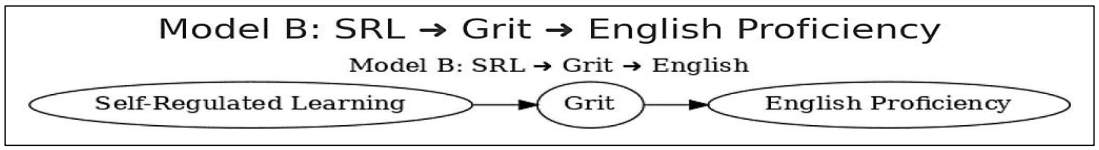

Figure 2: Model B: Self-Regulated Learning as a Precursor to Grit and English Proficiency

In contrast, Figure 2 shows the second model (Model B) which reverses the path: SRL ➔ Grit ➔ English proficiency. Here, students who regularly engage in planning, time management, and reflective practices develop grit over time through mastery experiences (18, 19). This model reflects dynamic systems theory in motivation, in which behaviors feedback into dispositions (20, 21). This model posits that students who actively engage in planning, monitoring, and reflective learning behaviors (such as similar to SRL) gradually develop grit through mastery experiences. Grit then contributes to their perceived English proficiency. The model reflects a process-oriented perspective in which strategic behaviors shape dispositions over time. SEM analysis allows both models to be tested against real data, evaluating which pathway better explains students perceived English performance.

Engagement: A Behavioral Foundation for SRL

While SRL is cognitive and strategic in nature, it does not occur in a vacuum. Classroom engagement; defined as active participation, attentiveness, and willingness to invest effort (22, 23), provides the observable behavioral foundation upon which SRL is built (24). Simply put, students who routinely attend class, take notes, and engage in discussions are more likely to develop the reflective and planning habits associated with SRL. In this sense, engagement can be seen as the behavioral trigger for the onset of strategic regulation (25). Moreover, engagement is influenced by both internal and external factors (26). Internally, a student's motivation and value toward learning drive participation (27). Externally, engaging instruction and classroom climate play essential roles (28). The interplay between engagement and SRL is thus both sequential and reciprocal (29), though most models treat engagement as a precursor to SRL. In this study, engagement was considered as a possible antecedent of grit alongside SRL and teacher motivation.

Teacher Motivation: External Support and Perceived Encouragement

Perceived teacher motivation refers to students' sense of encouragement, care, and enthusiasm communicated by the instructor (30). While more affective in nature, this construct has been linked to improved student persistence, classroom behavior, and academic confidence (31, 32). In language learning contexts, teacher support has been identified as a significant factor in boosting learner motivation (33, 34), particularly in low-confidence learners (35). Motivational support from teachers may influence grit by fostering a growth mindset environment where effort and improvement are valued over innate ability (36). In this context, students may feel safe to struggle, persist, and try again; behaviors core to grit. However, the strength of this relationship remains debated: *is teacher motivation a direct contributor to grit*, or *is its influence mediated through engagement and SRL*? The proposed model tests whether teacher motivation has a direct effect on grit, beyond the cognitive-behavioral pathway. Hence, to incorporate engagement and teacher motivation as predictors, the extended structural model expands Model B as follows in Equation [3, 4]:

$$\text{Grit} = \delta 1\ \text{SRL} + \delta 2\ \text{TM} + \delta 3\ \text{E} + \varepsilon 1 \quad [3]$$
$$\text{English} = \delta 4\ \text{SRL} + \delta 5\ \text{Grit} + \varepsilon 2 \quad [4]$$

Wherein SRL = self-regulated learning, TM = teacher motivation, E = classroom engagement, English = perceived English proficiency, δ coefficients = standardized path coefficients, and ε = error terms. This extended formulation allows the model to test whether external classroom factors (teacher motivation and engagement) contribute directly to grit, and whether their influence extends to English proficiency beyond the effects of SRL.

English Proficiency: A Multifactorial Outcome

Self-perceived English proficiency serves as the ultimate outcome variable in this study, aligning with Taiwan's national push toward bilingual education. Research in second-language acquisition has consistently linked SRL to higher language competence through strategies such as vocabulary review, self-testing, and planning (37). Grit has also been suggested to predict language success, though findings are inconsistent, particularly when self-regulatory strategies are statistically controlled (38). In contrast, external factors like engagement and teacher motivation tend to influence attitude and participation, but not always final proficiency levels (39). Hence, this study evaluates which among the behavioral (engagement), motivational (teacher), dispositional (grit), and strategic (SRL) variables significantly predict English confidence, as self-rated by students. Using SEM, to quantify the direct and indirect contributions of each variable.

