Evaluating the Impact of Online Courses and Digital Tools on Education Quality and Student Engagement in Chinese Higher Education

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Abstract: With the rapid digitalization of education, online learning has become an integral part of Chinese higher education, accelerated by the COVID-19 pandemic. This shift has raised questions about its effectiveness in maintaining education quality and student engagement. This study evaluates the effectiveness of online education in Chinese higher education, focusing on how online courses and digital tools impact education quality and student engagement. The Online Education Effectiveness Index (OEEI) examined four key factors: interactivity, accessibility, usability of digital tools, and adequacy of technical support. Data were collected through surveys from students in higher education institutions across China. The results indicate significant correlations between these factors and improved education outcomes, emphasizing the importance of interactive learning environments, accessible resources, and robust technical support. The findings offer practical insights for policymakers and educators aiming to enhance the online learning experience in higher education.

Keywords: Interactivity, Accessibility, Extent and Usability Of Digital Tools, Adequacy Of Technical Support And Resources, Online Education Effectiveness Index

Introduction

The evolution of online education in higher education represents a significant paradigm shift, reflecting broader technological advancements and changing societal needs. This transformation is particularly evident in China, where the rapid development of internet infrastructure and digital technologies has facilitated the widespread adoption of online learning platforms. The proliferation of Massive Open Online Courses (MOOCs), virtual classrooms, and digital resources has enabled higher education institutions to extend their reach, offering accessible and flexible learning opportunities to a broader audience.

The transition to online education has been further accelerated by global challenges, such as the COVID-19 pandemic. The need for social distancing measures necessitated an abrupt shift to online teaching and learning, demonstrating the scalability and adaptability of digital platforms. China's online education market reached 423 million users in 2022, showing the lasting impact of the shift to digital platforms. The increase in digital learning tools and

platforms, combined with improved technological infrastructure, has supported this growth. Furthermore, investment in the online education sector continued to expand, reflecting the sustained demand for flexible, accessible learning models[1].

For example, a 2023 study found that satisfaction rates among students, faculty, and parents post-pandemic were around 59.5%, 75.3%, and 70.7%, respectively. Synchronous online classes that included real-time interaction consistently yielded higher satisfaction rates compared to asynchronous formats, reflecting the importance of instructor feedback and peer interaction[2]. A significant aspect of digital learning tools is their ability to provide an immersive learning environment through interactive simulations, virtual laboratories, and gamification. These interactive features have been shown to significantly increase student engagement by making learning more engaging and less monotonous. According to a survey conducted by the China Internet Network Information Center, 78% of online learners reported a higher level of engagement when using digital learning tools that featured interactive elements. This data suggests that the use of digital tools not only makes education more accessible but also more engaging for students. The accessibility of digital learning tools also plays a significant role in enhancing student engagement. The ubiquity of smartphones and tablets has made mobile learning a preferred mode of education among students in China, with a report from the Ministry of Education indicating that over 60% of students engaged in online learning through mobile devices in 2019[3].

In summary of the above data, it can be seen that despite the rapid advancement of online education in China's higher education system, significant challenges remain. These factors are central to understanding how online education can enhance student engagement and education quality.

Factor 1: Interactivity, both synchronous and asynchronous, is vital for dynamic learning. Synchronous courses offer real-time engagement and immediate feedback, fostering community, while asynchronous courses provide flexibility but may cause isolation, impacting satisfaction and completion rates.

Factor 2: Accessibility goes beyond platform availability to inclusivity. The digital divide, especially for rural students, limits engagement and widens educational disparities, hindering the effectiveness of online learning.

Factor 3: The usability of tools like LMS, multimedia, and communication platforms is crucial for personalized and engaging learning. Usability directly affects student engagement and learning outcomes.

Factor 4: Adequate technical support is essential for smooth online learning. A survey conducted by the Ministry of Education of the People's Republic of China found students faced technical issues, with slow responses disrupting learning and reducing satisfaction.

This study aims to critically evaluate the effectiveness of online education in China's higher education system, particularly how digital tools and online courses impact education quality and student engagement. By using the Online Education Effectiveness Index (OEEI)—which measures engagement, satisfaction, and course completion rates—this

research provides a comprehensive analysis of current practices and identifies strategies to enhance digital learning.

Therefore, the following hypotheses were tested in the study:

Hypothesis 1: Interactivity of online courses has a positive impact on the OEEI

Hypothesis 2: Accessibility of online courses has a positive impact on the OEEI

Hypothesis 3: Extent and usability of digital tools has a positive impact on the OEEI

Hypothesis 4: Adequacy of technical support and resources has a positive impact on the OEEI

The hypothetical framework is shown as Figure 1.1.

