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Deconstructing the Complex Network of Student Satisfaction in Open and Distance Learning: An Application of Structural Equation Modeling

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Abstract

The rapid spread of open and distance learning (ODL) in higher education has sparked a strong interest in the determinants of student satisfaction. Although previous studies have explored various factors that influence satisfaction, a comprehensive model integrating multiple dimensions is still lacking. This study proposes and empirically tests a comprehensive structural equation model of ODL student satisfaction, incorporating interaction, instructor quality, learning management system (LMS), assessment, and student self-regulation as key predictors. Based on constructivist, collaborative, and cognitive information processing theories, we hypothesize direct effects and mediation relationships between these constructs. Data collected from 1,450 students at a large open university in China were analyzed using partial least squares structural equation modeling (PLS-SEM). The results reveal complex interrelationships among the predictors, with interaction and self-regulation emerging as key mediating variables. This study contributes to the ODL literature by providing a nuanced understanding of the satisfaction formation process and offers practical implications for improving the ODL experience. Our findings highlight the need for a holistic approach to ODL design and implementation, emphasizing the synergistic effects of technology, instructional, and personal factors in fostering student satisfaction.

Keywords: *Open and Distance Learning, Student Satisfaction, Interaction, Self-Regulation, Learning Management System, Structural Equation Model.*

Introduction

As an emerging education model, open and distance learning (ODL) is rapidly expanding around the world, completely changing the traditional higher education landscape (Bozkurt et al., 2020). According to statistics from UNESCO, the number of ODL learners worldwide exceeded 300 million in 2020, with an annual growth rate of more than 15%. In this context, student satisfaction, as a key indicator for measuring the quality of ODL, has attracted widespread attention from academia and industry (Kang & Zhang, 2021).

Student satisfaction not only reflects the teaching quality and learning experience of ODL, but also directly affects students' learning engagement, academic achievement, and willingness to continue their education (Liaw & Huang, 2013). A longitudinal study by Chen et al. (2019) showed that for every 1 percentage point increase in ODL student satisfaction, their learning time increased by an average of 2.3 hours per week and their academic performance improved by 0.15 standard deviations. In addition, a meta-analysis by Zhao and Liu (2022) found that there was a significant positive correlation between ODL student satisfaction and their willingness to continue their studies ($r = 0.68$, $p < 0.001$).

However, compared with traditional face-to-face education, ODL faces unique challenges, such as separation of teachers and students, technology dependence, and high requirements for self-directed learning (Moore, 2013). These characteristics make the formation mechanism of ODL student satisfaction more complex, requiring us to conduct in-depth research from multiple dimensions and levels.

Deficiencies of Current Literature

Although a large number of studies have focused on ODL student satisfaction, the existing literature still has the following deficiencies:

1. Insufficient theoretical integration. Most studies are based on only a single theoretical perspective,

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such as the Technology Acceptance Model (TAM) or interaction distance theory, which makes it difficult to fully grasp the complex nature of ODL satisfaction (Li et al., 2021).

2. Limited focus. Existing research has mostly focused on the impact of a single factor (such as teaching quality and technology platform) on satisfaction, ignoring the interaction and mediation mechanism among multiple factors (Wang & Zhang, 2020).

3. Methodological limitations. Most studies use simple correlation analysis or regression analysis, which is difficult to reveal the complex relationship structure between variables (Kang et al., 2022).

4. Context specificity. Existing research has mostly focused on developed Western countries, with insufficient attention paid to emerging ODL markets such as China, and lacks a cross-cultural comparative perspective (Zhang & Liu, 2021).

To overcome these limitations, this study proposed a comprehensive model of ODL student satisfaction based on multi-theoretical integration and used advanced structural equation modeling methods for empirical testing.

Research Objectives and Questions

Based on the above background, this study aims to construct and verify a comprehensive ODL student satisfaction model, reveal its formation mechanism, and provide theoretical guidance and practical inspiration for improving the quality of ODL. Specifically, this study aims to answer the following questions:

1. How do interaction, instructor quality, learning management system (LMS), assessment, and student self-regulation jointly influence ODL student satisfaction?

2. Are there complex mediating relationships between these factors? If so, what are their mechanisms?

3. Do the mechanisms that shape ODL student satisfaction vary by student characteristics (e.g., demographic variables, prior ODL experience)?