Methodology

Study Design

This study employed a cross-sectional survey design (40) to examine the relationships among SRL, motivational factors, grit, and perceived English proficiency among university students. Data were collected in December 2024 using a volunteer sampling (41) approach across three diverse higher education institutions in Taiwan, representing a technical vocational university, a private Catholic comprehensive university, and a national public university. These institutions were chosen to reflect a range of academic and cultural contexts. Overall, the design supports specification of alternative SEMs for testing competing directional hypotheses.

Participants

A total of 452 university students participated in the study. Participants were recruited during their English-related coursework. Volunteer opportunities were coordinated with the assistance of department secretaries, who informed students about the study and facilitated access to a short online or paper-based survey. To express gratitude for their participation, each student received a NT$50 convenience store coupon (approximately USD $1.50; as of 16 May 2025).

Data Collection Procedure

Students completed the survey during or immediately following their English classes. The questionnaire included demographic items (e.g., gender, age, year level, perceived English proficiency), followed by scales measuring grit (42), an authored self-made SRL inventory (which includes classroom engagement and perceived teacher motivation). No personally identifiable information was collected, and all participation was voluntary and anonymous.

Measures

The study included several sets of variables grouped as outcome, predictor, and contextual measures. All variables were self-reported through a paper-based survey administered during English-related coursework.

Outcome Variable

Perceived English Proficiency — Students self-rated their current English proficiency using a single-item measure on a 5-point Likert (43) scale (1 = Starter, 5 = Expert). Although the measure was based on self-assessment, students were instructed to anchor their rating to any previous English test results they had taken, such as the Test of English for International Communication (TOEIC) or the General English Proficiency Test (GEPT), a widely used national English assessment in Taiwan. Not all students had taken the same standardized examinations, so the item functioned as a practical, unified indicator of perceived communicative competence. Overall, this item served as a proxy for perceived communicative

competence and has been widely used in similar large-scale educational surveys to capture students' confidence in English use.

Predictor Variables

Grit - The grit scale consisted of eight items, including four reverse-coded items following Duckworth and Quinn's original instrument (42). Items assessed perseverance and consistency of effort, such as: "*I finish whatever I begin*" and "*Setbacks don't discourage me*." Reverse-coded items were recoded prior to analysis. However, the overall internal consistency was weak (Cronbach's α = .61, (44)), which led to cautious interpretation. Despite this, the scale was retained for comparative modeling based on prior validation in similar educational contexts.

Self-Regulated Learning (SRL) - was measured using five items derived from a validated exploratory factor analysis (EFA) (45) of classroom learning behaviors (author designed). These items reflect goal setting, planning, review, and persistence. Sample items include: "*I believe I can still improve my English skills*" and "*I encourage myself to study harder when I receive a low grade*." Responses were rated on a 5-point scale (1 = Strongly Disagree, 5 = Strongly Agree). The internal consistency for this scale was acceptable (Cronbach's α = .71 (44)).

Teacher Motivation - This construct was assessed using three items capturing students' perceptions of their teacher's support and encouragement. Example items include: "*I like the way my teacher teaches English*" and "*My teacher encourages me to learn*." Cronbach's alpha for this scale was α = .61, acceptable for short scales in exploratory research (46).

Classroom Engagement - Engagement was measured using eight items focusing on active classroom participation, attention, and effort. Example items: "*I listen attentively during English class*" and "*I take notes during lessons*." The internal consistency for this subscale was α = .76, indicating satisfactory reliability.

As noted earlier, the predictor variables SRL, teacher motivation, and classroom engagement are derived from the author's self-made (design) instrument. More specifically, items for SRL, teacher motivation, and classroom engagement were developed through a multi-step process. First, an initial item pool was generated based on Zimmerman's social-cognitive model of SRL (12), self-determination theory, and prior studies on student engagement and teacher support in language learning contexts. Second, three experts in educational psychology and language education reviewed the items for content relevance, clarity, and cultural appropriateness for Taiwanese university students. Third, a small pilot with approximately 30 students was conducted to check wording, response variability, and completion time. Items with poor discrimination or ambiguous wording were refined or removed. The final set of 16 items was then subjected to EFA and confirmatory factor analysis (CFA), as reported below, to establish their construct validity and reliability prior to structural modeling.

