Received: 2 November 2023 | Revised: 22 June 2024 | Accepted: 30 June 2024

DOI: 10.1111/hequ.12560

RESEARCH ARTICLE

Higher Education Quarterly WILEY

Online space for learning: Perceived educational environment typology, interpersonal interaction typology, and their relationship to international students' ability development in Chinese universities

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Abstract

The ways in which learning environments are spatially conceived have undergone a significant transformation from *space* as "a realm without meaning" into *place* as "a meaningful location." In this context, the relevance of online interactions and the significance of online space and place in facilitating positive learning are worth exploration. Drawing on a nationwide survey involving 1010 international students at 41 Chinese HEIs in the COVID-19 pandemic, this research applied k-means cluster analyses which produced a typology of international students' perceived online educational environments and another typology of their online interpersonal interactions. The logistic regression results indicated the predictive power of both typologies on ability development. The discussion highlights the importance of considering spatial dimensions of international students' online learning. Promoting international students' online interactions and supporting inclusive, engaging learning experiences require both *space* for hosting and *place* enabling intercultural learning. The research holds implications for the sustainable development of online international education in the post-COVID-19 era.

1 | INTRODUCTION

In September 2015, the United Nations Educational, Scientific and Cultural Organization (UNESCO) launched the 17 Sustainable Development Goals (SDGs), highlighting the pressing need to confront the challenges that our planet faces and calling for globally collective efforts to shift the world toward a sustainable and resilient future (United Nations, 2024a). Higher Education for Sustainable Development (HESD) is the response of UNESCO's higher education sector to the global challenges (UNESCO, 2024). HESD stands at the forefront of achieving these SDGs by cultivating knowledge and skills required for sustainable development, especially in areas such as justice and cultural diversity (United Nations, 2024b). While higher education remains critical for enriched learning and empowerment, the outbreak of COVID-19, which led to the massive transition of over 1.5 billion students from traditional face-to-face learning to online learning, challenges positive educational experiences and outcomes. In this public health crisis, international students are the most vulnerable population group, who have to cope with information technology and navigate online education with limited preparation, while facing financial and social challenges due to their immigration status (Firang, 2020).

To explore international students' online learning experiences in COVID-19, China offers an illustrative case for the following three reasons. Firstly, before the pandemic, China had firmly established itself as a global leading international education provider. In 2018, a total of 492,185 students from 196 different nations enrolled in 1004 Chinese higher education institutions (HEIs, Ministry of Education of China [MoE], 2019). Secondly, China was among the first countries adopting emergency online education in the pandemic. In response to the national policy of "continuing teaching while suspending in-person classes" released on February 5th, 2020 (gov.cn, 2020), Chinese HEIs mandated all teaching activities transition to online modes, involving both domestic and international student bodies. Thirdly, China has enforced the most stringent pandemic-related prevention and control measures. Although Chinese HEIs resumed class teaching for domestic students by fall 2020, the absolute majority of international students, as of Spring 2023, remained unable to return to their Chinese campuses, thereby depending fully on online instruction (Wen & Tian, 2022). Given the large population of international students involved in online education at Chinese HEIs, it is imperative to investigate their online learning experiences, an area that presently lacks adequate research.

The way how educational environment is conceived of has recently undergone a significant transition from a mere *space* to a more engaged *place*. Lamb and Vodicka (2018, p.15) articulated this distinction by positing that while space denotes "a realm without meaning," place represents "a meaningful location." It is worth noting that in this research, following Lamb and Vodicka (2018, p.15), we interpret "space" as an abstract and undifferentiated realm where activities take place, but the realm itself lacks inherent meaning or specific characteristics that define it. In contrast, we interpret "place" as a space imbued with meaning and significance, transformed through human engagement and interactions, thus making an "abstract realm" a "meaningful location." The provision of space alone is inadequate for fostering learning; an educational setting needs to evolve into an engaging and social place to facilitate positive learning outcomes (Wahlstedt et al., 2008).

Moreover, in this research, educational "environment" is interpreted as involving both the abstract aspects of "space" and the meaningful aspects of "place." It is a holistic concept that embraces both the physical or technical settings (space) and the socio-emotional significance (place) that students attach to these setting. Online educational environments, while being commonly perceived as static spaces for information exchanges via electronic devices and internet technology, can be transformed into places where students construct meaning and cultivate social connections therein (Wahlstedt et al., 2008). For international students located in disparate geographical regions, this transformation of the online space into a place ensures effective learning, reducing social distance and helping to create and sustain a sense of inclusiveness. In this context, understanding international students' perceptions of online educational settings and their online interpersonal interaction within the settings becomes crucial in analysing the emergence of this "placeness," and hence, worth exploration.

The present research adopted a typological approach and explored whether, and how, international students' positive online learning was associated with their perceptions of and interpersonal interactions within online educational environments. The person-centred typological approach, as contrasted with the variable-centred approach, allows nuanced understandings of learner differences while providing research findings which are generalizable through statistical analysis (Lu & Wen, 2024).

Additionally, in this research, positive online learning is assessed by international students' ability development. The Chinese concept "nénglì fāzhǎn" (literally translated as "ability development") is an umbrella term, covering the development of skills and abilities that are essential for enhanced academic performance. This Chinese concept often involves the development of cognitive skills and abilities, such as mathematical skills, reading comprehension, and quantitative reasoning abilities; meta-cognitive skills and abilities, such as critical thinking; and non-cognitive abilities, such as self-understanding and self-knowledge (Lu & Wen, 2024). In the current research, we also assess international students' development of global abilities, particularly their abilities to understand cultural differences and the complexity of international issues. The Chinese "ability development" is related to, but different from, the internationally discussed concept of "competence," which is often restricted to specific contexts and reflects individuals' potential to perform specific activities in meaningful task domains (Koeppen et al., 2008).

Data for this study were generated by a nationwide survey undertaken in the COVID-19 pandemic, involving 1010 international students at 41 full-time Chinese HEIs. The survey research sought to address the following questions:

1. What typologies can be derived which meaningfully differentiate the respondents' perceived online educational environments and online interpersonal interactions into distinct types?
2. Can the types of the respondents' perceived online educational environments predict their positive learning outcomes specifically measured by ability development?
3. Can the types of the respondents' online interpersonal interactions predict their positive learning outcomes specifically measured by ability development?

2 | INTERNATIONAL STUDENTS AND ONLINE EDUCATION IN CHINA OVER THE PANDEMIC

The outbreak of COVID-19 in early 2020 marked the beginning of an unprecedented public health emergency in China (State Council of China, 2020). In an effort to control and prevent the spread and impact of the pandemic, on February 5th, 2020, the Ministry of Education of China enacted the policy of "suspending classes without stopping learning." The policy extended to both local and international students, upholding educational continuity by transitioning to online learning. According to statistics released by the China Association of Foreign Student Association (CAFSA), during the initial phase of the pandemic, among all international students registered with 438 CAFSA member institutions, 45,785 stayed in China for the winter break. Another 41,256 were dispersed globally, who returned to their home countries but had to remain there due to international travel bans (Wen & Tian, 2022).

China's investment in information and communication technologies (ICT) over the past decades laid the groundwork for the rapid transition to online education in the pandemic. The national education excellence initiatives, including the "211 project," "985 project," and the current "double-first-class" scheme, have stressed the digitalization of higher education. The "10-year development plan of ICT in education" released in 2012 (MoE, 2012) and the "13th five-year plan for ICT in education" released in 2016 (MoE, 2016) proposed the strategic measures to promote the application and development of ICT in education with Chinese characteristics, leading to the construction of public online learning platforms, national and provincial-level "model" online courses, and Massive

Open Online Courses (MOOCs, Wang et al., 2018). Despite these measures, the sudden shift to online education during the pandemic presents challenges to Chinese HEIs, including inadequate infrastructure, a deficit in high-quality online courses, and a lack of faculty experience with digital pedagogies (Zhang et al., 2020).

By the spring of 2023, the persistence of these challenges was evident: the majority of international students staying outside China were unable to return to Chinese campuses, thereby extending their reliance on online learning. The prolonged online education presents significant challenges to these students, as well as to Chinese administrators and local faculty. The exploratory, unstructured interviews conducted by this research team yielded findings pinpointing international student interviewees' dissatisfaction with online learning environments and interpersonal interaction, leading to concerns about whether the online space effectively supports learning among international students in China (Tian & Lu, 2022). Given the small sample size of the interview study, which allows for few generalizable conclusions, it is urgent to conduct quantitative research to further illuminate international student perceptions and interpersonal interactions in the online educational space.

