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Online learning environments and approaches to learning among international students in China: the mediating roles of teacher- and student-initiated interactions

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ABSTRACT

This research investigated the relationships between international students' perceptions of online learning environments and their online learning approaches, as well as whether and how teacher- and student-initiated interactions mediated these relationships. A total of 1010 international students from 41 higher education institutions in China participated. Structural equation modelling analysis revealed a significant relationship between perceived online learning environments and learning approaches. Mediation analysis indicated that, through teacher-initiated interaction, environmental accessibility and interactivity positively influenced the surface approach to learning. In addition, environmental accessibility, interactivity, and flexibility significantly promoted a deep approach to learning *via* student-initiated interaction. Possible explanations and implications of these findings were discussed, contributing to a deeper understanding of international students' online learning experiences.

KEYWORDS

Online learning environments; student-instructor interactions; student approaches to learning; international students in China

Introduction

Since the COVID-19 outbreak, online learning has rapidly expanded across higher education institutions globally, providing flexible access for students who cannot attend traditional classrooms. During the pandemic, universities worldwide closed campuses and transitioned to online teaching, making it a prevalent mode of education. This shift was driven by emergency responses whilst being enabled by decades of development of educational technology, highlighting online learning as an emerging research field (Wei and Chou 2020). Over the past three years, much literature has explored students' experiences with emergency online learning (Yin 2023).

Although some surveys have focused on international students in Chinese universities (Zhang, Kuek, and Wu 2023), research in this area remains insufficient.

International students in China have faced difficulties in online learning, including inadequate teaching infrastructure, inexperienced instructors, and distractions when learning at home, which have negatively affected their learning (Yang 2020). Nevertheless, China has invested substantially in information and communication technologies (ICT) over the past decades, laying the foundation for the rapid transition to online education during the pandemic. This investment may drive more sustainable changes in pedagogy in the post-pandemic era. To support higher education institutions in enhancing international students' online learning experiences and ensure quality online education, further empirical research is needed.

International students' perceptions of online learning environments are significant determinants of effective learning. Researchers have investigated perceived features of online learning (Chang et al. 2015) and the influence of online learning environments on student engagement (Zang et al. 2022). Online learning environments provide space and opportunities for students in disparate geographical regions to interact and learn (Wahlstedt, Pekkola, and Niemelä 2008). However, the level of teacher-student interactions in online education, whether initiated by teachers or students, remains unsatisfactory, as the less directed nature of this modality tends to reduce social interaction, leading to less favourable learning outcomes compared to traditional face-to-face classes.

Approaches to learning provide insights into how students learn in higher education and are important determinants of learning outcomes (Guo et al. 2022). Recent years have seen increased research into student approaches to online learning, with findings confirming that these approaches are critical to online academic success (Ellis and Bliuc 2019; Han and Geng 2023). However, there is limited understanding of international students' approaches to online learning.

Drawing on the findings of a nationwide survey involving 1010 international students at 41 Chinese universities, this research investigated the influence of online learning environments and student-instructor interactions—initiated by either teachers or students—on international students' approaches to online learning. Specifically, it addressed:

1. What are the characteristics of international students' perceived online learning environments, student-instructor interactions, and student approaches to learning?
2. How do the international students' perceived online learning environments and student-instructor interactions influence their approaches to learning?
3. Do student-instructor interactions significantly mediate the relationships between international students' perceived online learning environments and their approaches to learning?

The Chinese online education context

Since the early twenty-first century, China has implemented systematic reforms to promote online education, establishing a vast, interconnected network of institutions

that leverages advanced information technologies. National initiatives, such as the 13th Five-Year Plan for ICT in Education (MoE 2016), introduced comprehensive strategies to advance ICT application in education with distinctive Chinese characteristics. These strategies included the construction of large-scale public online learning platforms, national 'model' online courses, and Massive Open Online Courses (MOOCs). In 2020, the MoE launched the International Online Teaching Platform Construction Project for higher education institutions. Subsequently, as the first national standard for digital campus construction, the Specification for Digital Campus Construction in Higher Education Institutions (Trial) (MoE 2021) was promulgated, formalising the transformation of higher education under the conditions of informatization.

Building upon these national frameworks, local educational councils and universities have introduced a range of initiatives, including the MOOC Westward Initiative and various ICT-driven programs in higher education (MoE 2022). In particular, since 2020, national double first-class universities have implemented the Digital-Twin initiative to reconstruct physical teaching environments virtually. Through the 'clone-class' model, this initiative enabled synchronous instruction connecting on-campus and remote learners, expanding access to high-quality courses across economically less advanced central and western China.

