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Relationship between flipped classroom effectiveness and satisfaction: the case of Vietnamese pre-service teachers

Hong Tieu Thi My[1], Thuy Pham Thi Thanh[2], Anh Bui Xuan[1]
[1]Faculty of Political Theory – Civic Education, Hanoi National University of Education, Hanoi, Vietnam
[2]Faculty of English, Hanoi National University of Education, Hanoi, Vietnam

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ABSTRACT

The study examines student satisfaction with the flipped classroom (FC) model in teacher education in Vietnam and investigates the mechanisms through which contextual factors influence satisfaction. The study integrates service performance (SERVPERF) and the technology acceptance model (TAM) to propose a structural model in which perceived learning effectiveness (EFF) serves as a mediating variable linking service quality and technological quality (LMS) to student satisfaction (SA). Data were collected from 871 first-year pre-service teachers and analyzed using partial least squares structural equation modeling (PLS-SEM). The results indicate that students generally report positive satisfaction with FC. EFF emerges as the strongest direct predictor of satisfaction and a key mediating mechanism. Learning materials and facilities show the strongest effects on EFF, followed by the LMS and academic as well as technical support, while instructor quality does not exhibit a significant direct effect. The findings highlight that student satisfaction is primarily driven by perceived learning value rather than isolated contextual factors, offering important implications for optimizing the design of FC in higher education.

Corresponding Author:

Anh Bui Xuan
Faculty of Political Theory – Civic Education, Hanoi National University of Education
136 Xuan Thuy Str, Cau Giay, Hanoi, Vietnam
Email: anhbx@hnue.edu.vn

1. INTRODUCTION

The rapid development of information technology and the internet has profoundly transformed the higher education landscape, creating both opportunities and challenges for educational institutions [1]. While e-learning offers flexibility in terms of time and space, as well as cost-effective access, it also faces several limitations, such as decreased learning motivation, limited face-to-face interaction, and a high risk of distraction due to heavy reliance on digital environments. This situation necessitates the search for pedagogical models that can balance the advantages of both online and face-to-face learning. In this context, the flipped classroom (FC) has emerged as a promising approach [2], [3]. By shifting knowledge acquisition to the pre-class phase and using in-class time for discussion, collaboration, and problem-solving activities, FC is considered a powerful means of promoting student-centered learning [4], [5]. A growing body of evidence suggests that FC can improve learning outcomes, enhance student autonomy and engagement [6], and increase learning satisfaction, although its actual effectiveness depends largely on the quality of its design and implementation [7].

However, empirical findings regarding student satisfaction with FC remain inconsistent. Some studies indicate that satisfaction levels in FC do not significantly differ from those in traditional classrooms [7]–[9], whereas others report substantial improvements in both learning outcomes and student

satisfaction [10]–[13]. This inconsistency suggests that the determinants of satisfaction in FC contexts may vary depending on cultural factors, technological conditions, and learning styles [14], [15]. In Vietnam, the FC remains relatively new in higher education [16]. The characteristics of Asian learning culture, reflected in a high level of dependence on lecturers and a tendency toward passive knowledge reception, along with disparities in digital competence and infrastructural conditions across institutions, may pose significant challenges to the implementation of the FC model. However, existing research in Vietnam has primarily focused on describing perceptions, attitudes, or post-intervention learning outcomes, with limited systematic analysis of the mechanisms through which contextual factors influence student satisfaction - particularly the mediating role of perceived learning effectiveness, a crucial yet underexplored variable in FC models [17]. Although the service performance (SERVPERF) and technology acceptance model (TAM) models have demonstrated their usefulness in predicting service quality, technology acceptance, and satisfaction in higher education, studies in FC contexts have rarely integrated these two theoretical frameworks. Notably, few studies have simultaneously examined learning materials, LMS platforms, instructors, facilities, and support services as a comprehensive service quality construct, while positioning perceived learning effectiveness (EFF) as a central mediating variable linking these factors to student satisfaction. In addition, most FC studies employ experimental or quasi-experimental designs with moderate or small sample sizes, and few have applied structural equation modeling to simultaneously assess both direct and indirect effects within a comprehensive framework - particularly in teacher education contexts. Research employing partial least squares structural equation modeling (PLS-SEM) with large samples to quantify the mediating role of EFF between contextual factors and student satisfaction in FC remains highly limited.

The core novelty of this study lies in three aspects. First, it uniquely integrates the SERVPERF framework with the TAM to evaluate both pedagogical and technological quality dimensions concurrently. Second, it uncovers the crucial mediating mechanism of EFF by validating the vital mediating role of EFF in linking quality inputs directly to student satisfaction (SA). Third, it provides pioneering empirical evidence from the context of Vietnamese teacher education, highlighting how integrated institutional support and high-quality materials—rather than direct instructor intervention—effectively drive learning satisfaction for first-year pre-service teachers. This study also offers practical value for lecturers and higher education institutions in Vietnam by helping them better understand the factors that affect student satisfaction when implementing the FC model. The findings are expected to inform policy decisions on improving teaching methods and to provide concrete strategies for optimizing the implementation of FC in teacher education, thereby enhancing learning quality and student satisfaction. To address these empirical gaps and practical needs, the study addresses two main research questions:

- What is the level of satisfaction among Vietnamese pre-service teachers with the FC model?
- Which factors influence their satisfaction, and how does perceived learning effectiveness mediate these relationships?

2. THEORETICAL BACKGROUND AND PROPOSED RESEARCH MODEL

2.1. The flipped classroom as a blended learning environment

The FC is conceptualized as a form of blended learning in which the acquisition of fundamental knowledge takes place before class through videos or online materials, while in-class time is devoted to interaction, discussion, and the application of knowledge with the support of the lecturer [18]–[20]. This structure enables students to prepare foundational knowledge in advance, thereby enhancing the effectiveness of interactive, practice-based, and application-oriented activities during face-to-face sessions [21].

In contrast to traditional teaching methods, the FC reverses the process of information delivery and processing [19], emphasizing students' active role in learning, while lecturers act as facilitators who organize activities, provide guidance, and support knowledge extension and problem-solving [15], [22], [23]. Structurally, this model is composed of at least three core components: digital learning resources, physical classroom, and supporting interactive platforms [24]. This indicates that students' experiences in FCs are shaped not only by the learning content but also by the quality of learning materials, the technological environment, instructional design, and the availability of supporting conditions. A growing body of research has shown that the FC can enhance higher-order thinking, increase students' motivation, and promote engagement [6], [25], while also facilitating personalized learning [26], [27]. However, the effectiveness of this model is not automatically guaranteed; rather, it depends substantially on students' pre-class preparation, the quality of learning materials, lecturer support, and the overall organization of the learning environment [28]. Challenges such as disparities in self-directed learning ability, motivation, and digital skills indicate that successful implementation of the FC requires appropriate instructional design and robust support systems [29]. In other words, the FC should be viewed as a blended learning ecosystem in which multiple contextual factors jointly shape how students experience learning and evaluate their outcomes.

