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CULTURAL AND REGIONAL PERSPECTIVES

Cross-cultural learning in virtual reality environment: facilitating cross-cultural understanding, trait emotional intelligence, and sense of presence

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Abstract
Cross-cultural learning projects were carried out in learning environments created using Web 1.0 or Web 2.0 technologies in previous related studies. However, such environments have a limited ability to provide learners with immersive learning experiences of a foreign culture and fail to make them feel virtually present in a foreign cultural context. In this study, we aimed to create such an environment, one that enables not only communication among learners from different cultures but also gives them a sense of presence and provides an immersive experience in a foreign culture without their being physically there. To this end, based on the cultural convergence theory, we designed a cross-cultural learning activity in virtual reality (VR) using a 360-degree video technology. Two groups of university students, one from China (n = 10) and the other from Uzbekistan (n = 11), who exchanged culture-related information with each other, participated in the activity. We investigated whether cross-cultural understanding and the trait emotional intelligence of the participants was facilitated after their participation in the activity. In addition, we explored the participants sense of perceived presence in the VR environment and their acceptance of VR technology. A mixed methods research approach was adopted. We analyzed the reflective journals of the participants, administered three questionnaires, and interviewed the participants. We obtained the following four findings: First, the participants had no prior knowledge of their foreign partners' cultures and traditions before the learning activity; however, they had knowledge that they could summarize, explain, compare, and contrast at the end of the activity. Second, the comparison of the results of the pre- and post-questionnaires showed that the two trait emotional intelligence constructs (i.e., self-control and emotionality) were significantly improved from the beginning of the activity to its end. Third, the participants perceived a high level of presence in the VR environment. Finally, the participants accepted VR technology in terms of its usefulness for cross-cultural learning and ease of use. The originality of this study lies in creating cross-cultural learning environments based on a 360-degree video technology that enables communication across cultures and gives learners a sense of presence and an immersive experience. The value of the study for the literature and its contribution to theoretical knowledge is that it creates virtual cross-cultural learning environments based on a 360-degree video technology and presents evidence suggesting that the cross-cultural learning environments created in this

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study can facilitate cross-cultural knowledge and perceived self-control, emotionality, and sense of presence.

Keywords 360-degree video · Acceptance · Cross-cultural understanding · Presence · Trait emotional intelligence · Virtual reality

Introduction

The development of computer technology has led to breaking the limitations of time and space, making communication among people from different cultures easier and more common (Chen & Yang, 2014). For this reason, intercultural interactions have become more frequent and observable in daily life (Çiftçi, 2016). However, the existence of cultural differences (Chen et al., 2019; de Albuquerque Moreira et al., 2019; Istiqomah, 2017; Shadiev & Huang, 2016) has become an important issue related to cultivating cross-cultural understanding (Jin, 2015).

Cross-cultural learning supported by various technologies has received considerable attention in the past few years (Avgousti, 2018; Çiftçi, 2016; Shadiev & Huang, 2020; Shadiev et al., 2021). There have been several review studies published up to date on technology-supported cross-cultural learning. For example, Avgousti (2018) reviewed studies on how online exchanges affect the development of cross-cultural communication among learners. The results showed that due to different time zones, learners mostly used asynchronous communication tools (e.g. twitter, blogs, podcasts, and e-mail). The results also revealed that communication among learners is multimodal, which affects the development of cross-cultural communication in various ways. Çiftçi (2016) summarized the research in the cross-cultural field with the main focus on technology and its effectiveness in terms of cross-cultural learning. The review results showed that various types of technology have been used in cross-cultural learning, e.g., emails or discussion boards, blogs, podcasts, or video conferencing. Learners were shown to be satisfied with such technologies, and their cross-cultural experiences and their cross-cultural communication increased.

The results of the above-mentioned review studies showed that cross-cultural learning projects were carried out in learning environments created using Web 1.0 or Web 2.0 technologies (e.g. email, instant messaging or videoconferencing). That is, these technologies were mostly used for the purpose of enabling participants from different countries to communicate with each other. Obviously, such technologies are limited in terms of their ability to immerse learners in a foreign culture and to allow them to be virtually present in a foreign cultural context. Therefore, in earlier studies, all experiences of foreign cultures and traditions were limited to exchanging culture-related information. Therefore, getting a sense of presence of and immersing into the target culture to gain authentic cultural experiences was feasible to a very limited degree or impossible.

