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THE EXPLORATION OF THE FACTORS INFLUENCING ONLINE LEARNING IN HIGHER EDUCATION INSTITUTIONS

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ABSTRACT
With the diverse applications of information technology and the trend toward online learning, many higher education institutions in China have established online learning platforms. These platforms provide teaching interaction and review services through remote login systems, breaking the limitations of time and space and expanding students' learning paths. However, due to the urban-rural disparities and diverse backgrounds of students from various regions, the needs for online learning platforms vary.Thus, this study uses interviews and questionnaires, combined with the Analytic Hierarchy Process (AHP) and Quality Function Deployment (QFD) to explore the improvement areas of online learning platforms in higher education institutions. The aim is to better understand students' overall functional needs for the online learning platforms provided by their institutions. The research results indicate that in terms of student needs, security and privacy, time cost, teaching methods, and diverse teaching resources are most important. For platform operational needs, timely updates, membership systems, information authenticity, and website activities are the most urgent improvement directions.I hope this paper can help higher education institutions optimize their online learning platform functions to better meet all users' needs.

Keywords:
Online Learning, Higher Education, Analytic Hierarchy Process (AHP), Quality Function Deployment (QFD), House of Quality (HoQ)

INTRODUCTION

Research Background and Motivation. According to the report released by the China Internet Network Information Center (CNNIC) in November 2024, there are 1.099 billion internet users in China, with an internet penetration rate of 78.0%. Against this backdrop, many educational institutions have integrated digital learning into their classroom content as an auxiliary tool, expanding the traditional learning environment. Similarly, higher education institutions in China have established campus digital learning environments, utilizing digital learning websites to provide an interactive learning platform for teachers and students. The diverse functional design of these platforms has increased the usage rate of online learning. However, the motivation of this study is to go beyond standardized digital learning websites and focus on user needs, exploring features of online learning platforms that truly meet users' demands.

Research Objective. This study aims to analyze the online learning needs of higher education institutions through interviews and questionnaires, combined with the Analytic Hierarchy Process (AHP) and Quality Function Deployment (QFD). By systematically analyzing and constructing the House of Quality (HoQ), it identifies technical needs and determines the priority of technical solutions. It is hoped that this study will help domestic higher education institutions improve the functionality and quality of their campus online learning platforms, providing students with a more comprehensive online learning experience.

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LITERATURE REVIEW

Online Learning. Online learning, also known as Distance Education or E-Learning, refers to educational activities where learners acquire knowledge or information through internet platforms without being restricted by space and time. Online learning includes learning activities conducted via computers, tablets, and mobile phones, and encompasses interactive learning using digital tools and resources. With the development of information technology, forms of online learning have diversified, including Massive Open Online Courses (MOOCs), synchronous online teaching, and self-paced courses.

Kuleshova and colleagues believe that online learning creates rich opportunities for learners by offering diverse content, assessments, and feedback. This mode of learning provides students with personalized, cost-effective, and engaging learning experiences, helping them achieve personal and professional goals. Rouf et al. note that while online learning presents new opportunities for scholars and teachers, it also brings challenges. Teachers face issues such as technological limitations, insufficient equipment, and communication barriers; whereas students must invest more time compared to traditional learning methods to address internet connectivity and reliability, as well as compatibility with educational media tools. Additionally, students' performance is influenced by course materials and teaching methods.

In online learning, both teachers and students must navigate challenges related to technological adaptability, self-management capabilities of learners, and modes of teacher-student interaction. Online education is rapidly gaining acceptance among teachers and students due to its high-quality teaching and convenient accessibility. Lin pointed out in 2021 that online learning has become an indispensable part of home offices and classrooms.

In summary, the biggest challenge for online learning is to utilize diverse digital learning media platforms to meet the specific functional needs of educators and learners, thus catering to the varied requirements of all users.

Analytic Hierarchy Process (AHP). The Analytic Hierarchy Process (AHP) is a multi-criteria decision analysis tool proposed by American operations researcher Saaty in 1971. This method breaks down complex problems into multiple levels of elements and determines the relative importance of each factor through pairwise comparisons, aiding decision-makers in prioritizing and choosing among different options. Combining qualitative and quantitative analysis, AHP is widely applied in multi-level decision-making problems.

