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Factors Influencing Learning Satisfaction in Flipped Classrooms

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Abstract

The study aims to investigate the factors influencing learning satisfaction among Chinese vocational college students in flipped classroom environments. Drawing on Illeris's Comprehensive Learning Theory, a structural equation model (SEM) was established, in which learner readiness (LR) and learning environment (LE) served as independent variables, interaction level (IL) and perceived learning quality (PLQ) as mediators and learner satisfaction (LS) as the dependent variable. Data collected from 358 students revealed that both learner readiness and the learning environment had significant positive effects on interaction level [$\beta = 0.329$, $p < 0.001$; $\beta = 0.309$, $p < 0.001$]. Learner readiness and interaction level also exerted significant positive effects on perceived learning quality [$\beta = 0.327$, $p < 0.001$; $\beta = 0.306$, $p < 0.001$]. Moreover, interaction level, learner readiness and perceived learning quality significantly predicted learning satisfaction [$\beta = 0.278$, $p < 0.001$; $\beta = 0.173$, $p = 0.008$; $\beta = 0.259$, $p < 0.001$]. The mediation analysis further confirmed that learner readiness (LR) had significant indirect effects on learning satisfaction through perceived learning quality (PLQ) and interaction level (IL) [$\beta = 0.075$, $p = 0.023$; $\beta = 0.081$, $p = 0.017$]. Additionally, interaction level had a significant indirect effect on learning satisfaction through perceived learning quality [$\beta = 0.062$, $p = 0.030$]. These findings confirm the positive effects of learner readiness and the learning environment on interaction level, perceived learning quality and learning satisfaction. Moreover, interaction level and perceived learning quality serve as key mediators between learner readiness and learning satisfaction.

Keywords: Comprehensive Learning Theory, Flipped Classroom, Influencing Factors, Learning Satisfaction, Structural Equation Modeling.

Introduction

In recent years, with the rapid development of information technology, the flipped classroom (FC) has emerged as an innovative instructional model integrating technology and learning theories and has become a major focus of higher education reform (1). In this model, knowledge transmission is shifted outside the classroom through videos, MOOCs, or online platforms, while classroom time is devoted to discussion, inquiry and interaction, thereby promoting a student-centered learning approach (2). Compared with traditional teacher-centered instruction, the flipped classroom enhances learner autonomy and participation and has been recognized as an effective means of improving learning motivation, academic achievement and satisfaction (3-5).

However, empirical evidence indicates that the effectiveness of flipped classrooms varies across instructional contexts. Some studies and meta-analyses report positive effects on learning satisfaction and academic performance (6-8), whereas others find that flipped classrooms do not consistently outperform traditional instruction (9, 10). For example, certain studies report no significant differences in academic performance and some students experience learning overload or negative emotions due to difficulties in adapting to self-paced learning (11). Cross-cultural research further suggests that students' perceived learning outcomes in flipped classrooms may be influenced by cultural background. Based on Hofstede's cultural dimensions theory, significant differences in perceived learning outcomes have been observed between German and American undergraduate students, reflecting variations in cultural values (12). These findings suggest that learning satisfaction in flipped classrooms is influenced by multiple interacting factors and that learner experiences may differ substantially.

To identify key determinants of learning satisfac-

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tion in flipped classrooms, scholars have examined this issue from multiple theoretical perspectives. Structural equation modeling (SEM) studies indicate that learning environment quality and teacher–student interaction are significant predictors of learning satisfaction (13). Research grounded in Social Cognitive Theory highlights the roles of self-efficacy and self-regulation in shaping learners' satisfaction (14). In addition, some studies adapt the Customer Satisfaction Index Model to educational contexts, emphasizing learning experience and satisfaction as core indicators of instructional quality (15). Collectively, these studies suggest that learning satisfaction in flipped classrooms is a multidimensional construct shaped by both instructional conditions and learner characteristics.

Overall, prior research has widely acknowledged that learning satisfaction in flipped classrooms is a complex and dynamic process influenced by multiple interrelated factors, including the learning environment, level of interaction, perceived learning quality, learner readiness and related factors. Building on Illeris's Comprehensive Learning Theory (16), this study adopts the theory as its theoretical foundation (as shown in Figure 1) and develops a conceptual model of learning satisfaction in flipped classrooms, as illustrated in Figure 2. The proposed model examines both the direct and indirect effects of the learning environment, interaction level, perceived learning quality and learner readiness on learning satisfaction, aiming to elucidate the underlying mechanisms of learning satisfaction in flipped classroom contexts and to provide theoretical and practical implications for the design and improvement of flipped classroom instruction.