Overall, the FC has been recognized as a model that transforms passive classrooms into active learning environments [30] yet its effectiveness is not consistent across contexts [9]. This inconsistency highlights the need for deeper investigation into the mechanisms through which service- and technology-related factors in FCs influence perceived learning effectiveness and student satisfaction.

2.2. Student satisfaction in the flipped classroom context satisfaction

Satisfaction is commonly described as a positive emotional state that arises when actual outcomes meet or exceed learners' initial expectations [31]. In higher education, satisfaction is an important indicator of educational quality [32] and is closely associated with learning motivation, engagement, and student retention [33]. High levels of satisfaction can also help reduce dropout rates and strengthen students' commitment to their learning process [34]. However, in the context of the FC, satisfaction should not be viewed merely as an immediate emotional response to a course, but rather as students' overall evaluation of the learning value provided by this model. Since the FC requires students to invest more effort in pre-class self-study, participate more actively during class, and adapt to technology-supported learning tools, their level of satisfaction depends not only on how well the "educational service" is delivered, but also on whether they genuinely perceive the model as enhancing their learning effectiveness. Therefore, explaining satisfaction in FCs requires a theoretical framework that captures the quality of the educational service experience, reflects the role of technology, and clarifies the psychological mechanisms through which these experiences are translated into students' satisfaction judgments.

2.3. SERVPERF and TAM – two theoretical foundations for the proposed research model

In this study, student satisfaction in the FC is explained through an integration of the SERVPERF framework and the TAM. The selection of these two theoretical frameworks is grounded in the nature of the FC as a blended learning environment, where students' experiences are shaped simultaneously by the quality of educational services and the quality of the technological platform. SERVPERF, proposed by Cronin and Taylor [35], is a service quality assessment model based on actual performance rather than the gap between expectations and perceptions, as in SERVQUAL. In the context of higher education - especially with relatively new learning models such as the FC - a performance-based approach is more appropriate, as students often find it difficult to form stable initial expectations about unfamiliar learning formats. Several studies have shown that SERVPERF provides strong, consistent measurement and better predictive power for satisfaction in educational settings [36]. Therefore, SERVPERF is adopted in this study as the foundation for conceptualizing the service quality components of the FC. Specifically, from a SERVPERF perspective, students' learning experiences in the FC are reflected through four groups of factors: the quality of learning materials (DOC), instructor quality (LEC), facilities (FAC), and academic as well as technical support (SUP). Among these, DOC refers to the clarity, currency, usefulness, and instructional support of learning materials; LEC reflects the lecturer's ability to organize, guide, provide feedback, and support students; FAC represents the physical and infrastructural conditions for learning; and SUP captures the availability, timeliness, and effectiveness of academic and technical support provided to students. Thus, SERVPERF helps explain the "educational service" dimension of the FC experience. However, SERVPERF alone is insufficient to fully explain students' experiences in the FC, as this model is strongly supported by technology, particularly the LMS and digital learning materials. Therefore, this study further draws on the TAM [37], [38] to conceptualize the technological dimension of the model. According to TAM, perceived usefulness (PU) and perceived ease of use (PEOU) are key determinants influencing users' attitudes, behavioral intentions, and satisfaction with a technological system.

In this study, the quality of the LMS platform (software) is conceptualized as a construct that simultaneously reflects both PU and PEOU. A stable, user-friendly, and easy-to-navigate LMS that effectively supports interaction can make students perceive learning as both easier to carry out and more beneficial to their learning process. In other words, software (SW) is used to represent the technological experience component of the model. This approach allows the study to avoid directly measuring PU and PEOU as separate variables, while still preserving the core theoretical logic of TAM in explaining how students evaluate the technological learning environment. Thus, SERVPERF and TAM do not operate independently but rather complement each other in explaining students' experiences in the FC. SERVPERF clarifies the educational service components, while TAM elucidates the technological dimension. The integration of these two frameworks enables the research model to more comprehensively capture the nature of the FC as a learning environment that is both pedagogical and technology driven.

2.4. The mediating role of perceived learning effectiveness

Although service and technological factors may create favorable learning conditions, they do not necessarily lead directly to student satisfaction. In the FC, what students evaluate is not only whether the

learning materials are of high quality, whether the LMS is convenient, or whether the lecturer is supportive, but more importantly, whether these conditions genuinely help them learn more effectively. Therefore, between contextual factors and satisfaction, there needs to be an intermediate psychological layer that reflects how students interpret the value of their learning experiences. In the study, this intermediate evaluative layer is conceptualized as EFF. EFF reflects the extent to which students feel that learning in the FC improves their academic performance, enhances their competence, develops their skills, and generates meaningful learning value. From this perspective, students are not satisfied merely because the learning environment is well organized; rather, they are satisfied when they perceive that the environment produces tangible learning benefits. Thus, EFF is regarded as a "psychological bridge" linking service experience, technological experience, and satisfaction. Positioning EFF as a central mediating variable also helps connect SERVPERF and TAM within a unified explanatory mechanism. From the SERVPERF perspective, the quality of learning materials, lecturers, facilities, and support can enhance students' perceptions of learning effectiveness. From the TAM perspective, an LMS that is easy to use and useful can likewise strengthen the perception that learning is more effective. When students interpret these conditions as leading to positive and valuable learning outcomes, they are more likely to develop higher levels of satisfaction with the FC model. Therefore, EFF is not merely a technical mediating variable in a statistical model, but a key theoretical construct that explains how contextual factors are transformed into student satisfaction.

2.5. Proposed research model and hypotheses

Based on the arguments, this study proposes a model in which students' experiences in the FC are shaped by two main groups of factors: educational service factors and technological factors. The educational service factors include learning materials, lecturers, facilities, and academic as well as technical support, conceptualized within the SERVPERF framework. The technological factor is represented by the quality of the SW, informed by TAM. These factors are hypothesized not only to exert direct effects on students' perceived learning effectiveness but also to indirectly influence student satisfaction through EFF.

Conceptually, the variables in the model are measured as perceptual constructs reflecting students' experiences in the FC. DOC represents the quality of digital learning materials and instructional resources; LEC reflects the quality of lecturers' organization, guidance, and support; FAC captures the physical and infrastructural conditions for learning; SUP refers to academic and technical support; SW represents the quality of the LMS experience in terms of stability, ease of use, convenience, and support for interaction; EFF reflects the extent to which students perceive that the FC model enhances their learning effectiveness; and SA represents students' overall satisfaction with the FC model. This conceptualization clarifies the role of each variable in the model and minimizes ambiguity among theoretical constructs. Accordingly, the study hypothesizes that DOC, LEC, FAC, SUP, and SW all have positive effects on EFF; that EFF has a positive effect on SA; and that EFF mediates the relationships between the contextual factors of the FC and student satisfaction. This model allows for the simultaneous examination of both direct and indirect effects among latent variables, thereby aligning with the research objective of explaining the mechanism through which student satisfaction is formed in the FC context.