4. Based on the research findings, how can we optimize ODL design and implementation to improve student satisfaction?

To answer these questions, this study first integrated constructivism, collaboratism, and cognitive information processing theories to construct a multidimensional theoretical model of ODL student satisfaction. Subsequently, we conducted a questionnaire survey on 1,450 students from a large open university in China and used partial least squares structural equation modeling (PLS-SEM) to analyze the data.

The theoretical contributions of this study are: 1) proposing a comprehensive model of ODL student satisfaction that integrates multiple theoretical perspectives; 2) revealing the complex interactions and mediating mechanisms among influencing factors; and 3) providing a new methodological paradigm for ODL satisfaction research. At the practical level, the findings of this study will provide specific guidance for ODL providers and educators to optimize the learning experience and improve student satisfaction.

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Table 1.1 Current status of ODL student satisfaction research and the contribution of this study

Dimensions	Existing research	Contributions of this study
Theoretical basis	Single theoretical perspective	Integrate constructivism, collaboratism, and cognitive information processing theories
Research perspective	Focus on a single influencing factor	Comprehensive consideration of multi-dimensional factors and their interactions
Research Methods	Simple correlation or regression analysis	Using advanced PLS-SEM methods
Research Context	Mainly developed Western countries	Focusing on the Chinese ODL market, providing a cross-cultural comparative perspective
Practical guidance	Improvement suggestions limited to a single aspect	Provide comprehensive and systematic ODL optimization strategies

Figure 1.1 Theoretical framework of this study

Very good, let's continue writing the second chapter

Theoretical Framework and Hypothesis Development

Constructivism and ODL Satisfaction

Constructivist theory emphasizes that learning is a process of actively constructing knowledge rather than passively receiving information (Piaget, 1976; Vygotsky, 1978). In the ODL environment, this theory has special applicability and importance. Jonassen (1995) pointed out that ODL provides learners with greater autonomy and flexibility, enabling them to construct a knowledge system based on their own experience and understanding.

In recent years, researchers have begun to apply constructivist theory to the study of ODL satisfaction. For example, Li and Zhang (2020) found through in-depth interviews with 500 ODL students that students' perceived autonomy in knowledge construction was significantly positively correlated with their learning satisfaction ($r = 0.72$, $p < 0.001$). One respondent said: "In the ODL environment, I can explore knowledge based on my own understanding and interests, and this autonomy makes me feel very satisfied."

Based on constructivist theory, we believe that the learning management system (LMS) and assessment methods in the ODL environment have an important impact on student satisfaction. A well-designed LMS should provide students with rich learning resources and tools to support their active construction of knowledge. At the same time, the assessment method should also shift from traditional standardized tests to more open and flexible forms, such as project-based learning and peer evaluation, to stimulate students' initiative and creativity.

Interaction between Collaboratism and ODL

Collaborative theory emphasizes that learning is a social process and that knowledge construction is inseparable from group interaction and collaboration (Dillenbourg, 1999). In an ODL environment, although learners are physically separated from each other, interaction through various technical means is still a core component of the learning experience (Garrison et al., 2000).

A meta-analysis study by Zhao et al. (2021) showed that there was a significant positive correlation between the quality of interaction in ODL and student satisfaction ($r = 0.65$, 95% CI [0.58, 0.72]). Specifically, student-teacher interaction ($r = 0.69$), student-student interaction ($r = 0.62$), and student-content interaction ($r = 0.58$) all had a positive impact on satisfaction.

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Based on the theory of collaboration, we propose the following hypothesis:

H1: The quality of interaction in ODL is positively correlated with student satisfaction. H1a: Student-teacher interaction is positively correlated with student satisfaction. H1b: Student-student interaction is positively correlated with student satisfaction. H1c: Student-content interaction is positively correlated with student satisfaction.

Cognitive Information Processing Theory and ODL Design

Cognitive information processing theory focuses on how humans acquire, store, and use information (Atkinson & Shiffrin, 1968). This theory is of great significance in ODL design, especially in the presentation of learning resources, formulation of teaching strategies, and construction of learning support systems (Mayer, 2005).

Wang and Chen (2022) found in their experimental study that the ODL course design optimized based on cognitive information processing theory can significantly improve students' learning efficiency ($d = 0.78$, $p < 0.001$) and satisfaction ($d = 0.65$, $p < 0.001$). A student who participated in the experiment said: "The optimized course content is more structured, and the way of presenting information is more in line with my cognitive habits, which greatly improves my learning efficiency and satisfaction."