Hypothetical Model of Factors Influencing Learning Satisfaction in Flipped Classrooms

Identification of Influencing Factors

Illeris's Comprehensive Learning Theory systematically integrates classical learning theories with contemporary research findings, providing a holistic perspective on the fundamental mechanisms of learning. The theory explains the learning process through two processes and three dimensions (as shown in Figure 1).

The two processes include the interaction process, which occurs between the individual and the environment and the acquisition process, which occurs between the individual and the environment and the acquisition process, which involves the learner's internal acquisition and

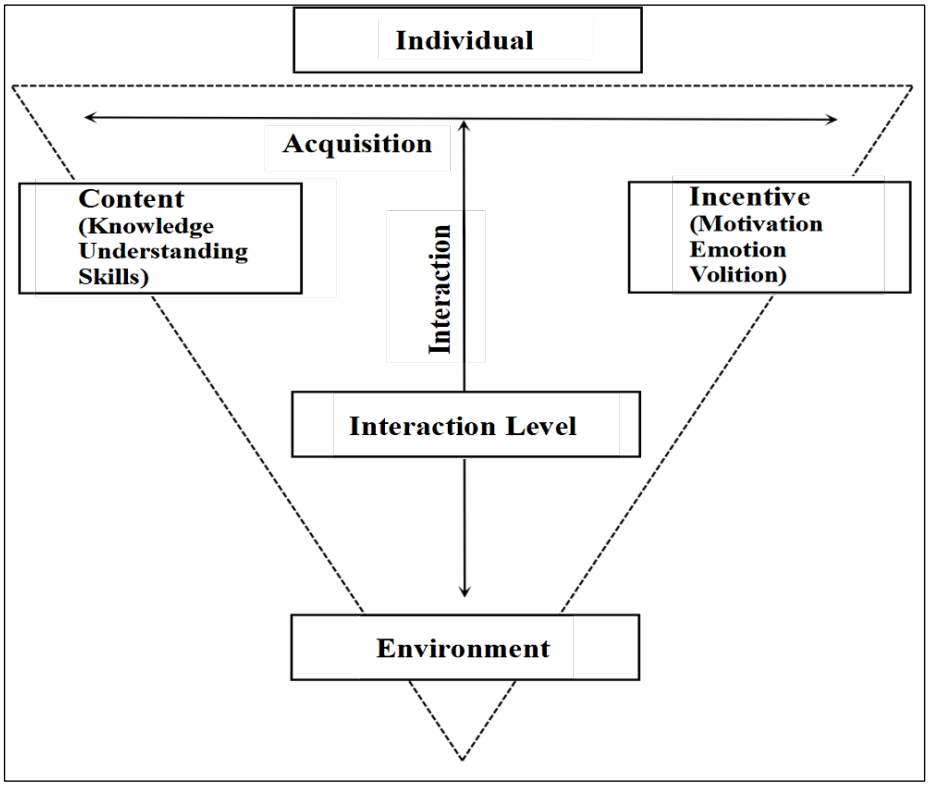

Figure 1: Illeris's Comprehensive Learning Theory

processing of knowledge and experience. One major contribution of the Comprehensive Learning Theory lies in the integration of these two processes into a unified framework, emphasizing that learning is essentially a dynamic and bidirectional interaction between the individual and the surrounding environment (17). Furthermore, Illeris divides learning into three interrelated dimensions: The content dimension refers to the specific knowledge, skills and attitudes acquired by the learner. The incentive dimension represents the internal psychological energy that drives learning, such as motivation, emotion and satisfaction. The interaction dimension involves the learner's engagement and communication with the learning context or social environment, including teachers, peers and learning resources (18). These three dimensions interact dynamically to form a comprehensive structural framework of learning, providing a solid theoretical foundation for exploring the relationships among learning motivation, learning outcomes and instructional strategies.

Based on Comprehensive Learning Theory and the pedagogical characteristics of the flipped classroom, learners are conceptualized as the subject and the learning environment as the object in this study (16). Accordingly, five key factors are proposed in the learning satisfaction model: learner readiness, learning environment, interaction level, perceived learning quality and learner satisfaction.

