



# Mechanisms linking self-regulated learning competence to perceived learning effectiveness among pre-service teachers in flipped classrooms

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## ABSTRACT

This study explains the mechanisms through which self-regulated learning (SRL) competence contributes to perceived learning effectiveness (PLE) among pre-service (PS) teachers in flipped classroom (FC) settings, with particular attention to the sequential mediating roles of student engagement (ENG) and learning satisfaction (SAT). Grounded in SRL and engagement theories, a mediation model linking SRL competence, ENG, SAT, and PLE was proposed and empirically tested in flipped teacher education courses in Vietnam. Data were collected from 1,119 PS teachers across multiple teacher education institutions. Structural equation modeling indicated that SRL competence strongly predicts ENG, while its direct effects on SAT and PLE are comparatively weaker. ENG significantly influences both SAT and PLE, and SAT emerges as the strongest predictor of PLE. Notably, the sequential pathway from SRL competence through engagement and satisfaction represents the most substantial indirect effect in the model, accounting for a large proportion of variance in PLE. These findings suggest that SRL competence enhances learning outcomes primarily by activating engagement and fostering SAT rather than through direct effects alone. The study advances FC research by elucidating the cognitive, behavioral, and affective mechanisms underlying PLE and offers practical implications for designing engaging and satisfying flipped teacher education environments in Vietnam.

**Keywords:** self-regulated learning competence, student engagement, learning satisfaction, perceived learning effectiveness, flipped classroom, pre-service teacher education

## INTRODUCTION

The rapid digital transformation in higher education (HE) in recent years, particularly in the aftermath of the COVID-19 pandemic, has accelerated the adoption of learner-centered instructional models. Among these, the flipped classroom (FC) has been widely recognized as a promising pedagogical approach for enhancing students' autonomy, motivation, and overall learning quality. A growing body of empirical studies and systematic reviews has demonstrated that FC can improve student engagement (ENG), interaction, positive learning emotions, and learning outcomes compared to traditional instructional models (Fisher et al., 2024; Lo & Hew, 2021; Turan & Akdag-Cimen, 2020). In Vietnam, FC has increasingly been implemented in

teacher education programs, an educational context that requires pre-service (PS) teachers not only to acquire disciplinary knowledge but also to develop self-directed learning capacity, critical thinking skills, and the ability to flexibly apply active teaching methods. However, the effectiveness of FC does not occur automatically; rather, it depends heavily on learner characteristics, particularly self-regulatory capacity, prior online learning experience, readiness for proactive engagement, as well as instructional design quality and underlying psychological and behavioral mechanisms such as engagement and learning satisfaction (SAT).

Within this context, self-regulated learning (SRL) is widely regarded as a core determinant of successful learning in FC environments. According to Zimmerman (2002) and Pintrich (2004), SRL refers to learners' proactive processes of goal setting, planning, monitoring, strategy regulation, and self-reflection through highly self-managed learning cycles. As a higher-order competence, SRL governs the entire sequence of pre-class, in-class, and post-class activities that characterize FC pedagogy. Despite extensive evidence supporting SRL as a foundation for active learning, empirical research explaining how SRL translates into learning outcomes through intermediate psychological and behavioral processes in FCs remains limited. Most existing studies have focused on describing the benefits, challenges, and overall effectiveness of FC (Al-Abdullatif, 2020; Baig & Yadegaridehkordi, 2023), while the indirect pathways through which SRL influences learning outcomes via psychological and behavioral variables have not been sufficiently elucidated. Recent studies suggest that SRL strongly predicts academic achievement, engagement, and persistence in FC settings (Jartitngarm, 2025), enhances learners' self-confidence (Namaziandost & Çakmak, 2020), and facilitates more effective use of metacognitive strategies (Judy Shih & Huang, 2022). Nevertheless, most of these studies have primarily examined direct effects, leaving the indirect mechanisms, particularly those critical in highly autonomous learning environments such as FC, largely unexplored.

One key mechanism mediating the relationship between SRL and learning outcomes is ENG, which captures students' active behavioral, emotional, and cognitive involvement throughout the learning process. As conceptualized by Fredricks et al. (2004), ENG comprises three interrelated dimensions: behavioral engagement, emotional engagement, and cognitive engagement, reflecting the extent to which learners invest effort and interest in learning activities. From a theoretical perspective, engagement represents the behavioral manifestation of self-regulation, as students' regulatory strategies are translated into observable participation, effort investment, and cognitive involvement during learning activities. Prior research has shown that FC tends to foster higher levels of ENG due to its interactive structure and the requirement for students to actively participate in both individual and collaborative tasks (Jia et al., 2023; Karaođlan Yılmaz & Yılmaz, 2023; Lo & Hew, 2020). However, the relationship between SRL and ENG in FC contexts, particularly in teacher education, has yet to be systematically examined using structural modeling approaches. This gap limits our understanding of how ENG functions as a critical conduit linking self-regulatory capacity with other important learning outcomes, including SAT and perceived learning effectiveness (PLE).

Alongside ENG, SAT reflects students' evaluative judgments regarding instructional materials, course design, in-class activities, and instructor support. Numerous studies have reported higher levels of SAT in FC compared to traditional instructional approaches (Gondal et al., 2024; Weiqian et al., 2024). SAT is also closely associated with ENG, learning motivation, and PLE. Nevertheless, SAT has often been treated as an independent outcome rather than being conceptualized as a sequential mediating variable linking ENG and PLE or SRL and PLE. From a theoretical perspective, satisfaction represents a critical affective component that captures learners' subjective valuation of learning experiences, thereby exerting a substantial influence on how they evaluate their learning effectiveness. Within this mechanism, engagement is often considered a precursor of satisfaction, as students who actively participate in learning activities are more likely to develop positive affective evaluations of the learning experience (Chukwu et al., 2026).

Moreover, PLE is an important indicator reflecting learners' perceptions of their level of understanding, ability to apply knowledge, learning progress, confidence, and competency development. In FC contexts, PLE may be a more appropriate dependent variable than academic scores, as it directly captures learners' positive learning experiences, one of the core objectives of the FC model. However, studies integrating SRL, ENG, SAT, and PLE into a comprehensive analytical framework remain scarce. This suggests that PLE may emerge as the final evaluative outcome of a cognitive-behavioral-affective process, in which self-regulation activates engagement, engagement shapes satisfaction, and satisfaction ultimately influences students' evaluation of learning effectiveness.

Based on the above analysis, three major research gaps can be identified. First, although SRL, engagement, satisfaction, and PLE have each been widely examined, studies integrating these constructs into a comprehensive explanatory model within FC environments remain limited. Second, little empirical research has examined the sequential mediating mechanism through which SRL influences learning effectiveness via engagement and satisfaction, despite strong theoretical indications that cognitive, behavioral, and affective processes operate in an interconnected manner. Third, empirical evidence from developing educational contexts, particularly teacher education in Vietnam, remains scarce, even though FC adoption has expanded rapidly in recent years.

Addressing these gaps, the present study aims to examine the relationships among SRL, ENG, SAT, and PLE among students in educational sciences and teacher education programs within FC contexts. Specifically, the study seeks to answer the following research questions (RQs):

1. **RQ1.** How does SRL influence learning engagement in FCs?
2. **RQ2.** What roles does learning engagement play in shaping SAT and PLE?
3. **RQ3.** Does SAT enhance PLE in FCs?
4. **RQ4.** Does SRL have direct effects on SAT and PLE?
5. **RQ5.** Do learning engagement and SAT mediate the relationship between SRL and PLE, and to what extent do these mediating effects occur?

This study makes three main contributions to the literature. First, it integrates SRL theory and ENG theory into a unified explanatory framework, linking cognitive, behavioral, and affective dimensions of learning in FC. Second, it develops and empirically validates a serial mediation model (SRL → ENG → SAT → PLE), providing evidence for the sequential psychological mechanism through which SRL influences PLE. Third, the study extends FC research to the context of Vietnamese teacher education, an educational setting that remains underrepresented in international literature, thereby enhancing the contextual generalizability of FC research. Conceptually, the proposed model assumes a hierarchical psychological process in which SRL is associated with ENG, ENG is related to SAT, and SAT is associated with PLE.