To validate the structure of the items used in this study, both EFA and CFA were conducted on the predictors (47). EFA was conducted using the software Statistical Product and Service Solutions (SPSS) version 26 on loan from the university. Using maximum likelihood extraction with oblimin rotation (48), the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .88, indicating meritorious suitability for factor analysis (49). Bartlett's test of sphericity was also significant, Chi-square (120) = 1474.93, $p < .001$, supporting the factorability of the correlation matrix (50). The analysis revealed a three-factor solution that accounted for approximately 33% of the total variance. Importantly, each of the factor displayed clean loadings (≥ 0.40) with minimal cross-loading (51). These results supported the conceptual grouping of items.

Then after, CFA was conducted using the *lavaan* package (52) in R to verify the three-factor structure suggested by EFA. The model included the 16 items grouped under SRL, Teacher Motivation, and Engagement as latent variables. The following fit indices indicated acceptable model fit: Chi-square (df = 101) = 203.82, $p < .001$; Root Mean-Square Error of Approximation (RMSEA) = 0.047, 90% Confidence Interval (CI) [0.037, 0.058]; Comparative Fit Index (CFI) = 0.962, Tucker-Lewis Index (TLI) = 0.950; and Standardized Root Mean Square Residual (SRMR) = .045. All of which are within the prescribed cutoff values (53, 54). Lastly, all items loaded significantly on their intended factors, and standardized factor loadings ranged from .50 to .74, supporting construct validity (6). These results confirmed that the three constructs were

statistically distinguishable and psychometrically sound for use in structural modeling.

Contextual Variables (Demographics)

Demographic and contextual information included:

Gender (0 = Female, 1 = Male)

Age (in years)

Year Level (1 = Freshman, 2 = Sophomore, 3 = Junior, 4 = Senior)

School Type (set): 1 = Technical/Vocational University; 2 = Private Catholic; Comprehen-sive University; and 3 = National/Public University.

These contextual variables were used in descriptive analyses, group comparisons, and SEM model control pathways. Each construct was represented as a latent variable within the SEM framework, with observed indicators serving as manifest variables. Measurement error (ε) was explicitly modeled, consistent with SEM practice, to ensure unbiased estimation of structural paths.

Data Analysis Plan

Research Objective (RO) 1: Testing Directiona-lity between Grit and SRL

To investigate whether grit predicts SRL or vice versa, two competing structural equation models were tested using the *lavaan* package (52) in R. Robust maximum likelihood (MLR) estimation was used to account for minor non-normality in the data. Syntax and model objects are available upon reasonable request (Equation [5, 6]).

Model A specified the path Grit ➜ SRL ➜ English proficiency

$$\text{SRL} = \beta_1\,\text{Grit} + \varepsilon_1,\ \text{English} = \beta_2\,\text{SRL} + \beta_3\,\text{Grit} + \varepsilon_2 \qquad [5]$$

Model B specified the reverse: SRL ➜ Grit ➜ English proficiency

$$\text{Grit} = \gamma_1\,\text{SRL} + \varepsilon_3,\ \text{English} = \gamma_2\,\text{Grit} + \gamma_3\,\text{SRL} + \varepsilon_4 \qquad [6]$$

Both models were saturated with an additional direct path from the first predictor to the outcome (e.g., Grit ➜ English; SRL ➜ English). Model comparison was performed using Akaike Information Criterion (AIC) (55) and Bayesian Information Criterion (BIC) (56). Lower AIC and BIC values indicate greater model parsimony. In addition, global fit indices (RMSEA, CFI, TLI, and SRMR). Standardized path coefficients were examined to determine directionality and effect size. SEM was specifically selected due to its ability to model complex interrelationships between observed and latent variables, and to compare theoretically competing models through AIC/BIC and nested model testing (6). All latent variables were assessed for discriminant and convergent validity prior to final model estimation.