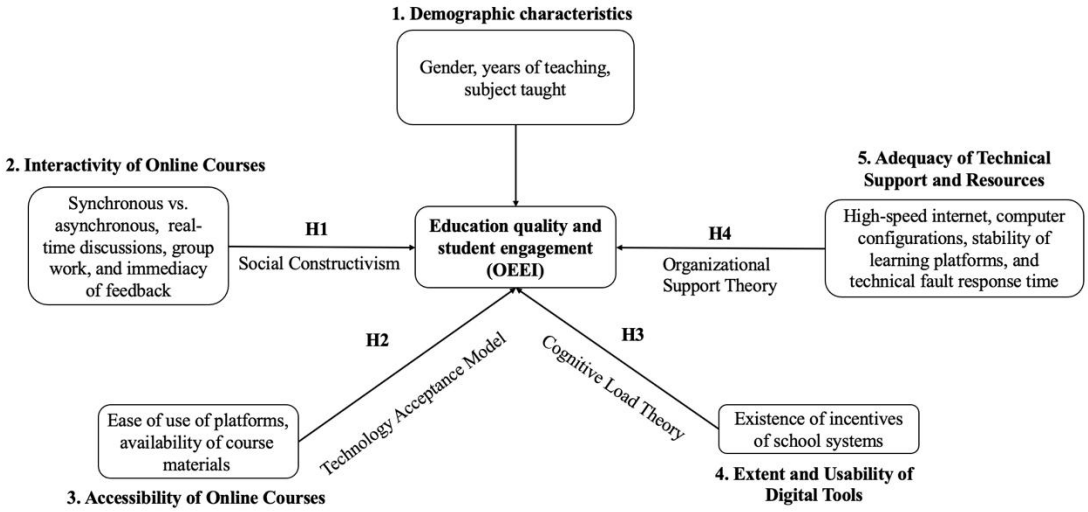

Figure 1.1 Hypothetical framework.

2 literature review

2.1 Interactivity of Online Courses and education quality and student engagement

Research has shown that both synchronous and asynchronous interactions contribute to various learning outcomes. Synchronous interactivity, such as real-time discussions and immediate feedback, has been positively associated with higher levels of student satisfaction and perceived learning[4]. On the other hand, asynchronous interactivity, which offers more flexibility, promotes reflective thinking and deeper understanding of course materials, as posited by O'Flaherty and Phillips .

Social constructivism, as proposed by Vygotsky, underscores the importance of social interaction and collaboration in learning. The theory of the Zone of Proximal Development (ZPD) suggests that learners achieve optimal results when interacting with more knowledgeable individuals. This theoretical framework aligns with the hypothesis that interactive online courses positively impact student engagement and course completion rates. Studies by Munna et al.and Alismaiel et al. support this, showing that courses designed with constructivist principles significantly improve student engagement and success rates. Thus, by integrating interactive elements that adhere to social constructivist theory, online education can effectively improve educational quality and learner outcomes[5].

2.2 Accessibility of Online Courses and education quality and student engagement

Accessibility encompasses several aspects, including the design of online platforms, the availability of course materials, and the provision of resources to meet diverse student needs. Research highlights the importance of integrating accessibility considerations from the outset. Ally (2004) emphasized that online course designs must ensure equal access to educational content, including for students with disabilities. Accessibility also extends to ease of use, with studies like Li et al showing that online platforms that are easy to navigate and reliable significantly enhance student satisfaction.

The Technology Acceptance Model (TAM) offers a theoretical framework for understanding how accessibility influences student engagement. TAM posits that students are more likely to adopt and engage with online platforms that are perceived as useful and easy to use. Lee demonstrated that students' perceptions of ease of use directly correlate with higher engagement and improved academic performance. The connection between accessibility and TAM is clear—Karaoğlan further confirmed that ease of use enhances student satisfaction and engagement in online learning environments.

2.3 Extent and Usability of Digital Tools and education quality and student engagement

Research consistently shows that frequent interaction with digital learning tools correlates positively with higher levels of student satisfaction and engagement. Roque et al. (2023) demonstrated that students who regularly use digital tools report more engagement and improved academic performance. These tools foster interactive and immersive learning environments, which contribute to deeper student involvement and better learning outcomes.