## LITERATURE REVIEW

### Flipped Classroom in Pedagogy University

FC is widely regarded as a representative instructional model in HE within the context of digital transformation, as it emphasizes shifting initial knowledge acquisition beyond the physical classroom and allocating in-class time to interaction, discussion, and the application of higher-order thinking skills. Recent systematic reviews have highlighted not only the rapid expansion of FC research but also the increasing diversity of its implementation across educational levels and disciplines (Kilavuz, 2024). Bergmann and Sams (2012), along with Bishop and Verleger (2013), define FC as an instructional approach in which students engage with core content through videos, digital materials, or online learning management systems prior to class, while classroom time is devoted to collaborative activities, problem-solving, discussion, and guided practice. The three-phase structure pre-class, in-class, and post-class enables students to learn flexibly at their own pace during the preparation stage and subsequently deepen their understanding through interactive, analytical, application-oriented, and reflective activities (Altas & Mede, 2020; Bishop & Verleger, 2013; Jeong et al., 2018; Sulistyowati et al., 2023). Within this pedagogical framework, instructors transition from the role of knowledge transmitters to designers and facilitators of learning experiences, orchestrating exploratory activities and supporting students' problem-solving processes during class sessions (Akçayır & Akçayır, 2018; Bosch-Farré et al., 2024).

However, empirical evidence indicates that the effectiveness of FC is not automatic but is strongly contingent upon learner characteristics and specific pedagogical design features. From the learner perspective, insufficient self-directed and SRL capacity has been identified as a major barrier. Hao (2016) and Yaşar and Polat (2021) report that students with limited self-learning skills often fail to complete pre-class tasks, resulting in difficulties in keeping pace with in-class activities. This phenomenon is particularly prevalent among students who are unfamiliar with active learning approaches or exhibit resistance to novel

instructional models (Balci et al., 2021; Yaşar & Polat, 2021). Regarding time management and workload, Grab and Bafralı (2025) demonstrate that difficulties in planning and allocating study time directly reflect limitations in students' self-directed learning competence. A proportion of learners tend to avoid or skip assigned pre-class tasks, thereby undermining the effectiveness of the entire instructional process (Hao, 2016; Jartitngarm, 2025).

Learning motivation is also considered a critical determinant of FC effectiveness. Baig and Yadegaridehkordi (2023), Nielsen (2023), and Umam et al. (2019) emphasize that when students do not clearly understand the value and pedagogical rationale of FC, they are more likely to engage superficially, demonstrate low proactivity, and exhibit reduced quality of participation. Collectively, these findings converge on the conclusion that FC effectiveness depends substantially on learners' self-regulatory capacity, intrinsic motivation, and time-management skills, while also being shaped by the quality of instructional design, including content, learning tasks, materials, and instructional support. In other words, FC creates a learning environment with high demands on SRL, while simultaneously offering substantial potential to enhance engagement, SAT, and PLE provided that learners meet the self-directed learning requirements.

In teacher education, FC has attracted particular attention for at least two reasons. First, by relocating foundational content delivery outside the classroom, FC compels PS teachers to proactively engage with learning materials, manage their time independently, and establish learning goals, thereby fostering self-regulatory capacity and lifelong learning competence core attributes of the teaching profession (Altas & Mede, 2020; Jeong et al., 2018; Umam et al., 2019). Second, participation in FC enables PS teachers to directly experience the role of "learning designers," as they learn to develop instructional videos, formative quizzes, and discussion forums aligned with specific pedagogical objectives. This experiential process contributes to the development of professional beliefs and readiness to implement FC in their future teaching practice (Birova et al., 2023; Lee et al., 2022).

Although the potential of FC in teacher education has been widely acknowledged, most existing studies have primarily focused on attitudes and learning outcomes, without systematically integrating psychological and behavioral mechanisms such as SRL, learning engagement, SAT, and PLE into a unified analytical framework. Moreover, teacher education contexts in developing countries such as Vietnam remain underrepresented in the international literature, despite the growing adoption of FC in teacher training institutions. This gap provides the rationale for the present study to develop and empirically test a structural model of  $SRL \rightarrow ENG \rightarrow SAT \rightarrow PLE$  among Vietnamese PS teachers.

### Self-Regulated Learning in Flipped Classrooms

The concept of SRL emerged from a paradigm shift in educational psychology from teacher-controlled learning models toward learner-centered approaches that emphasize students' active agency. Since the 1980s, SRL has been recognized as an independent research domain integrating cognitive, metacognitive, and motivational components. From a social-cognitive perspective, Zimmerman (2000) conceptualized SRL as a cyclical process comprising three phases: forethought, performance, and self-reflection through which learners proactively set goals, select strategies, monitor progress, and regulate behaviors to achieve personally meaningful outcomes. From a motivational perspective, Pintrich (2000) highlighted the central role of beliefs, goals, and task value in initiating and sustaining self-regulatory behaviors. Complementing these approaches, the model proposed by Winne and Hadwin (1998) delineates four stages: task definition, goal setting and planning, enactment, and adaptation or regulation, with internal feedback mechanisms serving as the foundation for strategy updating across iterative cycles (Rakovic et al., 2023). Collectively, SRL can be understood as a dynamic process through which learners actively set goals, monitor and regulate cognition, motivation, and behavior, and reflect on learning outcomes to optimize learning effectiveness.

Based on these theoretical frameworks, the present study operationalizes SRL as a multidimensional construct comprising six components:

- (1) goal setting,
- (2) metacognitive strategies,
- (3) cognitive strategies,
- (4) self-monitoring,

- (5) self-motivation, and
- (6) self-reflection and self-evaluation.

These components comprehensively capture the core phases of the self-regulatory cycle and align well with the requirements of FC environments, where students are expected to proactively plan, implement, monitor, and adjust their learning before, during, and after class sessions.

Over the past two decades, SRL research has expanded substantially into digital, blended, and flipped learning contexts. Rakovic et al. (2023) and Alkhalaf (2023) reported that FC environments impose heightened demands on SRL, as learners must independently organize study time, select and process learning materials, and attend class in a state of prior preparation. Analyses of learning behaviors in FC settings indicate that high-achieving students tend to employ a wider range of learning strategies, engage in regular pre-class preparation, and review content consistently, whereas lower-achieving students often adopt a reactive approach and rely on fewer strategies (Rakovic et al., 2023). Nielsen (2023) further emphasized that pre-class workload and strict deadlines render time-management skills a critical resource shaping the quality of student participation in FC.

In teacher education, intervention-based studies consistently demonstrate positive associations between SRL and both learning outcomes and learning experiences in FC contexts. Taghizade et al. (2023) reported that enhancing SRL led to improved academic performance among PS teachers, while Jartitngarm (2025) found that SRL was positively related to classroom satisfaction. Noguera Fructuoso et al. (2023) identified positive relationships between SRL and learning outcomes, although these effects did not always translate directly into higher grades, particularly among first-year students. Du et al. (2023) further showed that instructional designs explicitly embedding SRL requirements such as guiding questions and structured self-study pathways can strengthen SRL skills, increase course engagement, and enhance learning effectiveness. These findings suggest that SRL functions both as a prerequisite for effective FC implementation and as a malleable competence that can be cultivated through intentional pedagogical design.

From a pedagogical perspective, the FC can be viewed as an environment that externalizes the SRL cycle. Specifically, the pre-class phase corresponds to the forethought stage, during which learners set goals, plan their learning activities, and prepare instructional materials. The in-class phase reflects the performance stage, where learners apply strategies, monitor their progress, and regulate their behavior through interaction and problem-solving activities. The post-class phase corresponds to the reflection stage, in which learners evaluate the extent to which their goals have been achieved and adjust their strategies for subsequent learning cycles. Accordingly, the FC does not merely require SRL; it also makes the entire self-regulatory cycle more visible and intensified across learning phases. This perspective helps explain why SRL functions as a foundational determinant of both the quality of participation and learning outcomes in FC environments.

In summary, existing studies converge on the view that FC constitutes a learning environment with high SRL demands and that SRL is closely associated with learning outcomes and experiences in FC. However, most prior research has focused on the direct effects of SRL on achievement or satisfaction, without examining the mediating mechanisms involving ENG and SAT, or the indirect and serial pathways leading to PLE. Particularly in teacher education and especially in the Vietnamese context few studies have tested models in which SRL simultaneously predicts ENG, SAT, and PLE while also exerting indirect effects on PLE through these mediators. Addressing this gap is a central objective of the present study.

## Learning Engagement

ENG is widely regarded as a key psychological and behavioral construct that directly predicts learning outcomes and the quality of learning experiences in HE. According to the seminal three-component framework proposed by Fredricks et al. (2004), ENG comprises behavioral engagement (participation in learning activities such as completing tasks, discussions, and collaboration), emotional engagement (positive or negative affective responses toward learning, including interest, enjoyment, anxiety, or boredom), and cognitive engagement (investment of cognitive effort, use of metacognitive strategies, and engagement in higher-order thinking). This tripartite framework has been extensively applied to explain how ENG links individual learner characteristics with academic performance and other psychological outcomes.