Learner readiness refers to learners' preparedness prior to engaging in flipped classroom learning, including learning ability, motivation, technological proficiency and self-directed learning awareness (19). In flipped classrooms, learner readiness reflects students' capacity for autonomous pre-class learning and active participation in in-class activities (20). The learning environment represents an essential external condition of flipped classroom instruction, encompassing both online and offline components. The online environment includes learning platforms, digital resources and discussion tools, while the offline environment involves classroom atmosphere, instructional support and teacher–student interaction (21). Interaction level is a core mechanism through which flipped classrooms promote cognitive and emotional engagement (22). Interaction typically occurs in three forms: teacher–learner, learner–learner and learner–content interaction (23). These interaction types support feedback, collaboration and knowledge construction, thereby facilitating deeper learning (24). Perceived learning quality refers to learners' subjective evaluation of course content and instructional design, including content relevance, clarity and alignment with learning objectives. It reflects learners' perceptions of knowledge acquisition and skill development and serves as an important determinant of learning motivation and satisfaction (25, 26). Learner satisfaction represents learners' overall evaluation of their flipped classroom experience and functions as a key indicator of instructional effectiveness. It encompasses cognitive judgments, emotional responses and behavioral intentions related to the learning process (27-29).

Construction of the Satisfaction Hypothetical Model

Based on these factors, a hypothetical model of learning satisfaction in flipped classrooms is constructed from the perspectives of the interaction process and the acquisition process, as shown in Figure 2.

Interaction Process

In flipped classroom instruction, interaction represents a key mechanism through which learning conditions are translated into cognitive and affective outcomes. Prior research characterizes interaction as a multidimensional process involving teacher–student communication, peer collaboration and engagement with learning resources, encompassing both interpersonal and social attributes (5, 22). Empirical studies indicate that such interactions contribute to enhanced learning motivation, confidence and conceptual understanding (30). Within flipped classroom settings, instructional design typically separates knowledge acquisition and knowledge application, with interactive activities concentrated during in-class sessions. These activities—such as teacher–student dialogue, peer discussion and problem-based inquiry—provide opportunities for feedback, clarification and collaborative meaning-making, thereby supporting deeper learning (31). This integration of online self-learning and offline interaction mitigates temporal and spatial

constraints and enables timely instructional support (32).

Existing evidence further suggests that supportive learning environments, characterized by adequate resources and effective communication channels, facilitate higher levels of interaction and learner engagement, which in turn enhance perceived learning quality and learning satisfaction (33). Moreover, higher interaction levels have been associated with improved cognitive processing and emotional involvement, leading to more favorable learning outcomes in flipped classroom contexts (24). Based on these considerations, the following hypotheses are proposed:

H1: Learning environment has a significant positive effect on interaction level.

H2: Learner readiness has a significant positive effect on interaction level.

H3: Interaction level has a significant positive effect on perceived learning quality.

H4: Interaction level has a significant positive effect on learning satisfaction.

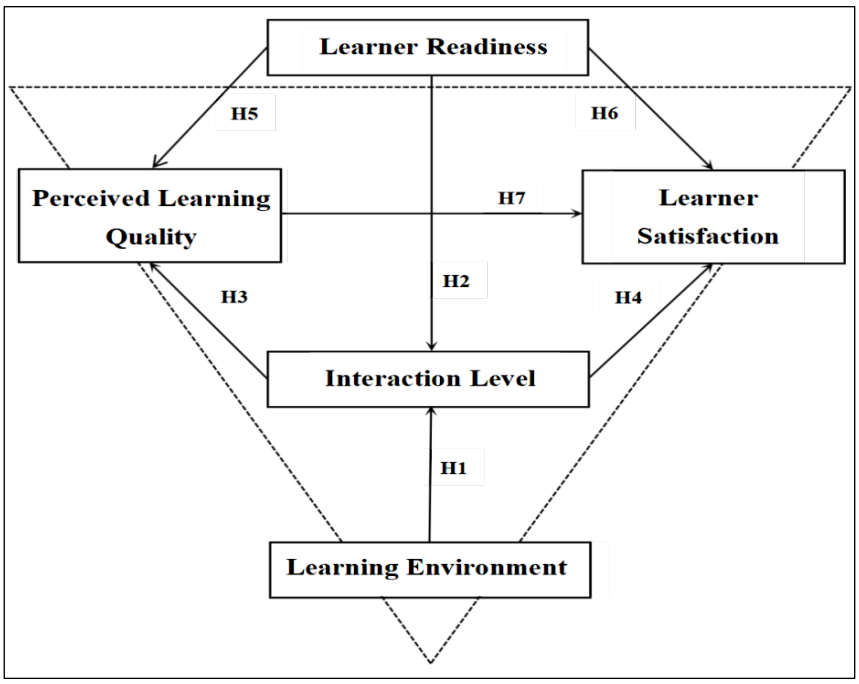

Figure 2: Hypothesized Model of Factors Affecting Learning Satisfaction in the Flipped Classroom

Acquisition Process

The acquisition process focuses on learners' internal cognitive and emotional processing during learning activities, with learner readiness identified as a central antecedent of effective knowledge construction. According to Comprehensive Learning Theory, learning outcomes are shaped not only by external interaction but also by internal cognitive processing and emotional regulation, in which learner readiness plays a pivotal role (16). Learner readiness encompasses learners' technological familiarity, self-efficacy, learning motivation and self-regulation, all of which are essential for effective engagement in flipped classroom learning (19).

