International Journal of Intercultural Relations 82 (2021) 109–120

Contents lists available at ScienceDirect

International Journal of Intercultural Relations

journal homepage: www.elsevier.com/locate/ijintrel

# An examination of the effectiveness of virtual reality technology for intercultural competence development

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ARTICLE INFO

*Keywords:*
Intercultural competence
Virtual reality
Simulated training
Assessment of learning outcomes
STEM education
Responses to COVID-19 pandemic

ABSTRACT

This study examines the effectiveness of virtual reality (VR) technology as an innovative learning platform in developing intercultural competence, including intercultural knowledge, attitudes, and beliefs. The research was based on data from undergraduate STEM students in a first-year technology course at a large public university in the Midwestern U.S. (n = 101). Online questionnaires measuring the universality-diversity dimension, tolerance of ambiguity, intercultural sensitivity, and cultural knowledge were used to collect pre-posttest data pre- and post-intervention. Paired sample t-tests assessing various components of intercultural competence yielded mean score increases from directly before (T1) to two weeks after (T2) the VR intervention. Furthermore, the study tested the specific relationship of participants' Intercultural Development Inventory (IDI) scores to intercultural competence measures. A linear regression revealed that students' pre-training IDI and cultural knowledge scores were significant predictors of their MGUDS score change, controlling for demographic variables such as gender, ethnicity, international student status, travel, and life history. Since objective measures of knowledge increased while self-report instruments such as the MGUDS showed mean decreases, the VR-based learning environment seems to have encouraged learners to develop a more realistic self-assessment of their level of intercultural competence. Results from this study suggest the importance of immersion (even when mobility is not possible) in developing intercultural competence and the potentials of VR technology in advancing intercultural learning. Implications for research and practice of intercultural competence development are discussed.

## Introduction

Increased globalization requires that students learn to navigate effectively across cultures and borders in order to be competitive later in careers in international and global environments (Deloitte, 2017; Sorrell, 2016; Zhang & Zhou, 2019). In recent decades, the low cost of international communication and our ability to automate processes worldwide have pushed the world to become truly global. As a result, employers increasingly seek workers who can not only accomplish the technical and procedural tasks assigned to them but also appropriately and effectively communicate with individuals across cultural boundaries. Employees need to coordinate, collaborate, and communicate internally and clients both locally and across the globe (Banks et al., 2015; Schanzenbach et al., 2016). Increased globalization has led to changes in the skills needed for undergraduate STEM students' success in terms of intergroup relations and intercultural communication in diverse contexts – what we refer to throughout this paper as intercultural competence.

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https://doi.org/10.1016/j.ijintrel.2021.03.009
Received 16 October 2020; Received in revised form 11 February 2021; Accepted 15 March 2021
Available online 31 March 2021
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Traditionally, undergraduates have received training and education in intercultural competence through study abroad, co-curricular programs, and coursework. However, each method has fundamental weaknesses. For example, study abroad programs – arrangements in which students complete part of their degree program through educational activities outside their home country – require significant financial and logistical investments. Programs that require mobility are also challenging when global travel is limited, as in the current pandemic era. Additionally, co-curricular programs, activities, and learning experiences that complement what students learn in school do not present a systematic, targeted learning approach because they are based on voluntary participation. As with study abroad, co-curricular programs (usually offered in a face-to-face setting) were severely constrained when higher education institutions went entirely online in response to the COVID-19 outbreak. Finally, coursework, which usually includes a number of major, minor, or elective courses that provide content around intercultural areas, typically focuses on cognitive learning, not necessarily behavioral or attitudinal development. Moreover, as with co-curricular opportunities, students can often self-select out of coursework, and those who most need intercultural learning are less likely to willingly engage in such experiences (Nadeem et al., 2020). While pandemic responses may not have negatively impacted course offerings themselves, the lack of skill and comfort of instructors teaching in the online environment suddenly, for the first time, and with little support or training may be limiting the effectiveness of online coursework typically offered in person for fostering intercultural development.