The COVID-19 pandemic further accelerated these transformations. In February 2020, the MoE implemented the nationwide policy of 'suspending classes without stopping learning', which ensured the continuity of instruction through online teaching. While this rapid transition responded effectively to disruptions, it also exposed persistent challenges, including uneven technological resources across universities, inefficiency in online course design, and limited opportunities for effective interaction (Wang, Yin, and King 2025).

Despite these national efforts to digitalise higher education, particularly through expanding infrastructure and technological innovation, less attention has been paid to students' lived experiences. Questions remain about how effectively online teaching supports meaningful learning, especially for international students who navigate additional cultural, spatial, and temporal barriers in their engagement with Chinese higher education. As universities continue to refine online and blended instructional modes, understanding how international students perceive and experience online learning is essential. Such enquiry contributes to advancing online education in China and beyond towards sustainable, high-quality practices that foster inclusive and engaging learning for a globally diverse student population.

Literature review

Students' perceptions of online learning environments

Perceptions of online learning environments refer to students' attitudes towards online learning environments facilitated by computers and internet-based technologies (Wei and Chou 2020). These perceptions involve how students view the implementation of technology in the learning processes necessary to acquire knowledge (Aparicio, Bacao, and Oliveira 2016). According to Moore, Dickson-Deane, and

Galyen (2011), learning environments may vary based on learning purposes, the target audience, access to physical and virtual contexts, and the types of learning content. Wei and Chou (2020) proposed important features for the perceived online learning environment among college students, comprising accessibility, interactivity, knowledge acquisition, and flexibility. Specifically, accessibility refers to the availability of multimedia learning resources. Interactivity concerns the opportunities for online communication and interaction with peers and teachers. Knowledge acquisition addresses the effectiveness of supporting learners in expanding their academic knowledge. Flexibility refers to the ability to manage learning independently of time and physical constraints.

Student approaches to learning

With the increasing importance of online learning, research has focused on understanding individual differences in students' intentions, motives, and learning behaviours when engaging in online learning environments. The student approaches to learning framework suggests that approaches to learning incorporate both an individual's motives and learning strategies (Biggs, Kember, and Leung 2001), and can be categorised into deep-level and surface-level processing (Biggs 1993), serving as a foundation for exploring students' online learning behaviours.

A range of quantitative instruments has been developed to study student approaches to learning, including the widely used revised two-factor version of the Study Process Questionnaire (R-SPQ-2F, Biggs, Kember, and Leung 2001), the Approaches to Studying Inventory (ASI, Entwistle and Ramsden 1983), and the Approaches and Study Skills Inventory for Students (ASSIST) which incorporates the Revised Approaches to Studying Inventory (RASI, Tait, Entwistle, and McCune 1998). While these tools reveal different structures in student approaches to learning, the distinction between surface and deep learning remains a consistent finding across studies in higher education. It is noted that students often combine elements of both approaches, creating unique learning profiles that reflect mixed strategies (Baeten et al. 2010).

Although the literature is abundant on student approaches to learning, there is a lack of research on international students' approaches to online learning within Chinese higher education institutions. To further our understanding of learning behaviours in online learning contexts, empirical research is urgently needed.

Teacher- and student-initiated interactions

Student-instructor interactions refer to the two-way communication between teachers and students, where both parties play active roles and are of equal importance (Moore and Kearsley 1996). Based on who initiates the interaction, it can be categorised as either teacher-initiated or student-initiated (Fang and Li 2014). Regular and substantive teacher-initiated interaction is essential for instructors to effectively support students in the online learning environment. This type of interaction can be demonstrated through the instructor's uses of announcements, content

delivery, and emails within learning management systems, outside of required class discussions (Woods 2002). Furthermore, effective indicators of teacher presence in online settings include the quality of teacher feedback and the extent to which content and course instructions encourage reflection (Garrison, Anderson, and Archer 1999).

Although instructors invest considerable effort in facilitating online courses, student-initiated interaction also occurs frequently (Kaul, Aksela, and Wu 2018). Studies have shown that student-initiated interaction promotes a deeper understanding of course content and enhances the overall quality of online discussions (Lee and Recker 2021). Jumaat and Tasir (2013) have observed that online interaction initiated by students often involves sharing opinions and knowledge. When such interaction is sustained and meaningful, it contributes to higher levels of knowledge construction, moving beyond mere responses to instructors' comments.

Relationships between perceptions of online learning environments and approaches to learning

Student perceptions of learning environments are considered key factors influencing their approaches to learning (Lizzio, Wilson, and Simons 2002). Studies have explored features of students' perceptions of online learning environments and their effects on learning approaches. The findings have highlighted that students adjust their approaches to learning based on their perceptions of learning environments and task requirements. For example, it is reported that positive perceptions of the learning context, such as perceptions of good teaching, clear goals and standards, and appropriate workload, are associated with a deep approach to learning (Ellis and Bluic 2019; Han and Geng 2023). In addition, environments perceived as supportive and encouraging of deeper intellectual engagement tend to promote deep learning strategies (Baeten et al. 2010). In contrast, negative perceptions, such as those of excessive workload or inadequate support, are linked to a surface approach to learning (Kyndt et al. 2011). When teachers emphasise knowledge transmission, students are more likely to adopt a surface approach to learning (Trigwell, Prosser, and Waterhouse 1999). Despite the recognised importance, how international students' perceptions of online learning environments affect their approaches to learning remains under-explored, making empirical exploration an urgent necessity.