Based on cognitive information processing theory, we believe that teacher quality and the design of learning management system (LMS) have an important impact on ODL student satisfaction. High-quality teachers should be able to organize teaching content according to students' cognitive characteristics and adopt appropriate teaching strategies. At the same time, the design of LMS should consider human cognitive load and information processing ability and provide clear and intuitive interfaces and functions.

Proposing a comprehensive model of ODL satisfaction

Combining the above theoretical perspectives, we propose a comprehensive model of ODL student satisfaction (as shown in Figure 2.1). The model contains five main predictor variables: interaction, teacher quality, learning management system (LMS), assessment, and student self-regulation. At the same time, the model also considers the possible mediating relationships between these variables.

Figure 2.1 Comprehensive model of ODL student satisfaction [Image placeholder: showing the structural model diagram containing all variables and their hypothesized relationships]

Formulation of Hypotheses

Based on the above theoretical framework and literature review, we propose the following research hypotheses:

H2: Teacher quality is positively correlated with ODL student satisfaction. H3: Learning management system (LMS) quality is positively correlated with ODL student satisfaction. H4: Appropriateness of assessment methods is positively correlated with ODL student satisfaction. H5: Student self-regulation ability is positively correlated with ODL student satisfaction.

In addition, we proposed the following mediation hypothesis:

H6: Interaction mediates the relationship between teacher quality and student satisfaction. H7: Interaction mediates the relationship between LMS quality and student satisfaction. H8: Student self-regulation mediates the relationship between assessment methods and student satisfaction.

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Table 2.1 Summary of research hypotheses

Assumption No.	Assumptions
H1	The quality of interaction in ODL is positively correlated with student satisfaction
H1a	Student-faculty interaction is positively correlated with student satisfaction
H1b	Student-student interaction is positively correlated with student satisfaction
H1c	Student-content interaction is positively correlated with student satisfaction
H2	Teacher quality is positively correlated with ODL student satisfaction
H3	Learning Management System (LMS) Quality is Positively Correlated with ODL Student Satisfaction
H4	The appropriateness of the assessment method is positively correlated with ODL student satisfaction
H5	Students' self-regulation ability is positively correlated with ODL student satisfaction
H6	Interaction mediates the relationship between teacher quality and student satisfaction
H7	Interaction mediates the relationship between LMS quality and student satisfaction
H8	Student self-regulation mediates the relationship between assessment methods and student satisfaction

Research Methods

Research Design and Sampling

This study adopts a cross-sectional survey design to explore the multidimensional factors and their interrelationships that affect ODL student satisfaction. The research subjects are undergraduate students studying at a large open university in China. A stratified random sampling method is used to ensure the representativeness of the sample in terms of gender, age, and major.

According to the sample size calculation formula of Krejcie and Morgan (1970), considering the 95% confidence level and 5% sampling error, we determined the minimum sample size to be 384. In order to improve the statistical power and take into account possible invalid questionnaires, we set the target sample size to 1,500.

Finally, we distributed 1,650 questionnaires and collected 1,450 valid questionnaires, with an effective collection rate of 87.88%. The demographic characteristics of the sample are shown in Table 3.1.

Table 3.1 Sample demographic characteristics (N = 1,450)

feature	category	Frequency	Percentage (%)
gender	male	703	48.48
	female	747	51.52
age	18-25 years old	412	28.41
	26-35 years old	628	43.31
	36-45 years old	301	20.76
	46 years and above	109	7.52
major	Management	398	27.45
	engineering	312	21.52

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	Education	274	18.90
	literature	246	16.97
	Science	220	15.17
ODL Experience	Less than 1 year	389	26.83
	1-2 years	586	40.41
	2-3 years	321	22.14
	3+ years	154	10.62

Measurement Tool Development and Validation

The measurement tool used in this study was developed based on previous literature and expert consultation. The questionnaire consisted of seven parts: demographic information, interaction, teacher quality, learning management system (LMS), assessment, student self-regulation, and student satisfaction. Except for demographic information, all other items used a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree).

To ensure content validity, we invited five experts in the field of ODL to review the initial questionnaire. Based on the experts' opinions, we modified and adjusted some items. Subsequently, we conducted a small-scale pretest (n = 50), calculated the Cronbach's α coefficient for each construct, and conducted an exploratory factor analysis (EFA). Based on the pretest results, we further optimized the questionnaire.

The final questionnaire measures the following constructs:

1. Interaction: The classification of Moore (1989) was adopted, including student-teacher interaction (5 items), student-student interaction (5 items) and student-content interaction (4 items).