3 | NOTIONS OF SPACE AND PLACE

Space serves as the "structure of the world," representing the "three-dimensional environment" where objects establish their relative locations and directional relationships (Harrison & Dourish, 1996, p. 68). Features inherent to space include spatial organization, which defines how objects and entities are distributed in relation to one another within physical or geographical confines. Additionally, it encompasses proximity, denoting the nearness or adjacency of entities, partitioning which segments large spaces into functional sections, and presence, which signifies a state of being within a specific location (Harrison & Dourish, 1996).

In contrast, while place exists within space, it transcends merely being "a point in space" (Platts-fowler & Robinson, 2015, p. 69). A place is not limited to a geographic location or a physical setting; it surpasses even the crucial access to resources and facilities within that location. Places are imbued with social relationships, meanings, and values: "A place is generally a space with something added—social meaning, convention, cultural understandings about role, function and nature and so on" (Harrison & Dourish, 1996, p. 69). Place bears with it the significance in social analysis; here the emphasis shifts from spatial features to understanding, perception, and interpretation which become the prime focuses of social investigation. Such research delves less into the three-dimensional "structure," but is interested in the lived human experiences within the structure. It explores how individuals perceive their senses of place (or experience feelings of "outsideness"), and how such perceptions bring about (or hinder) changes and developments (Platts-fowler & Robinson, 2015).

4 | TURNING ONLINE SPACE INTO LEARNING PLACE

Over recent decades, advancements in information technology have led to a large volume of research on remote, distance, and online learning. While definitions vary, the online educational environment is frequently conceptualized as a digital and technical space where information is disseminated, and courses are delivered via user interfaces, servers, web applications, and networking technologies (e.g., Caprara & Caprara, 2022). It has been argued that, despite significant investments in electronic devices and internet-based technologies, an over-emphasis on the design and maintaining of these online spaces has often overshadowed the need for an in-depth understanding of learners' needs and perceptions. This imbalance can potentially reduce the usability of online platforms, inhibit learner-centred pedagogy, or hinder collaborative learning (Wahlstedt et al., 2008).

Building upon the insights of Wahlstedt et al. (2008), this research interprets the online educational environment not merely as a digital, technical space, but as a dynamic place where learning emerges, shaped by learners' perceptions of online contexts and their active social interactions with peers and teachers. Such a perspective

recognizes both materialistic/digital and interpretive dimensions of the online educational environment. While the materialistic/digital presence can exhibit temporary stability, the interpretive aspect, rooted in the sense of the place, is inherently changeable and unavoidably subject to individual differences (Gieryn, 2000). In other words, the online educational environment, while containing devices, platforms, and internet-based technology, transcends its physical, digital, or technical characteristics. Instead, it evolves as a repository of meanings and values. The emergence of human senses of place cannot be pre-designed, but is based on learners' perceptions of the online environment and their online interpersonal interactions (Wahlstedt et al., 2008). Subsequent sub-sections will discuss these two prerequisites for the transformation of online space into learning place.

4.1 | Perceived online educational environments

Human engagement in the digital space, leading to the emergence of a sense of place or the feeling of "outsideness," includes individuals' perceptions of online learning environments mediated by reflexivity (Gieryn, 2000). "Space is the opportunity, and place is the understood reality" (Harrison & Dourish, 1996, p. 71). Empirical studies have illuminated how learners attribute meaning to their online education experiences. A positive perception, fostering a sense of place, supports effective learning. For example, learners have stressed the importance of easy access to multimedia educational resources in facilitating autonomous, self-directed exploration in online courses (Bouhnik & Marcus, 2006). The flexibility as a benefit of online education, overcoming temporal and spatial constraints, is frequently appreciated by students (Stone et al., 2019). Furthermore, the potential of web-based technology to enhance reflective learning and knowledge acquisition is acknowledged (Petrides, 2002). Synchronous or asynchronous communication opportunities provided by online courses have been linked to enhanced learning performance and exam scores (Wei et al., 2015).

In contrast, feelings of alienation or "outsideness" in the online space are likely to impede effective learning. Common critiques of online space voiced by learners involve the hard-to-use online learning platforms, unclear or inconsistent course structure, insufficient or inaccessible content, and inadequate online pedagogy (Palvia et al., 2018). Such critiques explain the research observations of higher dropout rates in online courses compared to traditional classroom teaching (Spitzer, 2001). These insights illuminate that students are not merely passive receivers of whatever is designed and presented in online courses. They actively engage, interpret, and navigate online educational environments in which they are situated. It is students' perceptions and interpretations, rather than the digital, technical space itself, that enable or hinder learning quality.

Adopting a typological approach, previous studies have explored learners' types in online education, revealing the broad diversity of learners regarding their uses of technology in education. For example, Van den Beemt et al. (2011) performed cluster analysis to categorize 2138 Dutch youngsters, who were intensive users of interactive media, into four distinct types: traditionalists, gamers, networkers, and producers. Eynon and Malmberg (2011) adopted latent profile analysis and segmented 1000 British youth based on their internet usage into four categories: peripherals, normatives, all-rounders, and active participators. Conducting structured interviews followed by cluster analysis, Stevens et al. (2018) grouped 16 British college students into two groups: traditional online learners and independent online learners.

Within the context of Chinese higher education, Tao (2008) applied k-means cluster analysis to categorize 145 undergraduate students in Taiwan into two distinctive cohorts: sceptics and optimists. The sceptics, constituting 50.9% of the respondents, held negative perceptions of online learning environments, while the remaining 49.1% of the sample, identified as optimists, positively perceived online courses. It is noteworthy that the questionnaire instrument used in Tao's study was initially developed to capture the perceptions of Chinese faculty, thereby including broader descriptors of online learning environments, for example, the perceived benefits regarding teaching and supervising classes, resource distribution, institutional strategy, and competitive positioning. Despite the contribution of typological research, there remains a scarcity of studies focusing on the perceptions of

international students. Aiming to close this gap, the current research performs k-means cluster analysis, exploring the types of international students' perceived online educational environments at Chinese universities and discussing the consequent impact of these perceptions on their learning.

4.2 | Online interpersonal interactions

Place derives meaning not only from learners' interpretations of non-human space but also from interpersonal interactions that occur within the space. Interpersonal interaction in educational contexts is defined as two-way contact for exchanges of information and construction of meaningful ideas, playing a significant role in successful learning (Baber, 2022). Constructivist scholars have emphasized that learning is best achieved through learners' working together (Vygotsky, 1978). Applying the constructivist theory to education has generated rich knowledge of the value of interactions among students and between students and teachers (Anderson, 2003). In online environments, research has documented a positive association between the frequency and intensity of interpersonal interactions and effective learning (Burnett et al., 2007; Sher, 2009). Empirical evidence confirms the benefits of online learner-instructor interactions, particularly in terms of guidance and feedback, for student effective learning (Anderson, 2003; Sun et al., 2022). Furthermore, research has proven the positive relationship between collaborative online learning activities—such as discussion, debate, and teamwork—and enhanced academic performance, course satisfaction, and student persistence (Faja, 2013). Online interactions have also been found to foster bonding between students and teachers, which in turn supports positive learning (Sarapin & Morris, 2015).

Despite these pedagogical benefits, literature has also identified some challenges to interpersonal interactions in online courses. For instance, students may exhibit a reluctance to communicate online (Gunawardena & Zittle, 1997), and teachers may not be adept at facilitating such communication (Moeller & Reitzes, 2011). Research conducted in the COVID-19 pandemic revealed a lack of learner-instructor interaction and poor peer communication as primary challenges in the emergency online education (Xia et al., 2022). Insufficient interpersonal interactions can exacerbate social distance and the feeling of isolation that online learners often experience, leading to a sense of being an "outsider," which negatively impacts online learning outcomes (Palvia et al., 2018).

Moreover, existing research has performed cluster analyses to investigate interpersonal interaction typologies within traditional, face-to-face educational contexts—ranging from science learning (Rickards et al., 2005) to mathematics (e.g., Maulana et al., 2012), as well as second language acquisition (e.g., Tajeddin & Kamali, 2020) across diverse cultural settings, including America (Wubbels & Levy, 1991), Australia (Rickards et al., 2005), and Turkey (Telli et al., 2007). However, such interaction typologies have been less frequently explored within online learning environments. Regarding Chinese higher education contexts, only one typological study has been identified (i.e., Yin & Shi, 2022). This cluster analysis categorized the Chinese sample engaged in both face-to-face and online learning into passive, active, digital, and realistic interactors, noting a preference for online engagement among digital interactors, whereas the other types favoured face-to-face interaction. To the best of our knowledge, no research has been conducted on the typologies of international students' online interpersonal interactions within Chinese HEIs. There is little understanding regarding the relationship between these students' online interpersonal interaction types and their learning outcomes.