Some new technologies have emerged, and some have become more mature. Scholars have begun to use them in the field of education because they have the potential to facilitate the learning process. One such technology is virtual reality (VR), which has the potential to create immersive learning environments in which learners may feel a good sense of presence and perceive learning contexts as authentic (Cebeci et al., 2019; Chien, Hwang, & Jong, in press; Riva et al., 2007; Terkildsen & Makransky, 2019; Shadiev et al., 2020). However, to the best of our knowledge, not many cross-cultural learning studies have been carried out using VR technology because of its recent emergence, high cost, sophistication,

and low availability (Shadiev & Sintawati, 2020; Shadiev et al., 2021), In addition, it is not easy to design high-quality VR content (Chien et al., in press). Specifically, whether cross-cultural understanding and trait emotional intelligence can be improved after learning activities supported by such technologies has not yet been tested. Therefore, this study is an attempt to address this existing gap in the field. We aimed to create an environment that enables not only communication among learners from different cultures but also gives them a sense of presence and immersive learning experiences in a foreign culture without them being physically there. That is, we designed a cross-cultural learning activity supported by VR technology based on a 360-degree video. We examined whether cross-cultural understanding and trait emotional intelligence can be improved by a learning activity carried out in a VR environment. In addition, we tested participants' perceived sense of presence in the VR environment and acceptance of VR technology.

In the following section, we give a brief review of previous related studies, and we also list our research questions. In the Methods section, we explain the methodology used in this study, including the participants, the cross-cultural learning activity, VR technology, and the data collection and analysis. In the section that follows, we report and discuss the research results. In addition, we explain the pedagogical usefulness of VR technology for cross-cultural understanding and trait EI. In the last section, we draw our conclusions, acknowledge the limitations of the study, and give suggestions for educators and researchers.

Literature review

Cross-cultural understanding

Cross-cultural understanding refers to the basic ability to correctly recognize, understand, and interpret various types of cultural information, e.g., the history, languages, and traditions of one's own country and those of other countries, as well as their cultural similarities and differences (Shadiev et al., 2019). According to cultural convergence theory (Gudykunst et al., 1988; Kincaid, 1979), information exchange and communication among learners from different cultures can lead to cross-cultural understanding. Achieving cross-cultural understanding of students is one of the primary aims of cross-cultural education. Although scholars and researchers hold different opinions with respect to its definition (Çiftçi, 2016; Hsu & Beasley, 2019; Shadiev et al., 2018), there is a tendency to define cross-cultural understanding as knowledge of cultural information (e.g., social groups, their products, practices, interactional processes, etc.) about country that a learner has that can be summarized, explained, compared, and contrasted by the learner.

Up to the present time, many studies on technology-supported cross-cultural learning have been carried out (Shadiev & Sintawati, 2020; Shadiev et al., 2021). In a study conducted by Wu (2018), Chinese students were engaged in intercultural asynchronous computer-mediated communication with their American partners. Wu (2018) explored how good vs. bad positioning of students in terms of communication can affect their cross-cultural understanding and language acquisition. Istiqomah (2017) proposed digital storytelling techniques to promote cross-cultural understanding. Students were engaged in digital storytelling activities by creating cultural videos intended to build multi-literacy. Chen and Yang (2014) carried out cross-cultural learning activities in which students from Taiwan, Pakistan, USA, and the United Arab Emirates communicated with each other using online

forums, weblogs, Skype, and email. Hsu and Beasley (2019) explored how cross-cultural learning and language learning between Taiwanese and American students can be facilitated by email and Skype interactions. The results of the above-mentioned studies indicated that online communication was beneficial for student cross-cultural learning and language learning. In addition, most students had positive perceptions of cross-cultural learning supported by technology.

Trait emotional intelligence

When interaction between cognition and emotions takes place, emotional intelligence (EI), including behavioral responses and adaptations, develops (Salovey & Mayer, 1990). According to Petrides et al. (2007), trait EI refers to a combination of behavioral dispositions and self-perceptions related to the ability of a person to recognize, process, and utilize emotion-related information. In addition, a combination of emotional perceptions located at the lower levels of personality hierarchies can also represent trait EI (Petrides, 2009). Trait EI is a construct that is composed of well-being, self-control, emotionality, and sociability.

Trait EI has received considerable attention in recent years primarily with a focus on its development (Luna et al., 2019; Ruiz-Ariza et al., 2018) or its role in predicting behavioral tendencies (Ghafoor et al., 2019; Shao et al., 2013). For example, Petrides et al. (2007) investigated the influence of trait EI on academic performance and learning behavior occurring at school. Their results showed that learning achievement and behavior can be influenced by trait EI, especially when disadvantaged and vulnerable students are considered. Luna et al. (2019) implemented an education model program and examined its effect on subjective well-being, trait EI, and social anxiety in students. Their results showed significant improvements in trait EI in the experimental group after the program.

Physical space, cyber space, and VR based on a 360-degree video

Physical space usually refers to the environment in the real world where people live, study, and work (Oldenburg, 1999). The notion of physical space is related to our everyday lives; it helps us to understand the world around us, the entities within it, and ours as well as others' actions in it (Bryant, 2001). Cyberspace has been defined as an environment that is created by people using computing technologies that people can enter and move through, interacting with both people and computers (Triberti et al., 2018). The main difference between these two environments is that physical space is infinite and not of our making, whereas cyberspace is finite and is of our making (Bryant, 2001). For example, students may enter their classroom, sit on their chairs, interact with their teachers or peers, etc. In physical space, actions, people, objects, and situations are real, whereas in cyberspace, they are not. That is, in cyberspace, students have to use computing technologies to act and communicate, and people, objects, and situations are artificially created by someone else (e.g., drawings or animations).