Cognitive Load Theory (CLT) provides a framework for understanding the importance of usability in reducing extraneous cognitive load. Paas, Renkl, and Sweller argue that intuitive tools help learners focus on the content rather than the interface, improving learning outcomes. Furthermore, frequent interaction with digital tools supports schema construction and the automation of learning processes, as demonstrated by Jung et al. When aligned with CLT principles, well-designed digital tools can optimize the learning experience by managing cognitive load effectively and catering to students' diverse cognitive capacities[6].

2.4 Adequacy of Technical Support and Resources and education quality and student engagement

High-speed internet access is a fundamental factor, as it enables students to access course materials and participate in synchronous activities without disruptions. Baloran et al found that students with reliable internet connections reported higher levels of engagement and satisfaction. Similarly, adequate computer configurations are essential for optimal performance in online learning environments. Reich demonstrated that students using outdated devices struggled with running necessary software, leading to lower engagement and academic outcomes.

These factors are supported by Organizational Support Theory (OST), which posits that perceived support from an

organization enhances performance and satisfaction. Rhoades and Eisenberger extended this theory to educational settings, suggesting that when students perceive high levels of technical support, their engagement and commitment to their studies increase. This theory is further substantiated by Bond et al, who found that access to adequate technological resources was a significant predictor of student engagement. Together, these findings affirm the importance of providing adequate technical support and resources to enhance the quality of online education and student engagement[7].

3 Methodology

3.1 Research Design

3.1.1 H1: Interactivity of Online Courses Has a Positive Impact on the OEEI

To quantify this interactivity, a questionnaire was designed using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The independent variable, interactivity, is measured across several dimensions. Firstly, real-time interaction through live discussions and webinars is assessed to gauge the synchronous communication between students and instructors, an essential component of the learning experience. Collaborative learning opportunities, including group projects, are another measure, encouraging peer engagement and fostering critical thinking skills. Timely and constructive feedback is also a key element, as it aids in improving performance and enhancing learning outcomes. Interactive course materials, such as quizzes and simulations, are evaluated for their ability to engage students actively and facilitate personalized learning paths. Lastly, the flexibility in communication channels, such as forums and email, is crucial for accommodating different learning styles and fostering interaction. These variables collectively aim to measure the degree of interactivity and its potential correlation with student engagement, satisfaction, and course completion rates.

3.1.2 H2: Accessibility of Online Courses Has a Positive Impact on the OEEI

The first measure is the ease of navigation on the platform, which evaluates whether students can intuitively locate course materials and manage assignments, contributing to a seamless learning experience. Another key factor is the accessibility of course materials, ensuring that all resources are available in inclusive formats, such as subtitles or readable PDFs, to support diverse learning needs. The clarity of technical requirements and the availability of technical support are also essential; these reduce potential barriers, making the course more accessible to a broader range of students. Mobile accessibility, another critical factor, assesses the usability of the course on smartphones and tablets, enhancing learning flexibility. Finally, flexibility in accessing course content is considered, allowing students to learn at their own pace and time, which is particularly beneficial for those with irregular schedules .

3.1.3 H3: Extent and Usability of Digital Tools Has a Positive Impact on the OEEI

The frequency of digital tool usage is the first measure, assessing how often students engage with tools like virtual labs, collaboration platforms, and multimedia resources. Ease of use is another significant factor, as tools that are easy to navigate and understand minimize frustration and increase the likelihood of consistent engagement. The integration of digital

tools with course content is also assessed, reflecting whether the tools enhance the learning experience by making the material more interactive and accessible. Digital tools' contribution to learning engagement is measured to understand their role in keeping students actively involved with the course. Finally, personalized learning through digital tools is evaluated, focusing on whether the tools allow students to learn at their own pace and according to their individual preferences.

3.1.4 H4: Adequacy of Technical Support and Resources Has a Positive Impact on the OEEI

The reliability of the technical infrastructure, including the stability of the online platform and the digital tools used in the course, is the first measure, as consistent performance is essential for uninterrupted learning. Another key measure is the accessibility of high-speed internet, which is fundamental for accessing video content, live discussions, and other bandwidth-intensive activities. The adequacy of personal computing resources is also considered, as students' ability to engage with the course depends on their access to functional hardware such as laptops or tablets. The responsiveness of technical support is measured to evaluate how quickly and effectively issues are resolved, minimizing disruptions to the learning process. Lastly, the provision of digital literacy training and resources is assessed, recognizing that students need certain technical skills to navigate online learning environments effectively.