Empirical research indicates that higher levels of learner readiness are positively associated with enhanced perceived learning quality and improved learning outcomes, which subsequently contribute to greater learning satisfaction (34). In addition, perceived learning quality has been shown to significantly influence learners' emotional evaluations of learning experiences, serving as a key determinant of learning satisfaction in flipped classroom environments (35). Based on the above, the following hypotheses are proposed:

H5: Learner readiness has a significant positive effect on perceived learning quality.

H6: Learner readiness has a significant positive effect on learning satisfaction.

H7: Perceived learning quality has a significant positive effect on learning satisfaction.

Methodology

Research Design

This study adopted a quantitative research approach using the survey method (36) within a

confirmatory research design framework to construct and validate a structural equation model (SEM) of learners' satisfaction in flipped classrooms. The research combined explanatory and correlational analysis methods to examine the relationships among the independent variables (learner readiness and learning environment), the mediating variables (interaction level and perceived learning quality) and the dependent variable (learner satisfaction).

Learner readiness and learning environment represent the external conditions of the learning process, whereas interaction level and perceived learning quality reflect the interactive and acquisition processes within the learning experience. Learner satisfaction serves as the outcome variable, measuring students' overall experiences and affective responses in flipped classrooms. By employing SEM, the study explores the structural relationships among latent variables to identify the key determinants and underlying mechanisms influencing learning satisfaction in flipped classroom settings.

Participants

The online learning component of this study was primarily supported by major MOOC platforms such as Rain Classroom and Smart Tree (Zhihuishu). Based on criteria such as course enrollment volume, popularity and implementation of flipped classrooms for more than one year, four representative higher vocational colleges in Shandong Province, China were selected as research sites.

Participants were students enrolled in blended teaching courses that integrated online and face-to-face instruction, thus providing a comprehensive representation of the teaching effectiveness and learning experience of flipped classrooms. The questionnaire was distributed by course instructors via the Wenjuanxing (Questionnaire Star) platform from early September to mid-October 2025, with a total of 400 questionnaires distributed and 358 valid responses collected, yielding a response rate of 89.5%. In terms of demographic characteristics, 48.9% of respondents were male and 51.1% were female. Approximately 70% were first- and second-year students. Regarding disciplinary background, 46.1% were from science and engineering programs, 30.2% from humanities and 23.7% from arts and other fields.

This study adopted a convenience sampling approach. Prior to completing the questionnaire, all participants were informed of the research purpose and procedures and participated on a voluntary basis with written informed consent obtained. No personally identifiable information was collected during the study and all data were used solely for academic research and analyzed anonymously. The research procedures adhered to ethical standards for educational research and were approved by the institutional research ethics committee of the authors' affiliated university.

Based on established criteria for SEM sample size and statistical power, the effective sample size in this study was found to meet the statistical requirements, thereby ensuring adequate representativeness and reliability (37).

Instrument

Based on existing research findings and expert consultation, a Flipped Classroom Learning Satisfaction Questionnaire was developed, consisting of five dimensions—perceived learning quality, learning environment, interaction level, learner readiness and learner satisfaction—with a total of 28 items. Table 1 presents the constructs of the research variables and example measurement items. The questionnaire adopted a five-point Likert scale, ranging from strongly agree [5] to strongly disagree [1]. Higher scores indicate a greater degree of agreement with the statements, reflecting stronger perceptions or experiences of the corresponding construct.

Prior to data analysis, the raw scores of the 28 items were normalized to ensure that all item scores fell within the range of 0 to 1, thereby enhancing the comparability and stability of subsequent statistical analyses. Subsequently, IBM SPSS Statistics for Windows, Version 27.0 (IBM Corp., Armonk, NY, USA) was used to assess the overall reliability and validity of the questionnaire. The results indicated that the questionnaire demonstrated high internal consistency, with a Cronbach's alpha coefficient of 0.93. In addition, the Kaiser–Meyer–Olkin (KMO) value was 0.912, suggesting that the data were suitable for factor analysis and that the questionnaire possessed good structural validity.