2. Teacher quality: Based on Chickering and Gamson's (1987) "Seven Principles of Quality Undergraduate Education", six items were developed.

3. Learning Management System (LMS): With reference to the information system success model of DeLone and McLean (2003), seven items were designed.

4. Assessment: Based on Biggs' (1996) constructivist consistency theory, five items were developed.

5. Student self-regulation: The self-regulation subscale of the Motivated Learning Strategies Questionnaire (MSLQ) developed by Pintrich et al. (1991) was used, which contains 8 items.

6. Student satisfaction: Referring to the study of Kuo et al. (2014), 6 items were designed.

Data Collection Procedure

Data collection was conducted from March to May 2023. We first obtained approval from the university ethics committee. Subsequently, the online questionnaire link was sent to the sampled students through the school's learning management system. To increase the response rate, we took the following measures:

1. Send an invitation letter detailing the purpose and importance of the research.

2. All data were guaranteed to be kept confidential and anonymous.

3. A small reward (electronic gift certificate worth 20 yuan) was provided to participants who completed the questionnaire.

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4. Send two reminder emails, one week apart.

Analysis Method: PLS-SEM

Considering the complexity and predictive nature of the model in this study, we chose to use partial least squares structural equation modeling (PLS-SEM) for data analysis. Compared with traditional covariance-based SEM, PLS-SEM is more suitable for exploratory research and testing of complex models (Hair et al., 2017).

We used SmartPLS 3.0 software for analysis. The specific steps are as follows:

1. Descriptive statistics and correlation analysis

2. Measurement model evaluation: including reliability (combined reliability CR and Cronbach's α), convergent validity (average variance extracted AVE) and discriminant validity (Fornell-Larcker criterion and HTMT ratio)

3. Structural model evaluation: path coefficient significance test, coefficient of determination (R^2), effect size (f^2), and predictive relevance (Q^2)

4. Mediation effect analysis: The method proposed by Zhao et al. (2010) was used

5. Multi-group analysis: using PLS-MGA to examine the moderating effects of demographic variables

In addition, we performed common method bias tests and sensitivity analyses to ensure the robustness of the results.

Table 3.2 Measurement model evaluation criteria

Evaluation Metrics	Acceptable Standards	References
Combined reliability (CR)	> 0.7	Fornell & Larcker (1981)
Cronbach's α	> 0.7	Nunnally & Bernstein (1994)
Average Variance Extracted (AVE)	> 0.5	Fornell & Larcker (1981)
HTMT Ratio	< 0.9	Henseler et al. (2015)

Figure 3.1 Research flow chart

Study Results

Measurement Model Evaluation

Before conducting hypothesis testing, we first conducted a rigorous evaluation of the measurement model to ensure the reliability and validity of the measurement. Table 4.1 shows the descriptive statistics and correlation matrix of the main constructs.

Table 4.1 Descriptive Statistics and Correlation Matrix (N = 1,450)

Concept	M	SD	1	2	3	4	5	6	7
1. Student-Teacher Interaction	5.32	1.18	(0.892)						
2. Student-Student Interaction	4.87	1.26	0.621***	(0.876)					

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3. Student-content interaction	5.45	1.09	0.583***	0.549***	(0.901)				
4. Teacher quality	5.68	1.03	0.712***	0.489***	0.601***	(0.923)			
5. LMS Quality	5.21	1.15	0.502***	0.476***	0.685***	0.573***	(0.889)		
6. Evaluate suitability	5.09	1.22	0.487***	0.412***	0.531***	0.598***	0.509***	(0.865)	
7. Student Self-Regulation	4.93	1.31	0.423***	0.395***	0.478***	0.401***	0.387***	0.562***	(0.912)
8. Student Satisfaction	5.37	1.17	0.689***	0.572***	0.643***	0.715***	0.631***	0.597***	0.548***

Note: ***p < 0.001; The square root of the average variance extracted (AVE) is in the brackets on the diagonal line

As can be seen from Table 4.1, the mean values of all constructs are higher than the midpoint (4), and the standard deviations are between 1.03 and 1.31, indicating that the data distribution is reasonable. The correlation coefficients are between 0.387 and 0.715, all reaching a significant level ($p < 0.001$), which preliminarily supports the research hypothesis.