5 | MARGARET ARCHER'S MORPHOGENETIC APPROACH

To further explore the transformation of online educational environments into "place," as opposed to static spaces, through social interactions and meaning construction, the research draws upon Margaret Archer's

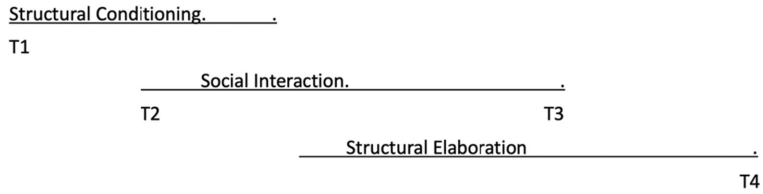

FIGURE 1 Basic morphogenetic sequence (Archer, 2020, p. 142).

morphogenetic approach (Archer, 2010). This approach serves as a methodological extension of the social ontology grounded in critical realism (Archer, 2020). The morphogenetic approach explains the dynamic interplay between structure and agency diachronically across varied time scales, outlining three sequential temporal phases: structural conditioning, social interaction, and structural elaboration (Archer, 2020). Figure 1 presents a single morphogenetic cycle based on two prepositions: firstly, structure logically antecedes the human actions that transform it (T1), and secondly, structural modifications and evolutions logically follow these actions, marking the commencements of a subsequent morphogenetic cycle (T4). As shown in Figure 1, while structure can be temporarily stable (T1), human agents, by immersing themselves in interactions with the structure (T2-T3), bring about structural elaboration (T4).

Archer's morphogenetic approach posits space as an inherent precondition for learning. Once course designers architect online modules, aspects such as the courses' technical features, delivery platforms, and pedagogical arrangements are set for a certain period of time. In addition, Archer posits learners as active agents who can "design and determine their responses to the structured circumstances in which they find themselves, based on what matters to them personally" (Archer, 2007, p. 11). It is through this engagement with online settings and social interactions with peers and teachers that individual learners assign meanings to spaces. This approach guides the present research toward examining how international students' perceptions and interpersonal interactions transform the pre-existing digital, technical spaces into places conducive to learning. It is worth noting that, although the process of place-making is endless—as Archer's T4 suggests—due to the scope constraints, this research will centre on the interplay between human agency and structure during T2–T3, while structural elaboration will not be the research focus.

6 | METHODOLOGY

6.1 | Participants

In the summer of 2021, we conducted a web-based questionnaire survey at 41 Chinese HEIs affiliated with CAFSA. To address the regional disparities in China's international education sector, we intentionally sampled universities from the developed eastern regions, the central regions, and the less-developed western regions. The sample comprised 41 universities across these regions, which were chosen through convenience sampling due to existing connections established by the research team in pre-pandemic surveys (see Tian et al., 2021). When the research was conducted, these institutions had shifted to the emergency online education for their international students. Prior to the conduction of the survey, research permission was obtained from international offices or schools of international education at the participating institutions. These institutions informed all their international students of the online survey link at the *WenJuanXing* survey platform. In the cover letter of the questionnaire, the research aim and objectives were fully explained, and the voluntary participation and confidentiality principles were emphasized. In total, 1010 valid responses to the questionnaire were received. The demographic details of these respondents are presented in Table 1.

TABLE 1 Participant demographic profiles.

Category	Frequency	%
Gender		
Male	598	59.2
Female	412	40.8
Total	1010	100.0
Prior online learning experience		
Yes	242	24.0
No	768	76.0
Total	1010	100.0
Continent of origin		
Asia	768	76.0
Africa	161	15.9
Europe, America, and Oceania	42	4.2
Missing value	39	3.8
Total	1010	100.0
Discipline		
Life sciences and medicine	292	28.9
Sciences and engineering	257	25.4
Life sciences and medicine	461	45.6
Total	1010	100.0
Medium of instruction		
Chinese-medium-instruction courses	321	31.8
English-medium-instruction courses	689	69.2
Total	1010	100.0

6.2 | Measures

The online questionnaire adopted in this study consisted of three major sections. The first section was to gather respondents' demographic information. In the second section, the Online Learning Perception Scale (Wei & Chou, 2020) was employed to measure respondents' perceptions of online educational environments in the following dimensions, i.e., perceived accessibility of multi-media learning sources, perceived interactivity facilitating interpersonal communication, perceived flexibility of online education, and perceived effectiveness in supporting knowledge acquisition. This section also measured respondents' interactions with peer learners and with their teachers online, as noted in studies by Bolliger and Martin (2018) and Kuo et al. (2014).

The third section measured positive learning outcomes using the Student Experience at Research University (SERU-International, 2023) scale on ability development in the following three dimensions, i.e., core skills, research capacities, and Chinese proficiency and global abilities. Respondents were asked to compare their skills and abilities at the start of their online courses with their current status at the time of the survey to determine the value added. All items in the second and third sections of the questionnaire were scored using a five-point Likert scale, ranging from 1 indicating “strongly disagree” or “poor” to 5 indicating “strongly agree” or “good.” Adjustments were made to the original scales, including the addition of one item to measure international students' proficiency in the Chinese language and the modification of certain expressions to better suit the aim of the current research.

Table 2 presents example items for each dimension of perceived online educational environment, online interpersonal interaction, and ability development scales.

6.3 | Data analysis

Confirmatory factor analysis (CFA) was employed using AMOS 22.0 to assess the construct validity of the measures. To evaluate the reliability of the measures, the Cronbach's alpha coefficients were computed. Descriptive statistical analysis was conducted using SPSS 22.0 to calculate the means and standard deviations of item responses.

Subsequently, the research performed cluster analyses to explore patterns of the participants' responses regarding their perceived online educational environments and online interpersonal interactions. This involved an iterative series of k-means analyses using SPSS 22.0. Given the exploratory nature of the k-means method, the research specified two, three, four, and five interaction clusters for extraction. Through this iterative analysis, distinct patterns related to the perceived online educational environments and online interpersonal interactions emerged. This research then conducted a Chi-square test to examine the relationships between types of perceived online learning environments and types of online interpersonal interactions. Finally, multinomial logistic regression analysis was performed to explore the impact of each type of perceived online learning environments and online interpersonal interactions observed in the clusters on ability development.

TABLE 2 Measurement scale.

Scale	Dimension	Number of items	Example item
Perceptions of OEE	Accessibility	4	My online course provided various multimedia learning resources
	Interactivity	5	My online course provided convenient tools to communicate with my classmates
	Flexibility	4	My online course overcame time and place constraints
	Knowledge acquisition	4	My online course enabled me to understand an abstract idea or concept
OII	Learner–learner interaction	12	Group activities during my online classes gave me chances to interact with my classmates
	Learner–instructor interaction	10	I received enough online feedback from my teachers
Ability development	Core skills	4	Analytical and critical thinking skills
	Research capacities	6	Ability to prepare and make a Presentation
	Chinese proficiency and global abilities	5	Chinese language proficiency

Abbreviations: OEE, online educational environments; OII, online interpersonal interactions.

7 | RESULTS

7.1 | Validity, reliability, descriptive statistics, and correlations

As a preliminary assessment, confirmatory factor analysis (CFA) was performed to verify the structures of the perceived online educational environment scale, online interpersonal interaction scale, and ability development scale. The goodness-of-fit indices used in the analysis were chi-square statistic (χ^2), root mean square error of approximation (RMSEA), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI). Schreiber et al. (2006) suggested benchmarks of RMSEA <0.08, CFI >0.90, and TLI >0.90 as thresholds for indicating an acceptable model fit. As presented in Table 3, the CFA results demonstrated an acceptable data fit for the scales, with RMSEA values ranging from 0.039 to 0.054, CFI values from 0.979 to 0.999, and TLI values from 0.975 to 0.997.

Cronbach's α coefficient for all factors were calculated and are presented in Table 4. Pallant (2020) suggested that a reliability coefficient exceeding .8 is an acceptable threshold in social science studies. The reliability coefficient factors in this research ranged from .918 to .970, indicating good internal consistency of the three scales. Besides, the composite reliabilities (CR) values ranged from 0.908 to 0.969, surpassing the recommended threshold of 0.7, and the average variance extracted (AVE) values ranged between 0.622 and 0.871, surpassing the threshold of 0.5 (Bagozzi & Yi, 1988). Hence, the convergent validity was established.