In Fig. 1, we compare the different characteristics of learning experiences in physical space and in cyberspace. In terms of cost, doing something in physical space is much more expensive compared to doing it in cyberspace. For example, it is expensive to physically visit a foreign country (i.e., in physical space) to learn its culture and traditions because of travel expenses. However, there is no need to pay any travel expenses when visiting a foreign country in cyberspace. The authenticity of and feeling of presence in physical space

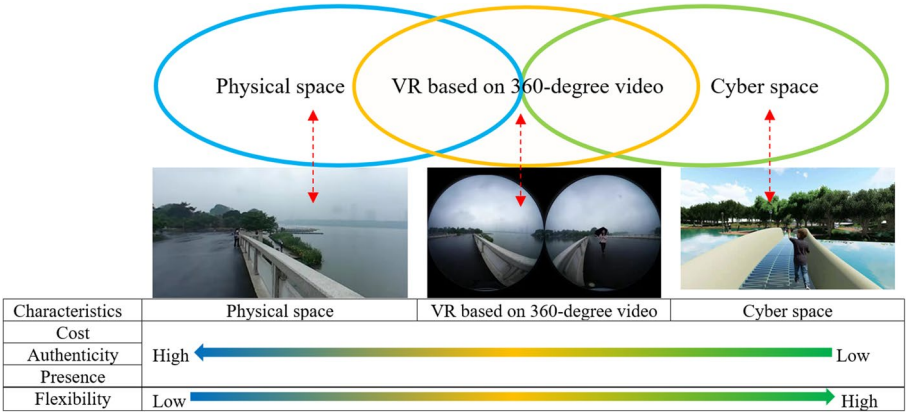

Fig. 1 Physical space, VR based on a 360-degree video and in cyberspace

is also higher than that in cyberspace. The main reason for this is because people, objects, and situations in a physical space are real, whereas they are not in cyberspace. On the other hand, the flexibility of doing something in physical space (e.g., traveling long distances or manipulating objects) is less than that in cyberspace.

In this study, we used 360-degree video technology to create virtual reality (VR) in order to improve the authenticity of learning experiences for students as well as their feeling of presence in cyberspace while maintaining their learning experience at a lower cost with a high degree of flexibility. VR is a computer simulation environment in which users navigate and manipulate virtual objects in a virtual world. Immersive learning environments can be created by VR in which a learner may immerse into a target culture and interact with its representatives using wearable devices (e.g., a VR headset).

Because 360-degree video technology presents recordings made on video cameras, people, objects, and scenarios in virtual space are the same as they are in physical space, so the degree of authenticity and immersion in learning experiences occurring in such spaces are higher than in cyberspace. When watching a 360-degree video using a VR headset, students can control and manipulate the video by rewinding, pausing, and changing the view of the learning content. Thus, the flexibility of their learning experiences is higher compared to that in physical space.

Trait emotional intelligence, cross-cultural learning, and VR

Scholars have pointed out that trait EI is influenced by various socio-cultural factors, for example, educational environments or interactive learning activities (Luna et al., 2019; Ruiz-Ariza et al., 2018; Terkildsen & Makransky, 2019). When studying virtual educational environments, scholars have found that the sense of presence in a VR environment has a positive relationship with aspects of the viewer's emotions (Cebeci et al., 2019; Riva et al., 2007; Terkildsen & Makransky, 2019). Therefore, sense of presence has been inferred to be a necessary prerequisite to inducing emotional activities (Terkildsen & Makransky, 2019). Furthermore, scholars have argued that virtual environments can serve as emotional mediators by triggering emotional responses (Cebeci et al., 2019). That is, participants have been observed to feel worried, fearful, uneasy, and troubled when presented with an stressful environment and to be relaxed, natural, and uninhibited when the

environment they are presented is relaxing. Jiménez-Murcia et al. (2009) and Ruiz-Ariza et al. (2018) suggested that the self-control construct of emotional intelligence can be facilitated by using VR technology. Although self-control was found to be improved in a study conducted by Jiménez-Murcia et al. (2009), there was no improvement in self-control in Ruiz-Ariza et al.'s study (2018).

Cross-cultural understanding can be developed as a result of communication and information exchange among students from different cultures. However, when engaged in cross-cultural interaction, students may feel anxious or nervous because of cross-cultural conflicts in the communication process (Chen & Yang, 2014, 2016; Hsu & Beasley, 2019; Jin, 2015). As mentioned earlier, emotional intelligence enables students to be aware of, control, and express their emotions as well as to handle cross-cultural relationships efficiently (Luna et al., 2019; Petrides et al., 2007; Salovey & Mayer, 1990). Therefore, emotional intelligence is very important in cross-cultural learning and should be considered by educators and researchers.