In FC contexts, ENG plays a particularly critical role because the model requires students to prepare before class, acquire foundational knowledge through videos or materials, and actively participate in in-class discussions, collaboration, and problem-solving. Fisher et al. (2017) found that students in FC settings exhibited higher levels of engagement, satisfaction, and learning outcomes than those in traditional classrooms. Yoon et al. (2020) demonstrated that ENG mediated the relationship between perseverance and cognitive achievement and served as a bridge between instructional support for learner autonomy and learning outcomes. Lin et al. (2019) reported that students who frequently viewed pre-class lecture videos tended to participate more actively in synchronous activities and achieved higher semester grades; completion of asynchronous tasks predicted content understanding, while punctuality and sustained interaction during face-to-face sessions enhanced collaboration and proactive learning behaviors. These findings indicate that ENG in FC is a multidimensional construct closely intertwined with motivation, SRL skills, and social interaction.

SRL is considered one of the most important predictors of ENG in FC environments. Students with high SRL typically manage time effectively, sustain motivation, and proactively select appropriate learning strategies, which in turn leads to higher levels of engagement during both pre-class and in-class phases (Hampton et al., 2019; Lin et al., 2019). Intervention studies by Yoon et al. (2020) showed that supporting SRL development enhanced students' planning, monitoring, and regulatory skills, resulting in increased behavioral engagement during preparation, higher cognitive engagement during class, and more positive emotional engagement throughout the course. Additionally, Yoon et al. (2020) identified autonomous motivation, controlled motivation, perceived self-efficacy, and perceived instructional quality as important contextual predictors of behavioral engagement in FC. These findings highlight ENG as an outcome of the interaction between individual learner characteristics (e.g., SRL, motivation, and self-efficacy) and pedagogical structures (e.g., FC design and instructor support).

Taken together, the evidence supports viewing ENG as a critical "linking mechanism" between learner characteristics and learning outcomes in FC. Building on this perspective, the present study positions ENG as a central mediator within the SRL → ENG → SAT → PLE model in the context of Vietnamese teacher education.

## Learning Satisfaction

SAT reflects students' overall positive affective state toward their learning experiences, encompassing evaluations of content quality, course structure, effectiveness of in-class activities, instructor support, and the alignment between learning processes and personal expectations. In HE, SAT is widely regarded as a key indicator of instructional quality and is closely associated with learning motivation, engagement, and student retention (Wu et al., 2010).

In FC contexts, numerous empirical studies have reported higher levels of SAT compared to traditional instructional approaches. Strelan et al. (2020) found that students evaluated FC experiences more positively due to the flexibility of the pre-class phase and the opportunities for deeper interactive engagement during class. Gondal et al. (2024) reported that FC enhanced students' confidence, understanding, and social interaction, all of which contributed to higher satisfaction. Weiqian et al. (2024) emphasized that SAT increases substantially when pre-class materials are clearly structured and comprehensible and when in-class activities provide meaningful opportunities for knowledge application. These findings suggest that SAT in FC emerges from the combined effects of instructional materials, course design, and interactive learning experiences. Conversely, insufficient pre-class preparation or poorly aligned materials may diminish SAT even when the technical aspects of FC are properly implemented.

From a psychological behavioral perspective, SAT is not merely an outcome of learning experiences but also a predictor of subsequent learning outcomes. Studies in FC and digital learning contexts indicate that students with higher SRL tend to report greater satisfaction, as they are better able to control learning pace, understand task requirements, and reduce stress associated with academic demands (Jartitngarm, 2025). Moreover, ENG particularly emotional and cognitive engagement has been identified as a strong predictor of SAT, as active participation, interest, and sustained cognitive effort are typically accompanied by more favorable evaluations of courses and instructional methods (Lo & Hew, 2021). These findings support the assumption that, in FC environments, SRL influences SAT both directly and indirectly through ENG.

SAT has also been shown to be a significant predictor of PLE. Galvin and Lucitt (2024) demonstrated that student satisfaction is closely linked to perceived learning value, motivation, and positive emotional states, which collectively enhance subjective evaluations of learning effectiveness. Together with prior evidence (Wu et al., 2010), these findings reinforce the view that SAT functions both as an outcome of learning conditions and as an affective-motivational bridge leading to PLE.

Despite the extensive examination of SAT as an important outcome of FC, its mediating role between SRL/ENG and PLE has not been sufficiently tested, particularly within a serial mediation framework (SRL → ENG → SAT → PLE). This gap is even more pronounced in studies involving Vietnamese PS teachers. Accordingly, the present study positions SAT as a mediator alongside ENG to clarify the mechanisms underlying the formation of PLE.

### Perceived Learning Effectiveness

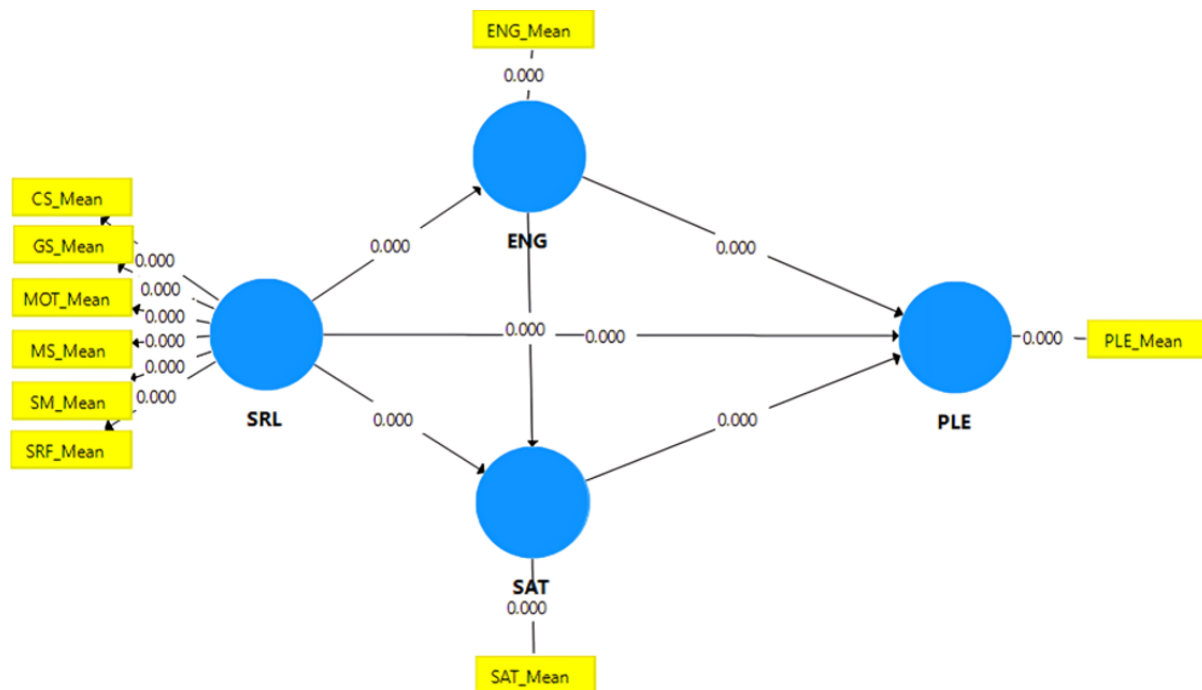
PLE refers to learners' self-evaluations of their learning progress, depth of understanding, ability to apply knowledge, and development of learning-related and transferable skills throughout a course. Unlike purely performance-based indicators such as test scores or grades, PLE emphasizes students' subjective perceptions of learning effectiveness, including perceived comprehension, practical applicability of knowledge, development of analytical and problem-solving skills, self-directed learning capacity, teamwork skills, and a sense of personal progress.

From a constructivist perspective, PLE reflects the extent to which learners internalize and construct knowledge through interaction with the learning environment, rather than relying solely on external indicators such as grades or assessment scores. In this sense, PLE represents the process of meaning-making during learning. At the same time, according to expectancy-value theory, when learners believe that their efforts lead to valuable outcomes and perceive meaningful progress, they are more likely to evaluate their learning as effective. Within FC environments, ENG, and SAT can therefore be understood as intermediary conditions that transform SRL efforts into perceptions of learning effectiveness. Consequently, PLE is often used as an important indicator reflecting the degree to which an instructional model aligns with learners' needs and expectations. In this regard, PLE should be viewed not only as a learning outcome indicator but also as a subjective evaluation integrating both cognitive achievement and learners' affective experiences.

In FC environments, the emphasis on higher-order cognitive activities during class provides favorable conditions for enhancing PLE. When classroom time is devoted to analysis, discussion, collaboration, and application of knowledge to authentic problems, students have greater opportunities to experience "deep understanding" and "being able to do," thereby fostering positive perceptions of learning effectiveness. However, PLE does not depend solely on in-class activities; it is closely linked to the quality of pre-class preparation, sustained engagement throughout the course, and satisfaction with content, structure, and instructional methods. Students who are insufficiently prepared or exhibit low engagement often struggle to keep pace with interactive activities, resulting in lower perceived effectiveness despite theoretically optimal FC designs.