The descriptive statistics are also summarized in Table 4. The means of the perceived online educational environment factors ranged between 2.97 and 3.13. The means of online interpersonal interaction factors were respectively 3.14 and 3.29. The ability development factors' means ranged between 3.11 and 3.24. Among all factors, learner–instructor interaction had the highest mean (3.29), whereas perceived online course interactivity had the lowest mean (2.97), lower than the median (3). The results showed that although international students were most likely to value online interaction with their course teachers, they were least likely to agree that online courses provided adequate opportunities to support interpersonal interactions.

In addition, the correlation analysis showed all factors were significantly correlated ($p < .01$), as presented in Table 4. All correlation coefficients were higher than .6, indicating moderate to high levels of positive correlations among all factors (Akoglu, 2018).

7.2 | Cluster analysis: International students' perceived online educational environments

When applied with two, three, four, or five pre-set clusters to extract, the research iteratively employed k-means cluster analysis. The exploratory cluster analysis revealed significant differences in perceived online educational environment factors among the clusters generated by a three-cluster solution, confirming the appropriateness of this three-cluster model. Thus, respondents' perceived online educational environments were interpreted as three

TABLE 3 Model fit indices.

Scale	$\chi 2$	df	*p*	RMSEA	CFI	TLI
Perceptions of OEE	377.038	111	<.00	0.049	0.989	0.986
OII	909.933	266	<.001	0.049	0.979	0.975
Ability development						
Core skills	7.896	2	.019	0.054	0.998	0.994
Research capacities	17.552	7	.014	0.039	0.997	0.994
Chinese proficiency and global abilities	6.427	3	.093	0.039	0.999	0.997

Abbreviations: OEE, online educational environments; OII, online interpersonal interactions.

TABLE 4 Reliability, discriminant validity, descriptive statistics, and correlation coefficients.

	CR	AVE	1	2	3	4	5	6	7	8	9
1. Accessibility	.948	.819	.952								
2. Interactivity	.956	.812	.873**	.956							
3. Flexibility	.938	.790	.836**	.859**	.941						
4. Knowledge acquisition	.964	.871	.849**	.860**	.888**	.964					
5. Learner—learner interaction	.969	.724	.761**	.777**	.719**	.721**	.970				
6. Learner—instructor interaction	.959	.698	.769**	.765**	.715**	.716**	.879**	.960			
7. Core skills	.927	.760	.760**	.750**	.733**	.793**	.682**	.692**	.923		
8. Research capacities	.908	.622	.776**	.756**	.745**	.788**	.713**	.722**	.908**	.943	
9. Chinese proficiency and global abilities	.914	.684	.745**	.738**	.737**	.760**	.686**	.685**	.877**	.910**	.918
Mean			3.13	2.97	3.02	3.02	3.14	3.29	3.11	3.24	3.17
Standard deviation			1.22	1.26	1.25	1.28	1.12	1.11	1.15	1.14	1.13

Note: Numbers on the diagonal denote Cronbach's α value, and numbers that are not on the diagonal indicate the correlation matrix.

**$p < .01$.

distinct types. Figure 2 presents the mean scores of each perceived online educational environment dimension across the three types.

Cluster 1 ($n = 328$, 32.5%) was named "positive perceptions of online educational environments." This cluster was characterized by the above-average means of the four online educational environment factors. On average, international students in this group held positive views of online courses in terms of accessible multi-media learning resources, opportunities for both synchronous and asynchronous interpersonal interactions, flexibility in overcoming time and space constraints, and the chances to acquire academic knowledge despite the suspicion of classroom instruction in the pandemic.

Cluster 2 ($n = 415$, 41.1%) was named "neutral perceptions of online educational environments," characterized by around average means of the four online educational environment factors. International students in this group recognized both the benefits and challenges of online learning. They neither agreed nor disagreed that their online courses offered adequate access to multimedia resources, provided technology-mediated opportunities for interpersonal communication, allowed flexibility in learning, or expanded their knowledge scope.

Cluster 3 ($n = 267$, 26.4%) was named "negative perceptions of online educational environment," characterized by far-below-average means of the four online educational environment factors. International students in this group held negative views of online education. On average, they tended to strongly disagree that their online courses offered easy access to online learning materials, provided opportunities for interpersonal interactions, allowed flexible learning, or adequately supported knowledge acquisition.

7.3 | Cluster analysis: International students' online interpersonal interactions

The research repeatedly performed k-means cluster analysis with various preset numbers of clusters, specifically two, three, four, and five. The exploratory cluster analysis revealed significant differences across the two online interpersonal interaction factors within the clusters generated by the three-cluster solution. Hence, the

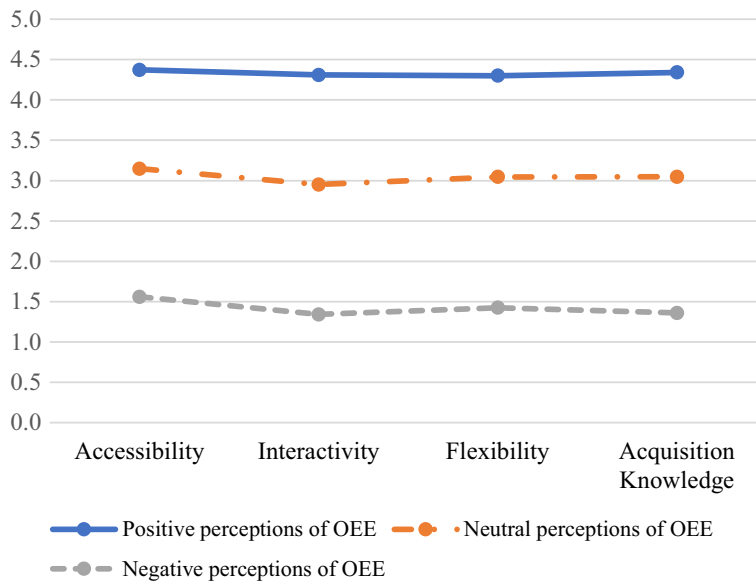

FIGURE 2 Typology of international students' perceived online educational environments. OEE, online educational environments.

respondents' online interpersonal interactions were classified into three distinct categories. Figure 3 illustrates the graphical presentation of the cluster profiles.

Cluster 1 (n=352, 34.9%) was named "proactive online interpersonal interactions." It was characterized by high means of the two online interaction factors. International students in this group reported extensive interaction with classmates and teachers in online courses. Through various electronic means, these socially active interactors sought opportunities to share ideas with peers, answer each other's questions, comment on each other's opinions, participate in collaborative projects and group discussions, and offer or request peer help when needed. They were eager to interact with course teachers online, actively asking teachers questions, responding to questions posted by teachers, and seeking help. These respondents also reported that they had received timely feedback from their teachers.

Cluster 2 (n=443, 43.9%) was named "moderate online interpersonal interactions," characterized by around average means of the online interaction factors. Students in this group were found in a middle ground between active and insufficient interactions. They tended not to actively pursue social interactions but still contributed meaningfully to group work or class discussions.

Cluster 3 (n=215, 21.3%) was named "limited online interpersonal interaction," characterized by far-below-average means of the online interaction factors. On average, these students disagreed that they frequently communicated with peers or teachers through electronic means. They seldom requested help or responded timely to others' requests. Rarely did they initiate discussions or participate in group activities that would lead to further interactions with teachers or classmates.

7.4 | Chi-square test: Influences of perceived online educational environment types on online interpersonal interaction types

The Chi-square test was performed to examine the relationships between international students' perceived online educational environment types and their online interpersonal interaction types. The results showed a significant effect of perceived environment types on online interaction types, with a medium effect value of 0.666 (see Table 5). International students with a positive perception of the online educational environments were more likely to engage in proactive online interpersonal interactions. In contrast, international students with a neutral

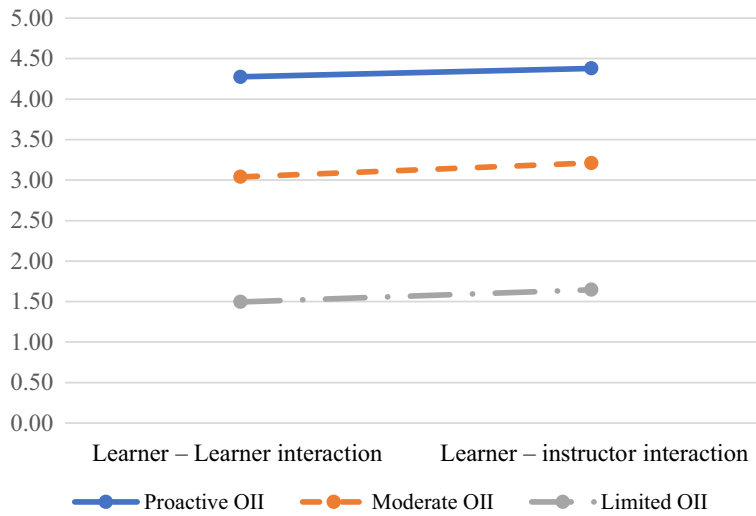

FIGURE 3 Typology of international students' online interpersonal interactions. OII, online interpersonal interactions.