RO2: Extended Model with Teacher Motivation and Engagement

To explore the added contributions of contextual classroom factors, an extended SEM model was constructed. This model included Teacher Motivation and Engagement as additional predictors of Grit, alongside SRL. The outcome variable remained perceived English proficiency. Path significance and model fit were assessed using robust maximum likelihood estimation (57). Non-significant predictors were retained for transparency. This model tested whether external (teacher/classroom) factors contribute to grit beyond internal learning behaviors (Equation [7]).

$$\text{Grit} = \delta 1\,\text{SRL} + \delta 2\,\text{TM} + \delta 3\,\text{E} + \varepsilon 1,\ \text{English} = \delta 4\,\text{SRL} + \delta 5\,\text{Grit} + \varepsilon 2 \qquad [7]$$

This specification formally nests teacher motivation (TM) and classroom engagement (E) as predictors of grit, while retaining SRL as both a direct and indirect predictor of English proficiency.

RO3: Identifying Key Predictors of English Proficiency

To identify the most significant predictors of students perceived English proficiency, standardized regression paths were interpreted from the final structural model. Variables examined included: SRL, Grit, Teacher Motivation, and Engagement. Additionally, Spearman correlation analyses were used to assess associations among all continuous study variables. Independent-samples t-tests and one-way Analysis of Variance (ANOVA)s was also conducted using SPSS to explore group differences in English proficiency by gender, school type, and year level.

Data Availability

The dataset used in this study is not publicly available due to participant confidentiality and institutional ethical guidelines. However, a de-identified subset of the data can be made available upon reasonable request to the corresponding author.

Results

Descriptive Statistics

As noted earlier, a total of 452 university students participated in the current study. The mean age of the sample was 20.87 years (Standard Deviation; DV = 1.49), with ages ranging from 19 to 29 years. The gender distribution was balanced, with 51.5% female (n = 233) and 48.5% male (n = 219). Students were drawn from three different types of higher education institutions: 42.5% attended a technical/vocational university, 35.4% were from a private Catholic comprehensive university, and 22.1% were from a national public university. In terms of academic level, the sample consisted primarily of second-year students (53.5%), followed by third-year (24.6%), fourth-year (11.1%), and first-year students (10.8%).

Descriptive statistics for the main study variables showed that students reported moderate levels of grit (Mean; M = 3.15, SD = 0.39) and self-regulated learning indicators, which includes interest (M = 3.08, SD = 0.70), perseverance (M = 3.38, SD = 0.66), and self-efficacy (M = 3.22, SD = 0.73). Classroom engagement was relatively high (M = 3.60, SD = 0.64), whereas perceived teacher motivation showed mid-range values (M = 2.92, SD = 0.70). Students' self-rated English proficiency averaged 2.43 (SD = 0.91) on a 5-point scale, suggesting substantial variability in their perceived communicative competence.

RO1: Testing Directionality between Grit and SRL

To determine whether grit predicts SRL or SRL predicts grit, two competing structural equation models were tested.

Model A specified: Grit ➔ SRL ➔ English proficiency (SRL = β_1 Grit + ε_1, English = β_2 SRL + β_3 Grit + ε_2)

Model B specified: SRL ➔ Grit ➔ English proficiency (Grit = γ_1 SRL + ε_3, English = γ_2 Grit + γ_3 SRL + ε_4)

Figure 3 shows that both models were saturated to allow for a direct path from the primary predictor to English proficiency. Fit indices for both models are Model A: AIC = 2141.99 and BIC = 2170.79, Model B: AIC = 1583.25 and BIC = 1612.05 with both models having RMSEA = 0, CFI and TLI = 1. Model B demonstrated substantially better fit across all information criteria. AIC and BIC values were lower for Model B, indicating greater model parsimony and better explanatory power. Although both models had perfect global fit indices (CFI, TLI, RMSEA), the information criteria favored Model B. Furthermore, path coefficients in Model B revealed that: SRL was positively associated with grit (β = .25, p < .001), SRL was positively associated with English proficiency (β = .25, p < .001), and Grit did not significantly predict English proficiency (β = –.06, p = .228). These results support the hypothesis that SRL precedes and partially explains the development of grit, rather than the reverse. Grit alone was not a significant direct predictor of English proficiency in this model.