In sum, a key challenge of developing intercultural competence is overcoming substantial economic and logistical constraints – obstacles that have increased in number and size throughout 2020 as the pandemic has unfolded. These obstacles must be addressed if we deploy evidence-based best practices such as experiential and reflective learning, safe learning environments, and individualized feedback on student performance. In addition, obstacles must be addressed with scalable solutions that more than a small percentage of students. A potential solution that may strike a balance between good pedagogy and scalable curriculum, especially in times of limited mobility and face-to-face contact, is the instructional medium of Virtual Reality (VR).

VR has been proven successful in achieving learning outcomes in other contexts due to its capacity to provide innovative, immersive and safe learning experiences (Grabowski & Jankowski, 2015; Kugler, 2017; Miller, 2016; Pagano et al., 2017; Xie et al., 2021). VR has a strong potential to serve as an effective learning approach for promoting all three domains of learning: cognitive (knowledge), affective (attitudes) and psychomotor (skills). VT also has the potential to help students master specific key components of intercultural competence, including communication skills, empathy, openness and curiosity. Furthermore, VR is advantageous due to being relatively easy and affordable to scale up for a large number of learners. With the advent of immersive online learning environments such as VR, multiplayer games, virtual military simulations, and immersive second language learning environments, these newer learning aids have demonstrated capacity for both technical and nontechnical skill development (Monahan et al., 2008; Pana et al., 2006; Rutledge et al., 2008).

Based on these advancements, immersive learning technologies present strong potential to serve as effective learning approaches for promoting all three domains of intercultural competence development, including knowledge (cognition), attitudes (affect) and skills (behaviors) (Colbert et al., 2016; Cordar et al., 2017). However, while a growing body of literature demonstrates the effectiveness of VR technology for learning technical subjects (Daniela & Lytras, 2019), empirical studies examining VR technology as a learning medium for nontechnical areas are much rarer (Bukhari & Kim, 2013). There is a gap in the literature on whether, to what extent, and how intercultural competency development occurs in the VR environment. In light of this gap, this empirical study examines the effectiveness of a VR simulation on intercultural competence development learning outcomes. We begin with a review of relevant literature that provides a basis for our hypotheses in this study, then describe our methods, present key findings, and discuss implications for scholars and practitioners of intercultural competence development.

## Literature review

### *Intercultural competence development and assessment*

Intercultural competence is the ability to communicate effectively and appropriately in intercultural situations based on one's intercultural knowledge, skills, and attitudes (Deardorff, 2006). Developing intercultural competence results in an improved understanding of other worldviews and the ability to manage thoughts, emotions, change, and ambiguity in order to effectively build bridges across cultural diversity in organizational settings (Zotzmann, 2015). Thus, intercultural competence is vital for individual success when interacting with culturally diverse individuals, including coworkers, suppliers, clients, and larger society in a globalized world (Lévy-Leboyer, 2007).

Many contemporary scholars view intercultural competence within a developmental framework – that is, as a set of related competencies that can improve over time and as a result of experience – rather than as a collection of static personality traits (Hammer, 2015). In other words, intercultural competence is imminently learnable. Various definitions of intercultural competence exist in scholarly literature, with some emphasizing the role of language and localized cultural knowledge and others focusing on globally transferable components such as positive attitudes towards cultural difference and cultural discovery skills (Acheson & Schneider-Bean, 2019). Most scholars, however, agree that intercultural competence is comprised of some combination of attitudes/affect (Byram et al., 2002; Howard-Hamilton et al., 1998), knowledge/cognition (Hernández-Bravo et al., 2017; Li et al., 2013), and skills/behavior (Daly et al., 2015; Gowindasamy, 2017; Heinzmann et al., 2015; Tuncel & Aricioglu, 2018).