3.1.5 Research Design of OEEI

The research design of the OEEI focuses on three dependent variables: student engagement, satisfaction, and course completion rates, which are critical indicators of online education success. Student engagement is measured by assessing how involved students feel in their learning process, including their participation in discussions and interaction with course materials. High engagement levels typically correlate with deeper learning and better academic performance. Student satisfaction is measured by evaluating the overall quality of the course, including the relevance and organization of the content, teaching strategies, and the achievement of learning outcomes. Finally, course completion rates are measured by gauging students' confidence in their ability to complete the course, which is a proxy for actual completion rates. High confidence levels often correlate with higher completion rates, providing insight into student commitment and the effectiveness of course delivery. This research design allows for a comprehensive assessment of online education outcomes, providing a detailed understanding of the OEEI. The complete questionnaire is shown in the Appendix.

3.2 Data Collection and Procedure

3.2.1 Participant Selection and Sampling Method

Participants were selected through a combination of stratified and convenience sampling to ensure representation across various demographics, including urban and rural areas, different educational levels, and institutional types. Stratification was applied based on region, educational level (undergraduate, postgraduate, part-time, and distance learners), and institution type (public, private, and technical universities). A total of 50 universities were selected for this study, with institutions chosen proportionally based on their rankings in the China University Rankings (CURI) to ensure a balanced

representation of top-tier, mid-tier, and lower-tier institutions. This approach ensured the inclusion of a wide range of experiences and perspectives from various academic backgrounds.

For each of the 50 universities, survey questionnaires were distributed until 10 completed responses were collected from each institution, ensuring a total of 500 responses across the entire sample. The universities included prestigious institutions such as Tsinghua University, Peking University, and Shanghai Jiao Tong University, as well as regional universities like Guangxi University and Inner Mongolia University, capturing a diverse range of experiences from different geographic and institutional backgrounds.

3.2.2 Sample Size

To determine the appropriate sample size for the study, the Krejcie and Morgan sampling formula will be utilized. This formula provides a method to decide on sample size based on the population size, desired level of confidence, and margin of error. For large populations, Krejcie and Morgan's table suggests a sample size of 384 for a population size exceeding 100,000 with a 95% confidence level and a 5% margin of error.

Total	*Sample*	*Total*	*Sample*	*Total*	*Sample*
10 ⇒	10	220 ⇒	140	1200 ⇒	291
15 ⇒	14	230 ⇒	144	1300 ⇒	297
20 ⇒	19	240 ⇒	148	1400 ⇒	302
25 ⇒	24	250 ⇒	152	1500 ⇒	306
30 ⇒	28	260 ⇒	155	1600 ⇒	310
35 ⇒	32	270 ⇒	159	1700 ⇒	313
40 ⇒	36	280 ⇒	162	1800 ⇒	317
45 ⇒	40	290 ⇒	165	1900 ⇒	320
50 ⇒	44	300 ⇒	169	2000 ⇒	322
55 ⇒	48	320 ⇒	175	2200 ⇒	327
60 ⇒	52	340 ⇒	181	2400 ⇒	331
65 ⇒	56	360 ⇒	186	2600 ⇒	335
70 ⇒	59	380 ⇒	191	2800 ⇒	338
75 ⇒	63	400 ⇒	196	3000 ⇒	341
80 ⇒	66	420 ⇒	201	3500 ⇒	346
85 ⇒	70	440 ⇒	205	4000 ⇒	351
90 ⇒	73	460 ⇒	210	4500 ⇒	354
95 ⇒	76	480 ⇒	214	5000 ⇒	357
100 ⇒	80	500 ⇒	217	6000 ⇒	361
110 ⇒	86	550 ⇒	226	7000 ⇒	364
120 ⇒	92	600 ⇒	234	8000 ⇒	367
130 ⇒	97	650 ⇒	242	9000 ⇒	368
140 ⇒	103	700 ⇒	248	10000 ⇒	370
150 ⇒	108	750 ⇒	254	15000 ⇒	375
160 ⇒	113	800 ⇒	260	20000 ⇒	377
170 ⇒	118	850 ⇒	265	30000 ⇒	379
180 ⇒	123	900 ⇒	269	40000 ⇒	380
190 ⇒	127	950 ⇒	274	50000 ⇒	381
200 ⇒	132	1000 ⇒	278	75000 ⇒	382
210 ⇒	136	1100 ⇒	285	100000 ⇒	384

Figure 3.1 Krejcie and Morgan Table

Considering potential issues such as non-response and incomplete or inaccurate responses, it is prudent to adjust the initial sample size to account for possible data attrition. For this study, an additional 20% will be added to the ideal sample size to compensate for the anticipated rate of invalid or incomplete questionnaires. Therefore, the total number of questionnaires to be distributed will amount to 460. This adjustment ensures that even with a 20% dropout or invalid response rate, the study will still have the 384 completed and valid

responses required for robust statistical analysis.