TABLE 5 Chi-square test.

	Proactive OII		Moderate OII		Limited OII		Total			
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	χ^2	*V*
Positive perceptions of OEE	268	26.5	60	5.9	0	0	328	32.5	895.608***	0.666
Neutral perceptions of OEE	66	6.5	306	30.3	43	4.3	415	41.1		
Negative perceptions of OEE	1	0.1	71	7.0	195	19.3	267	26.4		
Total	335	33.2	437	43.3	238	23.6	1010	100.0		

Abbreviations: OEE, online educational environments; OII, online interpersonal interactions.

***$p < .001$.

perception tended to engage in moderate online interpersonal interactions. Meanwhile, international students with negative perceptions reported limited online interpersonal interactions.

7.5 | Logistic regression analysis: Influences of perceived online educational environment types and online interpersonal interaction types on ability development

Multinomial logistic regression analysis was conducted to explore the relationships between international students' demographic factors, perceived online educational environment types, and online interpersonal interaction types with their ability development. As shown in Table 6, models 1, 3, and 5 examined the effects of demographic factors on ability development, explaining the variation in core skills, research capacities, and Chinese proficiency and global abilities by 9.7%, 9.2%, and 7.5%, respectively. Models 2, 4, 6 simultaneously examined the effects of

TABLE 6 Factors associated with international students' ability development.

	Dependent variable					
	Core skills		Research capacities		Chinese proficiency and global abilities	
Independent variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Gender (Female as reference)	0.014	0.014	−0.006	−0.005	−0.015	−0.014
Country of origin (Europe, America, and Oceania as reference)						
Asia	0.086	0.079	0.074	0.065	0.090	0.081
Africa	0.179**	0.121**	0.153*	0.092*	0.141*	0.080
Level of education (postgraduate as reference)	−0.148***	−0.054*	−0.141***	−0.044	−0.099**	−0.006
Medium of instruction (English as reference)	0.109**	0.055*	0.091*	0.036	0.122**	0.067*
Prior online learning experience (no prior experience as reference)	0.134***	0.012	0.111**	−0.014	0.120***	−0.0001
Discipline (Life sciences and medicine as reference)						
Arts, humanities, and social sciences	0.093*	0.005	0.129**	0.040	0.110*	0.025
Sciences and engineering	0.135**	0.055	0.162***	0.082**	0.126**	0.049
Institution type (Non-double-first-class university as reference)	−0.094*	−0.014	−0.102**	−0.019	−0.106**	−0.026
Perceived online educational environment types (negative as reference)						
Positive		0.679***		0.648***		0.640***
Neutral		0.398***		0.383***		0.369***
Online interpersonal interaction type (limited as reference)						
Proactive		0.284***		0.353***		0.325***
Moderate		0.163***		0.216***		0.214***
F	10.958***	101.643***	10.276***	112.215***	8.262***	90.160***
R^2	.097	.591	.092	.615	.075	.562

*$p < .05$; **$p < .01$; ***$p < .001$.

demographic factors, perceived online educational environment types, and online interpersonal interaction types on ability development, explaining the variation in core skills, research capacities, and Chinese proficiency and global abilities by 59.1%, 61.5%, and 56.2%, respectively.

Specifically, in Models 2, 4, and 6, when compared to the respondents with negative perceptions of online educational environments, the respondents with positive or neutral perceptions reported significantly higher levels of all three ability development factors. In model 2, respondents with positive or neutral perceptions of online educational environments respectively had an additional 0.679 and 0.398 units of core skills, respectively, compared to respondents holding negative perceptions. In model 4, such respondents had an additional 0.648 and 0.838 units of research capacities, respectively. Similarly, in model 6, they had an additional 0.640 and 0.369 units of Chinese proficiency and global abilities, respectively.

Additionally, respondents engaged in proactive or moderate online interpersonal interactions reported significantly higher levels of all three development factors than respondents having limited online interpersonal interactions. In model 2, respondents engaged in proactive or moderate online interpersonal interactions scored an additional 0.284 and 0.163 in core skills, respectively, compared to those with limited interactions. In model 4, actively and moderately interactive respondents added 0.353 and 0.216 to their research capacity scores, respectively. In model 6, they added 0.325 and 0.214 to Chinese proficiency and global abilities, respectively.

8 | DISCUSSION

8.1 | A typology of perceived online educational environments

This study performed k-means cluster analysis, generating a typological model that categorizes international students' perceived online educational environments into three distinct groups: positively perceived online environment, neutrally perceived online environment, and negatively perceived online environment. Disparities existed among these three groups in the levels of perceived accessibility to online learning materials, perceived opportunities for online interaction, perceived flexibility in education, and perceived support for knowledge acquisition. Respondents with neutral or negative perceptions were likely to interpret their online courses less favourably, whereas those with a positive attitude highlighted the benefits of the emergency online education, often downplaying its potential drawbacks.

The typological model this study suggests is different from the existing typological study which proposed a 2-cluster model of optimistic and sceptical learners based on domestic Chinese students' perceptions of online learning environments (Tao, 2008). In this research, the majority of respondents were either neutral or positive about their online learning experiences, indicating their recognition of ICT development in China and their appreciation of the prompt measures implemented by institutions to support online education during the COVID emergency. It is worth noting that a notable portion of respondents reported low mean scores across all dimensions of the online learning environments. This reflects the perceived organizational, technical, and pedagogical challenges faced by a substantial percentage of international students in the emergency online education setting (see Tian & Lu, 2022).

In all, the typology proposed in the current study presents the inherently subjective and individualized nature of online education. By "individualized nature," we stress that each student can interact with and perceive the online environment differently and that a course model effective for one learner might not be as effective for another. This typology confirms the arguments that learners' perceptions are critical in shaping the functionality of educational spaces (Harrison & Dourish, 1996). This insight challenges the over-emphasis on tools and technological advancements at the expense of considering individual learners' interpretations and understandings of the educational environments.

8.2 | A typology of online interpersonal interactions

The application of k-means cluster analysis produced a typology categorizing international students' online interpersonal interactions into three distinct groups: proactive interaction, moderate interaction, and limited interaction. Respondents in the moderate and limited interaction groups reported less frequent online communication, whereas those in the proactive cluster consistently demonstrated active interactions with peers and teachers in online courses. Specifically, the largest segment of the total respondents reported moderate levels of online interactions, neither participating actively nor insufficiently in online group work or class discussions. This pattern of interaction aligns with Nystrand and Gamoran's (1989) differentiation between procedural engagement and substantive engagement. The former referred to participation in interactive activities primarily for the satisfaction with course requirements or assessment criteria, which is different from substantial interactions driven by a genuine personal commitment to learning.

While a relatively small percentage of the total respondents reported low levels of online interaction, the overall size of this group remains substantial due to the large total number of respondents. Research literature has identified the scarcity of interpersonal interactions as a major concern in distance education, particularly at the infancy stage of online teaching, when communication primarily relied on asynchronous discussion forums and emails (Dailey-Hebert, 2018). In this study, the limited interaction group reported minimal engagement in discussions and collaborative projects. They also rarely initiated inquiries, sought clarifications, or received feedback from teachers. The high percentage of minimally interactive learners can be explained by the rapid transition to massive online education during the pandemic, mingled with the factors such as unstable internet connectivity, pedagogical unpreparedness, and international students' limited prior exposure to online learning environments.

Furthermore, the second highest percentage of the respondents were identified as proactive interactors, who manifested more personalized and intimate learning relationships that transcended mere interactions with technology. Their online learning experiences were multifaceted, involving interpersonal communication for academic purposes and for social and emotional support. The results highlighted the significant variances in interactive behaviours, showing the importance of understanding these nuanced learning experiences as a priority to support international students' online interpersonal interactions.