The American Association of Colleges and Universities led the creation of a series of rubrics for qualitative assessment in higher education known as the Valid Assessment of Learning in Undergraduate Education (VALUE) rubrics (AAC&U, 2010). Among these rubrics is the *Intercultural Knowledge and Competency*, which delineates six components of intercultural competence: the knowledge components of cultural self-awareness and cultural worldview frameworks, empathy and verbal/non-verbal communication skills, and

the attitudes of curiosity and openness. For the purposes of this study, we drew our learning outcomes of openness, curiosity, and worldview frameworks from this rubric and paired them with validated measures (described in more detail in the sections below). The study's theoretical framework is built upon Deardorff's (2006) Pyramid model of intercultural competence, because this model allows us to organize the components of intercultural competence into a hierarchy and understand their order of acquisition. The theoretical model justifies our choices of learning outcomes as foundational prerequisites for higher-order skills and as culture-general components that are transferable from one cultural context to others (Fig. 1).

Intercultural openness, for instance, is widely recognized as an important component of intercultural competency. In the AAC&U's (2010) VALUE rubric for Intercultural Knowledge and Competence, the attitude of openness involves both willingness to interact with culturally different others and the capacity to suspend judgment and consider alternate interpretations during those interactions. Many other intercultural competency models, including Deardorff's (2006) Pyramid model, highlight the importance of openness. In fact, Deardorff's model places openness at the base of the pyramid, implying that development of intercultural competency cannot continue without this foundational attitude. The same is true of intercultural curiosity, which Deardorff connects with tolerance of ambiguity and uncertainty.

Despite the complexity and variation that has characterized scholarly attempts to define intercultural competence, the AAC&U VALUE rubric, and Deardorff's work make clear that it is possible to operationalize the construct in ways that are accessible. There exists, in fact, a long history of intercultural competence assessment across a variety of contexts, including higher education institutions (Iseminger et al., 2020), particularly in international education (Vande Berg et al., 2009), industry (Huang et al., 2003), government (Miller & Tucker, 2015), and non-governmental organizations (Kimber, 2012). The construct is measurable both holistically and by focusing on its specific components (Fantini, 2009). Assessment of intercultural competence often takes the form of self-report psychometric measures such as the Intercultural Development Inventory (Hammer et al., 2003), the Global Competency Inventory (Stevens et al., 2014), the Cultural Intelligence Scale (Van Dyne et al., 2009), and the Beliefs, Events, and Values Inventory (Wandschneider et al., 2015).

A common study design for determining the effectiveness of interventions meant to increase intercultural competency is the comparison of pre- and post-test scores. For example, an intercultural psychometric might be administered before and after a university course (Snodgrass et al., 2018) or a study abroad program (Jones et al., 2019). One critique of this approach is that psychometric self-report measures sometimes result in over-estimations of participants' intercultural competence levels, particularly before intentional developmental work (Valdivia et al., 2018). For this reason, instruments such as the *Intercultural Development Inventory* (IDI) that include both subjective (Perceived Orientation, or PO) and objective (Developmental Orientation, or DO) scores are especially useful.