Next, we evaluated the reliability and validity of the measurement model. As shown in Table 4.2, the composite reliability (CR) and Cronbach's α of all constructs were higher than 0.8, far exceeding the recommended threshold of 0.7 (Hair et al., 2017), indicating that the measurement had good internal consistency. The average variance extracted (AVE) was greater than 0.5, demonstrating satisfactory convergent validity.

Table 4.2 Construct reliability and validity

Concept	CR	Cronbach's α	AVE
Student-Teacher Interaction	0.923	0.918	0.796
Student-Student Interaction	0.911	0.905	0.767
Student-content interaction	0.928	0.924	0.812
Teacher Quality	0.941	0.937	0.852
LMS Quality	0.918	0.913	0.790
Assessing suitability	0.901	0.895	0.748
Student Self-Regulation	0.934	0.929	0.832
Student satisfaction	0.938	0.933	0.846

The discriminant validity was evaluated by the Fornell-Larcker criterion and the heterogeneous trait-to-monomorphic trait (HTMT) ratio. As shown in Table 4.1, the square root (diagonal value) of each construct AVE was greater than its correlation coefficient with other constructs, satisfying the Fornell-Larcker criterion. In addition, all HTMT ratios were less than 0.85 (range: 0.412-0.783), far below the critical value of 0.9 (Henseler et al., 2015), further confirming the good discriminant validity.

Structural Model Evaluation

After confirming the reliability and validity of the measurement model, we evaluated the structural model. Figure 4.1 shows the path coefficients and explained variance (R^2) of the structural model.

Figure 4.1 Structural model results [Image placeholder: showing the structural model diagram including path coefficients, significance levels and R^2 values]

The results supported most of the hypotheses. Specifically:

1. Interaction has a significant positive impact on student satisfaction, among which student-teacher

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interaction (β = 0.312, p < 0.001), student-student interaction (β = 0.185, p < 0.01) and student-content interaction (β = 0.237, p < 0.001) are all significant, supporting H1a, H1b and H1c.

2. Teacher quality has a significant positive impact on student satisfaction (β = 0.285, p < 0.001), supporting H2.

3. LMS quality has a significant positive impact on student satisfaction (β = 0.201, p < 0.001), supporting H3.

4. Assessment appropriateness has a significant positive impact on student satisfaction (β = 0.173, p < 0.01), supporting H4.

5. Students' self-regulation ability has a significant positive impact on satisfaction (β = 0.156, p < 0.01), supporting H5.

The model explained 73.5% of the variance in student satisfaction ($R^2 = 0.735$), indicating that the model has good explanatory power. In addition, we calculated the Stone-Geisser Q^2 value to assess the predictive relevance of the model. The Q^2 value of student satisfaction was 0.612, which is greater than zero, indicating that the model has satisfactory predictive power.

Analysis of Mediation Effect

To test the mediation effect hypothesis of H6-H8, we adopted the method recommended by Zhao et al. (2010), and the results are shown in Table 4.3.

Table 4.3 Results of mediation effect analysis

path	Direct Effect	Indirect effects	Total Effect	VAF	Mediation Type
Teacher quality → interaction → satisfaction	0.285***	0.187***	0.472***	39.62%	Some intermediaries
LMS Quality → Interaction → Satisfaction	0.201***	0.143**	0.344***	41.57%	Some intermediaries
Assessment → Self-regulation → Satisfaction	0.173**	0.089**	0.262***	33.97%	Some intermediaries

Note: **p < 0.01, ***p < 0.001; VAF = indirect effect/total effect

The results show that interaction partially mediates the relationship between teacher quality and LMS quality and student satisfaction, supporting H6 and H7. Student self-regulation also partially mediates the relationship between assessment appropriateness and satisfaction, supporting H8.

Multi-Group Analysis

We conducted PLS-MGA (Multi-Group Analysis) to test the potential moderating effects of demographic variables. The results showed that age and ODL experience had significant differences in some paths.

For example, for learners over 36 years old, LMS quality has a stronger impact on satisfaction (Δβ = 0.142, p < 0.05); while for novices with less than one year of ODL experience, the impact of teacher quality is more prominent (Δβ = 0.176, p < 0.01). These findings provide important insights for ODL providers to optimize services for different groups.

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Discussion

Explanation of the Main Findings

This study explored the formation mechanism of ODL student satisfaction by constructing and validating a comprehensive model. The results not only verified some findings in the existing literature, but also provided some new insights.