Figure 1 illustrates the proposed research model of factors influencing perceived learning effectiveness and student satisfaction in the FC. The research hypotheses are formulated as: i) the quality of the LMS platform, learning materials, lecturers, facilities, and academic as well as technical support all have positive effects on students' perceived learning effectiveness in the FC model (H1); ii) perceived learning effectiveness has a positive effect on student satisfaction with the FC model (H2); iii) perceived learning effectiveness positively mediates the relationships between the contextual factors of the FC (SW, DOC, LEC, FAC, SUP) and student satisfaction (H3).

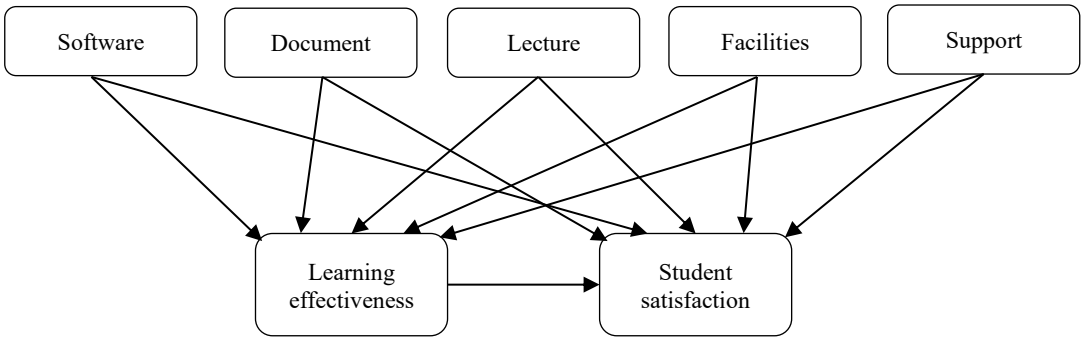

Figure 1. Model of factors influencing learning effectiveness and student satisfaction in FC

3. METHOD

3.1. Research design

This study adopts a quantitative correlational descriptive design using cross-sectional data. This design is chosen because the objective of the study is not to evaluate the effectiveness of an experimental intervention, but rather to describe the level of student satisfaction with the FC model and to examine the predictive relationships between instructional contextual factors, perceived learning effectiveness, and satisfaction. Specifically, the study pursues two main objectives: i) to determine the level of satisfaction among pre-service teachers with courses implemented using the FC model and ii) to test the role of contextual factors - including the LMS platform, learning materials, lecturers, facilities, and academic as well as technical support—in predicting EFF and SA through PLS-SEM.

A cross-sectional design is appropriate for the nature of the research questions, as it allows data to be collected at a point when students have gained sufficient experience with the FC model. This enables the study to describe the levels of the research variables and examine the relationships among latent constructs within a unified analytical framework. Since the study does not involve any instructional intervention, the findings should be interpreted in terms of predictive and explanatory relationships among variables rather than strict causal inferences. In other words, the results reflect how students perceive and evaluate their learning experiences in an already implemented FC context. Data was collected through an online questionnaire using standardized Likert-scale measures (five-point scale), allowing for the quantification of latent constructs and the simultaneous testing of both direct and indirect relationships among them. Given the objective of analyzing a model with multiple latent variables and a central mediating variable, a cross-sectional quantitative design combined with PLS-SEM is considered appropriate from both theoretical and methodological perspectives.

3.2. Research subjects and sample

The participants of this study were first-year pre-service teachers enrolled in courses implemented using the FC model during the surveyed semester. First-year students were selected because they are in the process of adapting to the university learning environment while simultaneously beginning to experience new instructional approaches, including the FC. Therefore, their perceptions are meaningful in reflecting levels of acceptance, perceived learning effectiveness, and satisfaction with the model.

The sample consisted of 871 first-year students from three different disciplinary fields. A convenience sampling method was employed, drawing participants from classes/courses that had implemented the FC model and were accessible during the data collection period. This approach is appropriate for testing the theoretical model in a real-world implementation context, where only students who have fully experienced the model can provide meaningful evaluations. The inclusion criteria were: students must have participated in courses organized using the FC model, must have experienced all pre-class, in-class, and post-class activities as designed, and must have voluntarily agreed to participate in the survey.

The demographic characteristics of the sample are presented in Table 1. Among the participants, females accounted for 86.6% and males for 13.4%. In terms of academic fields, 11.9% were from natural sciences, 35.7% from social sciences, and 52.3% from educational sciences. Regarding ethnicity, 79.9% of the students were Kinh, while 20.1% belonged to other ethnic groups.

Table 1. Demographic profile of students in research

	Characteristics	Percentage (%)
Gender	Male	13.4
	Female	86.6
Field of study	Natural Sciences	11.9
	Social Sciences	35.7
	Educational Sciences	52.3
Ethnic group	Kinh	79.9
	Others	20.1

Although the sample size is relatively large and suitable for structural model analysis, the use of convenience sampling means that the sample is not intended to be statistically representative of all university students in Vietnam. Therefore, the findings should be interpreted as empirical evidence within the context of first-year pre-service teachers participating in FC courses, rather than being directly generalized to all academic disciplines or institutions. In addition, the gender imbalance in the sample partly reflects common characteristics of certain teacher education programs, but it remains a factor to consider when evaluating the generalizability of the results. All participants took part in the survey voluntarily after being fully informed about the purpose and content of the study. Data was collected anonymously, with no personally identifiable

information recorded. The study adhered to ethical principles in research involving human participants, ensuring participants' right to refuse or withdraw at any time without any negative consequences.

3.3. Measurement instruments

Data were collected via an online questionnaire designed in Google Forms, using a five-point Likert scale ranging from 1 "strongly disagree" to 5 "strongly agree." The questionnaire was developed based on the proposed research model to measure seven latent constructs in the FC context, including SW, DOC, LEC, FAC, SUP, EFF, and SA. Each latent construct was measured by multiple observed variables reflecting specific aspects of students' learning experiences. In total, the questionnaire consisted of 40 observed items: SW was measured by 5 items, DOC by 5 items, LEC by 8 items, FAC by 4 items, SUP by 4 items, EFF by 9 items, and SA by 5 items. The use of multiple indicators for each construct ensures adequate coverage of the constructs' conceptual domains and provides a basis for assessing the reliability and validity of the measurement scales during the analysis phase.