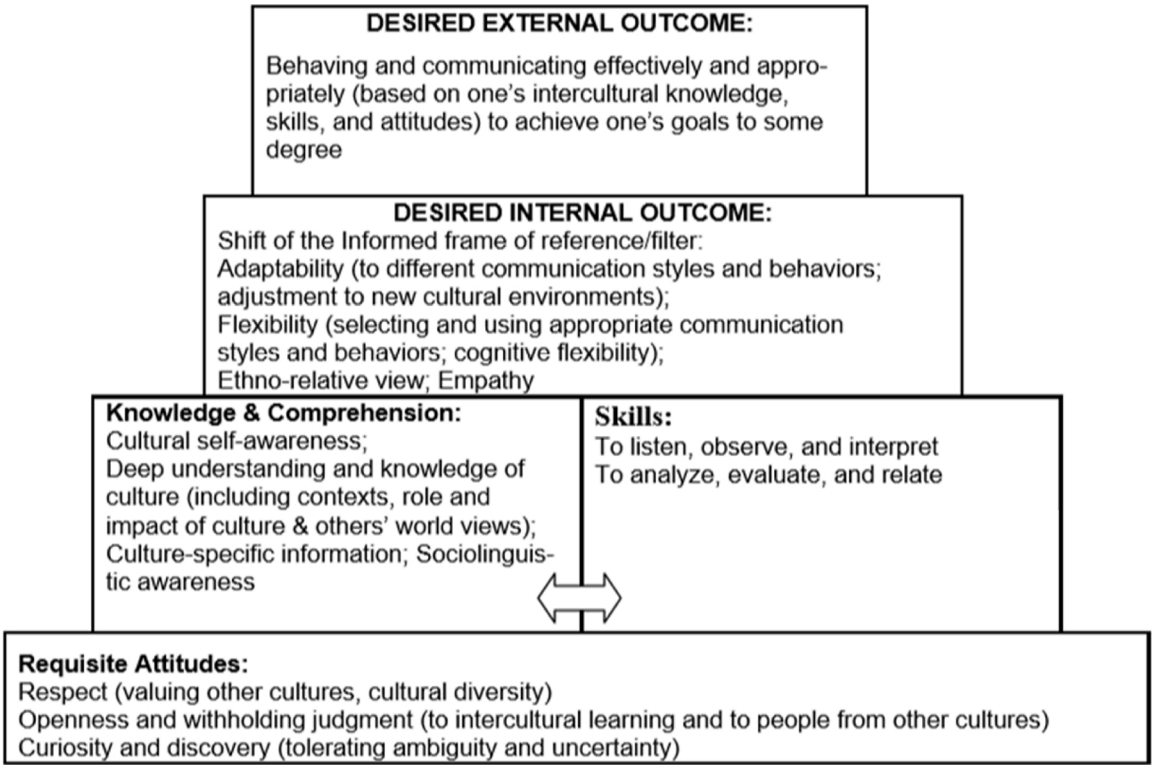


**Fig. 1.** Deardorff's (2006) Pyramid Model of Intercultural Competence.

*Virtual reality*

Virtual Reality (VR) technologies that utilize electronic eyewear to immerse an individual in a computer-simulated environment are considered emerging tools for providing engaging and autonomous learning for both academic and professional purposes. Recent technological advances have increased the resolution and dramatically reduced the cost of deploying VR material. The findings of a recent survey on the use of digital technologies to drive digital business transformation indicated that, of the 29 % of organizations that are using or piloting immersive learning technologies, 40 % reported that the tool exceeded their expectations and 60 % reported that the technology performed as expected (Cearley et al., 2017). Two decades ago, VR had to be played on a desktop computer or with custom-built proprietary headsets. However, commercially available VR headsets today are the most commonly used approach to deliver VR material; they provide a great sense of immersion, as they replace the real world with the virtual one through complete visual occlusion. These advances mean that VR has rapidly become an inexpensive and viable learning tool in fields such as engineering, medicine, chemistry, and other hard sciences (Clark et al., 2016; Freitas et al., 2006).

Most STEM disciplines employ VR training. However, some studies document the development of various skills in VR environment, including language acquisition (Thorne et al., 2009) and intercultural competencies (Caligiuri et al., 2011). One previous study involved a virtual environment for intercultural competence development through an avatar-based Second Life simulation (Coffey et al., 2013), a two-dimensional environment built primarily for social interaction. Despite limited scholarship on VR outside of STEM, however, the platform does hold promise for developing empathy, with empirical evidence supporting this claim documented in healthcare settings (Wijma et al., 2018). A feature of the VR environment that may support attitudinal development of this sort is its safety – that is, in contrast to in-class role plays or interactions in the real world, which have relational (e.g., judgment, offense) and emotional (e.g., shame, anxiety) consequences (Mesker et al., 2018; van Niejenhuis et al., 2018), VR offers a safe environment for the experimentation and practice of social skills. Although VR offers the prospect of exponentially increasing the scale of implementation and presents the advantages of a safe learning environment for engaging in potentially uncomfortable social interactions, VR as an immersive learning tool needs to be further tested for its capacity to contribute to the achievement of specific learning outcomes related to the development of intercultural competence (Diehl & Prins, 2008; Hickman & Akdere, 2017).