In online learning contexts, Alqurashi (2019) identified satisfaction and interaction as the strongest predictors of PLE. This finding suggests that PLE reflects not only individual learner competence but also the quality of instructional design and interactive learning experiences. When applied to FC contexts, this perspective implies that SAT and ENG both closely associated with students' interaction, emotional experiences, and motivation are likely to be critical predictors of PLE.

In the present study, PLE is selected as the final dependent variable in the SRL → ENG → SAT → PLE model, representing the ultimate outcome of a sequence of influences from self-regulatory capacity through engagement and satisfaction to PS teachers' subjective evaluations of their learning effectiveness. Based on this perspective, PLE can be conceptualized as the final outcome of a sequential psychological mechanism: SRL (cognitive-motivational activation) → ENG (behavioral-cognitive enactment) → SAT (affective evaluation) → PLE (integrated cognitive-affective outcome). This integrated approach allows PLE to be interpreted not merely as a direct consequence of individual capability, but as the product of a hierarchical cognitive-behavioral-affective process operating within FC environments. Focusing on PLE is particularly appropriate in



**Figure 1.** Proposed theoretical model and hypotheses (Source: Authors’ own elaboration using SmartPLS 4.0)

teacher education, where course success is not solely reflected in immediate grades but also in students’ perceived readiness to apply acquired knowledge and skills in future teaching practice.

Although PLE has been examined in studies of online and blended learning, the integrated relationships among SRL, ENG, SAT, and PLE in FCs for PS teachers have yet to be systematically modeled and tested using advanced techniques such as PLS-SEM and bootstrapped mediation analysis. The present study addresses this gap by conceptualizing PLE as the ultimate outcome of the serial mediation pathway  $SRL \rightarrow ENG \rightarrow SAT \rightarrow PLE$ , in alignment with the study’s title and five RQs.

## THEORETICAL MODEL AND RESEARCH HYPOTHESES

### Proposed Theoretical Model

This study proposes a theoretical model to explain the mechanism through which SRL influences PLE in FCs via two key mediating variables: learning engagement and SAT. Grounded in the theoretical perspectives and empirical evidence reviewed above, the model posits that:

- (a) SRL has direct effects on ENG, SAT, and PLE,
- (b) ENG functions as a behavioral-cognitive bridge linking SRL with SAT and PLE, and
- (c) SAT represents an affective-motivational component that strongly predicts PLE.

The model further assumes the presence of indirect and serial mediating pathways, specifically  $SRL \rightarrow ENG \rightarrow SAT \rightarrow PLE$ .

Conceptually, the proposed model assumes a hierarchical psychological process in which SRL functions as a cognitive-motivational activation mechanism, ENG represents the behavioral-cognitive manifestation of the self-regulation process, SAT reflects the affective evaluation of the learning experience, and PLE constitutes the final integrative outcome of this sequence of influences. Accordingly, PLE does not emerge directly from individual capability; rather, it develops through a sequential mediating process linking behavioral engagement with affective evaluation. **Figure 1** depicts the proposed theoretical model and hypotheses, where arrows represent the hypothesized relationships among the constructs, including both direct and indirect effects. The model proposes that SRL influences PLE directly and indirectly through ENG and SAT, forming a sequential mediation pathway ( $SRL \rightarrow ENG \rightarrow SAT \rightarrow PLE$ ).

## Research Hypotheses

Based on the theoretical model  $SRL \rightarrow ENG \rightarrow SAT \rightarrow PLE$  and the literature reviewed above, this study proposes the following hypotheses:

1. **H1.** SRL has a positive effect on students' learning engagement in FC.
2. **H2.** SRL has a positive effect on SAT.
3. **H3.** SRL has a positive effect on PLE.
4. **H4.** ENG has a positive effect on SAT.
5. **H5.** ENG has a positive effect on PLE.
6. **H6.** SAT has a positive effect on perceived PLE.
7. **H7.** ENG and SAT sequentially mediate the relationship between SRL and PLE.
8. **H8.** ENG mediates the relationship between SRL and PLE.
9. **H9.** SAT mediates the relationship between SRL and PLE.

## RESEARCH METHODOLOGY

### Participants and Sample

The study was conducted with 1,119 undergraduate students enrolled in education sciences and teacher education programs in Vietnam. A controlled convenience sampling strategy was employed, targeting courses that had implemented the FC model. During data collection, efforts were made to ensure diversity in terms of gender, year of study, academic major, academic performance (GPA), experience with FCs, experience with online learning, weekly self-study time, and primary learning devices, thereby enhancing the relative representativeness of the PS teacher population.

The detailed sample characteristics are presented in [Table 1](#).

All participants took part voluntarily and anonymously. They were informed in advance about the study's purpose and their right to withdraw at any time without penalty.

### Research Design and Procedure

This study adopted a quantitative, cross-sectional design to examine the effects of SRL on learning engagement, SAT, and PLE in FC courses. In addition, the study tested the individual and serial mediating roles of learning engagement and SAT in the relationship between SRL and PLE, while controlling for selected demographic and academic variables (year of study, GPA, FC experience, online learning experience, weekly self-study time, and primary learning device). The research procedure comprised two main stages:

Development and validation of the survey instrument: The questionnaire consisted of two sections:

- (1) demographic information and control variables, and
- (2) measurement scales for SRL, learning engagement, SAT, and PLE.

The instrument was reviewed by experts in education and educational measurement to ensure content validity and semantic clarity.

### Data Collection and Analysis

The official survey was administered online via Google Forms to classes and courses implementing the FC model. Incomplete responses were excluded, resulting in 1,119 valid questionnaires for analysis. Data were analyzed using SPSS 26.0, SmartPLS 4.0, and PROCESS macro (model 6) to test serial mediation effects.

### Measurement Instruments

All variables were measured using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree).

**SRL:** SRL was measured using 33 observed items, adapted from Zimmerman (2000), capturing six dimensions:

- (1) goal setting,

**Table 1.** Sample characteristics (N = 1,119)

Demographic variable	Category	Frequency (n)	Percentage (%)
Gender	Female	875	78.2
	Male	237	21.2
	Other	5	0.6
Year of study	First year	501	44.8
	Second year	385	34.4
	Third year	139	12.4
	Fourth year	94	8.4
Major	Social sciences & humanities	199	17.8
	Languages & literature	281	25.1
	STEM & technology	411	36.7
	Arts, physical education & national defense	45	4.0
	Educational sciences	128	11.4
	Early childhood, primary & special education	55	5.0
GPA	< 2.5	34	3.0
	2.50-2.99	171	15.3
	3.00-3.49	250	22.3
	≥ 3.50	150	13.4
	Not reported	514	45.9
FC experience	Once	408	36.5
	Twice	186	16.6
	More than twice	525	46.9
Online learning experience	Very low	33	2.9
	Low	64	5.7
	Moderate	558	49.9
	High	348	31.1
Weekly self-study time	Very high	116	10.4
	< 3 hours	134	12.0
	3-5 hours	255	22.8
	6-10 hours	366	32.7
	11-15 hours	190	17.0
Primary learning device	> 15 hours	174	15.5
	Smartphone	464	41.5
	Tablet	81	7.2
Total	Laptop/desktop	574	51.3
		1,119	100

- (2) metacognitive strategies,
- (3) cognitive strategies,
- (4) self-monitoring,
- (5) self-motivation, and
- (6) self-reflection and self-evaluation.

**ENG:** ENG was assessed using 18 observed items based on the three-component framework proposed by Fredricks et al. (2004), encompassing behavioral, emotional, and cognitive engagement in the FC context.

**SAT:** SAT was measured with 8 observed items reflecting students' satisfaction with course content, structure, learning activities, and instructional support in FC courses.

**PLE:** PLE was measured using 7 observed items capturing students' perceptions of their level of understanding, ability to apply knowledge, self-directed learning skills, teamwork skills, and overall learning progress in FC courses.

## Data Analysis

The data analysis strategy was implemented in several sequential steps:

Descriptive statistics and correlation analysis: Means and standard deviations were computed for SRL, ENG, SAT, and PLE. Pearson correlation analysis was conducted to examine the preliminary direction and strength of relationships among the main variables and to assess their consistency with the proposed hypotheses.

Scale reliability and factor structure: Internal consistency reliability was assessed using Cronbach's alpha coefficients. An exploratory factor analysis (EFA) was conducted on all 66 observed items to examine convergent and discriminant validity. The Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity were used to evaluate the suitability of the data for factor analysis.