Relationships among online learning environments, student-instructor interactions, and approaches to learning

Learning environments are key factors influencing student-instructor interactions in online learning (Purjamshidi, Fardanesh, and Norouzi 2014). Compared with face-to-face instruction, online teaching restricts teachers' choice of feedback but increases the frequency of teacher-initiated interaction (Yang and Lin 2020). In online learning, teacher-initiated interaction is dominant, and one of the causes for this phenomenon is student passivity due to technological glitches (Abdusyukur 2024). In particular, in online learning environments where curriculum resources are accessible,

teacher-initiated interaction tends to be more frequent than student-initiated interaction (Saw et al. 2008). The improvement of online learning environments enhances the presentation of teaching content, facilitates the acquisition of learning resources, and increases both teacher- and student-initiated interactions (Zhan et al. 2021). Effective design of online learning environments is essential to foster interaction in online learning (Weidlich and Bastiaens 2017).

Previous research has also explored the relationship between interactions and approaches to online learning, but the findings are inconclusive. For example, a study on college students in the United States reported that faculty-student rapport was positively correlated with a deep learning approach and negatively correlated with a surface learning approach (Mattanah et al. 2024). In contrast, research on high-achieving undergraduate students revealed that while student-instructor interactions were positively associated with a deep learning approach, it was insignificantly correlated with a surface learning approach (Yu, Li, and Shi 2013). Similarly, Yang (2012) reported that student-centered teaching methods significantly predicted a deep approach to learning, whereas teacher dominated classrooms with limited student-instructor interactions tended to promote surface learning. Garrison and Cleveland-Innes (2005) found that, after controlling for learning environmental factors, different types and levels of interaction did not significantly influence the surface learning approach but did lead to significant shifts towards a deep learning approach.

Little research has examined how student-instructor interactions, whether teacher- or student-initiated, mediate the relationship between online learning environments and students' approaches to online learning. However, Richardson's (2006) theoretical model provides a useful framework for understanding these relationships, as it involves mediation analysis of learning behaviours between the learning environments and learning outcomes in distance education. Moreover, extensive research on international students in traditional classroom settings has shown that meaningful interactions with host teachers are crucial for enhancing academic performance and supporting intercultural learning and development (Lu and Tian 2023; Tian and Lowe 2013). Despite this, there is a lack of quantitative analysis of international students' online interactions. Little research has focused on international students in China and explored the mediating roles of teacher- and student-initiated interactions between these students' perceptions of online learning environments and their approaches to online learning.

Research hypotheses

Drawing on the research literature reviewed above, the following hypotheses were formulated and are presented in Figure 1.

H1–H4: International students' perceptions of online learning environments are positively related to a deep learning approach (H1a, H2a, H3a, H4a) and negatively related to a surface learning approach (H1b, H2b, H3b, H4b).

H5: International students' perceptions of online learning environments are positively related to teacher-initiated interaction.

H6: Students' perceptions of online learning environments are positively related to student-initiated interaction.

H7: Teacher-initiated interaction is positively related to a deep learning approach (H7a) and negatively related to a surface learning approach (H7b).

H8: Student-initiated interaction is positively related to a deep learning approach (H8a) and negatively related to a surface learning approach (H8b).

H9: Student-instructor interactions, whether teacher- or student-initiated, mediate the influences of students' perceptions of online learning environments on student approaches to learning.

Methods

Participants

A questionnaire survey was conducted for data collection between July and August 2021. Forty-one Chinese higher education institutions were invited to participate in the survey *via* a web link to the questionnaire distributed through *Wen Juan Xing*,