Throughout the data collection and analysis process, ethical considerations are paramount. Participants are informed about the study's purpose, their right to withdraw at any time, and the measures in place to protect their anonymity and confidentiality. Consent is obtained before participation, and data is stored securely, accessible only to the research team.

3.3 Research methods

The research approach for assessing the effectiveness of online education in higher education in China, as measured by the OEEI, employs a comprehensive analytical framework. This framework integrates descriptive statistics, reliability and validity assessments, correlation analysis, and multiple regression analysis to provide a multifaceted understanding of the data collected through the questionnaire. Quantitative methods are more suitable than qualitative methods for measuring the effectiveness of online education due to their ability to provide objective, measurable, and generalizable data. By using statistical techniques such as descriptive statistics, correlation analysis, and multiple regression, quantitative methods allow researchers to assess specific variables like student engagement, satisfaction, and course completion rates, which are essential components of the OEEI.

4 Results

4.1 Descriptive statistics results

This descriptive statistical analysis draws from a sample size of 500 individuals, evenly distributed across gender, with males representing 51% and females 49%. Such a balanced gender representation ensures that any conclusions drawn can be broadly applicable without skewing towards a particular gender's educational experiences or outcomes.

Table 4.1 Descriptive statistics.

Items	Categories	N	Percent (%)	Cumulative Percent (%)
Gender	Female	245	49	49
	Male	255	51	100
Education	11~15 years	237	47.4	47.4
	More than 16 years	263	52.6	100
Subjects	Chinese	40	7.98	7.98
	Mathematics	47	9.38	17.37
	English	41	8.18	25.55
	Physics	49	9.78	35.33
	Chemistry	21	4.19	39.52
	Biology	52	10.38	49.9
	Geography	37	7.39	57.29
	Politics	30	5.99	63.27
	History	41	8.18	71.46

Art (music， art，etc.)	48	9.58	81.04
Information technology	46	9.18	90.22
Physical education	23	4.59	94.81
other	26	5.19	100
Total	500	100	100

Educationally, the data categorizes respondents based on years of education, with a nearly even split between those with 11-15 years (47.4%) and more than 16 years (52.6%) of education. This distinction allows for the examination of how additional educational background beyond the compulsory years may influence engagement with and the effectiveness of online education platforms. Subject-wise, the distribution covers a wide range of disciplines critical to a comprehensive educational experience. Notably, the most represented subjects are Biology (10.38%), Art (music, art, etc.) at 9.58%, and Mathematics and Information Technology, each capturing around 9% of the sample. Subjects such as Physics and History also show substantial representation, around 9.78% and 8.18% respectively. This diverse academic representation is crucial as it ensures that the analysis can consider how online education platforms cater to a wide range of academic interests and how these platforms might need to be tailored to different subject-specific requirements. The lesser-represented subjects include Chemistry and Physical Education, which could suggest areas where online platforms may be less developed or utilized. However, this also indicates an opportunity for targeted studies on the adequacy of online resources in these less-represented disciplines. Additionally, the inclusion of 5.19% of the respondents in 'other' subjects highlights the platform's versatility or gaps in catering to niche academic interests.

4.2 Reliability and validity results

4.2.1 Reliability Analysis

Reliability analysis is essential to ensure the internal consistency and stability of the questionnaire used to assess the OEEI. For this analysis, Cronbach’s alpha coefficient was employed to quantify the internal consistency of the questionnaire items across different constructs, with a threshold of 0.7 or higher considered acceptable. The results indicate high reliability across all sections of the questionnaire, with Cronbach’s alpha values for the items related to H1, H2, H3, and H4 measuring 0.853, 0.869, 0.872, and 0.849, respectively. The reliability analysis for the overall outcome variable (Y), which is designed to measure broader educational effectiveness, returned a slightly lower Cronbach’s alpha of 0.785. While this is still within the acceptable range.