Since all constructs in this study were measured using self-reported questionnaires collected at a single point in time, the potential risk of common method bias was assessed. Harman's single-factor test was conducted by entering all measurement items into an unrotated EFA. The results indicated that the first factor accounted for less than 50% of the total variance, suggesting that common method bias is unlikely to pose a serious threat to the validity of the findings. In addition, the variance inflation factor (VIF) values obtained from the regression analysis ranged from 2.481 to 3.475, which are below the commonly recommended threshold of 5, further indicating that multicollinearity is not a significant concern in the model.

This study employed PLS-SEM instead of covariance-based SEM (CB-SEM) due to its alignment with the study's predictive and variance-explanatory objectives. The proposed model includes multiple latent constructs and a serial mediation mechanism (SRL → ENG → SAT → PLE), resulting in considerable structural complexity. PLS-SEM is particularly suitable for estimating complex models with multiple endogenous constructs and indirect effects, especially when bootstrapping procedures are used to assess mediation. Furthermore, as the constructs were measured using Likert-type scales and may not fully satisfy multivariate normality assumptions, PLS-SEM provides a robust and methodologically appropriate analytical approach for testing the hypothesized mediation model. PLS-SEM was performed using SmartPLS 4.0 and consisted of two stages: Measurement model (outer model): Outer loadings, composite reliability (CR), convergent validity (average variance extracted [AVE]), and discriminant validity (heterotrait-monotrait [HTMT] ratio) were evaluated for the four latent constructs: SRL, ENG, SAT, and PLE.

**Structural model (inner model):** Path coefficients among SRL, ENG, SAT, and PLE were estimated. Several control variables (GPA, year of study, FC experience, weekly self-study time, and primary learning device) were included to reduce potential confounding effects. Statistical significance was assessed using bootstrapping with 5,000 resamples and 95% confidence intervals (CI). Coefficients of determination ( $R^2$ ) for ENG, SAT, and PLE were used to evaluate the explanatory power of the model.

**Serial mediation analysis (PROCESS model 6):** To further examine the robustness of the sequential mediation mechanism identified in the PLS-SEM analysis, a serial mediation analysis was conducted using the PROCESS macro (version 4.2; model 6), with the following specification:  $X = \text{SRL\_Mean}$ ;  $M_1 = \text{ENG\_Mean}$ ;  $M_2 = \text{SAT\_Mean}$ ;  $Y = \text{PLE\_Mean}$

A bootstrap procedure with 5,000 resamples (95% CI) was employed to estimate:

- (a) the total effect of SRL on PLE,
- (b) the direct effect of SRL on PLE,
- (c) specific indirect effects, including SRL → ENG → PLE (Ind1), SRL → SAT → PLE (Ind2), and SRL → ENG → SAT → PLE (Ind3), and
- (d) the total indirect effect.

This analytical approach enabled simultaneous testing of:

- (1) the direct effects of SRL on ENG, SAT, and PLE,
- (2) the individual mediating roles of ENG and SAT, and
- (3) the serial mediation mechanism SRL → ENG → SAT → PLE, consistent with the proposed theoretical model and RQs.

## RESULTS

### Descriptive Statistics

The descriptive analysis ([Table 2](#)) indicates that the mean scores of the observed variables ranged from 3.45 to 3.81 on the five-point Likert scale. All variables exhibited mean values above the neutral midpoint of

**Table 2.** Descriptive statistics of students' SRL at Hanoi National University of Education

Variable	Number of items	Mean	Standard deviation
SRL	33	3.56	0.90
ENG	18	3.71	0.87
SAT	8	3.72	0.86
PLE	7	3.67	0.85

**Table 3.** Cronbach's alpha reliability analysis

No	Scale	Number of items	Cronbach's alpha
1	SRL	33	0.976
2	ENG	18	0.954
3	SAT	8	0.947
4	PLE	7	0.945

**Table 4.** KMO and Bartlett's test of sphericity results

Test		Value
KMO	Measure of sampling adequacy	0.914
Bartlett's test of sphericity	Approximate Chi-square	6,725.563
	df	171
	Significance	0.000

3.0, reflecting generally positive perceptions and proactive learning behaviors among students during their participation in FC courses.

### Reliability and Validity of the Measurement Scales

The results of the Cronbach's alpha reliability analysis (**Table 3**) indicate that all measurement scales exhibit very high internal consistency.

All alpha coefficients substantially exceed the commonly accepted threshold ( $\alpha \geq 0.70$ ), indicating excellent internal consistency among the observed items within each scale.

An EFA was conducted on all 66 observed items across the four scales (SRL, ENG, SAT, and PLE). The KMO measure and Bartlett's test of sphericity are presented in **Table 4**.

The KMO value of 0.914 indicates a very high level of sampling adequacy for factor analysis. Bartlett's test of sphericity yielded  $\chi^2 = 6,725.563$ ,  $df = 171$ ,  $p < 0.001$ , demonstrating that the correlation matrix significantly differs from an identity matrix and satisfies the assumptions for factor analysis.

### Interpretation of Factor Loadings and Cross-Loadings

Items were retained based on established criteria for EFA. Specifically, items with primary factor loadings greater than 0.50 were considered acceptable, and a minimum difference of 0.20 between the primary loading and cross-loadings on other factors was required to ensure a clear factor structure. All retained items demonstrated substantial loadings on their intended constructs, and no problematic cross-loading patterns were observed. These results provide additional support for the construct validity of the measurement scales.

### Outlier Diagnostics

Prior to conducting regression, mediation (PROCESS), and PLS-SEM analyses, potential outliers were examined using both univariate and multivariate approaches. Standardized z-scores were inspected to identify extreme univariate values ( $|z| > 3.29$ ), while Mahalanobis distance was computed to detect multivariate outliers at the  $p < 0.001$  level. No observations exceeded the critical thresholds. Therefore, all 1,119 cases were retained for subsequent analyses. This data screening procedure enhances the robustness and stability of the model estimation results.

Taken together, the results from Cronbach's alpha and EFA confirm that:

- (1) all measurement scales demonstrate high internal reliability,
- (2) the dataset exhibits sufficient inter-item correlations for factor analysis, and

**Table 5.** Construct reliability and convergent validity

	Cronbach's alpha	rho_A	CR	AVE
ENG	0.954	0.957	0.959	0.565
PLE	0.945	0.945	0.955	0.753
SAT	0.947	0.947	0.956	0.729
SRL	0.976	0.976	0.977	0.566

**Table 6.** HTMT ratio matrix

	ENG	PLE	SAT	SRL
ENG				
PLE	0.820			
SAT	0.841	0.848		
SRL	0.783	0.736	0.729	

(3) preliminary evidence of construct validity was observed, supporting the appropriateness of proceeding to PLS-SEM measurement model assessment.

### Measurement Model Assessment in PLS-SEM

Before testing the structural relationships, the reliability and validity of the reflective measurement model were assessed using PLS-SEM procedures in SmartPLS 4. Internal consistency reliability, convergent validity, and discriminant validity were evaluated.

#### Construct reliability and convergent validity

**Table 5** presents the construct reliability and convergent validity results. All Cronbach's alpha values ranged from 0.945 to 0.976, substantially exceeding the recommended threshold of 0.70. Similarly, CR values ranged from 0.955 to 0.977, indicating excellent internal consistency across all constructs.

The AVE values ranged from 0.565 to 0.753, all above the recommended minimum threshold of 0.50. These findings confirm adequate convergent validity, suggesting that the indicators explain a substantial proportion of variance in their respective latent constructs.

#### Discriminant validity

Discriminant validity was assessed using the HTMT ratio, which is considered a more stringent criterion in contemporary PLS-SEM research. As shown in **Table 6**, all HTMT values ranged from 0.729 to 0.848, remaining below the conservative threshold of 0.85. Therefore, discriminant validity is established, indicating that the constructs are empirically distinct from one another.

Taken together, the reliability and validity results demonstrate that the measurement model is psychometrically sound and appropriate for subsequent structural model analysis.

### Correlations Among the Study Variables

The Pearson correlation matrix (**Table 7**) shows that all key variables are positively and significantly correlated with one another ( $p < 0.01$ ).

The results of the Pearson correlation analysis among the study variables (**Table 7**) indicate that all correlations are positive and statistically significant at the  $p < 0.01$  level. Specifically, SRL is strongly correlated with learning engagement ( $r = 0.755$ ), SAT ( $r = 0.700$ ), and PLE ( $r = 0.706$ ). ENG shows very strong correlations with SAT ( $r = 0.798$ ) and PLE ( $r = 0.778$ ). Notably, the correlation between SAT and PLE is exceptionally high ( $r = 0.869$ ), highlighting a particularly close association between these two constructs.