Most related studies on using VR in education have used cyberspace as the virtual learning environment (see Fig. 1). To the best of our knowledge, there have been no studies exploring the development of cross-cultural learning and emotional intelligence in VR environments based on a 360-degree video. Therefore, this study is an attempt to address this existing gap in the field. In terms of facilitating emotional intelligence constructs such as well-being, self-control, emotionality, and sociability in cross-cultural situations, we assume that VR technology based on a 360-degree video may be useful. When students visit a foreign country to learn the local culture and language, they have issues associated with well-being, emotion, and self-control, e.g., they may feel frustrated, insecure, and anxious because of unfamiliarity with the culture and the presence of cultural differences (Walters et al., 2009). These issues can be avoided, and students can learn the culture and language of foreign countries using VR technology. This technology helps students immerse in and have a better sense of presence of a foreign culture, enables them to obtain authentic cultural experiences and have better self-control, and their emotions will be more positive because they will be virtually abroad but physically in their own country. In terms of sociability, it is important to interact with people in a foreign country to facilitate cross-cultural learning. When students visit a foreign country, they go out and communicate with locals face to face. This type of communication is synchronous, and for this reason, students may feel hesitant and ill at ease. However, when using VR technology, communication can be either synchronous or asynchronous. This will thus help students interact with each other more efficiently and increase their levels of sociability (Waytz & Gray, 2018). For example, synchronous communication in VR is not face to face. During asynchronous communication, students have time to think about their responses before answering, and they can find additional information on the Internet to ensure that they are not offending the interlocutor, etc.

Presence in VR

VR technology based on 360-degree videos is distinguished from other types of media based on presence (Huang, Hwang, & Chang, in press; Vettehen et al., 2019; Walshe & Driver, 2019). Presence is "the subjective experience of being in one place or environment, even when one is physically situated in another" (Witmer & Singer, 1998, p. 225). A person psychologically perceives himself/herself as being "there" within a virtual environment (Bulu, 2012). According to scholars, involvement and immersion are important conditions

for experiencing presence. Scholars defined involvement as "a psychological state experienced as a consequence of focusing one's energy and attention on a coherent set of stimuli or meaningfully related activities and events" (Witmer & Singer, 1998, p. 227). Scholars have proposed that a higher level of involvement and immersion will lead to a higher level of presence in a virtual environment. In addition, the sensory fidelity of students and the interface quality of the technology tools affect both involvement and immersion and further affect presence (Wang et al., 2015). In the present study, we examined the sense of presence that students feel in a VR environment based on a 360-degree video during a cross-cultural learning activity and tested the students' acceptance of VR technology.

Research questions

In this study, we created cross-cultural learning environments based on a 360-degree video technology in which students from different countries could communicate with each other and could also feel a sense of presence and obtain immersive learning experiences in foreign cultural contexts. We aimed to test whether the cross-cultural understanding and trait emotional intelligence of the participants could be improved in such learning environments. In addition, we investigated the participants' perceived sense of presence in VR environments and acceptance of VR technology. To this end, the following four research questions (RQs) were addressed:

(1) Can a learning activity supported by VR technology facilitate cross-cultural understanding?
(2) To what extent can a learning activity supported by VR technology promote students' trait EI?
(3) What is the sense of presence students perceive in cross-cultural learning supported by VR technology?
(4) To what degree do participants accept VR technology?

Method

Participants

Twenty-one students, ten (9 females and 1 male) from a university in China and eleven (all females) from a university in Uzbekistan, participated in this study. All study participants provided informed consent. The participants from China were graduate students, ranging in age between 23 and 25. The participants from Uzbekistan were undergraduate students, ranging in age from 20 to 24. All of the participants were majoring in education science.

Cross-cultural learning activity

We designed the following three-step cross-cultural learning activity: (1) Self-introduction—the participants introduced themselves, their hobbies and interests, and their daily life and culture to their partners. The self-introduction had to be recorded in a 360-degree video and uploaded on the learning activity website; (2) Introducing local culture—each participant selected one cultural topic out of ten (i.e., handicraft, building, market, tradition,

my city, game, campus, cloth, festival, and food) and then introduced it to their partners. Each participant provided related traditions, history, and information about the selected cultural topic. The local culture introduction also had to be recorded as a 360-degree video and uploaded online; (3) Experiencing foreign culture—each participant watched videos created by their partners on their favorite topics, reflected on their personal experience with the foreign culture and traditions in their reflective report, and shared their report with others. Each of these steps lasted for about a week.

VR technology

Samsung Gear 360 was used to make the 360-degree videos. Gear 360 is a camera with two fish-eye lenses. It captures a full 360-degree view of the world around a user in the form of a video or photo. The Samsung Gear VR headset embedded with Samsung Galaxy S9 + smart phone was used in this study to watch the 360-degree videos. Samsung Gear VR is a mobile VR device that can provide a 101° field of view. It works with a wireless headset and Samsung Galaxy smartphones.