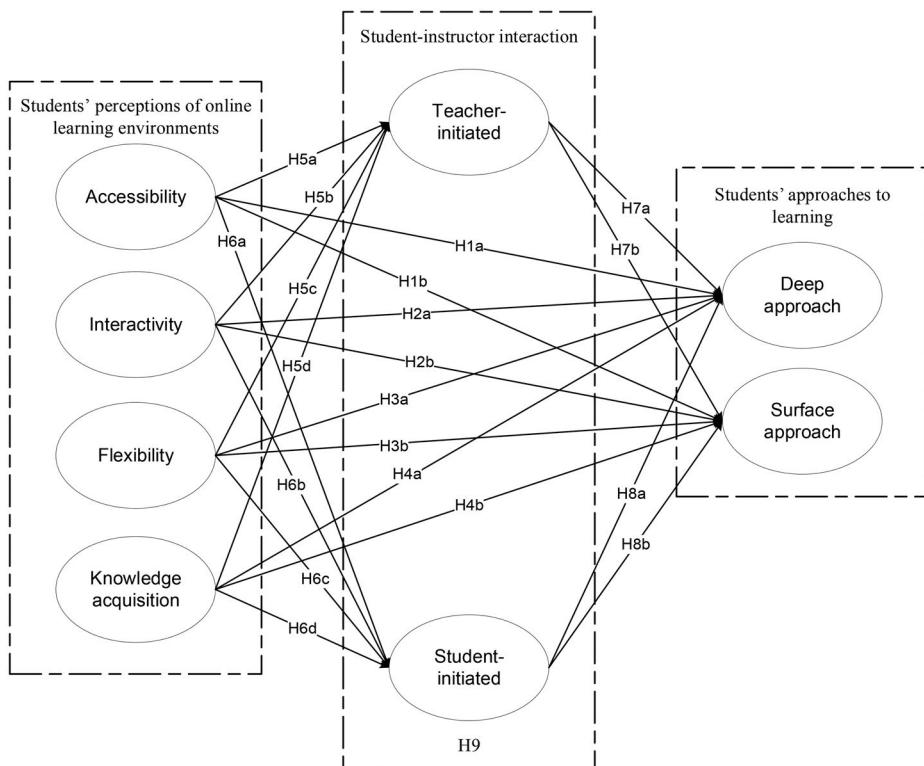


Figure 1. The hypothesised model. H9 denotes the mediating roles of teacher-initiated interaction and student-initiated interaction.

an online survey platform. The introduction section of the questionnaire clearly stated the purpose and procedure of the research, as well as the anonymity and confidentiality principles that the research abided by.

A total of 1010 responses were received. Of these respondents, 598 were males (59.2%) and 412 females (40.8%); 767 (75.9%) were from Asian countries, 161 (15.9%) from African countries, 42 (4.2%) from Europe, America, and Oceania, and 40 participants (4.0%) did not report their countries. In terms of disciplinary areas, 461 respondents (45.6%) majored in life sciences and medicine, 292 (28.9%) in arts, humanities, and social sciences, and 257 (25.4%) in sciences and engineering.

Measures

The questionnaire contained three scales: the *international students' perceptions of online learning environments* scale, the *international student and instructor interactions* scale, *international student approaches to learning* scale. Specifically, international students' perceptions of online learning environments were measured using the online learning perceptions scale developed by Wei and Chou (2020). This scale assessed four dimensions, i.e. accessibility (four items), interactivity (five items), flexibility (four items), and knowledge acquisition (four items). The accessibility dimension assessed international students' perceptions of their access to online learning resources. The interactivity dimension measured international students' perceptions of online interaction. The flexibility dimension assessed international students' perceived flexibility in their online learning experience. The dimension of knowledge acquisition assessed international students' perceptions of their abilities to acquire knowledge that broadened their horizons.

Student-instructor interactions were measured using a 10-item scale adapted from Bolliger and Martin (2018) and Kuo et al. (2014). Of these, four items measured teacher-initiated interactions, and six items measured student-initiated interactions. Following Biggs, Kember, and Leung (2001), international student approaches to learning were measured using two dimensions: deep and surface approaches, with each dimension assessed by 10 items. All items in the questionnaire were scored on 5-point Likert scales, ranging from '1 = strongly disagree' to '5 = strongly agree', except for the 20 items assessing learning approaches, which used a scale from 1 ('never or only rarely true of me') to 5 ('always or almost always true of me').

Statistical analyses

Using AMOS 23.0, confirmatory factor analysis (CFA) was conducted to test the validity of the scales. Cronbach's alpha coefficients were then calculated using SPSS 22.0 to test the reliability of the scales. Descriptive statistics (M , SD) and correlations were calculated using SPSS. Structural equation modelling (SEM) was subsequently applied to explore the relationships among participants' perceptions of online learning environments, online interactions, and approaches to learning.

Mediation analyses were conducted using AMOS to test the indirect effects of participants' perceptions of online learning environments on approaches to learning through online interactions. The bootstrapping technique (bootstrap samples = 5000) was employed to calculate confidence intervals (CIs) and test for indirect effects (Hayes 2009). If the values in the 95% CI were all positive numbers or all negative, the indirect effect was considered significant. If the value zero was included in the 95% CI, the indirect effect was considered non-significant.

To assess model fit for the CFA and SEM analyses, the Chi-square value (χ^2), the Comparative Fit Index (CFI), the Tucker-Lewis index (TLI), and the Root Mean Square Error of Approximation (RMSEA) were used. Following Schreiber et al. (2006) recommendations, thresholds of CFI > 0.90, TLI > 0.90, and RMSEA < 0.08 were adopted to determine an acceptable fit to the data.