RO2: Extended Model with Teacher Motivation and Engagement

To explore whether additional classroom-level factors contribute to grit and English proficiency, a second SEM was tested. This extended model added two predictors: Teacher Motivation and Classroom Engagement, alongside SRL as pathways to Grit, which in turn is associated with English proficiency. SRL also retained a direct path to English proficiency. Model Fit for the extended model showed adequate overall fit, with: Chi-square (2) = 1.67, p = .435, CFI = 1.000, TLI = 1.024, SRMR = 0.012, RMSEA = 0.000, 90% CI [0.000, 0.088], AIC = 1584.60, and BIC = 1621.62. Because both AIC (= $2k$ – 2 ln ($\hat{L}$)) and BIC (= k ln (n) – 2 ln ($\hat{L}$)) penalize complexity, the lower values for Model B confirm its greater parsimony and explanatory power relative to Model A. These indicators suggest that the model fit the data well and was not over-parameterized.

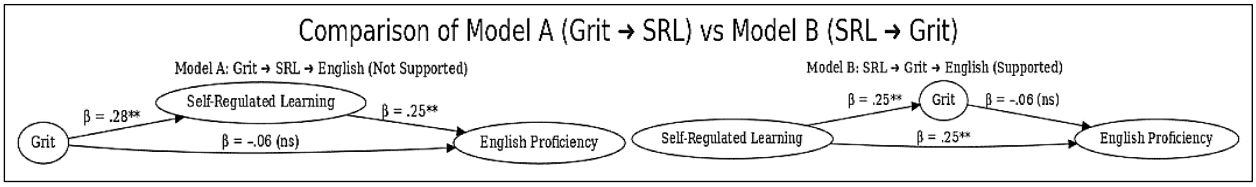

Figure 3: Comparison of Competing Directional Models for SRL and Grit

Table 1 shows the summarized results with only SRL had significant effects on both grit and English proficiency, reinforcing its central role. Neither teacher motivation nor classroom engagement significantly predicted grit, and grit itself remained a non-significant predictor of English proficiency. These findings suggest that internal learning behaviors (such as SRL) have stronger explanatory power than classroom-level motivational cues or behavioral engagement when it comes to predicting both grit and language confidence. Thus, while classroom environment may play a supportive role, it appears insufficient to drive persistence or perceived proficiency without active self-regulation by the learner.

Table 1: Key Standardized Path Results

Paths	β	*p* value	Interpretation
Predictor ➔ Grit			
SRL	.25	< .001	Small to moderate
Teacher Motivation	.08	.117	Not significant
Classroom Engagement	.01	.917	Negligible
Predictor ➔ English Proficiency			
Grit	-.06	.228	Not significant
SRL	.25	< .001	Small to moderate

Specifically, the $\beta = 0.25$ path from SRL to English proficiency indicates a small-to-moderate effect, suggesting that improvements in SRL practices could meaningfully enhance students' language confidence. The non-significant effects of teacher motivation and engagement, while surprising, imply that internal learning behaviors are more crucial for perceived success than external cues. Such as Equation [8, 9]:

$$\text{Grit} = 0.25\ \text{SRL} + 0.08\ \text{TM} + 0.01\ \text{E} + \varepsilon_5 \quad [8]$$

$$\text{English} = 0.25\ \text{SRL} - 0.06\ \text{Grit} + \varepsilon 6 \quad [9]$$

Substitution of standardized path estimates into the extended equations shows that only SRL significantly predicted both grit and English proficiency, while teacher motivation and engagement were negligible.

RO3: Identifying Key Predictors of English Proficiency

The final extended structural model was used to determine the most robust predictors of students' perceived English proficiency. As reported in RO2, SRL emerged as the only variable with a consistent, statistically significant effect ($\beta = 0.25$, $p < .001$). Grit ($\beta = -0.06$), teacher motivation ($\beta = 0.08$), and classroom engagement ($\beta = 0.01$) were non-significant predictors. To further explore these patterns, Spearman correlations were computed among all continuous study variables. SRL showed significant positive associations with both grit ($r = 0.28$, $p < .001$) and English proficiency ($r = 0.25$, $p < .001$), while grit did not correlate significantly with English proficiency ($r = -0.06$, non-significant). These bivariate associations correspond to the off-diagonal elements of the correlation matrix used as the input for SEM estimation, reinforcing SRL's central role.

In addition, group comparison analyses provided additional insight into contextual variation:

a) Gender - No significant difference in English proficiency was found between male and female students.
b) School Type – Students from technical/ vocational universities reported slightly higher proficiency than those from public institutions.
c) Year Level - A modest upward trend in proficiency was observed from first to fourth year.