To minimize measurement bias, the questionnaire items were designed to be clear, concise, and closely aligned with students' actual experiences in courses applying the FC model. The quality of the scales was evaluated not only based on theoretical grounding but also through empirical testing within the PLS-SEM framework, including assessments of internal consistency reliability, convergent validity, and discriminant validity. Detailed results of the measurement model evaluation, including reliability and validity within the PLS-SEM framework, are presented in the results section. To ensure strong methodological validity and reliability before the primary data collection phase, the measurement instrument underwent a structured development and validation process. First, regarding item adaptation, the initial survey indicators were adapted from validated scales in the existing literature and meticulously tailored to align with the theoretical framework of flipped learning in Vietnamese teacher education. To maintain strict linguistic and conceptual equivalence, a rigorous back-translation procedure was executed by independent language experts fluent in both English and Vietnamese. Second, to establish adequate content and face validity, the initial draft of the questionnaire was subjected to expert judgment by a panel consisting of three senior researchers specializing in educational technology and pedagogical methodology. The experts scrutinized the adapted items for clarity, contextual relevance, and theoretical alignment. Based on their qualitative assessments, minor wording adjustments were made to eliminate ambiguities. Third, following the expert review, a pilot testing phase was conducted with a small group of pre-service teachers (N=50) who shared identical demographic characteristics with the target population but were excluded from the final sample. Internal consistency checks were performed on the pilot data, and the preliminary results demonstrated that all measurement scales achieved robust reliability thresholds, confirming that the instrument was fully optimized for the main survey.

3.4. Data collection procedure

The survey was conducted during the final two weeks of the second semester of the 2024-2025 academic year, when students had fully experienced the FC model across its pre-class, in-class, and post-class phases. This timing helps ensure that the responses reflect a relatively comprehensive evaluation of students' learning experiences. Data were collected online via Google Forms. To minimize common method bias associated with self-reported data, several measures were implemented: i) the survey was conducted anonymously and voluntarily; ii) data were collected after a sufficiently long period of exposure to reduce the influence of short-term impressions; and iii) the questionnaire employed standardized scales with clear structure and multiple indicators for each construct. Nevertheless, since the data were collected from a single source at one point in time, the risk of common method bias cannot be eliminated and is acknowledged as a limitation of the study.

After the survey was completed, the data were screened, cleaned, coded, and prepared for analysis. Incomplete responses or those not meeting the inclusion criteria were removed before conducting statistical analyses. Given that data for both the predictor and outcome variables were collected from a single informant source at a single point in time, potential common method variance (CMV) was carefully addressed through procedural and statistical remedies to strengthen the methodological validity of the study. Procedural controls included psychological separation of items within the questionnaire design, ensuring respondent anonymity, and explicitly stating that there were no right or wrong answers to minimize socially desirable responding. Statistically, the explanation of common method bias was rigorously strengthened using Harman's single-factor test as the primary statistical procedure. All active indicators from the conceptual constructs were loaded simultaneously into an unrotated exploratory factor analysis (EFA). The statistical output revealed that the first principal factor accounted for less than the critical 50.0% threshold of the total variance. This empirical outcome strongly confirms that a single general factor does not dominate the variance within the dataset, demonstrating that common method bias does not pose a threat to the validity or integrity of the structural findings.

3.5. Data analysis and reasons for using PLS-SEM

After data cleaning, the dataset was analyzed using IBM SPSS Statistics in combination with PLS-SEM. SPSS was employed for data coding, screening, descriptive statistics, and preparing the dataset for subsequent analyses. PLS-SEM was then used to simultaneously test both the measurement model and the structural model of the study. The choice of PLS-SEM is based on three main reasons. First, the research model includes multiple latent variables and assumes both direct and indirect relationships among them. Compared to traditional regression techniques, PLS-SEM is more suitable for simultaneously estimating complex relationships among latent constructs within a single analytical framework. Second, the study aims to test a predictive model and explain the mechanism underlying student satisfaction in the FC context, which aligns with the application-oriented nature of PLS-SEM. Third, PLS-SEM allows for the simultaneous evaluation of measurement quality and structural relationships, which is particularly useful when integrating multiple theoretical constructs, such as in the SERVPERF–TAM model with a mediating variable.

The analysis procedure was conducted in two stages. In the first stage, the measurement model was assessed to evaluate the quality of the scales using indicators such as outer loadings, Cronbach's alpha, composite reliability, average variance extracted (AVE), and discriminant validity. In the second stage, the structural model was tested through path coefficients, significance levels, coefficients of determination (R^2), effect sizes, and both direct and indirect effects within the model. This approach enables the study not only to establish the reliability and validity of the measurement instruments but also to consistently test the research hypotheses regarding the roles of contextual factors, perceived learning effectiveness, and student satisfaction in the FC.

4. RESULTS AND DISCUSSION

4.1. Results

4.1.1. Measurement model assessment

The results of the measurement model assessment indicate that the scales used in the study meet the requirements for reliability, convergent validity, and discriminant validity. All outer loadings of the observed variables exceed the acceptable threshold, ranging from 0.701 to 0.927, suggesting that the indicators adequately reflect their corresponding latent constructs. Detailed outer loadings are presented in Table 2.

The indicators of reliability and convergent validity also meet the required thresholds. Specifically, Cronbach's alpha values range from 0.829 to 0.957, composite reliability (CR) ranges from 0.887 to 0.963, and the AVE ranges from 0.664 to 0.825. These results indicate that the measurement scales exhibit high internal consistency and satisfactory convergent validity. Detailed results are presented in Table 3. As presented in Table 3, the measurement model exhibits robust internal consistency and reliability. The Cronbach's alpha and CR values for all constructs exceed the recommended threshold of 0.70. Furthermore, all AVE values are strictly above the 0.50 benchmark, verifying acceptable convergent validity. These empirical indicators systematically demonstrate that the research instrument possesses an adequate level of reliability, accuracy, and validity.

Discriminant validity was assessed using the Heterotrait–Monotrait ratio (HTMT). The results indicate that all pairs of latent constructs have HTMT values below 0.90, with most below 0.80, confirming that the constructs in the model are well discriminated against in terms of measurement. Detailed results are presented in Table 4. Overall, the measurement model meets the requirements for reliability, convergent validity, and discriminant validity, and is therefore suitable for proceeding to structural model analysis.

4.1.2. Descriptive statistics of the study variables

The descriptive statistics indicate that students generally hold positive evaluations of the FC model, with mean scores of the constructs ranging from 3.71 to 4.14 on a five-point scale. Detailed results are presented in Table 5. Among the variable groups, instructor quality received the highest mean score (M=4.14), indicating that students hold positive evaluations of lecturers' professional competence, lesson preparation, organization of learning activities, and support. The LMS platform (SW) and learning materials (DOC) both obtained a mean score of 3.90, reflecting relatively positive evaluations of course organization on the LMS and the quality of online learning materials. Within the SW scale, the item related to interaction between students, lecturers, and peers via the LMS had a relatively lower score (SW.5=3.61). Similarly, within the DOC scale, the item regarding the attractiveness of lecture videos was slightly lower than the others (DOC.3=3.80).