In higher education, especially concerning online learning quality, there are often uncertainties, ambiguities, and evaluation difficulties. Thus, using AHP can evaluate the importance of various need factors and allocate weights based on multiple dimensions, such as students, teachers, and technical platforms. This helps educational managers prioritize needs, meet students' diverse demands, and improve the quality and efficiency of online learning.

Quality Function Deployment (QFD). Quality Function Deployment (QFD) is a quality management tool widely used in product and service development processes, introduced by Japanese professors Akao Yoji and Mizuno Shigeru. Its core idea is to translate customer needs and expectations into specific design and function requirements. Among the tools in QFD, the House of Quality (HoQ) is one of the most common. It visualizes different quality requirements and design targets, showing their relationships in charts or matrices. The HoQ primarily consists of six main parts: (1) the voice of the customer; (2) customer satisfaction level; (3) technical specifications; (4) relationship matrix between the voice of the customer and technical specifications; (5) correlation among technical specifications; and (6) comparison between competitors and target values.

Today, QFD is widely applied in the field of online learning in higher education. This method helps institutions understand the gap between students' expectations for online learning services and their actual experiences, thereby adjusting and optimizing course design to enhance the learning experience. It is also used to improve the adoption rate of online learning systems by accurately identifying and addressing key factors that influence students' use of online learning platforms.

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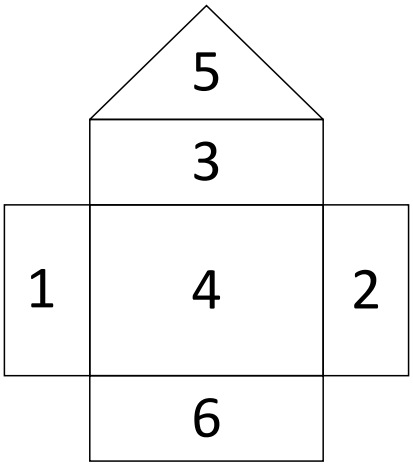

Figure 1 House of Quality framework

RESEARCH METHODOLOGY

This study will employ both the Analytic Hierarchy Process (AHP) and Quality Function Deployment (QFD) methods to explore the factors influencing online learning needs in higher education institutions. The aim is to gain an in-depth understanding of the urgent needs of online learning platform users, thereby assisting higher education institutions in better meeting all user demands through their online learning websites.

For this purpose, the Delphi method was used, involving 40 students from higher education institutions and 9 university teachers. Through multiple rounds of face-to-face interviews, we collected and categorized user needs into five main categories: professionalism, practicality, immediacy, service, and added value, as illustrated in Figure 2.

Subsequently, the direct line method was adopted to distribute questionnaires and obtain the relative weights of each category. The questionnaire survey lasted for 3 months, with 150 questionnaires distributed and 113 valid responses received, resulting in a response rate of 75.3%.