Results

Reliability and construct validity of the scales

Table 1 presents the descriptive statistics, correlations, and reliabilities of the variables under investigation. The means of the participants' perceptions of online learning environments ranged from 2.97 to 3.29. Among these factors, accessibility scored the highest ($M = 3.13$), while interactivity was rated the lowest ($M = 2.97$). Knowledge acquisition showed the greatest variation ($SD = 1.28$). The mean scores for the two student-instructor interaction factors were 3.20 and 3.34, while the mean scores for the two student approaches to learning factors were 3.08 and 2.88.

Table 1 also presents the correlation results for the eight factors, with all factors showing significant positive correlations. The correlations ranged from moderate to high, indicating moderate to strong relationships between the factors.

Measurement model

CFA was conducted to assess the construct validity of the measurement model. As shown in Table 2, the CFA results indicated the acceptable model fit indices. The factor loadings for the participants' perceptions of online learning environments ranged from 0.855 to 0.945. The composite reliability coefficients for accessibility, interactivity, flexibility, and knowledge acquisition were 0.948, 0.956, 0.938, and 0.964, respectively, all exceeding the recommended threshold of 0.70, indicating good composite reliability. The average variance extracted (AVE) values ranged from 0.790 to 0.871, which are well above the 0.50 benchmark, indicating high convergent validity.

The factor loadings for student-instructor interactions ranged from 0.819 to 0.900. The composite reliability coefficients were 0.918 for teacher-initiated interaction and 0.941 for student-initiated interaction. The AVE estimates were 0.736 for teacher-initiated interaction and 0.728 for student-initiated interaction.

Table 1. Reliability, discriminant validity, and correlation coefficients.

	Cronbach's α	CR	AVE	1	2	3	4	5	6	7	8
1. Accessibility	0.952	0.948	0.819	0.905							
2. Interactivity	0.956	0.956	0.812	0.873**	0.901						
3. Flexibility	0.941	0.938	0.790	0.836**	0.859**	0.889					
4. Knowledge acquisition	0.964	0.964	0.871	0.849**	0.860**	0.888**	0.933				
5. Teacher-initiated interaction	0.927	0.918	0.736	0.783**	0.785**	0.717**	0.779**	0.850			
6. Student-initiated interaction	0.944	0.941	0.728	0.710**	0.701**	0.667**	0.662**	0.847**	0.853		
7. Deep approach	0.955	0.954	0.676	0.793**	0.785**	0.794**	0.813**	0.734**	0.717**	0.822	
8. Surface approach	0.930	0.927	0.562	0.506**	0.523**	0.507**	0.501**	0.495**	0.449**	0.648**	0.750
<i>M</i>				3.13	2.97	3.02	3.20	3.34	3.08	2.88	
<i>SD</i>				1.22	1.26	1.25	1.28	1.19	1.13	1.07	1.00

Bold values on the diagonal denote the square roots of AVEs, and off-diagonal values indicate the correlation matrix.
** $p < 0.01$.

Table 2. Model fit indices.

Scale	χ^2	df	p	RMSEA	CFI	TLI
Online learning environments	377.038	111	$p < 0.001$	0.049	0.989	0.986
Student-instructor interactions	126.652	29	$p < 0.001$	0.058	0.990	0.985
Student approach to learning	1157.896	162	$p < 0.001$	0.078	0.941	0.931

For student approaches to learning, factor loadings ranged from 0.633 to 0.891. The composite reliability coefficients were 0.954 for the deep approach and 0.927 for the surface approach. The AVE estimates were 0.676 for the deep approach and 0.562 for the surface approach.

As for the discriminant validity, Table 1 shows that the square root of the AVE for each construct was larger than the correlations between that construct and any other constructs, indicating good discriminant validity (Hair et al. 2022).

Structural model

The SEM results are presented in Figure 2. Overall, the model showed an acceptable fit to the hypothesised model and the data ($\chi^2 = 4337.570$, $df = 1014$, $p < 0.001$, CFI = 0.938, TLI = 0.934, RMSEA = 0.057). As shown in Figure 2, accessibility was positively associated with the deep approach ($\beta = 0.169$, $p < 0.001$), but no significant relationship was found between accessibility and the surface approach. Thus, H1a was supported, but H1b was not. Interactivity was positively associated with the surface approach ($\beta = 0.207$, $p < 0.05$), with no significant relationship found with the deep approach, thus rejecting H2a and H2b. Flexibility was positively associated with both the deep approach ($\beta = 0.169$, $p < 0.05$) and the surface approach ($\beta = 0.189$, $p < 0.01$), supporting H3a but not H3b. Knowledge acquisition was positively associated with the deep approach ($\beta = 0.351$, $p < 0.001$), with no significant relationship with the surface approach, supporting H4a but not H4b.