Further assessment using the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy supports the suitability of the sample for factor analysis. The KMO values for all items exceed the acceptable threshold of 0.6, with individual KMO values for H1, H2, H3, and H4 being 0.867, 0.879, 0.88, and 0.869, respectively. For item Y, the KMO value is 0.706, which, while lower than the other constructs,

still supports the adequacy of the sample for factor analysis.

Table 4.2 Reliability analysis

Reliability analysis and KMO test				
Item	Cronbach α		kmo	n
	Items	Factor loading	Communalities	
	H1-1	0.74	0.649	
	H1-2	0.761	0.632	
	H1-3	0.698	0.601	
H1	0.853		0.867	5
H2	0.869		0.879	5
H3	0.872		0.88	5
H4	0.849		0.869	5
Y	0.785		0.706	3

4.2.2 Validity Analysis

In this study, all factor loadings exceeded the commonly accepted threshold of 0.4, indicating a strong association between the questionnaire items and their corresponding factors. This suggests that each item is appropriately aligned with its intended construct, supporting the validity of the measurement model. For the interactivity of online courses (H1), the factor loadings for the five items (H1-1 to H1-5) ranged from 0.698 to 0.761, demonstrating that these items strongly correlate with the underlying construct of interactivity. The communalities for these items were all above 0.6, further confirming that the interactivity construct is well-defined and robustly captured by these items. For accessibility (H2), the factor loadings for items H2-1 through H2-5 were similarly high, ranging from 0.736 to 0.78, indicating a strong relationship with the accessibility factor. This consistency in high loadings and communalities indicates that the factor model is appropriate for explaining the variance in responses related to accessibility. The extent and usability of digital tools (H3) also displayed very high loadings, with the highest loading being 0.799. This demonstrates a strong alignment between the questionnaire items and the construct of digital tool usage, confirming that the digital tools' extent and usability are effectively captured by these items. Similarly, the technical support construct (H4) showed loadings between 0.704 and 0.771, indicating that the items effectively measure the adequacy of technical support and resources in online education. Although some items in H4 had slightly lower communalities, the values remained sufficiently high to validate the construct. Finally, for the overall educational effectiveness index (Y), items Y1, Y2, and Y3 showed the highest factor loadings, ranging from 0.781 to 0.791, indicating that these items strongly capture the broader educational outcomes, further validating the measurement of the OEEI.

Table 4.3 actor loading (Rotated)

H1-4	0.72	0.647
H1-5	0.756	0.65
H2-1	0.756	0.654
H2-2	0.736	0.65
H2-3	0.745	0.639
H2-4	0.746	0.666
H2-5	0.78	0.697
H3-1	0.754	0.662
H3-2	0.73	0.642
H3-3	0.79	0.694
H3-4	0.761	0.659
H3-5	0.799	0.691
H4-1	0.756	0.663
H4-2	0.771	0.645
H4-3	0.744	0.623
H4-4	0.75	0.621
H4-5	0.704	0.629
Y1	0.781	0.695
Y2	0.781	0.702
Y3	0.791	0.706

Note: Blue indicates that the absolute value of loading is greater than 0.4, and red indicates that the communality is less than 0.4.

4.3 Correlation analysis results

4.3.1 Correlation for Interactivity of Online Courses (H1) and OEEI (Y)

The interactivity of online courses (H1) shows a correlation coefficient of 0.399 with the OEEI. This moderate positive relationship suggests that enhancements in interactivity—measured by the frequency of real-time interactions, opportunities for collaborative learning, and the quality and timeliness of feedback—are significantly linked to improved educational outcomes, including student engagement, satisfaction, and course completion rates. This finding supports Hypothesis 1 and emphasizes that a higher level of interactivity is crucial for enhancing student experiences in online education, ultimately improving the overall effectiveness of the learning environment.

4.3.2 Correlation for Accessibility of Online Courses (H2) and OEEI (Y)

The correlation coefficient of 0.394 between the accessibility of online courses (H2) and the OEEI indicates a moderate positive relationship. This supports Hypothesis 2, highlighting the importance of designing online courses with user-friendly platforms and accessible content to maintain high levels of student participation, satisfaction, and overall course effectiveness.

4.3.3 Correlation for Extent and Usability of Digital Tools (H3) and OEEI (Y)

The extent and usability of digital tools (H3) correlate with the OEEI at 0.334, indicating a positive relationship, albeit slightly weaker than for interactivity and accessibility. The results support Hypothesis 3, suggesting that the more effectively digital tools are integrated into the

course, the higher the effectiveness of the online education system. This emphasizes the importance of using well-designed, user-friendly tools to facilitate active student participation and enhance the learning experience.