8.3 | Perceived online educational environment typology, interpersonal interaction typology, and their relationships to international students' ability development

The results of the Chi-square test showed a significant association between the perceived environment types and the online interpersonal interaction types. Specifically, respondents' perceptions of online educational environments, be they positive, neutral, or negative, were correspondingly related to the extent of their online interpersonal interactions, categorized as proactive, moderate, or limited groups. Previous research has stressed the complementary nature of technology-penetrated online educational environments and student interactions, rather than viewing them as contradictory (Donnelly, 2010). The current study contributes to the existing literature by suggesting that international students' online interpersonal interactions are likely to be enhanced when they perceive the online educational environments as sufficiently supporting their access to learning materials, facilitating the exchanges of ideas and emotions, and aiding in knowledge acquisition.

The research compared international students' ability development among three perceived online educational environment types and three online interpersonal interaction types, after controlling for demographic factors. The logistic regression analysis results showed that perceived online educational environment types were the significant predictors of ability development. Research has highlighted the linkage between positive perceptions of learning environments and learning success (Shehnaz & Sreedharan, 2011). The present research illuminated how the variations in learners' perceptions of online educational environments influenced their academic development

in core skills, research capacities, and Chinese proficiency and global abilities. Respondents who believed that online educational environments provided accessible subject matters, supported interpersonal interactions, facilitated flexible learning, and promoted knowledge acquisition reported higher levels of ability development. This contrasted with those holding neutral perceptions and was significantly higher than respondents who found online courses less accessible, insufficiently interactive, inflexible, and unsupportive of knowledge acquisition.

The regression analysis results also revealed a significant association between the typology of online interpersonal interactions and ability development. International students who were proactively interactive exhibited the most significant progress in abilities, followed by those who were moderately and minimally interactive. Previous research focusing on classroom contexts stressed the value of interactions, both among learners and between learners and instructors, for knowledge building (e.g., Faja, 2013). In particular, the typological research conducted by Yin and Shi (2022) reported a connection between Chinese college students' interactive patterns and their academic achievement. Active interactors showed better performance compared to their less interactive peers, as evidenced by enhanced computer and research skills, successful thesis completion, and higher course average grades.

The present study, centred on international students in the emergency online education, confirmed the significant role of online interpersonal interactions in fostering positive learning outcomes. For those reporting proactive interactions, a high level of peer interactions facilitated the co-construction of meaning, while significant learner-instructor interactions contributed to enhanced learning. For those reporting moderate or limited interactions,

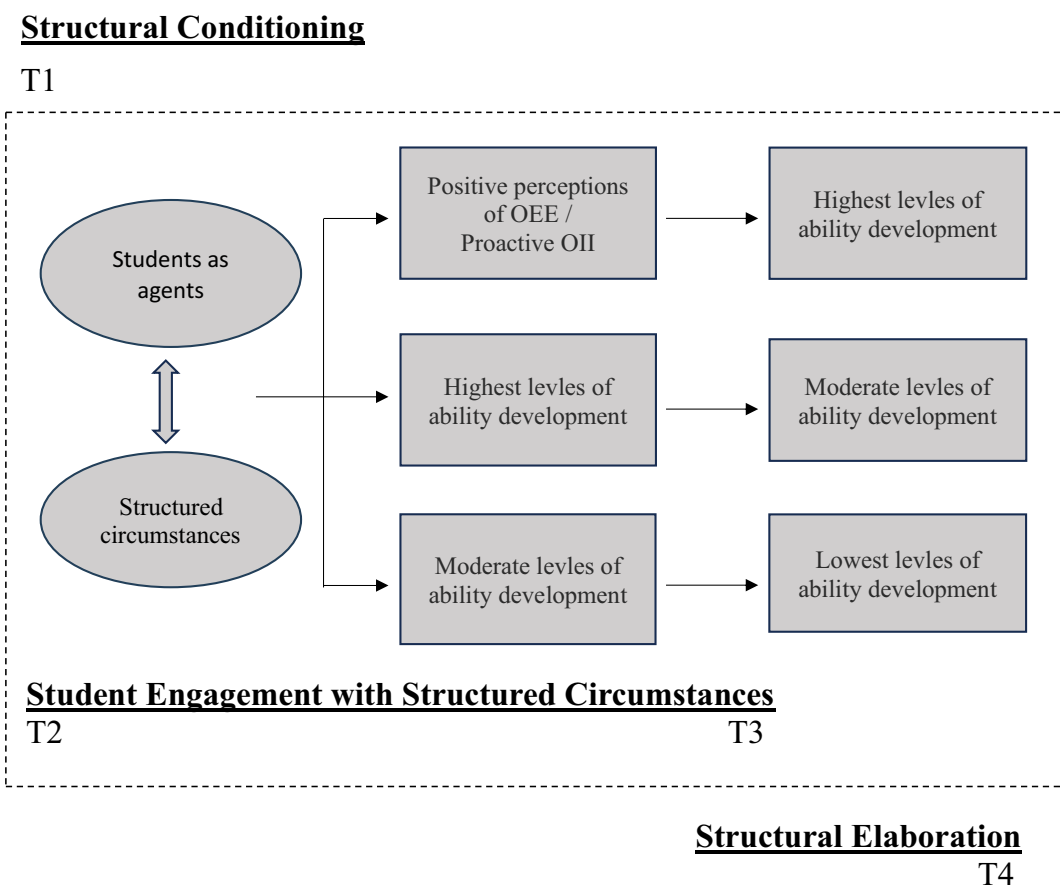

FIGURE 4 Online learning of international students in China: Expanded Archer's morphogenetic sequence. OEE, online educational environments; OII, online interpersonal interactions.

the collaborative knowledge creation and sharing were moderately to seriously hindered, timely feedback from teachers was impeded, and overall ability development suffered. Moreover, it was argued that learners would thrive when interpersonal interactions evolved into relationships, thereby cultivating a community of learning (Dailey-Hebert, 2018). In the pandemic situation when extended physical distancing was inevitable, online interactions play a vital role in mitigating feelings of isolation, supporting the sense of place to emerge. Furthermore, through interpersonal interactions, international students can then communicate their emerging senses of place, enabling the formation of virtual learning communities and further enhancing positive learning (Conrad, 2005).

9 | CONCLUSIONS

UNESCO's 2030 Agenda for Sustainable Development, with its 17 interlinked goals, provides a blueprint for a "better and more sustainable future" for all peoples on the planet (United Nations, 2024a). At HEIs, classroom face-to-face teaching plays an essential role in facilitating students' understanding of and reflection on real-world challenges within local and global environments. However, the outbreak of COVID-19 led to HEIs' rapid transition to online instruction, threatening HESD (Wen & Tian, 2022). Since the outbreak of COVID-19, China has been delivering higher education to its international students via online modes of instruction. Drawing on the survey involving 1010 international students at 41 Chinese HEIs, this research developed a typology of international students' perceived online educational environments and another typology of international students' online interpersonal interactions. The results showed that international student perceived online educational environments transcended a simple dichotomous pattern of either being positive or negative, but rather spanned a spectrum between positive and negative attributes, with each type comprising multiple dimensions subject to variations within individual respondents' perceptions. Similarly, international students' online learning interactions lay on a continuum between proactive interactions and limited interactions while individual respondents could engage to different degrees in interactions with teachers and peers.

Moreover, through the logistic regression analysis, the research investigated the impact of the perceived online educational environment types and the online interpersonal interaction types on international students' ability development. The results indicated the predictive power of both these typologies on ability development, highlighting two important elements transforming online digital spaces into place allowing learning to happen. The first element is the humanization of the online educational environments; it is the learners' perceptions, interpretations, and understandings that transform otherwise impersonal technological platforms into vibrant place where learning emerges. The second element is the social presence of both peers and teachers. Through continual communication and interactions, an online community of learning practice is created and sustained. In the situation characterized by stringent pandemic-related prevention and control measures, such social facets of online education are crucial, reducing feelings of isolation and ensuring engaging learning experiences for international students dispersed across various global locales.

This research has the following limitations. Firstly, the sample of the survey may not represent the international student demographic composition in China, and the results may not be generalized to international students' online education after the COVID-19 pandemic. Moreover, the research developed a perceived online educational environment typology based on the analysis of the environmental features over four dimensions, and the online interpersonal interaction typology over two dimensions. Other ways to measure the variables may shed new light on these typologies. The research's scope also exclusively investigated the influences of perceived online environment types and online interaction types on international students' ability development. Future research may combine quantitative and in-depth qualitative methods to explore the dynamics influencing international students' evolving senses of place, or exacerbating their feelings of "outsideness" in the digital space.