These correlation results provide preliminary empirical support for **H1-H6** and offer initial evidence addressing **RQ1-RQ4**.

### Linear Regression Model Predicting Perceived Learning Effectiveness

The results of the multiple linear regression analysis (**Table 8**) indicate that the model is highly statistically significant ( $F = 1325.967$ ;  $p < 0.001$ ), with a coefficient of determination of  $R^2 = 0.781$ . This suggests that the three independent variables SRL, ENG, and SAT jointly explain 78.1% of the variance in PLE.

**Table 7.** Pearson correlations among variables in the research model

		ENG_Mean	SAT_Mean	PLE_Mean	SRL_Mean
ENG_Mean	Pearson correlation	1	.798**	.778**	.755**
	Sig. (2-tailed)		.000	.000	.000
	N	1,119	1,119	1,119	1,119
SAT_Mean	Pearson correlation	.798**	1	.869**	.700**
	Sig. (2-tailed)	.000		.000	.000
	N	1,119	1,119	1,119	1,119
PLE_Mean	Pearson correlation	.778**	.869**	1	.706**
	Sig. (2-tailed)	.000	.000		.000
	N	1,119	1,119	1,119	1,119
SRL_Mean	Pearson correlation	.755**	.700**	.706**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	1,119	1,119	1,119	1,119

Note. \*\*Correlation is significant at the 0.01 level (2-tailed)

**Table 8.** Results of the linear regression analysis between SRL, ENG, SAT, and PLE

Model	R	R <sup>2</sup>	Adjusted R <sup>2</sup>	Standard error of the estimate	Change statistics				
					R <sup>2</sup> change	F change	df1	df2	Sig. F change
1	.884 <sup>a</sup>	.781	.780	.34503	.781	1325.967	3	1115	.000

Note. <sup>a</sup>Predictors: (Constant), SAT\_Mean, SRL\_Mean, & ENG\_Mean

**Table 9.** Results of multiple linear regression predicting perceived learning effectiveness

Coefficients <sup>a</sup>								
Model	Unstandardized coefficients		Standardized coefficients		t	Sig.	Collinearity statistics	
	B	Standard error	Beta				Tolerance	VIF
1	(Constant)	.071	.062		1.148	.251		
	SRL_Mean	.141	.024	.129	5.847	.000	.403	2.481
	ENG_Mean	.185	.030	.163	6.252	.000	.288	3.475
	SAT_Mean	.649	.024	.648	27.031	.000	.342	2.927

Note. <sup>a</sup>Dependent variable: PLE\_Mean

All independent variables exhibit positive regression coefficients and are statistically significant at a very high level ( $p < 0.001$ ), indicating that increases in these factors are associated with corresponding increases in students' PLE. Among the three predictors, SAT shows the highest standardized beta coefficient ( $\beta = 0.648$ ), suggesting that it is the strongest predictor of PLE. This is followed by ENG with  $\beta = 0.163$  and SRL with  $\beta = 0.129$  (see [Table 9](#)).

These findings provide empirical support for **H3**, **H5**, and **H6**, and partially address **RQ2-RQ4**.

### Testing the Sequential Mediation Model (PROCESS Model 6)

Sequential mediation analysis was conducted using PROCESS v4.2, with the following specification:  $X = \text{SRL\_Mean}$ ;  $M_1 = \text{ENG\_Mean}$ ;  $M_2 = \text{SAT\_Mean}$ ;  $Y = \text{PLE\_Mean}$ , employing 5,000 bootstrap samples and 95% CI.

#### Regression equations

- (1)  $\text{SRL} \rightarrow \text{ENG}$ : The regression coefficient was  $B = 0.7291$ ,  $p < 0.001$ ,  $\beta = 0.7555$ , indicating a strong, positive, and statistically significant effect of SRL on learning engagement.
- (2)  $\text{SRL and ENG} \rightarrow \text{SAT}$ : SRL had a positive and significant effect on SAT ( $B = 0.2480$ ,  $p < 0.001$ ,  $\beta = 0.2278$ ), while learning engagement exerted a substantially stronger effect ( $B = 0.7057$ ,  $p < 0.001$ ,  $\beta = 0.6255$ ). These results suggest that both SRL and engagement positively predict SAT, with engagement being the more influential factor.
- (3)  $\text{SRL, ENG, and SAT} \rightarrow \text{PLE}$ : SRL ( $B = 0.1408$ ,  $p < 0.001$ ,  $\beta = 0.1291$ ), ENG ( $B = 0.1845$ ,  $p < 0.001$ ,  $\beta = 0.1633$ ), and SAT ( $B = 0.6490$ ,  $p < 0.001$ ,  $\beta = 0.6480$ ) all showed positive and statistically significant effects on PLE. Among these predictors, SAT exerted the strongest influence.

**Table 10.** Results of testing direct, indirect, and total effects (PROCESS, SPSS)

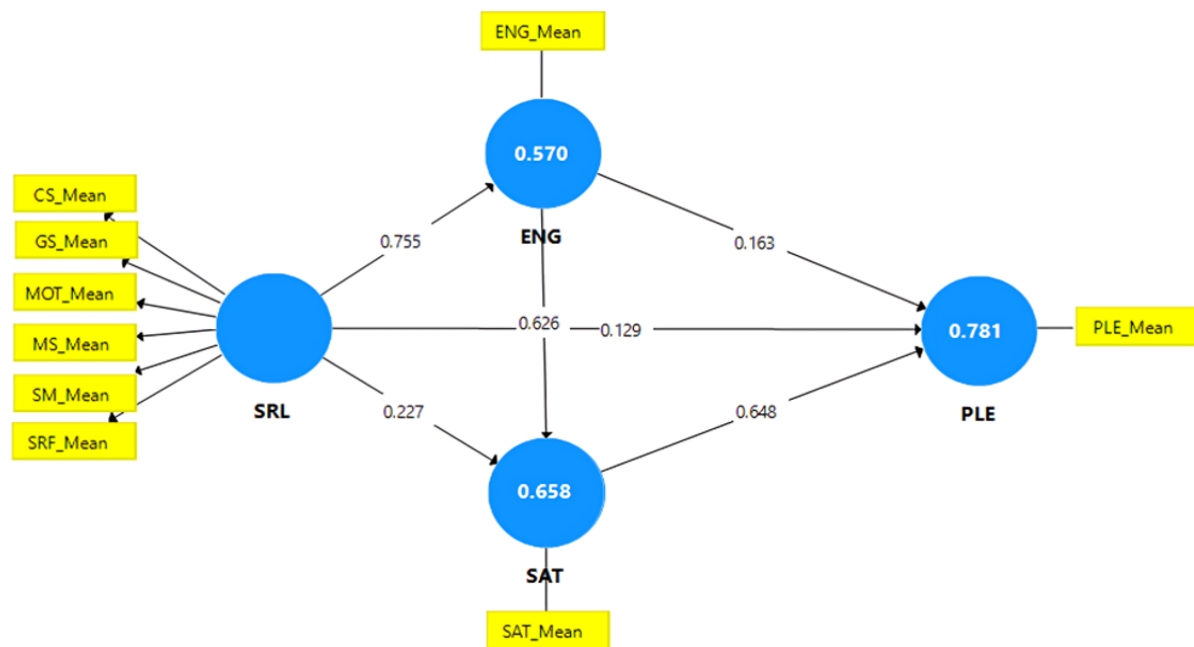
Type of effect	Coefficient (B)	SE	95% CI	Conclusion
Total effect (SRL → PLE)	0.7702	0.0231	[0.7249; 0.8155]	Significant
Direct effect (SRL → PLE)	0.1408	0.0241	[0.0935; 0.1880]	Significant
Total indirect effect (via ENG & SAT)	0.6295	0.0284	[0.5741; 0.6855]	Significant

**Table 11.** Indirect effects of SRL on PLE bootstrap 5,000 samples, 95% CI

Indirect path	$\beta$	BootSE	95% CI	Conclusion
Ind1: SRL → ENG → PLE	0.1345	0.0353	[0.0692; 0.2071]	Significant
Ind2: SRL → SAT → PLE	0.1610	0.0355	[0.0951; 0.2365]	Significant
Ind3: SRL → ENG → SAT → PLE	0.3340	0.0287	[0.2763; 0.3888]	Significant

**Table 12.** Standardized indirect effects in the serial mediation model (bootstrap 5,000 samples, 95% CI)

Indirect path	Standardized $\beta$	95% CI	Conclusion
Ind1: SRL → ENG → PLE	0.1234	[0.0633; 0.1906]	Significant
Ind2: SRL → SAT → PLE	0.1476	[0.0878; 0.2150]	Significant
Ind3: SRL → ENG → SAT → PLE	0.3062	[0.2546; 0.3549]	Significant



**Figure 2.** The SRL-ENG-SAT-PLE serial mediation model (Source: Authors' own elaboration using SmartPLS 4.0)

**Total, direct, and indirect effects**

The total indirect effect (0.6295) accounts for approximately 82% of the total effect of SRL on PLE, indicating a strong sequential mediation mechanism (see **Table 10**).