Teacher-initiated interaction was positively related to both accessibility ($\beta = 0.417$, $p < 0.001$) and interactivity ($\beta = 0.451$, $p < 0.001$), but no significant relationship was found with flexibility or knowledge acquisition. Thus, H5a and H5b were supported, while H5c and H5d were not.

With the exception of knowledge acquisition, the remaining three factors of international student's perceptions of online learning environments (accessibility, $\beta = 0.394$, $p < 0.001$; interactivity, $\beta = 0.247$, $p < 0.01$; flexibility, $\beta = 0.142$, $p < 0.01$) were positively associated with student-initiated interaction, supporting H6a, H6b, and H6c, but not H6d.

Teacher-initiated interaction was positively associated with the surface approach ($\beta = 0.210$, $p < 0.001$), but no significant relationship was found with the deep approach. Thus, H7a and H7b were rejected.

Finally, student-initiated interaction was positively related to the deep approach ($\beta = 0.262$, $p < 0.001$), but no significant relationship was found with the surface approach, supporting H8a but not H8b.

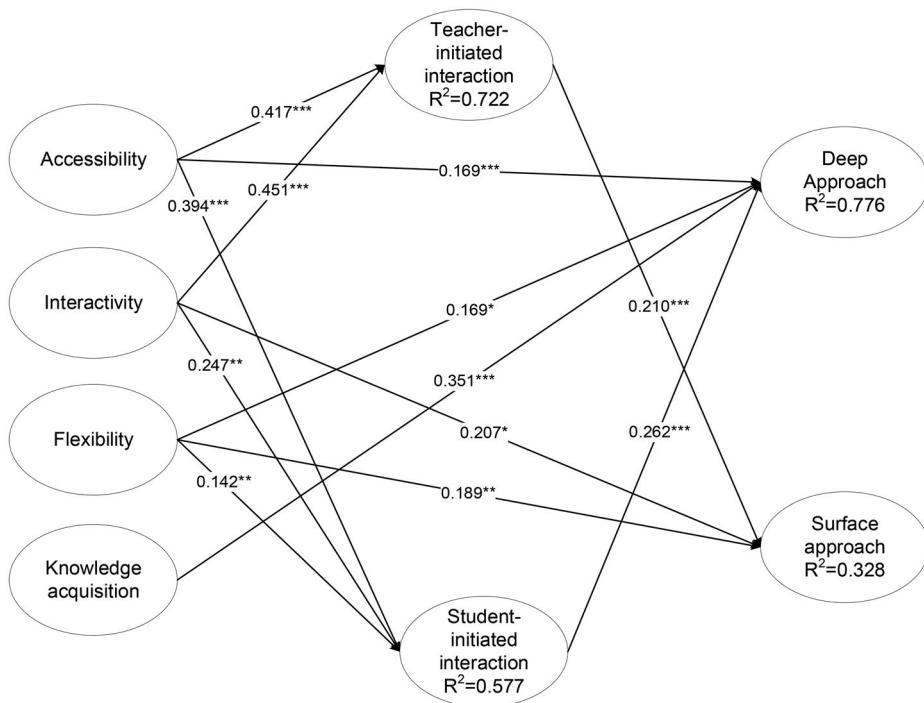


Figure 2. The SEM results model results show significant regression paths ($N=1010$).

Note: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$; paths with non-statistically significant associations ($p \geq 0.05$) are not presented.

Mediation analysis

To assess the significance of potential mediating factors, a bootstrapping test was conducted based on 5000 samples. Table 3 presents the results of the mediation analysis. The results showed that student-instructor interactions significantly mediated the relationships between international students' perceptions of online learning environments and their approaches to learning.

This study reports the standardised estimate of indirect effect, with a 95% confidence interval (CI). Table 4 shows the indirect effects of international students' perceptions of online learning environments on the deep and surface learning approach, mediated by teacher-initiated and student-initiated interactions. The mediation analysis supported H9, showing that student-instructor interactions mediated the relationships between international students' perceptions of online learning environments and their approaches to learning. Specifically, the mediation effects of teacher-initiated interaction were 0.088 (CI = [0.038, 0.158]) and 0.095 (CI = [0.043, 0.167]) for the paths from accessibility and interactivity to the surface approach. The mediation effects of student-initiated interaction were 0.103 (CI = [0.056, 0.167]), 0.065 (CI = [0.021, 0.121]), and 0.037 (CI = [0.005, 0.076]) for the paths from accessibility, interactivity, and flexibility to the deep approach. The variances explained by international students' perceptions of online learning environments and student-instructor interactions for the deep and surface approaches were 0.776 and 0.328.