Data collection and analysis

To answer each research question (RQ), both quantitative and qualitative data were collected: (a) the participants' reflective reports were used to answer RQ1, (b) the participants' responses to a trait EI questionnaire were used to answer RQ2, (c) the participants' responses to a questionnaire (i.e., perceived presence) were used to answer RQ3, and (d) the participants' responses to a questionnaire (i.e., VR technology acceptance) and interview data were used to answer to answer RQ4.

Reflective reports and one-on-one semi-structured interviews

The students were asked to write a reflective report describing their experience with cross-cultural learning supported by VR technology. We explored the students' acceptance of VR technology for cross-cultural learning by interviewing them. Each interview lasted approximately 30 min, in which the students were asked open-ended questions. All interviews were transcribed. The content of the reflective reports and interviews transcripts was analyzed by two researchers using open coding (Strauss & Corbin, 1990). The researchers highlighted and coded the parts of the reflective reports that represented the cross-cultural understanding of the participants. The codes then were grouped together to summarize, explain, compare, and contrast the dimensions (i.e., keywords from Bloom's taxonomy for the "Understanding" category). With respect to technology acceptance, the researchers highlighted and coded the parts of the interviews that demonstrated acceptance of VR technology, such as usefulness and ease of use (i.e., dimensions of the TAM (the technology acceptance model).

The trait and emotional intelligence questionnaire short form (TEIQue-SF) questionnaire

This instrument was used to measure the trait EI of the participants. The questionnaire included 30 items in four constructs: well-being, self-control, emotionality, and sociability.

Examples of some of the items are presented in Table 1. The items could be answered on a seven-point Likert scale. We anchored the end points of the scale with "completely disagree" (1) and "completely agree" (7). For more details regarding the TEIQue-SF scale, please refer to Petrides (2009).

Perceived presence questionnaire

We measured the sense of presence of the participants in the VR cross-cultural environment using a questionnaire adapted from the Presence Questionnaire. The questionnaire included four dimensions, involvement, sensory fidelity, adaption/ immersion, and interface quality, with a total of 19 items (Table 2). We anchored the end points of the scale with "completely disagree" (1) and "completely agree" (7). For more details regarding the Presence Questionnaire, please refer to Witmer et al. (2005).

Acceptance of VR technology questionnaire

We measured the acceptance of VR technology by the participants using a questionnaire adapted from the technology acceptance model. The questionnaire included two dimensions, usefulness and ease of use, with a total of 12 items: (Table 3). We anchored the end points of the scale with "strongly disagree" (1) and "strongly agree" (5). For more details regarding this instrument, please refer to Davis (1989).

Results

The students had no prior knowledge of their foreign partners' cultures and traditions before participating in this study. An analysis of the students' reflection reports showed that they learned some important information about the culture and related traditions of their partners from the content of the 360-degree videos (Fig. 2) and were able to summarize, explain, compare and contrast this information at the end of the activity. Extracts from the reflective reports related to foreign festivals, clothing, and buildings are provided below.

> *I learned about a traditional festival in their country called Memorial Day. She was standing in the memorial square. The square has eternal flames, monuments and statues. In front of the monument is the eternal flame, built in 1999 to commemorate the 400,000 Uzbek soldiers who died in World War II. The monument tells them that nothing is forgotten; no one is forgotten. The war has touched every family in Uzbekistan. The monument serves as a precaution against the past, protecting them from rash decisions and inhumane acts. This is similar to our country's Army Day, the Nanjing massacre memorial, and others.* [Code: Summarize/Code: Explain]
> *I found that the traditional costumes of Uzbekistan are very similar to those in Xinjiang province. Therefore, I am very puzzled whether the two regions were connected at some stage in history, perhaps during Zhang Qian's diplomatic mission to the western regions in the Han dynasty.* [Code: Compare]
> *I remember seeing a video where there were some traditional buildings, for example, mosques, which are different from our traditional buildings. The color of these buildings is very bright, and they have large domes with conical shapes, whereas Chinese classical architecture is clearly characterized by cornices, bucket arches, and large roofs.* [Code: Contrast]

Table 1 Trait EI items with significant difference between pre- and post-test results

No.	Items	Pre-test		Post-test		t	p
		Mean	SD	Mean	SD		
1	Expressing my emotions with words is not a problem for me	5.40	.966	6.20	.632	− 2.753	.022
2	I don't often find it difficult to see things from another person's viewpoint	5.30	.675	6.00	.816	− 3.280	.010
15	On the whole, I'm able to deal with stress	5.30	.675	6.00	.667	− 4.583	.001
17	I'm normally able to "get into someone's shoes" and experience their emotions	4.90	1.197	5.90	0.738	− 3.000	.015
18	I don't normally find it difficult to keep myself motivated	5.00	1.333	5.70	1.252	− 3.280	.010
23	I often pause and think about my feelings	4.50	1.958	5.90	0.876	− 2.689	.025