Table 2. Outer loadings of observed variables

Item	DOC	EFF	FAC	LEC	SA	SUP	SW
Doc.1	0.855						
Doc.2	0.869						
Doc.3	0.865						
Doc.4	0.882						
Doc.5	0.767						
Eff.1		0.880					
Eff.2		0.897					
Eff.3		0.876					
Eff.4		0.838					
Eff.5		0.847					
Eff.6		0.836					
Eff.7		0.888					
Eff.8		0.843					
Eff.9		0.857					
Fac.1			0.846				
Fac.2			0.867				
Fac.3			0.701				
Fac.4			0.835				
Lec.1				0.859			
Lec.2				0.827			
Lec.3				0.885			
Lec.4				0.871			
Lec.5				0.861			
Lec.6				0.895			
Lec.7				0.872			
Lec.8				0.889			
SW.1							0.857
SW.2							0.855
SW.3							0.775
SW.4							0.862
SW.5							0.764
Sa.1					0.904		
Sa.2					0.927		
Sa.3					0.896		
Sa.4					0.909		
Sa.5					0.905		
Sup.1						0.870	
Sup.2						0.901	
Sup.3						0.895	
Sup.4						0.874	

Table 3. Reliability and convergent validity of the measurement scales

Item	Cronbach's alpha	rho_A	Composite reliability	AVE
DOC	0.902	0.906	0.928	0.720
EFF	0.957	0.958	0.963	0.744
FAC	0.829	0.839	0.887	0.664
LEC	0.954	0.956	0.961	0.757
SA	0.947	0.947	0.959	0.825
SUP	0.908	0.909	0.935	0.784
SW	0.881	0.886	0.913	0.679

Table 4. Discriminant validity (HTMT)

Item	DOC	EFF	FAC	LEC	SA	SUP	SW
DOC							
EFF	0.759						
FAC	0.753	0.754					
LEC	0.800	0.685	0.755				
SA	0.741	0.892	0.716	0.665			
SUP	0.650	0.637	0.717	0.660	0.611		
SW	0.825	0.712	0.721	0.731	0.704	0.640	

Perceived learning effectiveness (EFF) had a mean score of 3.88, suggesting that students generally perceive positive learning value from the FC model. Within this construct, the item related to improving self-directed learning ability received the highest score (EFF.8=3.98), whereas the item concerning improvement in communication skills was relatively lower (EFF.6=3.75). Student satisfaction (SA) had a mean score of 3.85, indicating a relatively high level of satisfaction with the FC experience. The items within the SA scale

ranged from 3.83 to 3.93, reflecting a consistently positive evaluation trend. Compared to the other variable groups, facilities (FAC) recorded the lowest mean score (M=3.71). Notably, the item related to internet accessibility on campus had the lowest score in the entire descriptive dataset (FAC.3=3.02) and also the largest standard deviation (SD=1.244), indicating substantial variation in students' experiences with connectivity conditions. Academic/technical support (SUP) achieved a mean score of 3.73, reflecting a moderate but not particularly strong evaluation. In summary, the descriptive statistics suggest that the FC model is received relatively positively by students. However, aspects such as interaction on the LMS, the attractiveness of lecture videos, technical support, and especially connectivity infrastructure remain comparatively weaker areas in the dataset.

Table 5. Descriptive statistics of the study variables

Code	Measurement items	Mean	Std. Deviation
Software (SW)		3.90	
Sw.1	The course is clearly organized and easy to understand on the LMS platform	4.01	.783
Sw.2	Learning content and tasks are clearly displayed on the LMS system interface	4.08	.783
Sw.3	The LMS system is stable, not overloaded, tasks are not lost	3.78	.921
Sw.4	The system allows me to control my learning activities	4.01	.758
Sw.5	The LMS platform easily allows me to interact with lecturers and other students	3.61	.998
Document (DOC)		3.90	
Doc.1	Online lectures are provided with complete information about the subject	3.90	.803
Doc.2	Information from online lectures is always updated and clear	3.96	.773
Doc.3	Lesson videos are made easy to watch, attractive, and rich	3.80	.850
Doc.4	Appropriately prepared learning materials complement the lectures	3.93	.793
Lecturer (LEC)		4.14	
Lec.1	Lecturers prepare thoughtful and thorough lectures	4.18	.714
Lec.2	Lecturers have high professional knowledge	4.30	.702
Lec.3	Lecturers convey knowledge clearly and easily to understand	4.14	.749
Lec.4	Lecturers effectively use technological equipment in teaching	4.11	.743
Lec.5	Lecturers are ready to support me during the online learning process	4.08	.772
Lec.6	Lecturers organize and guide live classroom activities in an engaging and effective way	4.08	.752
Lec.7	Lecturers provide timely feedback on learning tasks, exercises, and tests	4.08	.757
Lec.8	Lecturers create a good learning environment and always encourage participation and interaction	4.16	.720
Facilities (FAC)		3.71	
Fac.1	The classroom is clean, airy and spacious	3.95	.824
Fac.2	Teaching facilities are fully equipped to facilitate modern teaching	3.97	.778
Fac.3	Internet access is available anywhere on campus	3.02	1.244
Fac.4	The library provides full study and research materials for students	3.92	.785
Support (SUP)		3.73	
Sup.1	The university/ lecturers organize training sessions or small seminars to help students master how to use the learning management system (LMS).	3.69	.825
Sup.2	The university has staff to support online learning quickly.	3.65	.852
Sup.3	The university provides technical support channels (such as email, online chat) to resolve issues related to online learning quickly and effectively.	3.78	.831
Sup.4	The university/ lecturer provided me with detailed documents and video instructions on how to use online learning support tools.	3.80	.826
Effective (EFF)		3.88	
Eff.1	The FC model can improve my learning performance	3.82	.835
Eff.2	The FC model can improve my learning efficiency	3.82	.827
Eff.3	The FC model helps me save time	3.85	.825
Eff.4	The FC model helps me save on learning costs	3.92	.815
Eff.5	The FC model helps me improve my teamwork skills	3.81	.870
Eff.6	The FC model helps me improve my communication skills	3.75	.931
Eff.7	The FC model helps me improve my time management skills	3.88	.801
Eff.8	The FC model helps me improve my self-study ability	3.98	.802
Eff.9	I feel like participating in a FC model	3.83	.882
Satisfied (SA)		3.85	
Sa.1	I feel satisfied because the FC course meets my learning needs	3.87	.826
Sa.2	I feel satisfied with the FC course because my learning is more effective	3.83	.845
Sa.3	I am satisfied with the online learning experiences during use	3.91	.782
Sa.4	Overall, I am satisfied with the courses using the FC model	3.93	.776
Sa.5	I look forward to continuing learning in the FC model	3.87	.862