Data Analysis and Processing

Data were analyzed using Mplus version 8.3 (Muthén & Muthén, Los Angeles, CA, USA). The study primarily employed structural equation

modeling (SEM) techniques, which included confirmatory factor analysis (CFA), standardized parameter estimation, model fit evaluation, reliability and validity testing, regression analysis and mediation effect analysis. These procedures were conducted to examine the structural relationships among variables and to validate the hypothesized model of factors influencing learner satisfaction in flipped classrooms.

Table 1: Construct of the Research Variables

No.	Variables	Items (Example Statements)	References
1-6	Perceived Learning Quality (PLQ)	Compared with traditional learning methods, the flipped classroom allows me to learn more knowledge in less time.	(35)
7-12	Learning Environment (LE)	I find the online learning system easy to operate.	(38, 39)
13-17	Interaction Level (IL)	Interaction among students is easier in the flipped classroom than in the traditional classroom.	(30)
18-23	Learner Readiness (LR)	The flipped classroom provides clear guidance for learning.	(19)
24-28	Learner Satisfaction (LS)	Overall, I am satisfied with the teaching model of the flipped classroom.	(40)

Results

Confirmatory Factor Analysis

Since the measurement instruments adopted in this study were adapted from well-established scales and further refined through expert consultation, the content validity and item discrimination were adequately ensured. The results of the confirmatory factor analysis (CFA) indicated that most items demonstrated strong factor loadings. Items with standardized factor loadings below 0.60 were removed. As a result, the final measurement model retained six items for Learner Readiness (LR), six items for Perceived Learning Quality (PLQ), six items for Learning Environment (LE), five items for Interaction Level (IL) and five items for Learner Satisfaction (LS).

As shown in Table 2, the results of the reliability and convergent validity analyses revealed that all standardized factor loadings exceeded 0.60, with corresponding p-values below 0.001, indicating a high level of statistical significance. The Composite Reliability (CR) values ranged from 0.848 to 0.887, reflecting strong internal consistency across all dimensions (41). The Average Variance Extracted (AVE) values ranged from 0.525 to 0.569, demonstrating that each latent construct accounted for a substantial proportion of variance among its observed variables and met the acceptable threshold for convergent validity (42). In addition, all Squared Multiple Correlations (SMC) exceeded 0.36, with most items approaching or exceeding the ideal benchmark of 0.50, suggesting satisfactory item reliability and construct representativeness.

Discriminant Validity Analysis

As shown in Table 3, all constructs demonstrated average variance extracted (AVE) values greater than 0.50, indicating adequate convergent validity. Discriminant validity was confirmed, as the square root of each AVE value (displayed in bold along the diagonal) exceeded the corresponding inter-construct correlation coefficients (shown in the lower triangle of the matrix), in accordance with the Fornell–Larcker criterion (41). These results suggest that each construct in the model is empirically distinct from the others, confirming the overall discriminant validity of the measurement model.

The structural model (as shown in Figure 2) was analyzed using the Maximum Likelihood (ML) estimation method. The model fit indices are summarized in Table 4. The results indicate that the model achieved an acceptable level of fit, with values meeting the recommended thresholds: $\chi^2/df < 3$, CFI > 0.90, TLI > 0.90, RMSEA < 0.08 and SRMR < 0.08 (43, 44). Collectively, these indices demonstrate that the hypothesized model provides a good representation of the underlying relationships among the variables and is suitable for subsequent hypothesis testing.

Table 2: Reliability and Convergent Validity

Dim.	Item	Parameters of significant test				Item Reliability	Composite Reliability	Convergence validity
		Estimate	S.E.	Z	p-Value	R-square	CR	AVE
PLQ	PLQ1	0.694	0.031	22.248	***	0.482	0.883	0.563
	PLQ2	0.906	0.015	60.546	***	0.821		
	PLQ3	0.657	0.034	19.463	***	0.432		
	PLQ4	0.890	0.016	56.413	***	0.792		
	PLQ5	0.665	0.033	20.042	***	0.443		
	PLQ6	0.642	0.035	18.255	***	0.412		
LE	LE1	0.676	0.033	20.324	***	0.457	0.868	0.525
	LE2	0.806	0.024	33.241	***	0.650		
	LE3	0.693	0.032	21.513	***	0.480		
	LE4	0.763	0.027	28.12	***	0.583		
	LE5	0.686	0.033	21.026	***	0.471		
	LE6	0.713	0.031	23.213	***	0.509		
IL	IL1	0.839	0.024	35.007	***	0.704	0.848	0.529
	IL2	0.751	0.029	26.024	***	0.564		
	IL3	0.696	0.033	21.388	***	0.485		
	IL4	0.672	0.035	19.434	***	0.451		
	IL5	0.664	0.035	18.756	***	0.442		
LR	LR1	0.737	0.028	26.492	***	0.544	0.887	0.569
	LR2	0.726	0.029	25.327	***	0.526		
	LR3	0.877	0.018	49.755	***	0.768		
	LR4	0.618	0.036	17.161	***	0.382		
	LR5	0.788	0.024	32.928	***	0.621		
	LR6	0.755	0.026	28.522	***	0.569		
LS	LS1	0.640	0.036	17.533	***	0.409	0.854	0.540
	LS2	0.809	0.025	31.949	***	0.655		
	LS3	0.750	0.029	25.469	***	0.563		
	LS4	0.760	0.029	26.537	***	0.578		
	LS5	0.705	0.032	21.914	***	0.497		