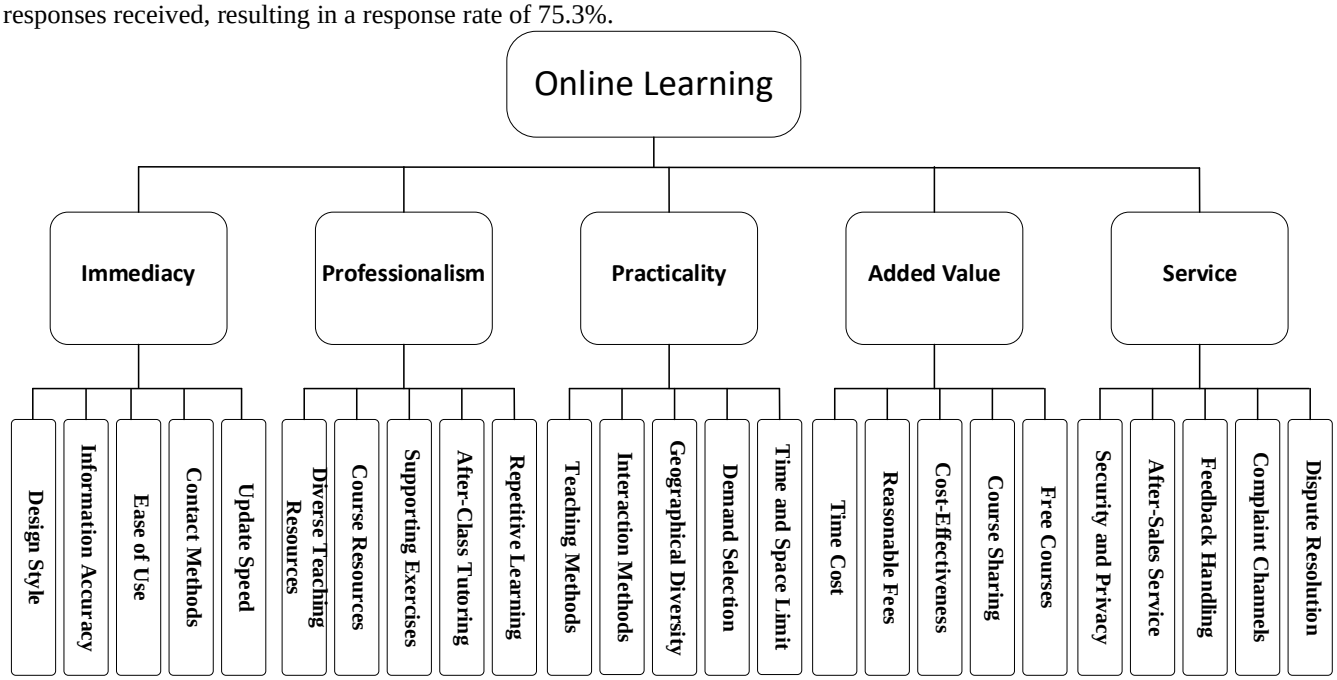

Figure 2 Hierarchical Stucture Diagram

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DATA ANALYSIS

Establishing Hierarchical Analysis.

Constructing the Pairwise Comparison Matrix. The pairwise comparison data obtained from the research questionnaires are summarized, and their geometric mean is calculated. The final results are presented in the form of a pairwise comparison matrix. Below is an example of the professionalism of user need items, as shown in Equation 1.

$$\begin{bmatrix} 1 & 1.1536 & 1.3867 & 1.4016 & 1.1247 \\ 0.8669 & 1 & 1.5908 & 1.7051 & 1.5311 \\ 0.7211 & 0.6286 & 1 & 1.5578 & 1.4163 \\ 0.7135 & 0.5864 & 0.6419 & 1 & 1.2311 \\ 0.8891 & 0.6531 & 0.7061 & 0.8123 & 1 \end{bmatrix} \quad (Equation\ 1)$$

Calculating the Eigenvector (Relative Weight). Based on the values in the pairwise comparison matrix mentioned above, the eigenvector is calculated by finding the geometric mean. The formula is shown in Equation 2, where represents the eigenvector and a_ij denotes the values in the pairwise comparison matrix, i, j=1, 2, ⋯, n.

$$w_i = (\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}} \Big/ \sum_{i=1}^{n} (\prod_{j=1}^{n} a_{ij})^{\frac{1}{n}} \quad i, j = 1,2,..,n$$

(Equation 2)

Conducting Consistency Check. To ensure that respondents maintain consistency in pairwise comparison questionnaires, a consistency check is necessary. This helps to correct unreasonable evaluation results and avoid adverse effects on decision-making. The Analytic Hierarchy Process (AHP) measures the consistency of the pairwise comparison matrix through the Consistency Ratio (C.R.), primarily based on the Consistency Index (C.I) and Consistency Ratio (C.R.).

According to Saaty (1980), when the Consistency Ratio (C.R.) is less than or equal to 0.1, the consistency level is considered acceptable. The Consistency Index (C.I) is calculated using the following formulas (Equations 3 and 4), where λ_max represents the maximum eigenvalue, n is the number of factors (should be less than or equal to 0.1), C.I is the Consistency Index, w' is the maximum eigenvalue of each column, $w_1; w_2; w_n$ are the eigenvectors.

$$C.I = \frac{\lambda_{\max} - n}{n-1}$$

(Equation 3)

$$\lambda_{\max} = \frac{1}{n}\left(\frac{w_1'}{w_1} + \frac{w_2'}{w_2} + \cdots + \frac{w_n'}{w_n}\right)$$

(Equation 4)

Finally, we need to calculate the Consistency Ratio (C.R.) to confirm whether the C.R. value is less than or equal to 0.1. If the C.R. value does not exceed 0.1, it indicates that the consistency level is within an acceptable range. The calculation method is shown in Equation 5.

$$C.R = \frac{C.I}{R.I}$$

(Equation 5)

where C.R. is the Consistency Ratio and must be less than or equal to 0.1. R.I. (Random Index) is the Random Consistency Index, as shown in Table 1.