These trends were visualized using heatmaps, which showed the distribution of English proficiency levels across gender in Figure 4, school type in Figure 5, and year level in Figure 6. These heatmaps can be interpreted as graphical representations of conditional means across categorical groups, highlighting that proficiency differences by school type and year level are more pronounced than those by gender. Results showed relatively even distributions across gender but clearer differences by school type and year level, with upper-year and technical university students reporting higher perceived proficiency.

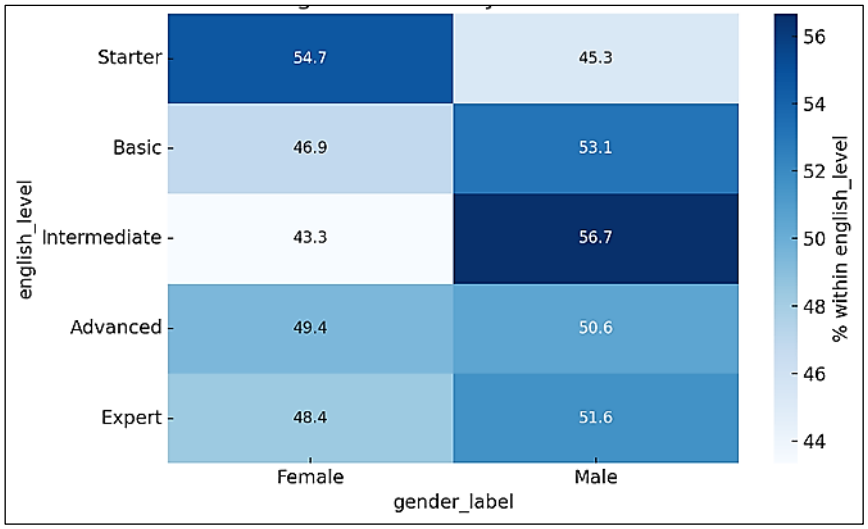

Figure 4: Heatmaps Comparing English Proficiency with Gender

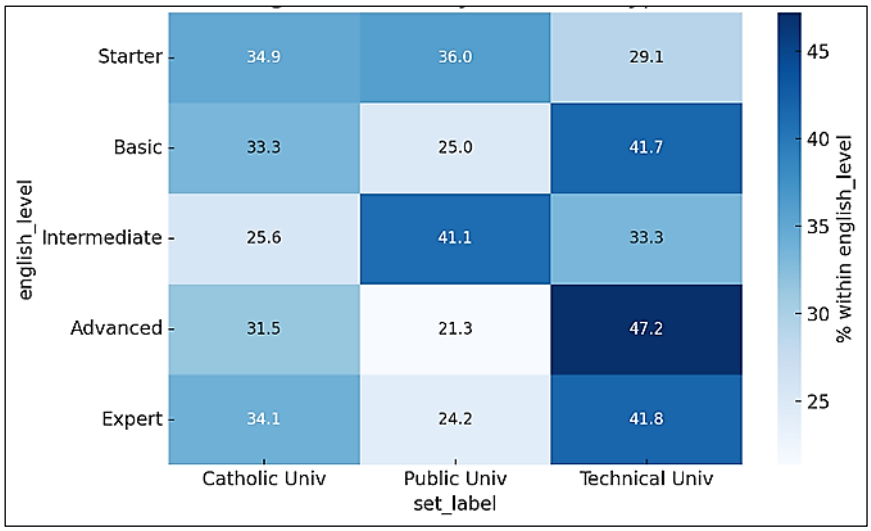

Figure 5: Heatmaps Comparing English Proficiency with School Type

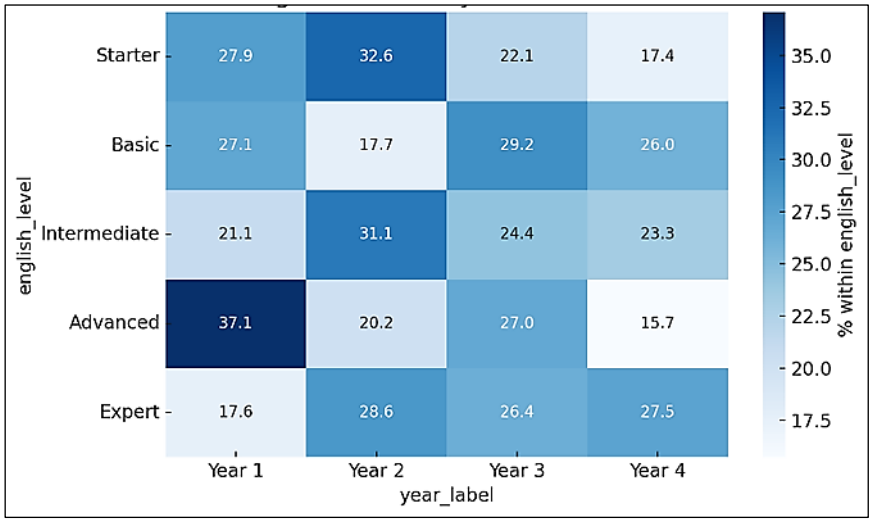

Figure 6: Heatmaps Comparing English Proficiency with Year Level

Discussions

RO1: Directionality Between Grit and SRL

The first research objective sought to examine the directional relationship between grit and SRL. Findings clearly supported Model B, in which SRL precedes grit, over Model A, which conceptualized grit as a precursor to SRL. These results align with theoretical perspectives that view strategic behavior, rather than personality traits, as the foundation of academic success (12). Students who report more frequent goal setting, monitoring, and review also tend to report higher perseverance, suggesting that grit co-occurs with, and may develop alongside, active self-regulation. This finding resonates with arguments in recent literature that question the primacy of grit as a driver of learning. While grit has been widely promoted as a success trait (8, 9), its empirical role appears to depend on the presence of effective learning strategies. As some researchers in the past (10, 11) suggested, grit may emerge when students gain confidence through successful planning and persistence. In this study, SRL had a significant impact on both grit and English proficiency, while grit alone showed no direct relationship with language outcomes; supporting Credé's critique (16) that grit may be overemphasized without proper contextual grounding. The superiority of Model B was confirmed not only conceptually but mathematically, as both AIC and BIC, defined by AIC = $2k - 2\ln(\hat{L})$ and BIC = $k\ln(n) - 2\ln(\hat{L})$, which favored the SRL-driven model despite equal global fit indices. This illustrates how information-theoretic approaches provide decisive criteria when competing models are otherwise indistinguishable.

RO2: The Role of Engagement and Teacher Motivation in Grit Development