Note: ***p< 0.001; PLQ=Perceived Learning Quality, LE=Learning Environment, IL=Interaction Level, LR=Learner Readiness, LS=Learner Satisfaction.

Table 3: Convergent and Discriminant Validity

Dim.	Items	Convergent Validity	Discriminant Validity				
		AVE	PLQ	LE	IL	LR	LS
PLQ	6	0.563	**0.750**				
LE	6	0.525	0.524	**0.725**			
IL	5	0.529	0.453	0.449	**0.727**		
LR	6	0.569	0.467	0.498	0.488	**0.754**	
LS	5	0.540	0.473	0.600	0.464	0.418	**0.735**

Note: ***p< 0.001; PLQ=Perceived Learning Quality, LE=Learning Environment, IL=Interaction Level, LR=Learner Readiness, LS=Learner Satisfaction.

Table 4: Model Fit Indices

Fit Index	Recommended Value	Model Value	Result
ML χ^2	Smaller is better	734.684	—
df	Larger is better	342	—
χ^2/df (Normed Chi-square)	$1 < \chi^2/df < 3$	2.148	Acceptable
CFI	> 0.90	0.924	Acceptable
TLI	> 0.90	0.916	Acceptable
RMSEA	< 0.08	0.057	Acceptable
SRMR	< 0.08	0.071	Acceptable

As shown in Table 5, the factor analysis of flipped classroom satisfaction revealed several significant relationships. First, perceived learning quality, interaction level and learner readiness were found to have positive and significant effects on learner satisfaction [$p < 0.01$]. Second, learning environment and learner readiness demonstrated positive and highly significant effects on interaction level [$p < 0.001$]. Furthermore, both interaction level and learner readiness had strong positive effects on perceived learning quality [$p < 0.001$]. These findings indicate that all proposed hypotheses were supported.

Among the seven supported hypotheses, the standardized estimates show that a one standard deviation increase in perceived learning quality leads to a 0.259 standard deviation increase in learner satisfaction; a one standard deviation increase in learning environment results in a 0.309 standard deviation increase in interaction level; and a one standard deviation increase in interaction level contributes to a 0.306 standard deviation increase in perceived learning quality. The R^2 values of the structural model for the endogenous variables were 0.331, 0.309 and 0.299, respectively. According to established reference standards, these values indicate a moderate level of explanatory power for the proposed model (45).

Table 5: Analysis of Research Model Hypotheses

DV	IV	Estimate	S.E.	Z	p-Value	R^2	Hypothesis
LS	PLQ	0.259	0.062	4.147	***	0.331	Support
	IL	0.278	0.065	4.251	***		Support
	LR	0.173	0.065	2.661	0.008		Support
IL	LE	0.309	0.063	4.899	***	0.309	Support
	LR	0.329	0.062	5.355	***		Support
PLQ	IL	0.306	0.061	5.046	***	0.299	Support
	LR	0.327	0.059	5.590	***		Support

Note: ***p< 0.001; PLQ=Perceived Learning Quality, LE=Learning Environment, IL=Interaction Level, LR=Learner Readiness, LS=Learner Satisfaction.

Mediation Effect Analysis

As shown in Table 6, the mediation analysis results indicate that learner readiness (LR) in the flipped classroom had a significant total effect on learner satisfaction (LS) [$\beta = 0.332$, $p < 0.001$], suggesting that learner readiness positively predicts learner satisfaction. However, the direct effect was not significant [$\beta = 0.153$, $p = 0.073$], while the total indirect effect was significant [$\beta = 0.179$, $p < 0.001$]. This finding demonstrates a full mediation effect, meaning that the influence of learner readiness on learner satisfaction occurs entirely through mediating variables (46).