4.1.3. Structural model results

After the measurement model was validated, the structural model was estimated using PLS-SEM to test the hypotheses regarding the relationships among contextual factors, perceived learning effectiveness, and student satisfaction. The results show that SW, DOC, LEC, FAC, and SUP jointly explain 60.6% of the

variance in EFF (R^2=0.606), while these variables together with EFF explain 74.3% of the variance in SA (R^2=0.743). These values indicate a moderate explanatory power for EFF and a high explanatory power for SA. A summary of these results is presented in Table 6.

a. Indirect effects, total effects, and effect sizes

The total effects, effect sizes (f^2), and coefficients of determination (R^2) are presented in Table 6. For EFF, the effect sizes indicate that learning materials and facilities play more prominent roles than the other variables in explaining this construct. SW and SUP have smaller yet still meaningful effects, whereas LEC does not demonstrate a clear contribution. For SA, the path EFF → SA shows a very large effect size ($f^2 \approx 0.70$), confirming that EFF is the central variable in the model. In contrast, the direct effect sizes of contextual factors on SA are all very small. In terms of indirect and total effects, DOC, FAC, SUP, and SW all influence SA through EFF. Specifically: DOC, FAC, and SUP do not have significant direct effects on SA, but they exert significant indirect effects via EFF; SW has both a small direct effect on SA and an indirect effect through EFF; LEC does not show significant direct effects on either EFF or SA, and therefore, there is no clear evidence of an indirect effect through EFF. Overall, the structural model results confirm that EFF serves as a central mediating variable, transmitting the effects of contextual factors- particularly DOC, FAC, SW, and SUP- on student satisfaction in the FC.

Table 6. Total effects, effect sizes, and coefficients of determination

Item	Loading factor				
	Direct effect	Indirect effect	Total effect	f-square	R-square
DOC-EFF			0.285	0.068	0.606
FAC-EFF			0.248	0.068	
SUP-EFF			0.121	0.020	
SW-EFF			0.163	0.027	
EFF-SA			0.678	0.704	0.743
DOC-SA		0.193	0.281	0.009	
FAC-SA		0.168	0.206	0.002	
SUP-SA		0.082	0.108	0.001	
SW-SA		0.110	0.186	0.009	

b. Direct effects of variables on EFF and SA

The standardized path coefficients, t-values, and p-values obtained from the bootstrapping procedure are presented in Table 7. For perceived learning effectiveness, four contextual factors exhibit positive, statistically significant effects. Among them, learning materials is the strongest predictor (β=0.285; p<0.001), followed by facilities (β=0.248; p<0.001), the LMS platform (β=0.163; p=0.001), and academic/technical support (β=0.121; p<0.001). In contrast, instructor quality does not have a statistically significant direct effect on EFF (β=0.091; p=0.093). Regarding student satisfaction, EFF exhibits the strongest direct effect and is highly significant (β=0.678; p<0.001). Among the contextual factors, only SW shows a positive and statistically significant direct effect on SA (β=0.076; p=0.043), whereas the direct paths from DOC, FAC, SUP, and LEC to SA are not statistically significant. These findings indicate that, in the current model, contextual factors are primarily linked to SA through EFF, while SW, in addition to its indirect effect, also has a small direct effect on SA.

To further clarify the structural relationships among the contextual factors, perceived learning effectiveness, and student satisfaction, the results of the structural model are illustrated in Figure 2. The figure presents the standardized path coefficients obtained from the PLS-SEM analysis, highlighting both the direct and indirect relationships among the constructs. Figure 2 shows that perceived learning effectiveness plays a central mediating role in the model. Among the contextual factors, learning materials have the strongest positive effect on EFF (β=0.285), followed by facilities (β=0.248), LMS quality (β=0.163), and academic/technical support (β=0.121). Lecturer quality shows a relatively weak and non-significant effect on EFF (β=0.091).

In addition, EFF has the strongest direct effect on student satisfaction (β=0.678), confirming its role as the key explanatory mechanism in the model. Most contextual factors influence SA indirectly through EFF, while SW also demonstrates a small direct effect on SA (β=0.076). The model explains 60.8% of the variance in EFF and 74.4% of the variance in SA, indicating substantial explanatory power.

To further strengthen the methodological and practical validity of the structural findings, a critical distinction must be delineated between statistical significance (p-value) and practical significance (effect size, f^2). As systematically structured in this section, while the standardized path coefficients illustrated in Figure 2 are statistically significant, the empirical effect sizes presented in Table 7 fall strictly within a modest range between 0.02 and 0.06. Crucially, this variance should not be misinterpreted as a lack of educational utility. Rather, from a critical and systemic perspective, it highlights a profound pedagogical shift

inherent to the FC ecosystem in teacher education. In isolation, no single quality factor can act as a silver bullet to guarantee student engagement. However, when integrated concurrently, they yield a highly robust joint explanatory power, accounting for 74.3% of the total variance in pre-service teachers' satisfaction (R^2=0.743) as shown in Table 6. This collective synergy implies that rather than over-investing in a single isolated component—such as instructor intervention—institutions must adopt a holistic infrastructure policy where high-quality learning materials, technical LMS stability, and continuous academic support work in tandem to foster effective learning outcomes and long-term satisfaction.

Table 7. Path coefficients of the structural model

Item	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T Statistics (|O/STDEV|)	P values
EFF -> SA	0.678	0.675	0.037	18.408	0
DOC -> SA	0.088	0.088	0.046	1.911	0.056
FAC -> SA	0.037	0.038	0.033	1.133	0.258
SUP -> SA	0.026	0.025	0.028	0.92	0.358
SW -> SA	0.076	0.079	0.037	2.022	0.043
LEC -> SA	0.031	0.031	0.04	0.785	0.432
DOC -> EFF	0.285	0.29	0.056	5.076	0
FAC -> EFF	0.248	0.244	0.053	4.652	0
SUP -> EFF	0.121	0.119	0.034	3.539	0
SW -> EFF	0.163	0.168	0.049	3.301	0.001
LEC -> EFF	0.091	0.088	0.054	1.683	0.093