4.3.4 Correlation for Adequacy of Technical Support and Resources (H4) and OEEI (Y)

The correlation between the adequacy of technical support and resources (H4) and the OEEI is 0.391, demonstrating a moderate positive relationship. The findings support Hypothesis 4, showing that the availability of robust technical infrastructure and responsive support is vital for ensuring the effectiveness of online education. Adequate technical support minimizes disruptions in the learning process and maintains student engagement, further contributing to the overall success of online education platforms.

Table 4.4 Pearson correlations

	Y	H1	H2	H3	H4
Y	1				
H1	0.399	1			
H2	0.394	0.498	1		
H3	0.334	0.455	0.431	1	
H4	0.391	0.421	0.453	0.396	1

* $p<0.05$ ** $p<0.01$

4.4 Multiple regression results

4.4.1 Regression for Interactivity of Online Courses (H1) and OEEI (Y)

The regression analysis reveals a positive and significant relationship between the interactivity of online courses (H1) and the OEEI, with a coefficient B=0.194 and β=0.187. This indicates that interactivity, quantified through aspects like real-time interactions, collaborative learning opportunities, and timely feedback, significantly contributes to the effectiveness of online education. The results support Hypothesis 1, demonstrating that enhancing interactivity positively impacts student engagement, satisfaction, and course completion rates.

4.4.2 Regression for Accessibility of Online Courses (H2) and OEEI (Y)

For the accessibility of online courses (H2), the regression analysis shows a positive and significant impact on the OEEI, with a coefficient B=0.170 and β=0.170. Accessibility is quantified by ease of platform navigation, the availability of course materials in diverse formats, and mobile accessibility. Hypothesis 2 is supported, confirming that increased accessibility leads to improved educational outcomes, such as enhanced student engagement and higher satisfaction.

4.4.3 Regression for Extent and Usability of Digital Tools (H3) and OEEI (Y)

The extent and usability of digital tools (H3) also show a positive effect on the OEEI, with a coefficient B=0.098 and β=0.098. Digital tools are measured by their frequency of use, ease of integration with course content, and contribution to personalized learning. These tools, including simulations, quizzes, and interactive videos, were assessed through student feedback on their usability and impact on the learning experience. While the effect size is smaller than other variables, Hypothesis 3 is supported, suggesting

that well-integrated, user-friendly digital tools play a significant role in enhancing the online education experience.

4.4.4 Regression for Adequacy of Technical Support and Resources (H4) and OEEI (Y)

The adequacy of technical support and resources (H4) has the strongest effect on the OEEI, with a coefficient B=0.212 and β=0.196. This variable was measured by assessing the reliability of technical infrastructure, the responsiveness of technical support, and the availability of necessary resources, such as high-speed internet and adequate computing equipment. The significant positive relationship supports Hypothesis 4, highlighting the critical role that technical support plays in ensuring a seamless online learning experience. Reliable infrastructure and effective technical assistance are crucial for maintaining student engagement and satisfaction, ultimately enhancing the OEEI.

Table 4.5 Regression analysis

	Unstandardized Coefficients		Standardized Coefficients	*t*	*p*	Multicollinearity Check	
	B	Std. Error	*Beta*			VIF	tolerance
Constant	0.823	0.162	-	5.076	0.000**	-	-
H1	0.194	0.050	0.187	3.897	0.000**	1.524	0.656
H2	0.170	0.048	0.170	3.529	0.000**	1.535	0.652
H3	0.098	0.046	0.098	2.132	0.033*	1.405	0.712
H4	0.212	0.050	0.196	4.269	0.000**	1.393	0.718
R 2			0.251				
Adj *R* 2			0.245				
F			*F* (4,495)=41.500,*p*=0.000				
D-W Value			2.017				

Note：Dependent Variable=Y

* $p<0.05$ ** $p<0.01$

5 Discussion and implications

5.1 Strategies to Improve Student-Teacher Interaction

The interactivity of online courses is a crucial factor in improving the OEEI, with a positive correlation to student engagement, satisfaction, and course completion rates. Student-teacher interaction can be enhanced by integrating synchronous communication tools, such as live video sessions, real-time messaging, and virtual office hours. These tools foster real-time engagement and provide immediate feedback, creating a more supportive and interactive learning environment. Personalized feedback is another important strategy, allowing teachers to offer detailed, individualized guidance to students. Platforms can incorporate tools for voice or video feedback, making the process more interactive. Asynchronous communication through discussion forums, LMS announcements, and emails also plays a significant role in maintaining student-teacher interaction. Active participation by instructors in these forums can foster meaningful dialogue and further improve engagement. Gamification, such as quizzes and leaderboards, can motivate students to interact more with course materials and instructors, improving the overall learning

experience. Lastly, one-on-one mentorship opportunities through virtual office hours can provide personalized support, especially for students who may feel disconnected from the course content, enhancing both engagement and performance.