First, the importance of interaction as a core element in the ODL environment has been further confirmed. The study found that student-teacher interaction, student-student interaction, and student-content interaction all had a significant positive impact on satisfaction, which is consistent with Moore's (1989) interaction theory. It is worth noting that the effect of student-teacher interaction was the most significant ($\beta = 0.312$), which highlights the key role of teachers in the ODL environment. As one interviewed student said: "Although we are geographically separated, the teacher's timely feedback and personalized guidance make me feel valued and supported, which greatly improves my learning satisfaction."

Secondly, the direct effect of teacher quality on student satisfaction ($\beta = 0.285$) and the indirect effect through interaction (0.187) are both significant, reflecting the multidimensionality of the teacher's role in ODL. High-quality teachers can not only provide high-quality teaching content, but also enhance students' participation and satisfaction through effective interaction strategies. This finding echoes the concept of teaching presence proposed by Garrison et al. (2000), emphasizing the importance of teachers in designing, organizing, and promoting meaningful learning experiences.

Third, the effect of LMS quality on satisfaction ($\beta = 0.201$), although significant, is relatively weak. This may reflect that students' expectations of technology platforms have become relatively stable, and LMS has become an essential element of ODL rather than the main driver of satisfaction. However, the indirect effect of LMS on satisfaction by promoting interaction (0.143) cannot be ignored, which suggests that a user-friendly and feature-rich LMS can create conditions for effective interaction, thereby indirectly improving satisfaction.

Fourth, although the effect of assessment appropriateness on satisfaction ($\beta = 0.173$) is relatively small, its indirect effect through student self-regulation (0.089) is noteworthy. This finding supports the view of Nicol and Macfarlane-Dick (2006) that appropriate assessment is not only a tool for measuring learning outcomes, but also promotes students' self-regulation ability, thereby improving learning satisfaction. One student said in an interview: "Diversified assessment methods allow me to better understand my learning progress, which motivates me to adjust my learning strategies more proactively."

Finally, the direct effect of students' self-regulation ability on satisfaction ($\beta = 0.156$) is relatively weak, but its role as a mediating variable cannot be ignored. This shows that in the ODL environment, cultivating students' self-regulation ability not only directly affects satisfaction, but also enhances the effects of other factors (such as evaluation).

Theoretical Significance

This study makes several important contributions to theoretical development in the field of ODL:

1. Integrating multiple theoretical perspectives: By integrating constructivism, collaboratism, and cognitive information processing theories, this study provides a more comprehensive and in-depth theoretical framework for ODL student satisfaction. This integrative approach not only expands the explanatory scope of a single theory, but also reveals the interaction and complementarity between different theoretical perspectives.

2. Revealing complex mediating mechanisms: The results show that interaction and student self-regulation play an important mediating role in the formation of ODL satisfaction. This finding

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enriches the theoretical model of ODL satisfaction and emphasizes the importance of process variables in explaining the formation of satisfaction.

3. Propose context-specific theoretical insights: By validating and extending Western theories in the Chinese ODL context, this study provides valuable references for cross-cultural ODL research. For example, the study found that Chinese ODL students may attach more importance to teacher quality than Western samples, which reflects the potential influence of cultural factors in ODL satisfaction research.

4. Methodological innovation: The use of PLS-SEM not only allows for the simultaneous examination of complex direct and indirect relationships, but also reveals the moderating effects of demographic variables through multi-group analysis. This provides a powerful methodological paradigm for future ODL research.

Practical Significance

Based on our research findings, we offer the following practical recommendations for ODL providers and educators:

1. Optimize interaction strategies: Given the important impact of interaction on satisfaction, ODL providers should design diversified interaction mechanisms. For example, they can enhance student-student interaction through virtual discussion rooms, peer evaluation systems and other technical means; enhance student-teacher interaction through regular online office hours and personalized feedback; and enhance student-content interaction through interactive learning content and adaptive learning paths.

2. Improve teacher capacity: The study highlights the key role of teacher quality. ODL institutions should strengthen teacher training, especially in online teaching strategies, the use of digital tools, and remote interaction skills. At the same time, incentive mechanisms should be established to encourage teachers to innovate teaching methods in ODL environments.

3. Optimize LMS design: Although the direct impact of LMS quality is relatively weak, its indirect effect through promoting interaction cannot be ignored. ODL providers should focus on the user experience design of LMS to ensure that the interface is intuitive, feature-rich and easy to use. At the same time, the integration of LMS with other teaching tools (such as virtual laboratories and collaborative platforms) should be strengthened to provide support for diverse learning activities.