All indirect effects are statistically significant as the 95% bootstrap CI do not include zero. Among them, the serial mediation path SRL → ENG → SAT → PLE exhibits the strongest indirect effect, indicating that SRL primarily influences PLE through a sequential behavioral-emotional mechanism (see **Table 11**).

**Standardized indirect effects**

The standardized coefficient is highest for Ind3 ( $\beta = 0.3062$ ), confirming that the SRL → ENG → SAT → PLE pathway represents the most influential effect chain in the proposed model (**Table 12**). The standardized indirect effects further validate that the sequential pathway SRL → ENG → SAT → PLE (**H7**) constitutes the strongest mediation effect, while simultaneously providing additional empirical support for **H8** and **H9**.

**Results of the PLS-SEM model**

**Table 13.** Bootstrapping results and path coefficients in the PLS-SEM model

Path	Standardized coefficient ( $\beta$ )	BootSE	t-value	p-value	95% CI	Conclusion
SRL → ENG	0.7549	0.0241	31.273	< 0.001	[0.7045; 0.7985]	<b>H1</b> supported
SRL → SAT	0.2269	0.0440	5.155	< 0.001	[0.1446; 0.3162]	<b>H2</b> supported
SRL → PLE	0.1288	0.0287	4.481	< 0.001	[0.0753; 0.1877]	<b>H3</b> supported
ENG → SAT	0.6263	0.0449	13.951	< 0.001	[0.5338; 0.7099]	<b>H4</b> supported
ENG → PLE	0.1635	0.0429	3.807	< 0.001	[0.0822; 0.2506]	<b>H5</b> supported
SAT → PLE	0.6482	0.0381	17.011	< 0.001	[0.5705; 0.7190]	<b>H6</b> supported

Note. SmartPLS output with bootstrapping: n = 1,119; 5,000 bootstrap samples; & 95% CI

**Table 14.** R<sup>2</sup> and explanatory power of the model

Endogenous variable	R <sup>2</sup>	Evaluation
ENG	0.57	Good explanatory power
SAT	0.66	High explanatory power
PLE	0.78	Very high explanatory power

**Table 15.** Specific indirect effects in the mediation model (bootstrap 5,000 samples, 95% CI)

Indirect effect	Mediation pathway	Standardized effect ( $\beta$ )	95% CI	Conclusion
Ind1	SRL → ENG → PLE	0.1345	[0.0692; 0.2071]	Significant
Ind2	SRL → SAT → PLE	0.1610	[0.0951; 0.2365]	Significant
Ind3	SRL → ENG → SAT → PLE	0.3340	[0.2763; 0.3888]	Significant (largest)

Figure 2 shows the SRL-ENG-SAT-PLE serial mediation model.

Table 13 shows the bootstrapping results and path coefficients in the PLS-SEM model.

### Interpretation of Structural Path Coefficients

Beyond statistical significance ( $p < 0.001$  for all paths), the standardized coefficients reveal meaningful differences in effect magnitude. The strongest direct effect in the model is observed for SAT → PLE ( $\beta = 0.6482$ ), representing a large effect size and indicating that SAT is the most influential predictor of PLE.

The path ENG → SAT ( $\beta = 0.6263$ ) also demonstrates a strong effect, confirming that engagement plays a central role in shaping students' SAT. In contrast, the direct effect of SRL → PLE ( $\beta = 0.1288$ ) is comparatively small, suggesting that SRL primarily influences PLE indirectly through engagement and satisfaction rather than through a dominant direct pathway.

Notably, the magnitude of SRL → ENG ( $\beta = 0.7549$ ) indicates a very strong predictive relationship, underscoring the foundational role of SRL in activating subsequent motivational and emotional processes within the FC context.

SRL explains 57% of the variance in ENG, while SRL and ENG jointly account for 66% of the variance in SAT. Furthermore, SRL, ENG, and SAT explain 78% of the variance in PLE (see Table 14). These R<sup>2</sup> values indicate substantial explanatory power, suggesting that PLE in FCs is strongly shaped by students' self-regulatory behaviors and the subsequent engagement-satisfaction process.

Table 15 shows that all three specific indirect effects from SRL to PLE are statistically significant, as their 95% CI do not include zero. Among them, the sequential mediation pathway ENG → SAT → PLE (Ind3) exhibits the largest effect size ( $\beta = 0.3340$ ), indicating that learning engagement and SAT function as the dominant sequential mediators in the relationship between SRL and PLE.

The remaining indirect pathways (SRL → ENG → PLE and SRL → SAT → PLE) are also significant, reflecting the multidimensional influence of SRL on students' learning experiences and outcomes. The PLS-SEM results fully support the mediating roles of ENG (**H8**), SAT (**H9**), as well as the sequential mediation of ENG → SAT (**H7**).

Overall, the findings demonstrate that all hypotheses (**H1-H9**) are supported with high statistical confidence. SRL serves as a foundational construct by strongly predicting learning engagement and exerting both direct and indirect effects on SAT and PLE. Learning engagement not only stems from SRL but also plays a crucial mediating role in shaping satisfaction and effectiveness outcomes. SAT emerges as the strongest

predictor of PLE and represents a key emotional-motivational link within the sequential mediation mechanism  $SRL \rightarrow ENG \rightarrow SAT \rightarrow PLE$ .

The dominance of indirect effects indicates that PLE is formed primarily through processes of engagement and satisfaction. These results provide a robust quantitative foundation for the discussion section, particularly regarding the mechanisms through which SRL operates in FC environments and the pivotal roles of engagement and satisfaction in enhancing PLE.

## DISCUSSION

This study aims to elucidate the mechanism through which SRL is translated into PLE in the FC through two key mediators: ENG and SAT. Within the context of Vietnamese teacher education, the findings provide robust empirical evidence reinforcing the central role of SRL while clarifying a sequential pathway linking ENG to SAT.

First, the results indicate that SRL is the strongest predictor of ENG, suggesting that learners' ability to set goals, monitor progress, and regulate learning strategies constitutes a prerequisite for effective participation in both pre-class preparation and in-class interaction. This finding is fully consistent with theoretical perspectives proposed by Zimmerman (2000), Pintrich (2000), and Winne and Hadwin (1998), which conceptualize self-regulation as a mechanism that activates learning motivation and behavioral control. Compared with prior studies, this result extends existing knowledge in two important ways. First, while previous research primarily described barriers associated with insufficient SRL in FC settings (e.g., Hao, 2016; Yaşar & Polat, 2021), the present study quantifies the magnitude of SRL's influence on ENG using concrete statistical evidence. Second, the findings contribute to ongoing debates regarding the learner-dependency of the FC model. Rather than assuming that FC inherently enhances engagement, the results demonstrate that ENG increases substantially only when learners possess sufficiently developed SRL competencies. This insight is particularly salient in the Vietnamese context, where PS teachers have traditionally been exposed to passive learning modes and have limited experience with active learning approaches.

Second, the findings reveal that ENG is not only directly influenced by SRL but also serves as a critical conduit leading to SAT and, subsequently, PLE. This result aligns with the three-dimensional model of engagement proposed by Fredricks et al. (2004), which emphasizes behavioral, emotional, and cognitive engagement as foundational to learning quality. In FC environments, ENG is especially crucial because learners must transition between two learning phases: content acquisition at home and higher-order task processing in class. The present study extends prior research by demonstrating that ENG functions as a nexus between internal learner capacity (as manifested through SRL) and both affective and cognitive outcomes (SAT and PLE). Although previous studies (e.g., Fisher et al., 2017; Lin et al., 2019; Yoon et al., 2020) have highlighted the role of ENG in learning outcomes, they have rarely embedded ENG within a multivariate model incorporating both SRL and SAT. Accordingly, this study contributes to the literature by positioning ENG as a central component in the operational mechanism of FC: SRL enables ENG, and ENG, in turn, drives SAT and PLE.

Third, SAT emerges as the strongest predictor of PLE, corroborating findings from research in online and blended learning contexts (Alqurashi, 2019; Galvin & Lucitt, 2024; Wu et al., 2010). This underscores the pivotal role of affective experiences in shaping learners' perceptions of learning effectiveness. For PS teachers, SAT reflects not merely immediate satisfaction but also confidence in their ability to transfer acquired knowledge to future teaching practice. A novel contribution of this study lies in identifying SAT as a "hinge variable" that connects ENG to PLE. In FC settings, where in-class activities are highly interactive, satisfaction arises when students perceive tangible benefits from the learning process, such as deeper understanding, effective collaboration, and timely instructional support. Thus, SAT represents both a direct outcome of learning experiences and a critical condition that enhances learners' evaluation of their own learning effectiveness.