Table 3. Mediation analysis of student-instructor interactions on the relationships between students' perceptions of online learning environments and student approaches to learning.

Dependent variables	Independent variables	Total effect	Direct effect	Mediation effect via student-instructor interactions
Deep approach	Accessibility	0.273***	0.169**	0.103***
	Interactivity	0.065**	—	0.065**
	Flexibility	0.207**	0.169*	0.037*
	Knowledge acquisition	0.351***	0.351***	—
Surface approach	Accessibility	0.088***	—	0.088***
	Interactivity	0.302**	0.207*	0.095***
	Flexibility	0.189*	0.189*	—
	Knowledge acquisition	—	—	—

Note. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Table 4. The estimates of indirect effects with a 95% confidence interval.

	Path	Product of coefficients			Bootstrapping bias-corrected 95% CI	
		Estimate	SE	p	Lower limit	Upper limit
1	Accessibility→Teacher-initiated interaction→Surface approach	0.088	0.030	$p < 0.001$	0.038	0.158
2	Accessibility→Student-initiated interaction→Deep approach	0.103	0.028	$p < 0.001$	0.056	0.167
3	Interactivity→Teacher-initiated interaction→Surface approach	0.095	0.031	$p < 0.001$	0.043	0.167
4	Interactivity→Student-initiated interaction→Deep approach	0.065	0.025	0.006	0.021	0.121
5	Flexibility→Student-initiated interaction→Deep approach	0.037	0.018	0.024	0.005	0.076

Discussion

Characteristics of international students' perceptions of online learning environments, student-instructor interactions, and student approaches to online learning

This study revealed important features of international students' perceptions of online learning environments, student-instructor interactions, and student approaches to online learning. The descriptive statistics indicated that among the four dimensions of online learning environments, interactivity was viewed least positively and scored lower than the median value (3), suggesting that respondents tended to disagree that online courses provided adequate opportunities for teacher-student interactions. The other three dimensions, i.e. accessibility, flexibility, and knowledge acquisition, were slightly higher than the median value (3), reflecting the tendency among the participants to agree that online courses provided access to multimedia learning resources, assisted in flexible learning by overcoming temporal or physical restrictions, and adequately supported knowledge acquisition.

The mean scores for teacher-initiated interaction and student-initiated interaction were slightly above the median value (3). While this suggests that both teacher-initiated and student-initiated interactions were somewhat above average, they were not strong enough to reflect a particularly high or positive level of interactions. In other words,

interactions occurred but lacked the depth, frequency, or positivity necessary to be considered highly engaging.

In addition, the mean score for the deep approach to online learning was slightly higher than for the surface approach, although the level of the deep approach to online learning was still low. Specifically, the surface approach to online learning scored lower than the median value (3), indicating that participants sometimes engaged in memorisation and tended to disagree that they were satisfied with merely acquiring explicit book knowledge. In contrast, the deep approach scored slightly above the median, indicating that participants tended to agree that they regularly engaged in analytical and reflective learning.

Direct effects of international students' perceptions of online learning environments and student-instructor interactions on student approaches to online learning

Using the SEM method, this research investigated the direct influences of international students' perceptions of online learning environments and student-instructor interactions on their approaches to online learning. Consistent with our hypotheses, the findings showed that accessibility, flexibility, and knowledge acquisition were positively associated with a deep approach to online learning. These findings are consistent with those of previous studies conducted in both face-to-face classroom contexts (Yu, Li, and Shi 2013) and online learning contexts, which also suggested a positive relationship between students' perceptions of their learning environments and the adoption of a deep learning approach.

However, it is worth noting that the expected benefits of interactive opportunities in online courses, such as asking questions or providing real-time feedback, did not lead to a more engaged learning approach among international students in this research. One possible explanation is that participants did not perceive their online learning environments as highly interactive. Given that the mean score for interactivity was below the median value (3), these international students tended to disagree that the online interaction opportunities were rich or effective, which may have limited their engagement in deep learning (Wei and Chou 2020).

In addition, contrary to our hypotheses, interactivity and flexibility were found to be positively related to the surface approach to online learning. The results contrast with previous research, which reported that the flexibility of online learning supported self-directed, deep learning approach (Kemp and Grieve 2014). One possible explanation is that challenges, such as internet connectivity issues, limited technological resources, and a lack of well-developed online teaching methods may have hindered international students' engagement, leading them to adopt surface learning strategies instead.

Furthermore, our findings supported one hypothesis (H8a) regarding the relationship between international students' interactions with instructors and their approaches to online learning. In addition, contrary to our hypothesis (H7b), teacher-initiated was found to be positively related to the surface approach to online learning. However, the findings did not support H7a or H8b. Specifically, this study

revealed that student-initiated interaction significantly predicted an increased tendency to adopt a deep approach to online learning, but did not reduce the likelihood of engaging in surface learning. This suggests that while student-initiated interaction was present, they may have lacked the depth or focus necessary to fully discourage surface-level learning practices, as prior research has noted that effective interaction quality plays a key role in supporting deeper engagement (Garrison and Cleveland-Innes 2005).