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Table 1. Random Index (R.I) Values

Dimension of A	1	2	3	4	5	6	7	8	9
R.I	0.0	0.0	0.58	0.96	1.12	1.24	1.32	1.41	1.45

Based on the five categories of the research hierarchical structure shown in Figure 3, a questionnaire data analysis is performed for each category. The Analytic Hierarchy Process (AHP) procedure is then repeated to obtain the Consistency Index (C.I) and Consistency Ratio (C.R) values for the pairwise comparison matrices of immediacy, professionalism, practicality, added value, and service, as shown in Table 2.From Table 2, it can be observed that all the C.R values obtained in this study are less than 0.1, indicating that the data results of this study are within an acceptable range.

Table 2. Summary Table of Main User Needs Weightings

Main Items	C.I Value	R.I Value	C.R Value
Professionalism	5.073536	1.12	0.016414
Immediacy	5.062611	1.12	0.013976
Added Value	5.127762	1.12	0.028518
Practicality	5.10273	1.12	0.022931
Service	5.130922	1.12	0.029224

Finally, the weight values for the five main user needs items are calculated, with the results shown in Table 3, which corresponds to the left side of the House of Quality diagram in Figure 3.

Table 3. Summary Table of User Needs Weighting

Main Items	Sub Items	Weight	Main Items	Sub Items	Weight
Professionalism	Diverse Teaching Resources	0.2694	Immediacy	Design Style	0.2360
	Course Resources	0.2271		Information Accuracy	0.2534
	Supporting Exercises	0.2032		Ease of Use	0.1961
	After-Class Tutoring	0.1598		Contact Methods	0.1572
	Repetitive Learning	0.1405		Update Speed	0.1574
Added Value	Time Cost	0.2975	Practicality	Teaching Methods	0.2786
	Reasonable Fees	0.2305		Interaction Methods	0.2476
	Cost-Effectiveness	0.2003		Geographical Diversity	0.1760
	Course Sharing	0.1495		Demand Selection	0.1693
	Free Courses	0.1223		Time and Space Limit	0.1285

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Service	Security and Privacy	0.2981	Service	Complaint Channels	0.1537
	After-Sales Service	0.2320			
	Feedback Handling	0.1883		Dispute Resolution	0.1254

Establishing the House of Quality. Using the weight values obtained from the Analytic Hierarchy Process (AHP), we gradually construct the House of Quality (HoQ) in the Quality Function Deployment (QFD) methodology. The steps are as follows.

User Needs Items. To explore the factors influencing online learning needs in higher education institutions, this study focuses on the user needs of online learning platforms. Through multiple rounds of interviews with 40 students and 9 teachers from domestic higher education institutions, we systematically collected their needs and expectations. After organizing and summarizing, the user needs items were categorized into five main categories: professionalism, immediacy, added value, practicality, and service. The specific results are shown in Table 4. This process forms the first step in building the HoQ within the QFD methodology. The interview results are presented systematically and structurally, forming the user needs portion of the HoQ.

Table 4. User Needs Items

Main Item	**Sub Item**	**Main Item**	**Sub Item**
Professionalism	Diverse Teaching Resources	Immediacy	Design Style
	Course Resources		Information Accuracy
	Supporting Exercises		Ease of Use
	After-Class Tutoring		Contact Methods
	Repetitive Learning		Update Speed
Added Value	Time Cost	Practicality	Teaching Methods
	Reasonable Fees		Interaction Methods
	Cost-Effectiveness		Geographical Diversity
	Course Sharing		Demand Selection
	Free Courses		Time and Space Limit
Service	Security and Privacy	Service	Complaint Channels
	After-Sales Service		
	Feedback Handling		Dispute Resolution

Technical Requirements Items. To meet user needs, the construction and maintenance personnel of online learning platforms must propose technical solutions. Through interviews, this study has identified the current platform's technical responses to these needs and has established a structured project list, as shown in Table 5.