Fourth, although SRL exerts direct effects on both SAT and PLE, these effects are considerably weaker than its indirect effects mediated through ENG and SAT. This finding helps explain inconsistencies reported in previous studies, in which SRL did not always strongly predict learning outcomes or perceived learning (e.g., Noguera Fructuoso et al., 2023). The present results suggest that SRL does not automatically generate satisfaction or perceptions of effectiveness; rather, it must be "activated" through engagement and

“translated” through satisfaction. This has important theoretical implications: SRL constitutes a foundational capability, but it does not yield ultimate learning outcomes unless students are actively engaged and experience positive affective responses. In other words, SRL is a necessary but insufficient condition for success in FC contexts.

Fifth, the most salient finding of this study is the presence of a strong sequential mediation effect from SRL to ENG, from ENG to SAT, and from SAT to PLE. This pathway represents the largest and most consistent effect in the model, indicating that PLE is formed through three logically connected stages. Specifically, self-regulation prepares students for learning, engagement enhances participation and experiential quality, and satisfaction transforms positive experiences into perceptions of effective learning. A key contribution of this study lies in clarifying the integrative roles of ENG and SAT, which have typically been examined separately in prior research. In FC environments, ENG activates interaction and higher-order thinking, while SAT consolidates positive emotions and reinforces beliefs about learning effectiveness. Together, they constitute a powerful sequential mechanism, as evidenced by the model’s ability to explain 78% of the variance in PLE. This represents a significant theoretical advancement by proposing a pathway that closely aligns with the pedagogical logic of FC. Importantly, the magnitude of the sequential indirect effect (SRL → ENG → SAT → PLE) exceeding the direct effect of SRL on PLE suggests that SRL operates primarily through a behavioral-affective transformation process rather than a direct cognitive route. In practical terms, students’ regulatory skills do not automatically translate into perceptions of effectiveness unless they are first manifested as observable engagement and subsequently reinforced through positive affective evaluations. This reinforces the pedagogical view that engagement functions as an activating mechanism, while satisfaction serves as a consolidating mechanism in FC learning.

Sixth, this study contributes to theory in three primary ways. First, it integrates four core constructs into a comprehensive model. Unlike fragmented approaches in prior research, the SRL → ENG → SAT → PLE model captures the full cognitive-behavioral-affective mechanism underlying learning in FC environments, thereby enriching theories of motivation and self-regulation in digital learning contexts. Second, the study clarifies the sequential roles of ENG and SAT by confirming that ENG is not only an outcome of SRL but also the starting point of a causal chain leading to SAT and PLE, while SAT is empirically validated as a pivotal determinant of PLE. Third, the study extends the FC literature to the Vietnamese teacher education context. While most FC research has been conducted in developed countries, this study provides large-scale empirical evidence from an under-researched context, thereby enhancing the external validity and contextual breadth of FC theory.

Finally, the findings highlight a coherent mechanism linking SRL, ENG, and SAT to PLE, suggesting important implications for instructional design in FC environments.

Despite these practical strengths, several boundary conditions should be acknowledged. These findings further imply that instructional design in FCs should prioritize developmental sequencing over technological sophistication. Investments in digital tools or multimedia materials may yield limited impact if students lack sufficient self-regulatory competencies or if engagement opportunities are poorly structured. The model suggests that strengthening SRL strategies (e.g., structured goal-setting prompts, guided reflection tasks, or metacognitive scaffolds) is likely to generate cascading benefits across engagement and satisfaction, thereby amplifying perceived effectiveness.

Although the sequential mediation model demonstrates strong explanatory power, its effectiveness is likely contingent upon contextual and learner-related factors. The capacity of SRL to activate engagement may depend on instructional quality, scaffolding design, and students’ readiness for autonomous learning. In settings where active learning experience is limited or pedagogical support is insufficient, the transition from SRL to ENG and SAT may be weakened.

Additionally, cultural learning norms may moderate the engagement-satisfaction relationship. In traditionally teacher-centered environments, students may require structured transitional support to fully benefit from the identified mechanism. Future research should therefore examine potential moderating variables such as disciplinary context, digital competence, and instructional design features to strengthen the model’s generalizability.

This study has several limitations that should be acknowledged. First, the data were collected using self-reported measures at a single point in time, which may introduce the potential risk of common method bias.

Although diagnostic tests suggest that this issue is unlikely to substantially affect the results, future research could reduce this risk by employing longitudinal designs or collecting data from multiple sources. Second, the cross-sectional design limits the ability to establish causal relationships among the constructs examined. Longitudinal or experimental studies would provide stronger evidence regarding the directional relationships proposed in the model.

In sum, course designers and instructors should view the FC not merely as a reordering of content delivery (pre-class versus in-class) but as an integrated pedagogical system. When SRL is systematically cultivated, in-class engagement is multidimensionally promoted, and SAT is intentionally supported; these three elements, when addressed coherently, can maximize PLE among PS teachers.

## RECOMMENDATIONS

Based on the findings, several practical recommendations can be derived for FC implementation. First, the results demonstrate a clear pathway from SRL capacity through engagement and satisfaction to PLE. Accordingly, fostering SRL should be treated as an explicit instructional objective rather than an assumed learner characteristic. Instructors can embed structured goal-setting prompts at the beginning of each pre-class module, provide guided preparation checklists, and incorporate brief metacognitive reflection tasks that require students to monitor their learning progress. Low-stakes formative quizzes administered before class can further support students in evaluating understanding and adjusting strategies accordingly.

Second, engagement should be intentionally designed rather than left to spontaneous interaction. To convert SRL into observable ENG, in-class time should prioritize collaborative problem-solving, case-based discussions, peer instruction, and real-time polling activities. Clearly defined group roles and tasks requiring application and analysis of pre-class content can strengthen behavioral and cognitive engagement.

Third, SAT can be enhanced through instructional coherence and feedback quality. Alignment between pre-class materials, in-class activities, and assessment criteria is essential. Timely, specific, and constructive feedback reinforces students' sense of competence and progress, thereby strengthening the affective foundation of perceived effectiveness. Opportunities for student reflection and voice can further consolidate positive learning experiences.

Moreover, FC design should follow a developmental sequence rather than isolated interventions: pre-class scaffolding that strengthens SRL, in-class structures that activate ENG, and feedback mechanisms that consolidate SAT. Instructional sophistication should prioritize developmental alignment over technological complexity. Investments in digital tools may yield limited benefits if regulatory competencies and engagement structures are insufficiently developed. Strengthening SRL strategies is therefore likely to generate cascading effects across engagement and satisfaction, ultimately amplifying PLE.

## CONCLUSION

This study elucidates the operational mechanism of the FC by integrating four core constructs, SRL, ENG, SAT, and PLE into a comprehensive predictive model. The findings indicate that SRL does not exert a strong direct effect on PLE; rather, its influence is predominantly transmitted through the sequential mediation pathway of  $ENG \rightarrow SAT$ . This sequential mediating mechanism demonstrates substantial explanatory power and helps identify a coherent and robust mechanism underlying the functioning of the FC model in teacher education.

From a theoretical perspective, the study offers three major contributions. First, it extends the theoretical foundation by explicitly identifying a sequential pathway linking SRL, ENG, and SAT to PLE. Second, it strengthens the empirical validity of the proposed model through a large-scale dataset and a rigorous analytical approach that combines PLS-SEM with sequential mediation analysis. Third, it provides empirical evidence from the Vietnamese context, thereby enhancing the generalizability of the FC model to learner populations and educational settings that have been underrepresented in prior research.

From a practical standpoint, the findings emphasize that enhancing PLE requires a systemic approach in which SRL is deliberately cultivated, ENG is promoted through the design of highly interactive learning activities, and SAT is reinforced through coherent and well-structured learning experiences. The results

demonstrate that these factors do not operate independently but instead form a tightly interconnected chain, suggesting that the most effective pedagogical interventions are those that simultaneously target all three constructs.

Although the use of a cross-sectional design limits causal inference, the study establishes a solid theoretical framework for describing the operational mechanism of the FC in teacher education. Future research should employ longitudinal designs or experimental interventions to more rigorously test causal relationships and to assess the long-term effects of the SRL-ENG-SAT-PLE pathway. Nevertheless, within its current scope, the study makes meaningful contributions to both theory and practice and offers valuable guidance for optimizing pedagogical design in learner-centered educational contexts.

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