5.2 Developing User-Friendly Learning Platforms

Accessibility has a strong positive correlation with the OEEI, impacting student engagement, satisfaction, and course completion rates. Developing user-friendly platforms is essential for improving accessibility. These platforms should be intuitive and customizable to meet diverse learner needs, ensuring that students of varying technical proficiency can navigate courses with ease. Accessibility features, such as screen readers, adjustable text sizes, and voice recognition software, should be integrated to support students with disabilities. Additionally, platforms should support multiple devices, including smartphones and tablets, and be optimized for use on low bandwidth or unstable internet connections. Features like offline mode and downloadable materials can ensure continued learning in areas with unreliable internet. Real-time technical support is crucial in preventing technological barriers from hindering the learning process. By focusing on these areas, institutions can ensure that their online education platforms are accessible to all students, improving the overall effectiveness of online education.

5.3 Upgrading Digital Infrastructure for Enhanced Usability

The usability of digital tools is directly related to student engagement and satisfaction, as highlighted by Hypothesis H3. Upgrading digital infrastructure is essential for ensuring the seamless functioning of online education platforms. Institutions should invest in high-performance servers to accommodate large numbers of concurrent users, particularly as online course enrollments continue to grow. Platforms should feature an intuitive interface that simplifies navigation and ensures quick access to key resources, such as lectures and assignments. Responsive design is critical to ensure compatibility with multiple devices, particularly mobile phones, which are widely used by students. Cloud-based solutions can enhance scalability, allowing students to access and collaborate on course materials from any location. By integrating AI-powered tools for personalized learning and real-time feedback, institutions can further enhance the usability of digital tools. Reliable communication tools, including video conferencing and live chat, should be incorporated into the platform to ensure smooth interactions between students and instructors.

5.4 Establishing Robust Technical Support Systems

Technical support plays a critical role in the success of online education, as highlighted by Hypothesis H4. Institutions should focus on proactive maintenance of their online platforms, regularly updating software and conducting system checks to identify potential vulnerabilities. A responsive help desk system, offering multiple channels for assistance, should be available to both students and faculty, with 24/7 support being essential for online education. Real-time issue resolution is critical during live lectures or assessments, ensuring that students' learning experiences are not disrupted by

technical problems. A tiered support system can expedite the resolution of more complex issues, allowing front-line staff to address simpler problems quickly. By establishing a robust technical support system, institutions can minimize downtime, improve student satisfaction, and enhance the overall effectiveness of their online education platforms.

6 Conclusion and limitations

6.1 Conclusion

This study explored the impact of online education on higher education in China, focusing on how interactivity, accessibility, the usability of digital tools, and technical support contribute to the OEEI. The findings confirmed that these four factors significantly enhance education quality, student engagement, and course completion rates. The research was grounded in a theoretical framework, utilizing Social Constructivism, the Technology Acceptance Model, Cognitive Load Theory, and Organizational Support Theory to assess the influence of these variables on the OEEI. The study employed quantitative methods, including correlation and regression analyses, to validate the proposed hypotheses. The results confirmed that increased interactivity, defined through tools like live chats, group projects, and personalized feedback, has a positive effect on student engagement and satisfaction. Similarly, greater accessibility, such as user-friendly platforms and inclusive course materials, enhanced the OEEI by reducing barriers to education. The usability of digital tools also played a critical role, as students who found the tools easy to use demonstrated higher levels of engagement. Lastly, adequate technical support and resources were confirmed as crucial for ensuring that students could engage effectively with online courses. The OEEI developed in this study offers a comprehensive metric for assessing the quality and effectiveness of online education.

6.2 Proposals for Future Work

While this study provides valuable insights, it acknowledges certain limitations and proposes directions for future research. First, the study's focus on China’s higher education system limits the generalizability of its findings. Future research should conduct comparative studies across different countries to better understand how cultural, technological, and policy differences affect online education. Additionally, incorporating a mixed-methods approach with qualitative data from interviews or focus groups could provide deeper insights into students' and educators' experiences with online learning.

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