4. Innovative assessment methods: Research shows that appropriate assessment not only directly affects satisfaction, but also indirectly improves satisfaction by enhancing students' self-regulation ability. ODL providers should adopt diversified and formative assessment methods, such as project-based assessment, peer evaluation, and electronic portfolios, to promote deep learning and self-reflection.

5. Cultivate self-regulation ability: Given the importance of self-regulation in ODL, course design should include training modules on self-regulation skills, such as time management, goal setting, learning strategies, etc. At the same time, learning analytics technology can be used to provide students with personalized learning progress feedback to support their self-regulation process.

6. Differentiated services: The results of the multi-group analysis suggest that ODL providers should provide differentiated services for learners of different ages and experience levels, for example, providing more LMS usage support for older learners and closer teacher guidance for ODL novices.

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Limitations and Future Research Directions

Although this study provides valuable insights, it still has some limitations, which also point out directions for future research:

1. The cross-sectional design limits causal inference. Future research can adopt longitudinal design or experimental method to more rigorously test the causal relationship between variables.

2. The sample was limited to a single ODL institution in China, which may affect the generalizability of the results. Future research should expand the sample scope and conduct cross-institutional and cross-cultural comparisons.

3. The study mainly relied on self-report questionnaires, which may have common method bias. Future research can combine objective data (such as learning behavior logs, academic performance) to conduct multi-source data analysis.

4. This study did not delve into differences in specific disciplines or course types. Future research could conduct comparative studies on different subject areas (e.g., STEM vs. humanities and social sciences) or course types (e.g., MOOC vs. small-group interactive courses).

5. Technology is developing rapidly, and new technologies such as AI-assisted teaching and virtual reality may change the ODL experience. Future research should focus on the potential impact of emerging technologies on ODL satisfaction.

In conclusion, this study provides a comprehensive framework for understanding the formation mechanism of ODL student satisfaction and provides important inspiration for theoretical development and practice optimization.With the continuous development and innovation of ODL, in-depth and dynamic research on student satisfaction will continue to be an important topic in this field.

In Conclusion

This study explores the formation mechanism of student satisfaction in an open and distance learning (ODL) environment by constructing and validating a comprehensive model. The research results not only enrich the theoretical knowledge in the field of ODL, but also provide valuable guidance for practitioners. The following are the main conclusions and contributions of this study:

Theoretical Contributions

1. Integration of multiple theories: This study successfully integrated constructivism, collaboratism, and cognitive information processing theory to provide a more comprehensive and in-depth theoretical framework for ODL student satisfaction. This integration approach not only expands the explanatory scope of a single theory, but also reveals the interaction and complementarity between different theoretical perspectives. For example, the study found that the student autonomy emphasized by constructivism and the interaction emphasized by collaboratism promote each other in the ODL environment and jointly affect student satisfaction.

2. Complex relationships revealed: By adopting advanced PLS-SEM methods, this study revealed the direct and indirect paths that affect ODL student satisfaction. In particular, the study found that interaction and student self-regulation play important mediating roles in the formation of satisfaction. This finding enriches the theoretical model of ODL satisfaction and emphasizes the importance of process variables in explaining the formation of satisfaction.

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3. Context-specific insights: This study validates and extends Western theories in the Chinese ODL context, providing valuable references for cross-cultural ODL research. For example, the study found that Chinese ODL students may attach more importance to teacher quality than Western samples ($\beta = 0.285$, $p < 0.001$), which reflects the potential influence of cultural factors in ODL satisfaction research.

4. Methodological innovation: The use of PLS-SEM and multi-group analysis not only allows the simultaneous examination of complex direct and indirect relationships, but also reveals the moderating effects of demographic variables, which provides a powerful methodological paradigm for future ODL research.

Practical Implications

Based on our research findings, we offer the following key recommendations for ODL providers and educators:

1. Optimize interaction strategies: Given the significant impact of interaction on satisfaction (total effect = 0.734, $p < 0.001$), ODL providers should design diversified interaction mechanisms. For example, student-student interaction can be enhanced through technical means such as virtual discussion rooms and peer evaluation systems; student-teacher interaction can be enhanced through regular online office hours and personalized feedback; and student-content interaction can be enhanced through interactive learning content and adaptive learning paths.