Specifically, the Bootstrap analysis with 5,000 resamples (as shown in Table 6) showed that the 95% confidence interval for the LR → PLQ → LS path was [0.027, 0.164], which does not include zero, indicating a significant mediating effect. Similarly, the 95% confidence interval for the LR → IL → LS path was [0.029, 0.168], also excluding zero, confirming a significant mediating effect (47). Additionally, the 95% confidence interval for the LR → IL → PLQ → LS chain mediation path was [0.008, 0.063], which was marginally significant ($p = 0.052$). This result suggests that learner readiness may also exert an indirect effect on learner satisfaction through a sequential mediation of interaction level and perceived learning quality.

Furthermore, the total effect of interaction level (IL) on learner satisfaction (LS) was significant [$\beta = 0.280$, $p < 0.001$], with both a significant direct effect [$\beta = 0.218$, $p = 0.005$] and a significant total indirect effect [$\beta = 0.062$, $p = 0.03$]. These findings indicate a partial mediation effect, where interaction level influences learner satisfaction both directly and indirectly through other variables (48). More precisely, the 95% confidence interval for the IL → PLQ → LS path was [0.022, 0.144], excluding zero, demonstrating that

interaction level affects learner satisfaction significantly through perceived learning quality (PLQ) (47).

In summary, learner readiness exerts a significant indirect effect on learner satisfaction through both perceived learning quality and interaction level, while interaction level partially mediates its effect through perceived learning quality. These findings validate the multidimensional mechanism of influence among key factors in the flipped classroom learning environment.

Table 6: Bootstrap mediation test results

Path	Point Estimate	Pruduct of Coeffieicent			Bootstrap 5000 Times 95%CI			
		S.E.	Z	p-Value	Bias Collected		Percentile	
					Lower	Upper	Lower	Upper
Total								
LR→LS	0.332	0.074	4.506	***	0.205	0.495	0.191	0.474
IL→LS	0.280	0.080	3.494	***	0.132	0.452	0.133	0.452
Specific Indirect								
LR→PLQ→LS	0.075	0.033	2.274	0.023	0.027	0.164	0.021	0.148
LR→IL→LS	0.081	0.034	2.378	0.017	0.029	0.168	0.023	0.154
LR→IL→PLQ→LS	0.023	0.012	1.946	0.052	0.008	0.063	0.005	0.051
IL→PLQ→LS	0.062	0.029	2.174	0.030	0.022	0.144	0.016	0.126
LE→IL→LS	0.082	0.047	1.766	0.077	0.017	0.199	0.016	0.196
LE→IL→PLQ→LS	0.023	0.014	1.679	0.093	0.006	0.066	0.004	0.057
Direct								
LR→LS	0.153	0.085	1.791	0.073	0.001	0.338	-0.008	0.326
IL→LS	0.218	0.077	2.815	0.005	0.071	0.380	0.073	0.384

Note: ***p< 0.001; PLQ=Perceived Learning Quality, LE=Learning Environment, IL=Interaction Level, LR=Learner Readiness, LS=Learner Satisfaction.

Discussion

This study focused on the factors influencing learner satisfaction in flipped classroom environments. Based on Illeris's Comprehensive Learning Theory, a hypothesized satisfaction model was constructed to examine the relationships and mediating effects among key variables. The empirical analysis yielded the following conclusions and pedagogical recommendations.

First, the interaction level (IL) has a significant and strong direct positive effect on learner satisfaction (LS). The structural equation modeling results indicate that interaction is one of the most critical determinants of satisfaction, exerting a substantial direct impact. This finding suggests that the richer and more meaningful the interaction among learners, teachers, peers, learning content and platforms, the higher the level of satisfaction (49). According to connectivism theory, when learners establish effective connections with knowledge, technology and others, their learning processes become deeper and more constructive. Furthermore, a strong learning community and interactive atmosphere encourage higher-order learning and reflective engagement (50). Therefore, in blended or flipped classroom teaching, instructors should enhance learning quality and satisfaction by fostering community building, group collaboration and online interaction to strengthen both peer and teacher-student connections.

Second, learner readiness (LR) does not directly affect learner satisfaction (LS) but demonstrates a significant full mediation effect through interaction level (IL). The results reveal that learner readiness—manifested in learning autonomy, self-regulation and technological competence—does not directly increase satisfaction. Instead, it enhances learners' engagement and interaction levels, which subsequently raise satisfaction (51). This indicates that the influence of learner readiness on satisfaction operates indirectly through promoting interactive behavior. Therefore, instructional design should emphasize cultivating learners' study skills, digital literacy and self-regulatory abilities to lay the foundation for effective interaction in blended learning contexts.