Theoretically, the research demonstrates the applicability of Archer's morphogenetic approach in guiding the investigation of transformation from space to place in fostering effective learning. As shown in Figure 4, Archer's

emphasis on space as an antecedent to learning highlights the temporal disparity between space and place. Amid COVID-19's transition to extensive remote instruction, online course developers encountered unprecedented challenges. Yet, once constructed, the technical and digital aspects of online courses maintain relative stability over a certain period of time, forming the "structural conditions (T1)" for international students' learning attainments in virtual settings. In addition, the research results highlight a dialectic interplay between human agents and the online milieu during T2–T3, suggesting that spaces evolve into places when spaces are endowed with meaning through human engagement. In this transforming process, reflexivity emerges as crucial; it is through individual students' interpretations of the online environments, and their interactions with peers and teachers, that they gain learning and development. This dynamic highlights the actualization of the transition from mere space to a meaningful place of education.

From a pedagogical standpoint, this research provides insights into the design of online courses as technologically mediated learning place. The findings contribute to the "structural elaboration (T4)" as depicted in Figure 4, which fosters an advanced form of "structural conditioning" through successive morphogenetic cycles (Archer, 2020). This process is important for supporting sustainable online international education. First, the results pinpointed the dangers of sidelining human perceptions in the design and improvement of online educational courses. As technological advancements continue, it is important for course designers to maintain ongoing dialogues with international student cohorts. Empathetic understandings of these students' priorities would create a more inviting online space for the sense of learning place to emerge.

Specifically, the cluster analysis results pointed to a three-cluster typology of international students' perceptions of online learning environments. The result that nearly one-quarter of the respondents hold negative perceptions is alarming, while the largest percentage of the respondents falling into the neutral type also warrants attention, even though the neutral group has not reported strong opinions against any online learning environment factors and hence, can be relatively less challenging to be motivated to advocate for online education. Winning over the neutral and negative groups requires efforts from international education providers to build student-centred online learning environments. Possible interventions include securing international students' access to rich online learning materials, dedicating resources to ensuring flexible online learning and supporting the acquisition of knowledge through the adoption of technology and digital tools.

The results of the current research also proposed a typology classifying international students' online interpersonal interactions into three groups, with slightly over one-third reporting proactive interactions, nearly half having moderate interactions, and another quarter being limited interactors. The combined high percentage of the respondents with moderate to limited interactions indicates the need for online courses to adopt interactive pedagogical strategies. Possible remedies include the provision of discussion forums and virtual teaching hours, which can strengthen the benefits of online education while retaining the advantages of face-to-face classroom dynamics. To support sustainable online international education in the post-pandemic era, it is also suggested that faculties and institutions develop strong incentive plans and provide high-quality training opportunities so that teachers are motivated to continuously engage in online course design and pedagogy refinement, skilfully integrating interactive activities into online teaching.

Moreover, considering the significant impact of perceived online educational environment types on ability development, it is suggested that online courses be designed as student-centred, catering to the needs of international students by providing flexible education, ensuring access to high-quality educational materials, supporting the acquisition of subject knowledge, and developing their academic abilities. Given the significance of learner-learner and learner-instructor interactions, international students' host institutions and instructors are recommended to ensure that the adoption of technologies truly expands interpersonal interactions and thus promotes optimal learning outcomes.

CONFLICT OF INTEREST STATEMENT

None.

DATA AVAILABILITY STATEMENT

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

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REFERENCES

Akoglu, H. (2018). User's guide to correlation coefficients. *Turkish Journal of Emergency Medicine*, *18*(3), 91–93. https://doi.org/10.1016/j.tjem.2018.08.001

Anderson, T. (2003). Getting the mix right again: An updated and theoretical rationale for interaction. *The International Review of Research in Open and Distributed Learning*, *4*(2), 1–14. https://doi.org/10.19173/irrodl.v4i2.149

Archer, M. S. (2007). *Making our way through the world: Human reflexivity and social mobility*. Cambridge University Press.

Archer, M. S. (2010). Morphogenesis versus structuration: On combining structure and action 1. *The British Journal of Sociology*, *61*, 225–252. https://doi.org/10.1111/j.1468-4446.2009.01245.x

Archer, M. S. (2020). The morphogenetic approach; critical realism's explanatory framework approach. In P. Róna & L. Zsolnai (Eds.), *Agency and causal explanation in economics* (pp. 137–150). Springer. https://doi.org/10.1007/978-3-030-26114-6_9

Baber, H. (2022). Social interaction and effectiveness of the online learning. *Asian Education and Development Studies*, *11*(1), 159–171. https://doi.org/10.1108/AEDS-09-2020-0209

Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science*, *16*(1), 74–94. https://doi.org/10.1007/BF02723327

Bolliger, D. U., & Martin, F. (2018). Instructor and student perceptions of online student engagement strategies. *Distance Education*, *39*(4), 568–583. https://doi.org/10.1080/01587919.2018.1520041

Bouhnik, D., & Marcus, T. (2006). Interaction in distance-learning courses. *Journal of the American Society for Information Science and Technology*, *57*(3), 299–305. https://doi.org/10.1002/asi.20277

Burnett, K., Bonnici, L. J., Miksa, S. D., & Kim, J. (2007). Frequency, intensity and topicality in online learning: An exploration of the interaction dimensions that contribute to student satisfaction in online learning. *Journal of Education for Library and Information Science*, *48*(1), 21–35.

Caprara, L., & Caprara, C. (2022). Effects of virtual learning environments: A scoping review of literature. *Education and Information Technologies*, *1-40*, 3683–3722. https://doi.org/10.1007/s10639-021-10768-w

Conrad, D. (2005). Building and maintaining community in cohort-based online learning. *International Journal of e-Learning and Distance Education*, *20*(1), 1–20.

Dailey-Hebert, A. (2018). Maximizing interactivity in online learning: Moving beyond discussion boards. *Journal of Educators Online*, *15*(3), 1–26. https://files.eric.ed.gov/fulltext/EJ1199230.pdf

Donnelly, R. (2010). Harmonizing technology with interaftion in blended problem-based learning. *Computer & Education*, *54*(2), 350–359. https://doi.org/10.1016/j.compedu.2009.08.012

Eynon, R., & Malmberg, L. E. (2011). A typology of young people's internet use: Implications for education. *Computers & Education*, *56*(3), 585–595. https://doi.org/10.1016/j.compedu.2010.09.020

Faja, S. (2013). Collaborative learning in online courses: Exploring students' perceptions. *Information Systems Education Journal*, *11*(3), 42–51.

Firang, D. (2020). The impact of COVID-19 pandemic on international students in Canada. *International Social Work*, *63*(6), 820–824. https://doi.org/10.1177/0020872820940030

Gieryn, T. F. (2000). A space for place in sociology. *Annual Review of Sociology*, *26*(1), 463–496. https://doi.org/10.1146/annurev.soc.26.1.463

Gunawardena, C. N., & Zittle, F. (1997). Social presence as a predictor of satisfaction within a computer mediated conferencing environment. *American Journal of Distance Education*, *11*(3), 8–25. https://doi.org/10.1080/08923649709526970

Harrison, S., & Dourish, P. (1996). Re-place-ing space: The roles of place and space in collaborative systems. In *Proceedings of the 1996 ACM conference on computer supported cooperative work* (pp. 67–76). https://doi.org/10.1145/240080.240193

Koeppen, K., Hartig, J., Klieme, E., & Leutner, D. (2008). Current issues in competence modeling and assessment. *Zeitschrift für Psychologie/Journal of Psychology*, *216*(2), 61–73. https://doi.org/10.1027/0044-3409.216.2.61

Kuo, Y. C., Walker, A. E., Schroder, K. E., & Belland, B. R. (2014). Interaction, internet self-efficacy, and self-regulated learning as predictors of student satisfaction in online education courses. *The Internet and Higher Education*, *20*, 35–50. https://doi.org/10.1016/j.iheduc.2013.10.001

Lamb, T., & Vodicka, G. (2018). Collective autonomy and multilingual spaces in super-diverse urban context. In G. Murray & T. Lamb (Eds.), *Space, place and autonomy in language learning* (pp. 9–28). Routledge.