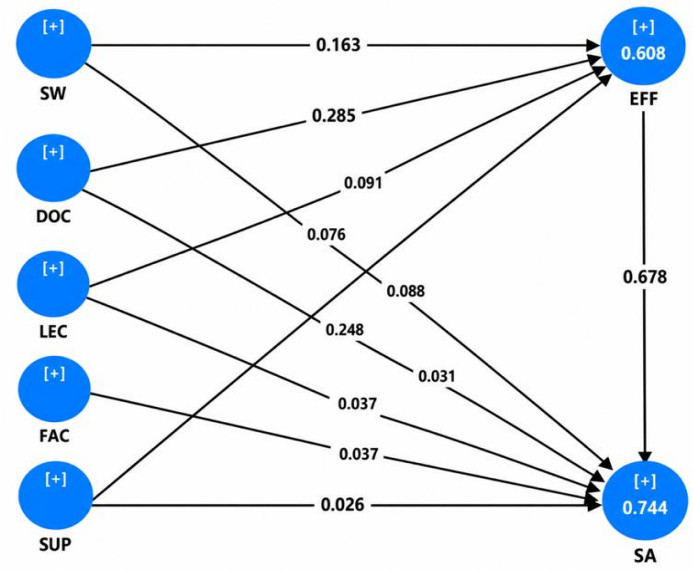

Figure 2. Relationships among factors influencing student satisfaction with the FC model

4.2. Discussion

The study was conducted to address two central questions: the level of satisfaction among Vietnamese pre-service teachers with the FC, and the mechanisms through which contextual factors of this model relate to satisfaction, particularly through the mediating role of perceived learning effectiveness. The findings not only indicate a relatively positive level of student acceptance of the FC but also clarify that their satisfaction is primarily shaped by whether they perceive the model as genuinely enhancing their learning effectiveness.

4.2.1. Student satisfaction and experiences in the flipped classroom

The descriptive analysis results show that Vietnamese pre-service teachers generally report a relatively positive level of satisfaction with courses organized using the FC model. This suggests that, in the research context, FC is perceived as a feasible and appropriate instructional approach rather than merely a superficial innovation. This finding is consistent with previous studies, which have documented positive learner evaluations of FC in terms of flexibility, self-paced learning, and greater autonomy in the learning

process [39]. At the same time, the present study contributes additional evidence from the context of Vietnamese pre-service teachers, indicating that acceptance extends beyond perception to include relatively favorable learning experiences. However, the level of evaluation is not uniform across factor groups. Students rate lecturers and learning materials highly, while factors such as the LMS, facilities, and academic/technical support receive comparatively lower evaluations. This pattern suggests that learners tend to respond more positively to elements directly associated with their day-to-day learning activities-particularly instructional support from lecturers and the quality of learning materials - whereas foundational conditions such as technical infrastructure and support services are less consistently rated. Thus, the findings not only reflect the level of acceptance of FC but also highlight that the quality of its implementation depends significantly on specific organizational conditions.

Several notable limitations in the descriptive results should also be considered. In particular, the attractiveness of lecture videos and the level of interaction on the LMS received lower mean scores compared to other items. In addition, the item related to Internet access on campus recorded the lowest mean and the highest variability within the FAC construct. These findings indicate that, although FC is evaluated positively overall, students' learning experiences are still influenced by the quality of digital content design, the interactivity of the system, and the stability of connectivity infrastructure. In other words, a relatively high level of satisfaction does not necessarily imply that all components of the FC have been fully optimized.

More importantly, these descriptive findings should be interpreted in relation to the structural model analysis. Specifically, although some factors are rated highly in terms of perception, their influence on satisfaction is not necessarily direct but is primarily mediated through perceived learning effectiveness. This suggests that differences in student experiences do not merely reflect surface-level satisfaction but are closely related to how these factors contribute to the learning value that students actually perceive. In response to the first research question, it can therefore be concluded that Vietnamese pre-service teachers are generally satisfied with the FC model. However, this satisfaction reflects a non-uniform experiential structure and should be understood in relation to the indirect mechanism through EFF, which will be further examined in the following sections of the discussion.

4.2.2. The central role of perceived learning effectiveness in shaping satisfaction

A key finding of this study is the central role of EFF in predicting student satisfaction. Specifically, the path from EFF to SA is the strongest in the entire model and exhibits a large effect size, indicating that satisfaction does not primarily stem from students' positive evaluations of individual contextual factors, but rather from the extent to which they perceive these factors as genuinely enhancing their learning effectiveness. In other words, satisfaction with the FC is not simply associated with the presence of an LMS, digital learning materials, or flexible classroom organization, but depends on whether these elements are translated into clearly perceived learning value.

This finding is consistent with prior research emphasizing the role of perceived effectiveness in shaping satisfaction in active and technology-supported learning models [6], [13]. However, the present study extends previous evidence by demonstrating that EFF is not only associated with SA but also functions as a central mediating mechanism through which contextual factors of FC influence satisfaction in the context of Vietnamese pre-service teachers. This finding reinforces the argument that in blended learning environments, student satisfaction should be understood as the outcome of an evaluative process of learning value, rather than merely an emotional response to surface-level organizational conditions.

In the context of teacher education, this finding carries particular significance. As future teachers, pre-service students tend to evaluate instructional models through the lens of perceived learning effectiveness, reflecting a strong orientation toward practical value and the substantive impact of pedagogical innovation. This helps explain why EFF emerges as the central mechanism linking learning experiences to overall satisfaction in the proposed model.

4.2.3. Contextual factors influencing perceived learning effectiveness and satisfaction

The structural model results indicate that learning materials and facilities are the two contextual factors with the strongest effects on EFF, while SW and SUP also exert positive but relatively weaker influences. At the same time, the direct paths from DOC, FAC, and SUP to SA are not statistically significant; only SW affects both EFF and has an additional small but significant direct effect on SA. This pattern suggests that contextual factors do not generate satisfaction directly and uniformly; rather, most of their effects are transmitted through EFF.

DOC emerges as the strongest predictor of EFF, consistent with the core logic of the FC, where most foundational content is shifted to the pre-class phase. When digital learning materials are clear, up-to-date, accessible, and effectively support pre-class preparation, students are more likely to enter the classroom in a higher state of readiness, thereby enhancing their perceived learning effectiveness. This finding aligns with previous studies highlighting the decisive role of learning material quality in the success of FC [40].

Moreover, the present results suggest that quality is not only about content completeness but also about the pedagogical design of digital resources. The relatively lower rating for the attractiveness of lecture videos indicates that while materials may be informative, they are not yet fully optimized for a learning experience. This observation is consistent with Bishop and Verleger [20], who noted the challenges of designing effective instructional videos in FC.

FAC also has a significant effect on EFF but no direct impact on SA, indicating that students tend to perceive facilities as a foundational condition rather than a direct source of satisfaction. When classrooms, equipment, and especially connectivity infrastructure meet learning requirements, they facilitate smoother learning processes, thereby indirectly enhancing satisfaction through EFF. The descriptive findings on internet access on campus, characterized by a -low mean and high variability, support this interpretation, suggesting that connectivity remains an uneven experience. Therefore, in the FC context, FAC should be understood not only as physical resources but also as the overall readiness of the digital learning environment.