Third, the learning environment (LE) does not exert a direct effect on satisfaction but influences it indirectly through interaction level and perceived learning quality (PLQ). The analysis demonstrates that when the learning environment encourages interaction, provides stable technical support and offers abundant learning resources, students exhibit higher interaction and stronger

perceptions of learning quality, leading to greater overall satisfaction (52). This finding implies that the learning environment plays a foundational supporting role in the model: while it may not directly enhance satisfaction, it indirectly fosters positive emotions and learning engagement by improving interaction and perceived quality (53). It has been emphasized that an effective blended learning environment should integrate online and offline teaching in an organic manner, thereby stimulating students' active participation in knowledge construction and collaborative interaction (54). Hence, educators should continue optimizing the learning environment by improving platform functionality and classroom support systems to ensure high-quality teaching conditions.

Finally, perceived learning quality (PLQ) has a significant positive effect on learners' satisfaction, but evidence supporting its role as a mediator remains limited. A positive relationship was identified between perceived learning quality (PLQ) and learners' satisfaction, which is consistent with previous findings demonstrating that high-quality learning experiences can significantly enhance learners' satisfaction (24). Despite this significant association, several indirect paths involving PLQ reached only marginal significance, with confidence intervals approaching zero, indicating insufficient evidence for a robust mediating effect. Therefore, although enhancing perceived learning quality may contribute to improved satisfaction, current evidence is inadequate to support the conclusion that PLQ plays a broad and important mediating role in the effects of learner readiness, learning environment and interaction level on satisfaction. Future research is encouraged to expand sample sizes, refine PLQ measurement instruments, or incorporate moderating variables to further examine its potential mediating mechanisms.

Conclusion

Against the backdrop of the widespread adoption of innovative instructional approaches such as flipped classrooms in higher vocational institutions, this study, grounded in Illeris' comprehensive learning theory, constructed and empirically tested a model of factors influencing learners' satisfaction in flipped classroom contexts. Specifically, the study systematically examined the mechanisms through which learner readiness, learning environment, interaction and perceived learning quality affect learner satisfaction. The results indicate that interaction is the key determinant of learner satisfaction, exerting a significant and stable direct positive effect, thereby underscoring the central role of interaction in flipped classroom pedagogy. In contrast, learner readiness and the learning environment do not directly influence learner satisfaction; rather, they primarily operate through indirect pathways by enhancing learning interaction and optimizing learning process experiences, reflecting the hierarchical structure of "supportive conditions–learning processes–learning outcomes" inherent in flipped classroom settings. Although perceived learning quality is positively associated with learner satisfaction, its mediating effects across multiple pathways did not demonstrate consistent statistical significance, suggesting that learners' perceptions of instructional quality may be jointly shaped by contextual characteristics and individual differences.

From a theoretical perspective, these findings further elaborate the formation mechanisms of learner satisfaction in flipped classrooms and extend the applicability of Illeris' comprehensive learning theory to blended and flipped learning contexts. From a practical standpoint, the results highlight the necessity of adopting an interaction-centered approach in flipped classroom instructional design. Systematically enhancing learners' pre-class readiness and continuously optimizing learning environments and instructional support conditions can create a solid foundation for effective interaction, thereby promoting learner satisfaction and overall learning experiences.

Nevertheless, this study is subject to certain limitations. The sample was drawn primarily from specific regions and institutional types and the cross-sectional research design constrains the external validity and causal interpretability of the findings. Future research should expand sample sources and disciplinary contexts, incorporate longitudinal designs and learning analytics and adopt a dynamic perspective to examine changes in learner satisfaction and its underlying mechanisms. Additionally, integrating potential moderating variables and online learning big data

would enable a more comprehensive and objective evaluation of the actual effectiveness of flipped classrooms and inform pathways for their continuous improvement.

Abbreviations

IL: Interaction Level, LE: Learning Environment, LR: Learner Readiness LS: Learner Satisfaction, PLQ: Perceived Learning Quality, SEM: Structural Equation Model.

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Author Contributions

Xueli Wang: conceptualization, methodology, data collection, data analysis, drafted the manuscript, Mohd Muslim Md Zalli: methodology, revision of the manuscript, Peipei Tan: revision of the manuscript, Wenli Lu: data collection. All authors reviewed and approved the final manuscript.

Conflict of Interest

The authors have no conflict of interest.

Data Availability

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

Declaration of Artificial Intelligence (AI) Assistance

The authors declare no use of Artificial intelligence (AI) for the write-up of the manuscript.

Ethics Approval

The study was performed in accordance with the ethical principles set forth in Helsinki declaration. After explaining the purpose and procedures of the study, we obtained informed consent from all participants.

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