Table 2 The participants' perceived presence

No.	Dimensions	Mean	SD
	Involvement		
1	How much were you able to control VR content?	5.62	.921
2	How natural did your interactions with the environment seem?	5.33	.913
3	How much did the visual aspects of the environment involve you?	5.67	.856
4	How compelling was your sense of objects moving through space?	5.48	1.078
5	How much did your experiences in the virtual environment seem consistent with your real-world experiences?	5.43	.870
6	How completely were you able to actively survey or search the environment using vision?	5.48	1.123
7	How compelling was your sense of turning around inside the virtual environment?	6.14	.854
8	How involved were you in the virtual environment experience?	5.67	.856
	Total	5.60	.949
	Sensory fidelity		
9	How much did the auditory aspects of the environment involve you?	5.81	.873
10	How well could you identify sounds?	5.43	1.165
11	How well could you localize sounds?	5.29	1.102
12	How closely were you able to examine objects?	5.00	.949
13	How well could you examine objects from multiple viewpoints?	5.14	1.062
	Total	5.33	1.053
	Adaptation/immersion		
14	How quickly did you adjust to the virtual environment experience?	5.76	.889
15	How completely were your senses engaged in this experience?	5.29	.956
16	Were there moments during the virtual environment experience when you felt completely focused on environment?	5.38	1.024
17	How easily did you adjust to the control devices for virtual environment/watching VR video?	5.62	1.024
18	Was the information provided through different senses in the virtual environment (e.g., vision, hearing) consistent?	6.00	1.095
	Total	5.610	1.014
	Interface quality		
19	The visual display quality did not interfere or distract you from performing required activities	5.810	.814

This result suggests that the cross-cultural understanding of the students improved after the learning activity.

According to the results, the students scored higher on the post-test items in the trait EI questionnaire as compared to the pre-test items. However, the difference between the pre- and post-test was significantly different only for items in the emotionality (items # 1, 2, 17, 23) and self-control (item # 15) constructs, $p < .05$ (see Table 1). That is, the students scored significantly higher on these two constructs after cross-cultural learning than they did before. Therefore, this result suggests that the trait emotional intelligence of the students related to emotionality and self-control improved during this study.

According to the results of the perceived presence questionnaire (Table 2), almost all of the students confirmed that they perceived themselves to have a high level of involvement in the VR environment (the total mean value was 5.60, and the standard deviation was .949). In the interviews, the participants said that they could control content with the VR device. They also felt that the visual aspects of the environment involved them, and their sense of turning around inside the virtual environment was very compelling. Most students perceived high levels of sensory fidelity in the VR environment (the total mean value = 5.33, the standard deviation = 1.053). In the interviews, the participants mentioned that they were able to identify and localize sounds very well. In addition, they felt involved in the auditory aspects of the environment.

The results showed that the majority of the students perceived their adaptation/immersion in the VR environment as high (mean value = 5.610, standard deviation = 1.014). The students said in the interviews that they could quickly adjust to the VR environment; e.g., they easily adjusted to the control devices for the VR environment and could easily watch the VR videos. The students also stated that they perceived that the information provided through different senses in the VR environment was consistent. Finally, most of the students found the interface quality to be good (M = 5.810; SD = .814). That is, the visual display quality did not interfere with their experience or distract them while they were watching the 360-degree videos.

Below are two extracts from the interviews demonstrating the students' perceived sense of presence:

> *I can see the 360-degree environment around my partner, which is more useful than the 2D video… I can turn around and look at the buildings around me, and so on… While introducing her culture, she would ask me to observe something, and I could do it based on her instructions. I also wanted to go along with her when she walked in the other direction. I felt like I was "there" and wanted to explore with her.*
>
> *... at the end of the experience, I needed a moment to make sure I was in the real world. Although it was very short experience, I'm sure it was because I was really immersed in it.*

However, a few students expressed some concerns regarding their VR experience. Some students complained that the video was recorded in a noisy environment, so they could not hear the speaker well when watching the video. Other students said that some videos were recorded when the camera was not close enough to cultural artifacts. As a result, they could not examine them in detail. These issues need to be addressed in the future by the instructors and the students. For example, 360-degree videos should be recorded in noise-free environments, and the camera should be close to the objects of interest so that foreign partners can hear the recorded audio and see details of the recorded objects well.