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Table 5. Technical Requirements Items

Technical Requirements	
Timely Updates	Guidance Services
Customer Service Consultation	Daily Maintenance
Transaction Security	Website Layout
Membership System	Information Authenticity
Language Adaptation	Data Privacy
Participation Level	Live Classes
Course Certification	Source Channels
Website Activities	Design Features

Relationship Matix. To evaluate whether the functionality and quality of online learning platforms meet user needs, this study is based on user feedback and aims to improve online learning service quality. This is to better meet user needs and provide a reference for future construction of online learning platforms in higher education institutions.

This study establishes a table of user needs and a table of technical requirements for online learning platforms. By using a relationship matrix, the two are linked to analyze the importance of user needs and related technical requirements (relationship strength ranging from 1 to 5). By multiplying the importance of user needs by the related strength, the final weighted total score is obtained, as shown in Equation 6.

$$X = \sum_{i=1}^{n} w_i * k_i \qquad \text{(Equation 6)}$$

Among them, X = total score; w_i = weight; k_i = relationship strength.

A higher total score indicates that, under limited resources, the online learning platform should prioritize the implementation of technical solutions. By using the relationship matrix, platform information personnel can understand the degree of alignment between the services provided and user needs, thereby laying a foundation for better meeting user demands, as shown in Figure 3.

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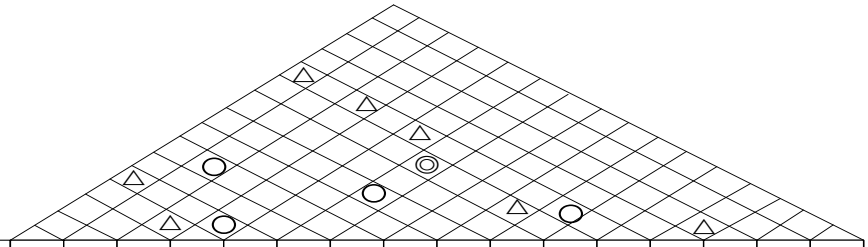

Customer Needs		Weight	Timely Updates	Design Features	Services Guidance	Customer Service Consultation	Daily Maintenance	Transaction Security	Website Layout	Membership System	Information Authenticity	Language Adaptation	Data Privacy	Participation Level	Live Classes	Course Certification	Source Channels	Website Activities
Immediacy	Design Style	0. 2329	0	5	5	3	0	0	5	2	2	0	0	4	0	0	0	3
	Information Accuracy	0. 2514	4	0	0	0	5	4	2	0	5	4	4	4	3	5	5	3
	Ease of Use	0. 1984	3	4	5	4	4	4	5	3	3	5	3	5	4	0	0	3
	Contact Methods	0. 1588	4	4	0	0	0	0	2	0	3	2	0	4	3	0	2	4
	Update Speed	0. 1585	5	0	0	0	5	4	2	3	5	0	0	4	5	0	5	5
Professionalism	Diverse Teaching Resources	0. 2727	3	0	0	0	0	0	0	4	5	0	0	4	4	5	5	3
	Course Resources	0. 2280	5	0	0	0	0	0	0	5	5	3	0	3	4	5	4	4
	Supporting Exercises	0. 2018	4	0	0	0	0	0	0	5	5	0	0	0	0	4	4	4
	After-Class Tutoring	0. 1578	3	0	0	0	0	0	0	5	2	3	0	0	0	0	0	0
	Repetitive Learning	0. 1396	4	4	0	0	0	0	0	5	2	0	0	0	0	0	0	0
Practicality	Teaching Methods	0. 2830	4	4	4	4	0	8	0	5	3	0	4	4	4	2	0	3
	Interaction Methods	0. 2490	0	4	4	3	0	0	0	4	4	3	3	4	4	2	0	4
	Geographical Diversity	0. 1726	0	0	0	0	0	0	0	0	2	4	0	3	0	0	0	0
	Demand Selection	0. 1689	3	4	4	3	0	0	0	3	0	3	0	4	0	4	0	3
	Time and Space Limit	0. 1264	0	0	0	0	0	0	0	0	3	0	0	0	4	0	0	0
Added Value	Time Cost	0. 2979	3	0	4	4	5	4	3	3	5	4	2	3	4	4	4	3
	Reasonable Fees	0. 2294	3	0	0	4	4	5	2	4	2	3	4	0	3	4	4	3
	Cost-Effectiveness	0. 2024	0	0	0	0	0	4	0	4	2	0	0	2	0	2	4	3
	Course Sharing	0. 1512	0	0	0	0	0	0	0	4	2	0	0	1	2	0	0	4
	Free Courses	0. 1191	0	4	0	3	0	0	0	0	2	0	0	0	0	0	0	4
Service	Security and Privacy	0. 2980	5	0	0	4	5	5	2	2	0	0	5	1	0	3	4	0
	After-Sales Service	0. 2313	4	2	4	4	4	5	3	4	0	0	4	0	0	0	3	2
	Feedback Handling	0. 1871	5	0	0	4	4	5	0	3	0	0	3	0	0	3	0	0
	Complaint Channels	0. 1557	2	0	0	4	0	5	0	0	0	0	3	0	0	0	0	0
	Dispute Resolution	0. 1240	3	0	0	4	0	5	0	0	0	0	3	0	0	0	0	0
Total Score			14. 1	6. 9	7. 1	10. 3	8. 4	10. 6	5. 9	14. 5	13. 2	7. 3	8. 8	11. 0	9. 6	10. 3	10. 3	12. 1
Priority Order			1	15	14	10	12	5	16	2	3	13	11	8	9	6	7	4