Lu, G., & Wen, S. (2024). A student engagement typology and its relationship to ability development in Chinese universities. *The Asia-Pacific Education Researcher*, *33*(1), 93–102. https://doi.org/10.1007/s40299-023-00711-7

Maulana, R., Opdenakker, M. C., den Brok, P., & Bosker, R. J. (2012). Teacher–student interpersonal behavior in secondary mathematics classes in Indonesia. *International Journal of Science and Mathematics Education*, *10*, 21–47. https://doi.org/10.1007/s10763-011-9276-1

Ministry of Education, China. (2016). "Thirteenth five-year plan" of educational informatization. http://www.moe.gov.cn/srcsite/A16/s3342/201606/t20160622_269367.html

Ministry of Education of China. (2012). Ten-year development plan of educational informatization (2011–2020). http://www.moe.gov.cn/srcsite/A16/s3342/201203/t20120313_133322.html

Ministry of Education of China. (2019). The statistics of international students in China in 2018. https://www.moe.gov.cn/jyb_xwfb/gzdt_gzdt/s5987/201904/t20190412_377692.html

Moeller, B., & Reitzes, T. (2011). Education development center, Inc. (EDC). In *Integrating technology with student-centered learning*. Nellie Mae Education Foundation. https://www.edc.org/sites/default/files/uploads/Integrating-Technology-with-Student-Centered-Learning.pdf

Nystrand, M., & Gamoran, A. (1989). Instructional discourse and student engagement. *Research in the Teaching of English*, *40*, 392–412.

Pallant, J. (2020). *SPSS survival manual: A step-by-step guide to data analysis using IBM SPSS*. Routledge.

Palvia, S., Aeron, P., Gupta, P., Mahapatra, D., Parida, R., Rosner, R., & Sindhi, S. (2018). Online education: Worldwide status, challenges, trends, and implications. *Journal of Global Information Technology Management*, *21*(4), 233–241. https://doi.org/10.1080/1097198X.2018.1542262

Petrides, L. A. (2002). Web-based technologies for distributed (or distance) learning: Creating learning-centered educational experiences in the higher education classroom. *International Journal of Instructional Media*, *29*(1), 69–77.

Platts-Fowler, D., & Robinson, D. (2015). A place for integration: Refugee experiences in two English cities. *Population, Space and Place*, *21*(5), 476–491. https://doi.org/10.1002/psp.1928

Rickards, T., Brok, P. D., & Fisher, D. (2005). The Australian science teacher: A typology of teacher–student interpersonal behaviour in Australian science classes. *Learning Environments Research*, *8*, 267–287. https://doi.org/10.1007/s10984-005-1567-4

Sarapin, S. H., & Morris, P. L. (2015). Faculty and Facebook friending: Instructor- student online social communication from the professor's perspective. *The Internet and Higher Education*, *27*, 14–23. https://doi.org/10.1016/j.iheduc.2015.04.001

Schreiber, J. B., Nora, A., Stage, F. K., Barlow, E. A., & King, J. (2006). Reporting structural equation modeling and confirmatory factor analysis results: A review. *The Journal of Educational Research*, *99*(6), 323–338. https://doi.org/10.3200/JOER.99.6.323-338

SERU-International. (2023). *Center for studies in higher education*. University of California. https://cshe.berkeley.edu/seru/seru-international

Shehnaz, S., & Sreedharan, J. (2011). Students' perceptions of educational environment in a medical school experiencing curricular transition in United Arab Emirates. *Medical Teacher*, *33*(1), e37–e42. https://doi.org/10.3109/0142159X.2011.530312

Sher, A. (2009). Assessing the relationship of student-instructor and student-student interaction to student learning and satisfaction in web-based online learning environment. *Journal of Interactive Online Learning*, *8*(2), 102–120.

Spitzer, D. R. (2001). Don't forget the high touch with the high-tech in distance learning. *Educational Technology*, *41*(2), 51–55.

State Council of China. (2020). Fighting COVID-19: China in action. https://english.www.gov.cn/news/topnews/202006/07/content_ WS5edc559ac6d066592a449030.html

Stevens, K. J., Guo, Z., & Li, Y. (2018). Typology and hierarchy of students' motivations to use technology in learning. *Australasian Journal of Information Systems*, *22*, 1–30.

Stone, C., Freeman, E., Dyment, J. E., Muir, T., & Milthorpe, N. (2019). Equal or equitable?: The role of flexibility within online education. *Australian and International Journal of Rural Education*, *29*(2), 26–40. https://doi.org/10.47381/aijre.v29i2.221

Sun, H., Sun, T., Sha, F., Gu, X., Hou, X., Zhu, F., & Fang, P. (2022). The influence of teacher–student interaction on the effects of online learning: Based on a serial mediating model. *Frontiers in Psychology*, *13*, 1–10. https://doi.org/10.3389/fpsyg.2022.779217

Tajeddin, Z., & Kamali, J. (2020). Typology of scaffolding in teacher discourse: Large data-based evidence from second language classrooms. *International Journal of Applied Linguistics*, *30*(2), 329–343. https://doi.org/10.1111/ijal.12286

Tao, Y. H. (2008). Typology of college student perception on institutional e-learning issues–an extension study of a teacher's typology in Taiwan. *Computers & Education*, *50*(4), 1495–1508. https://doi.org/10.1016/j.compedu.2007.02.002

Telli, S., Den Brok, P., & Cakiroglu, J. (2007). Students' perceptions of science teachers' interpersonal behaviour in secondary schools: Development of a Turkish version of the Questionnaire on Teacher Interaction. *Learning Environments Research*, *10*, 115–129. https://doi.org/10.1007/s10984-007-9023-2

Tian, M., & Lu, G. (2022). Online learning satisfaction and its associated factors among international students in China. *Frontiers in Psychology*, *13*, 916449. https://doi.org/10.3389/fpsyg.2022.916449

Tian, M., Lu, G., Li, L., & Yin, H. (2021). International undergraduate students in Chinese higher education: An engagement typology and associated factors. *Frontiers in Psychology*, *12*, 680392. https://doi.org/10.3389/fpsyg.2021.680392

United Nations. (2024a). Take action for the sustainable development goals. https://www.un.org/sustainabledevelopment/sustainable-development-goals/

United Nations. (2024b). Transforming our world: the 2030 agenda for sustainable development. https://sdgs.un.org/2030agenda

United Nations Educational Scientific and Cultural Organization. (2024). Higher education and the SDGs. https://www.iesalc.unesco.org/en/the-contribution-of-higher-education-to-the-sdgs/

Van den Beemt, A., Akkerman, S., & Simons, P. R. J. (2011). Patterns of interactive media use among contemporary youth. *Journal of Computer Assisted Learning*, *27*(2), 103–118. https://doi.org/10.1111/j.1365-2729.2010.00384.x

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Wahlstedt, A., Pekkola, S., & Niemelä, M. (2008). From e-learning space to e-learning place. *British Journal of Educational Technology*, *39*(6), 1020–1030. https://doi.org/10.1111/j.1467-8535.2008.00821_1.x

Wang, Y., Liu, X., & Zhang, Z. (2018). An overview of e-learning in China: History, challenges, and opportunities. *Research in Comparative and International Education*, *13*(1), 195–210. https://doi.org/10.1177/1745499918763421

Wei, H. C., & Chou, C. (2020). Online learning performance and satisfaction: Do perceptions and readiness matter? *Distance Education*, *41*(1), 48–69. https://doi.org/10.1080/01587919.2020.1724768

Wei, H. C., Peng, H., & Chou, C. (2015). Can more interactivity improve learning achievement in an online course? Effects of college students' perception and actual use of a course-management system on their learning achievement. *Computers & Education*, *83*, 10–21. https://doi.org/10.1016/j.compedu.2014.12.013

Wen, G., & Tian, M. (2022). International students in China: Teaching, learning and management during the COVID-19 pandemic. *Journal of International Students*, *12*(S1), 1–6. https://doi.org/10.32674/jis.v12iS1.4604

Wubbels, T., & Levy, J. (1991). A comparison of interpersonal behavior of Dutch and American teachers. *International Journal of Intercultural Relations*, *15*(1), 1–18. https://doi.org/10.1016/0147-1767(91)90070-W

Xia, Y., Hu, Y., Wu, C., Yang, L., & Lei, M. (2022). Challenges of online learning amid the COVID-19: College students' perspective. *Frontiers in Psychology*, *13*, 1–13. https://doi.org/10.3389/fpsyg.2022.1037311

Yin, H., & Shi, L. (2022). Which type of interpersonal interaction better facilitates college student learning and development in China: Face-to-face or online? *ECNU Review of Education*, *5*(1), 9–36. https://doi.org/10.1177/2096531121010818

Zhang, W., Wang, Y., Yang, L., & Wang, C. (2020). Suspending classes without stopping learning: China's education emergency management policy in the COVID-19 outbreak. *Journal of Risk and Financial Management*, *13*(3), 55. https://doi.org/10.3390/jrfm13030055

How to cite this article: Tian, M., & Lu, G. (2024). Online space for learning: Perceived educational environment typology, interpersonal interaction typology, and their relationship to international students' ability development in Chinese universities. *Higher Education Quarterly*, *00*, e12560. https://doi.org/10.1111/hequ.12560