The second model extended the analysis by testing whether engagement and teacher motivation serve as significant predictors of grit. Surprisingly, neither construct showed a significant direct effect, though both were moderately correlated with SRL. These results suggest that while engagement and teacher support are important enabling conditions, they may not directly foster grit unless students are also strategically regulating their learning. This echoes the position that engagement is foundational, but insufficient on its own. As noted in the previous literature review, engagement provides the behavioral "trigger" for SRL (24, 25), but its effects may be channeled through cognitive strategies rather than independently producing dispositional change. Similarly, the influence of perceived teacher motivation, though supported in earlier studies (30, 35), may work best in tandem with SRL (36). The current findings nuance this literature by suggesting that external motivation and behavioral engagement are not sufficient to spark grit without internal regulation. Within a mathematical perspective, although the extended model fit well, the lack of improvement in AIC/BIC relative to Model B demonstrates mathematically that increased model complexity does not necessarily yield greater explanatory power. This underscores the principle of parsimony: additional predictors should be retained only when they reduce information loss.

RO3: Identifying Strongest Predictors of English Proficiency

The third research objective aimed to identify the most robust predictors of self-perceived English proficiency. Across both structural models, SRL was the only consistent and significant predictor. Neither grit, engagement, nor teacher motivation directly explained variance in English confidence once SRL was accounted for. This reinforces the centrality of SRL in language learning, as previously established in second-language research (37). Interestingly, although engagement and teacher motivation were positively correlated with SRL and grit, their lack of direct effect on English proficiency supports earlier arguments that they may influence participation and attitude, but not final outcomes (39). Meanwhile, grit, though often assumed to be vital for language achievement, did not contribute significantly when controlling for SRL, adding weight to the argument that grit's effects are largely mediated by strategic behaviors (38). These findings echo prior work by Dörnyei and Ushioda (58), who also found SRL to be a more consistent predictor of language success than motivational traits. However, unlike a studie (8), grit was not a significant predictor when SRL was included, aligning instead with meta-analysis

(38), which challenged grit's unique contribution. Importantly, this finding was reinforced by the SEM correlation matrix, in which SRL showed significant off-diagonal associations with both grit and English proficiency, whereas grit did not correlate significantly with proficiency. Expressed in matrix notation, SRL emerges as the central latent construct driving the system, consistent with both theoretical and mathematical evidence.