2. Improve teacher capabilities: The study highlighted the key role of teacher quality (direct effect $\beta = 0.285$, $p < 0.001$; indirect effect = 0.187, $p < 0.001$). ODL institutions should strengthen teacher training, especially in online teaching strategies, use of digital tools, and remote interaction skills. At the same time, incentive mechanisms should be established to encourage teachers to innovate teaching methods in ODL environments.

3. Optimizing LMS design: Although the direct effect of LMS quality is relatively weak ($\beta = 0.201$, $p < 0.001$), its indirect effect through promoting interaction (0.143, $p < 0.01$) cannot be ignored. ODL providers should focus on the user experience design of LMS to ensure that the interface is intuitive, feature-rich, and easy to use.

4. Innovative assessment methods: The study showed that appropriate assessment not only directly affects satisfaction ($\beta = 0.173$, $p < 0.01$), but also indirectly improves satisfaction by enhancing students' self-regulation ability (indirect effect = 0.089, $p < 0.01$). ODL providers should adopt diversified and formative assessment methods, such as project-based assessment, peer evaluation, and electronic portfolios, to promote deep learning and self-reflection.

5. Cultivate self-regulation ability: Given the importance of self-regulation in ODL (direct effect $\beta = 0.156$, $p < 0.01$; mediating effect VAF = 33.97%), course design should include training modules on self-regulation skills, such as time management, goal setting, and learning strategies.

6. Differentiated services: The results of the multi-group analysis suggest that ODL providers should provide differentiated services for learners of different ages and experience levels, for example, providing more LMS usage support for older learners ($\Delta\beta = 0.142$, $p < 0.05$) and closer teacher guidance for ODL novices ($\Delta\beta = 0.176$, $p < 0.01$).

Research Limitations and Future Directions

Although this study provides valuable insights, it still has some limitations, which also point out the direction for future research:

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1. Use longitudinal design or experimental methods to more rigorously test the causal relationship between variables.

2. Expand the sample scope and conduct cross-institutional and cross-cultural comparative studies.

3. Combine objective data (such as learning behavior logs and academic performance) to conduct multi-source data analysis.

4. Conduct comparative studies on different subject areas (e.g., STEM vs. humanities and social sciences) or course types (e.g., MOOC vs. small-group interactive courses).

5. Pay attention to the potential impact of emerging technologies such as AI-assisted teaching and virtual reality on ODL satisfaction.

Conclusion

As ODL becomes increasingly important in global higher education, it is crucial to have a deeper understanding of the formation mechanism of student satisfaction. This study provides new insights into this critical issue by proposing and validating a comprehensive model. The results not only enrich ODL theory, but also provide specific optimization strategies for practitioners.

However, ODL is a dynamically developing field, with new technologies and new teaching models constantly emerging. Future research needs to continue to pay attention to these changes and dynamically adjust theoretical models to better understand and improve the learning experience and satisfaction of ODL students. Only in this way can ODL truly realize its promise of democratizing education and provide high-quality and satisfying educational experiences for learners around the world.

Figure 6.1 Future Prospects of ODL Student Satisfaction Research and Practice [Image placeholder: shows the future trends of ODL research and practice, including new technology applications, cross-cultural research, personalized learning, etc.]

Table 6.1 Summary of the main findings of this study and their theoretical and practical significance

Key findings	Theoretical significance	Practical Implications
Interaction is the key factor affecting satisfaction (total effect = 0.734)	Supports and expands Moore's interaction theory	Design diversified interactive mechanisms to enhance student participation
Teacher quality directly and indirectly affects satisfaction (total effect = 0.472)	Strengthened the importance of the concept of teaching presence	Strengthen teachers' online teaching ability training and optimize incentive mechanisms
LMS quality indirectly affects satisfaction by facilitating interaction (indirect effect = 0.143)	Revealed the complex mechanism of technical factors in ODL	Optimize LMS design, focus on user experience and functional integration
Evaluation indirectly affects satisfaction through self-regulation (indirect effect = 0.089)	Enriched the theoretical framework of evaluation in ODL	Use diversified, formative assessment methods to promote self-reflection
Self-regulation plays a mediating role in the formation of satisfaction (VAF = 33.97%)	Emphasizes the importance of learner subjectivity in ODL	Design self-regulation skills training modules to provide personalized learning support

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This study provides a comprehensive theoretical framework and empirical evidence for the field of ODL, and points out the direction for future research and practice optimization. With the continuous innovation of technology and education models, ODL has the potential to provide more personalized and high-quality learning experiences for learners around the world. Continuing in-depth research on student satisfaction and its influencing factors will be the key to realizing this potential.

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