Another noteworthy result is that while the teacher-initiated interaction significantly predicted the surface approach to online learning, it did not significantly promote a deep approach. This result indicates that although teachers likely provided structured support—such as guiding tasks or facilitating discussions—that supported students' completion of immediate learning and tasks, this type of interaction did not substantially encourage deep learning. The reason may be that teacher-initiated interaction, while helpful for immediate tasks, such as answering pre-designed questions, was not designed to foster critical thinking or self-driven exploration among international students in an online setting.

The mediating role of student-instructor interactions

This research conducted the SEM analysis to explore the relationships between international students' perceptions of online learning environments and approaches to online learning through student-instructor interactions. The results confirmed the hypothesis that participants' interactions with instructors mediated the relationship between their perceptions of online learning environments and approaches to online learning. Specifically, student-initiated interaction was found to mediate the effect of students' perceptions of online learning environments on their deep approach to online learning. The results indicated that student-initiated interaction, enhanced by perceived accessibility, interactivity, and flexibility of online learning environments, was positively related to the deep learning approach.

Contrary to the hypothesis (H7b), teacher-initiated interaction was positively associated with the surface approach. Mediation analysis revealed that two out of the four dimensions of participants' perceptions of online learning environments, i.e. accessibility and interactivity, had a significant indirect impact on the surface approach, mediated by teacher-initiated interaction. In other words, accessibility and interactivity enhanced the surface approach to online learning through teacher-initiated interaction. The results suggest that teaching and instructions adaptable to individual students' learning needs remain insufficient in online courses (Sun and Chen 2016).

Limitations and recommendations for future research

The present study has several limitations. First, the cross-sectional design limits the ability to infer causal relationships between the variables of interest. Future research may adopt a longitudinal design to verify the paths identified in the present study. Second, this study relied solely on questionnaire data. Future studies may incorporate different data sources to assess international students' online learning approaches

and triangulate the findings. Additionally, this study did not consider participants' nationality, gender, or disciplinary background. Future research can explore how demographic factors influence international students' online learning experiences. Finally, this research focused on students' perspective, which is valuable in its own right. To provide a more comprehensive understanding, future research is encouraged to investigate institutional practices and pedagogical innovations, particularly from the viewpoints of administrators and instructors.

Conclusion

Since the COVID-19 outbreak, online education has become an increasingly distinctive feature of higher education systems worldwide, and China has played a leading role in this global transformation. Supported by decades of investment in information and communication, Chinese universities have built extensive digital infrastructures and innovative instructional models that continue to reshape teaching and learning practices. Nevertheless, little research attention has been devoted to understanding how students, particularly international students dispersed across borders, actually experience and engage with these online learning environments.

Drawing on data from a nationwide survey of 1010 international students at 41 Chinese higher education institutions, the present research revealed important characteristics of international students' perceptions of online learning environments, interactions with instructors, and approaches to online learning, as well as positive correlations between perceived online learning environments, interactions with instructors, and approaches to online learning. The SEM analysis showed that three online environmental dimensions, along with interaction initiated by international students, had significant direct effects on the deep approach, while two online environmental dimensions and teacher-initiated interaction had direct effects on the surface approach. Mediation analysis further confirmed that student-instructor interactions served as significant mediators between international students' perceptions of online learning environments and their approaches to online learning.

These findings offer insights for improving online learning and teaching in higher education in China and beyond. To foster a deep approach to online learning among international students, it is suggested that universities create and maintain positive online learning environments, ensure access to online learning materials, and enhance international students' opportunities for knowledge acquisition. Secondly, this research revealed that insufficient interactivity hindered deep learning, while environmental accessibility, interactivity, and flexibility promoted it through student-initiated interaction. These findings confirm that effective interaction is crucial for enhancing engagement and improving academic performance in online environments, highlighting the importance of online course design that genuinely promotes interactivity and engagement to better support international students' learning.

Besides, the results indicated that teacher-initiated interaction alone did not enhance deeper, reflective learning but mediated the relationships between environmental accessibility, interactivity, and surface learning. To address these, faculty could design activities that stimulate student initiative, such as open-ended questions,

collaborative projects, and reflective tasks, whilst maintaining flexibility to support self-directed learning.

Interaction, by its nature, involves social and psychological connections. Given its significance in online learning, it is crucial for host universities and faculty to encourage, coordinate, and scaffold intercultural interaction. Supporting international students in establishing online learning communities, fostering long-term bonds, and ultimately achieving intercultural development through online learning should be a top priority.

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Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding authors.

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