Table 3 The participants' perceptions of VR technology

#	Dimensions	Mean	SD
	Usefulness		
1	Using VR technology in my learning would enable me to accomplish tasks more quickly	4.24	.700
2	Using VR technology would improve my learning performance	4.29	.644
3	Using VR technology in my learning would increase my productivity	4.00	.632
4	Using VR technology would enhance my effectiveness on learning	4.24	.539
5	Using VR technology would make it easier for my learning	4.24	.700
6	Overall, I found VR technology to be useful for my learning	4.48	.512
	Total	4.25	.628
	Ease of use		
7	Learning to operate VR technology would be easy for me	4.38	.498
8	I would find it easy to use VR technology to do what I want to do	4.33	.577
9	My interaction with VR technology would be clear and understandable	4.19	.680
10	I would find VR technology to be flexible to interact with	4.29	.644
11	It would be easy for me to become skillful at using VR technology	4.48	.680
12	Overall, I found VR technology to be easy to use	4.52	.602
	Total	4.37	.615

Our result suggests that most students had high sense of presence in the learning environment created by VR technology. Some issues were also reported, and they need to be considered in the future.

The results of the questionnaire showed that the participants had positive perceptions of VR technology (Table 3). They perceived VR technology to be useful for cross-cultural learning (Mean = 4.25; SD = .628). In addition, the participants perceived that VR technology was easy to use (Mean = 4.37; SD = .615) during the learning activity.

In the interviews, the participants confirmed their responses to the questionnaire. In addition, several other benefits of VR technology for learning were reported during the interviews; e.g., the participants could learn about and experience a cultural experience in an authentic context [Code: Authentic]. Some extracts from the reflective reports are provided below.

> *Because I will have no opportunity to visit that place, even though I can find some related information on the Internet, I still feel that my learning experience supported by VR was authentic and that I felt a high level of presence.*
> *It's a great way to communicate with people from Uzbekistan through virtual reality. Because there are so many constraints, this is probably the most economical and achievable approach.*
> *… both the APP used on the phone and the interfaces on the head-mounted display device are simple, and their interaction is clear and understandable.*

This result suggests that the students accepted VR technology. They perceived it as useful for cross-cultural learning and as easy to use during the learning activity.

Fig. 2 360-degree video: **a** festival; **b** clothing; **c** building

Discussion

One of the purposes of this study was to explore how cross-cultural understanding develops in a cross-cultural learning project supported by VR technology. Through an analysis of the reflective reports, we found that students' cross-cultural understanding was changed during the learning activity. Our results showed that the students had no prior knowledge about their partners' culture and related traditions before their participation in this study. However, at the end of it, their cross-cultural understanding was evident in their reflective reports. This finding suggests that the participants gained cross-cultural understanding. That is, the students were able to understand a foreign culture and related traditions, to summarize what they learned, and to explain the similarity and differences between the culture and related traditions of their foreign partners and those of their own. Our finding is in line with cultural convergence theory (Gudykunst et al., 1988; Kincaid, 1979). Furthermore, our results are consistent with those of previous studies (Chen & Yang, 2014, 2016; Hsu & Beasley, 2019; Jin, 2015). The

students in previous studies also communicated and exchanged culture-related information with each other using Web 1.0 or Web 2.0 technologies (e.g., email, instant messaging, video conferencing, or social network services), and as a result, their cross-cultural learning was enhanced (Chen & Yang, 2014, 2016; Hsu & Beasley, 2019; Jin, 2015; Wu, 2018). However, in contrast to previous studies, we employed VR technology to create a cross-cultural learning environment that enabled the students not only to communicate and exchange culture-related information with each other but also to immerse in a foreign cultural environment, feel a sense of presence in that environment without being physically there, and have an authentic learning experience.

Our results showed a significant increase in emotionality and self-control, i.e., two constructs of trait EI. Scholars have suggested that trait EI can be influenced by several factors, including learning content, activities, or environments (Luna et al., 2019; Ruiz-Ariza et al., 2018; Terkildsen & Makransky, 2019). Perhaps, in our study, these factors had some influence on emotionality and self-control. It is possible that one of them was the students' perceived sense of presence in the VR environment. Scholars have argued that sense of presence positively influences trait EI (Cebeci et al., 2019; Riva et al., 2007; Terkildsen & Makransky, 2019). For example, in contrast to a physical environment, a VR environment is not an stressful environment, so learners feel relaxed, natural, and uninhibited (Cebeci et al., 2019). Furthermore, because a VR environment is man-made, students have better self-control in this type of environment (Jiménez-Murcia et al., 2009; Ruiz-Ariza et al., 2018). For example, students can rewind, pause, or stop their 360-degree videos anytime they want.

It is also possible that development of the cross-cultural understanding of the students positively influenced the increase in emotionality and self-control. The students learned about a foreign culture and related traditions, and because their learning progress was good, so was their emotional state. In addition, for the cross-cultural learning process to be effective, the students had to have good self-control, e.g., they had to prepare good quality learning content and communicate it to their foreign partners in a timely manner. Therefore, active involvement in the learning activity presented in this study could possibly have influenced their degree of self-control.

However, there was no significant increase in the well-being and sociability related to the students' trait EI. Perhaps this was because in the present study, well-being and sociability were not related to the learning content, activity, or environment. That is, our cultural topics did not cover anything related to well-being, and the students did not socialize much during the study.