SW is a distinctive factor in the model, as it not only has a significant effect on EFF but also exerts a small yet statistically significant direct effect on SA. This finding suggests that the LMS functions not merely as a learning support tool but also as an integral part of the learner experience. When the system is stable, user-friendly, and effectively supports interaction, students not only perceive their learning as more effective but may also develop direct satisfaction from the experience of using the system. This result is consistent with previous studies on the role of LMS in digital learning [26], [40], while extending them by identifying two parallel mechanisms of influence: an indirect effect through EFF and a direct effect through system experience.

SUP has a positive but relatively small effect on EFF and no direct impact on SA, indicating that academic and technical support primarily serves as an enabling condition rather than a direct source of satisfaction. This finding aligns with prior research on online and blended learning, where support helps reduce technological barriers, enhances adaptability, and thereby improves perceived learning effectiveness [17], [41]. The limited magnitude of SUP's effect also suggests that support services in this context may not be sufficiently salient for students to recognize them as a direct driver of satisfaction.

Taken together, DOC, FAC, SW, and SUP do not influence satisfaction in the same direct manner; instead, they primarily operate as contextual conditions within the FC ecosystem. Their effects are largely transmitted through EFF, reinforcing the argument that student satisfaction in FC is shaped by how learning conditions are translated into perceived learning value, rather than by isolated factors alone.

4.2.4. The role of the lecturer variable in the structural model

A notable finding is that LEC does not show statistically significant direct effects on either EFF or SA, despite receiving high ratings in the descriptive analysis. This result differs from many studies emphasizing the central role of lecturers in FC and blended learning [13], [20] and therefore requires careful interpretation. Three possible explanations can be considered. First, the high mean and low standard deviation of LEC suggest consistently positive but low-variance evaluations, which reduces its ability to function as a predictor of differences in EFF and SA. In other words, lecturers may represent a general strength of the context, but not a sufficiently differentiating factor across individuals to explain variation in learning outcomes and satisfaction.

Second, in the FC context, the influence of lecturers may operate indirectly through other components of the learning experience, such as learning materials, activity design, or LMS organization. As lecturers are directly involved in designing and coordinating these elements, part of their influence may be "absorbed" into variables such as DOC, SW, SUP, or FAC. Therefore, the lack of significant direct paths from LEC to EFF and SA does not imply that lecturers are unimportant. Third, generational factors may offer an additional explanation. Generation Z students, who tend to exhibit higher autonomy in digital environments, may be less likely to perceive instructors as direct sources of learning effectiveness, instead viewing them as designers and facilitators of the learning ecosystem. However, this remains a plausible interpretation based on the current data, as the study did not directly measure such variables.

From an academic perspective, this finding does not diminish the role of lecturers but suggests that in technology-rich learning environments, their influence primarily operates through indirect channels-particularly through the design of learning materials, organization of activities, and coordination of digital learning systems. Future research should therefore develop more refined measures of instructional design competence and digital pedagogical skills to better capture this mechanism.

4.2.5. Implications for flipped classroom design

From a design perspective, the PLS-SEM results indicate that optimizing the FC should not rely on improving individual components in isolation, as their effects on student satisfaction are largely indirect. Instead, priority should be given to factors that significantly influence EFF, the central mediating variable

linking contextual conditions to SA. Specifically, learning materials and facilities have the strongest effects on EFF, followed by LMS quality and support, while the direct role of instructors is not statistically significant. These findings imply that effective FC design should be approached as an integrated system, in which pedagogical and technological components are coherently aligned to enhance perceived learning effectiveness, thereby indirectly improving student satisfaction.

5. CONCLUSION

The study found that Vietnamese pre-service teachers generally reported a positive level of satisfaction with the FC. The results indicate that perceived learning effectiveness plays a central role in shaping student satisfaction, serving as the key mechanism through which learning materials, facilities, the LMS platform, and academic and technical support influence students' learning experiences. These findings support an integrated perspective that combines educational service quality and technological experience in explaining satisfaction in blended learning environments. The non-significant direct effect of the lecturer variable further suggests that lecturers may contribute to satisfaction indirectly through instructional design, learning activities, and the organization of the digital learning environment.

From a practical perspective, the findings highlight the importance of developing the FC as an integrated teaching–learning ecosystem. Efforts to improve teaching quality should focus on strengthening factors that enhance perceived learning effectiveness, including the quality of digital learning materials, instructional videos, technological infrastructure, LMS functionality, and academic and technical support. The results suggest that the effectiveness of the FC depends not only on classroom activities but also on how the overall learning experience is designed and supported.

Several limitations should be acknowledged. The study relied on self-reported, cross-sectional data collected from first-year pre-service teachers in specific higher education institutions in Vietnam, which may limit the generalizability of the findings. Future research should incorporate objective behavioral data, adopt longitudinal designs, and examine the model across different disciplines and student populations. In addition, variables such as digital literacy, learning motivation, engagement, learning styles, and prior experience with educational technology may be considered to provide a more comprehensive understanding of the conditions under which the FC is effective. Overall, the value of the FC lies not merely in reversing the instructional sequence but in creating learning experiences that students perceive as effective.

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Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Hong Tieu Thi My	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓	
Thuy Pham Thi Thanh	✓	✓	✓			✓		✓	✓	✓	✓	✓		✓
Anh Bui Xuan	✓			✓		✓	✓		✓	✓	✓		✓	✓

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [ABX], upon reasonable request.

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BIOGRAPHIES OF AUTHORS

Hong Tieu Thi My is a lecturer at Faculty of Political Theory – Civic Education, Hanoi National University of Education, Vietnam. Her main research directions are pre-service and in-service teacher training; teaching methods; using technologies and ICT in teaching. Relating to her research area, she has written and published books, and several articles in prestigious journals and international conference proceedings. She can be contacted at email: tieumyhong@hnue.edu.vn.

Thuy Pham Thi Thanh has been teaching English at Hanoi National University of Education for more than 20 years. She earned her M.A degree in the University of Languages and International Studies - Vietnam National University, Hanoi. Her Ph.D degree focuses on linguistics, in both English and Vietnamese. Her major interests are four skills of English, vocabulary, linguistics, and methods of teaching and learning English. She has published many articles on Vietnamese and international education and linguistics journals. She has had numerous opportunities to attend various conferences, including the CamTESOL International Conference 2025 in Cambodia and the VietTESOL International Convention 2025. She can be contacted at email: phamthanhthuy09@gmail.com.

Anh Bui Xuan is currently working in the Department of Political Theory and Civic Education. Her research focuses on teaching methodology, life skill education, and value education. Her contributions include the development of civic education textbooks, teacher manuals, and participation in various educational research projects at different levels. She has also authored several related scientific publications. She can be contacted at email: anhbx@hnue.edu.vn