Conclusion

This study investigated the directional and structural relationships between SRL, grit, classroom engagement, teacher motivation, and English proficiency among university students in Taiwan. By comparing two competing models, the results support a process-driven view in which SRL (and not grit) serves as the central predictor of both perseverance and language confidence. The findings challenge trait-based assumptions about grit's primacy and instead underscore the foundational role of strategic learning behaviors. From a methodological perspective, the competing models were expressed and tested as structural systems, with information-theoretic criteria (AIC, BIC) providing decisive evidence in favor of the SRL-driven pathway. This illustrates how mathematical modeling can resolve conceptual debates by comparing alternative structural specifications. Additionally, while teacher motivation and classroom engagement were conceptually relevant, their effects were not statistically significant when SRL was accounted for. This suggests that while classroom-level factors may set the stage for learning, they are not sufficient to drive student perseverance or perceived proficiency unless students are actively self-regulating. Importantly, these results contribute to the growing body of research advocating for SRL-focused educational interventions, especially in language education. The study also exemplifies the use of SEM as a mathematical tool for testing motivational and cognitive pathways in complex learning environments.

Based on the findings, several recommendations are offered for educators, curriculum developers, and researchers. These recommendations are grounded not only in educational theory, but also in the mathematical validation of SRL's centrality through structural equation modeling.

A) Integrate SRL training into language instruction. English courses should explicitly teach students how to set goals, plan study schedules, monitor their progress, and reflect on outcomes. Embedding these strategies can support both language learning and the development of academic persistence.
B) Use formative assessments and reflective tasks. Activities that prompt learners to track their progress or reflect on challenges may encourage both SRL and long-term perseverance.
C) Reconsider grit as a secondary outcome. Rather than treating grit as a prerequisite for success, it should be approached as an emergent characteristic shaped by engagement in strategic learning over time.
D) Lastly, support teacher professional development in motivational feedback. While not a direct predictor in this study, teacher encouragement still likely plays a role in shaping classroom climate and student engagement, especially among lower-confidence learners.

Several limitations must be acknowledged. First, the study relied on cross-sectional, self-reported data, which limits causal inference and may introduce common method bias. Future research should consider longitudinal or experimental designs to confirm directional relationships over time. Second, the grit scale exhibited low internal reliability in this context, suggesting that cultural adaptations or alternative measurements may be needed for university populations in Taiwan. Third, perceived English proficiency was measured using a single-item self-assessment, which, while practical, may not fully capture actual language skills. Future studies could triangulate this with standardized test scores or teacher evaluations. Lastly, the model focused on individual and classroom-level predictors; future research could integrate institutional, technological, or socio-emotional variables to expand the predictive scope. Moreover, because the present models were specified in a cross-sectional framework, they estimate associations rather than dynamic causal processes; future research could extend this work using longitudinal SEM, dynamic systems modeling, or Bayesian estimation to refine the mathematical representation of bidirectional pathways. Despite

these limitations, this study contributes valuable insights into the motivational and behavioral pathways that shape language learning and offers a replicable model for future research at the intersection of education, psychology, and mathematical modeling.

Abbreviations

CE: Classroom Engagement, TM: Teacher Motivation, TLI: Tucker–Lewis Index.

Acknowledgement

The author thanks the participating classes and department staff at the three universities for facilitating data collection.

Author Contributions

Tsu-chia Julia Hsu: conceptualization, methodology, investigation, formal analysis, visualization, writing—original draft, writing—review and editing.

Conflict of Interest

The author declares no conflict of interest.

Declaration of Artificial Intelligence (AI) Assistance

Ref-N-Write was used to check grammar and readability. All text was reviewed and edited by the author, who takes full responsibility for the content.

Ethics Approval

This study involved routine classroom activities with voluntary, anonymous participation. Institutional guidelines indicated that formal review was not required. Informed consent was obtained; participation or non-participation had no effect on grades.

Funding

No external funding was received for this study.

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How to Cite: Hsu TJ. Self-Regulated Learning, Grit, and English Proficiency: A Structural Equation Modeling Study of University Students in Taiwan. Int Res J Multidiscip Scope. 2026; 7(1): 634-647.
DOI: 10.47857/irjms.2026.v07i01.08146