Through the analysis of the questionnaires and interviews, we found that the students perceived a good sense of presence in the VR environment, particularly as it related to involvement, sensory fidelity, adaption/ immersion, and interface quality. This finding suggests that VR technology based on a 360-degree video is a potential tool for cross-cultural learning since it may create a learning environment in which students perceive a sense of presence well. This finding is in line with the results of other studies; however, the focus of earlier studies was not on cross-cultural learning but rather was on other subjects, e.g., language learning, psychology, media, civil defense, etc. (Çakiroğlu & Gökoğlub, 2019; Chien et al., in press; Higuera-Trujillo et al., 2017; Huang et al., in press, Vettehen et al., 2019).

The students had positive perceptions of VR technology, including its usefulness for cross-cultural learning and ease of use. The students also mentioned that VR technology created a culturally authentic learning environment. According to the students, this environment was useful for learning. This finding suggests that the students accepted VR

technology. We were unable to compare this finding with the findings of earlier studies because scholars have paid very little attention to acceptance of VR technology.

Pedagogical usefulness of VR technology for cross-cultural learning and trait IE

Based on the results, three important points related to the pedagogical usefulness of VR technology for cross-cultural learning and trait IE are discussed as follows: First, the results of the questionnaire indicating acceptance of VR technology, as well as the interviews, showed that the students perceived VR technology based on 360-degree video to be a useful tool for cross-cultural learning. VR technology can create a learning environment in which students from different cultures can interact with each other in order to learn each other's culture and traditions. It is likely, and in line with the cultural convergence theory, that, in the process of communication and exchanging culture-related information, cross-cultural learning takes place. In addition, the learning environment created by VR technology provides authentic contexts because the content of 360-degree videos is recorded in cultural contexts and presented by students who represent that culture.

Second, VR technology can be useful in regard to emotionality and self-control (i.e., two important constructs of trait IE). VR technology enables students to virtually visit different places with cultural importance in foreign countries without physically leaving their own homeland. Furthermore, student communication in a VR environment can be flexible (e.g., synchronous but not face to face or asynchronous with enough time to think and respond to a partner). Therefore, the emotions of students will tend to be positive because they feel safe and secure in the VR environment. Because a VR environment is man-made, students can control and manipulate it. For example, when watching a 360-degree video, students can rewind and pause the video or change their view of the learning content. Therefore, students' sense of self-control and self-efficacy can be facilitated in a VR environment.

Third, VR technology based on a 360-degree video can be used to create cross-cultural learning environments in which students can perceive a high level of sense of presence. This is because a 360-degree video presents contexts recorded on video cameras, and therefore, people, objects, and scenarios in virtual space look the same way as they appear in real life. For example, students can learn about culture and traditions much better than they would otherwise under such circumstances, and their knowledge will become deeper when they have a compelling sense of turning around inside the virtual environment. In this case, students can observe not only cultural objects presented by a partner but also the surrounding context. Then, students will be able to connect cultural information with the context it is related to.

Conclusion

Our results showed that cross-cultural understanding improved during the learning activity supported by VR technology. There was a significant increase in trait EI related to emotionality and self-control. In addition, the students had a high perceived sense of presence, and they accepted the VR technology as useful for learning.

Based on these results, we suggest that VR technology can be used during cross-cultural learning activities. VR technology based on a 360-degree video is relatively cheap and available compared to other VR devices (Vettehen et al., 2019). We also found that this type of technology is useful for cross-cultural learning and is easy to use. In contrast to other technologies (e.g., Web 1.0 or Web 2.0), the instructors and students can make cross-cultural learning environments authentic, immersive, and create a high sense of presence using VR technology (Chien et al., in press). When designing cross-cultural learning activities in a VR environment based on a 360-degree video, the instructors and students may refer to the three main points discussed in this work regarding the pedagogical usefulness of VR technology for cross-cultural learning and the development of trait IE. In addition, they should consider the issues associated with 360-degree videos that were reported by the students. For example, they should record videos in noise-free environments, and cultural artifacts should be located a short distance from the camera.

Limitations and future research directions

In this study, the participant sample was small. For this reason, our results cannot be broadly generalized. Future studies may consider this limitation and involve a larger number of participants. A control group was absent, and therefore, we couldn't show the effectiveness of the intervention on learning outcomes. Future studies may consider carrying out similar studies in which the learning outcomes of the intervention and control groups can be compared. Our learning activity was not related to well-being and self-control (which are important constructs of trait EI). This is why we did not observe any changes in these constructs. In the future, researchers may wish to consider exploring these two constructs by incorporating topics related to well-being and activities that foster socialization. In the future, scholars also may wish to explore the relationships between the affordances of VR technology, such as presence and immersion and cross-cultural learning outcomes. In addition, synchronous interaction among participants in VR environments could be investigated.

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Data availability The datasets generated and analyzed during the current study are not publicly available but will be provided by the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The study was approved by the ethics committee of Nanjing Normal University, China and performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki.

Informed consent Informed consent was obtained from all individual participants included in the study.

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