Figure 3 House of Quality

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Correlation Matrix. The correlation matrix indicates the relationship and strength between various technical requirements. ◎ represents a strong positive correlation, ○ represents a correlation, △ represents a weak correlation, as shown in the triangle at the top of Figure 3. Using the correlation matrix, one can better understand how multiple solutions cooperate during implementation and balance them accordingly.

CONCLUSIONS AND SUGGESTIONS

With the diverse applications of information technology and the trend toward online learning, many higher education institutions in China aim to establish a learning platform that integrates course communication, personalized learning, and resource sharing to meet the diverse needs of teachers and students across the campus. This study uses the Analytic Hierarchy Process (AHP) and Quality Function Deployment (QFD) methods to deeply analyze the online learning needs of higher education institutions, categorizing them into five main areas: professionalism, immediacy, service, practicality, and added value.

Professionalism includes high weights for teaching resources, course resources, and supporting learning. Immediacy includes high weights for design style, information accuracy, and ease of use. Service includes high weights for security and privacy, feedback handling, and after-sales service. Practicality includes high weights for teaching methods, interaction forms, and geographical diversity. Added Value includes high weights for time cost, reasonable fees, and cost-effectiveness. Overall, the top six weights are: security and privacy, time cost, teaching methods, diverse teaching resources, information accuracy, and interaction forms.

In terms of technical requirement solutions, the relationship matrix of the House of Quality (HoQ) and the ranking of total scores indicate that the most urgent needs are timely updates, membership systems, information authenticity, website activities, transaction security, and course certification.

In summary, current online learning platforms on the market have not fully met the users' needs for educational resources. Therefore, the government should formulate relevant policies to encourage higher education institutions to invest in and build innovative and effective online learning platforms. By organizing training and seminars, they can enhance the awareness and ability of teachers and students to use online learning platforms, promote digital education, and narrow the gap in educational resources between different regions.

As service-oriented teaching platforms, there is a responsibility to develop features that better align with users' actual needs. Higher education institutions should prioritize the development and improvement of features such as security and privacy protection, time cost control, diverse teaching methods, and increased diversity of teaching resources based on survey results to better meet user needs. On this basis, establishing a comprehensive update mechanism for online learning platforms ensures the timeliness and authenticity of information, enhancing user trust. At the same time, a complete user support system should be established to provide online consultation, feedback handling, after-sales service, and other diversified support, ensuring that users can receive timely help when encountering problems while using the platform.

Users should actively utilize the resources provided by online learning platforms to enhance their self-learning abilities, adapt to diverse learning formats and content, and improve learning effectiveness. By actively participating in the trial and feedback of the platform, users can help schools better understand their real needs, thereby promoting the optimization and improvement of the platform.

Through this study, it is hoped that the user experience of online learning platforms in higher education institutions can be effectively enhanced, meeting users' diverse needs, and thereby improving the effectiveness and satisfaction of online learning.

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