The central research question driving this study was, to what extent would the VR simulation support both participants' development of intercultural competence and their realistic self-assessment of their intercultural competence level? Based on contemporary literature, we believe that the results of this study would support the following hypotheses:

**Hypothesis 1**. The VR intervention will increase learners' knowledge of cultural worldview frameworks.

Given the demonstrated capacity of VR to support the development of both technical and nontechnical skills in other contexts, it is reasonable to assume that a theoretically grounded VR intervention will successfully achieve targeted cognitive learning outcomes in this case. Specifically, the VR module in this study was designed to increase learners' understanding of where cultures lie on the polychronic-monochronic spectrum, to what extent their own and other cultures value power distance, and differences between task and relationship orientations. We sought evidence for this hypothesis in positive score changes in the cultural knowledge items administered to learners in a pre-posttest design.

**Hypothesis 2**. As a result of engaging in a VR-based learning environment, participants will develop a more realistic self-assessment of their intercultural competence levels.

Literature has often highlighted the differences between subjective and objective measures of intercultural competence, noting that many learners overestimate their competence levels, especially before interventions. In this study, we expect to find that actively practicing intercultural interactions in a safe and immersive environment such as VR would encourage participants to more realistically gauge their attitudes and skills. Evidence for this hypothesis was expected to emerge in pre-posttest decreases in scores on attitudinal measures such as the *Miville-Guzman Universality-Diversity Short Scale* (MGUDS-S) (Miville et al., 1999), changes that IDI scores would also predict.

## Methodology

*Participants*

Data were collected from freshman students in an entry-level technology course at a large land grant university in the Midwestern US. The course employs active learning strategies in a flipped and blended learning environment to teach design thinking for students in STEM majors. In total, 101 students completed the study. The participants average age was 18.93, with 71.3 % of participants identifying as male and 28.7 % as female. White/Caucasian students accounted for 60.4 % of the sample, along with 12.9 % Asians and 5.9 % African Americans.

*Intervention*

The module allowed students to experience an international case in an immersive VR platform rather than discussing or roleplaying the case in a class setting. The simulation scripts were developed as an experience collaborating with international organizations, wherein participants attempt to engage with their counterparts from Latin America and develop a joint project. The VR simulations were recorded with a 360-degree video camera using live actors. Participants watched and interacted orally with these videos via an

Oculus Rift VR headset. The simulation was composed of three sections, each lasting 15 min, and each section contributed to a single storyline relating to the joint project. After each section was complete, participants engaged in a metacognitive debriefing segment that discussed various worldview frameworks emphasized in the simulations, such as the polychronic-monochronic spectrum, power distance, and task/relationship orientation.

The VR script was built on several theoretical intercultural constructs, including time, power, and task/relationship orientations. First, a foundational construct was the spectrum between more polychronic (i.e., attending to multiple things simultaneously, most concerned with the present moment, and perceiving oneself as in control of time) and more monochronic orientations (i.e., organizing activities around the clock, attending strictly to schedules, and perceiving oneself as subject to the constraints of time) (Hall, 2012). Second, Hofstede's (1997) value continuum for power distance, or the extent to which members of a cultural group tend to be comfortable with power differentials and more vertical hierarchies within organizations and social groups, was essential to the simulation content. Finally, differences between task (i.e., goal achievement is the focus) and relationship orientations (i.e., concern for and caretaking of others is a priority) (Bass, 1990) helped shape the simulation script.

### *Procedure*

Participants completed the online pretest survey prior to the intervention (Time 1). The combined intercultural competency survey included demographic information and several validated measures: The MGUDS-S (Miville et al., 1999), *Tolerance for Ambiguity Scale* (TAS) (Herman et al., 2010), Chen and Starosta's *Intercultural Sensitivity Scale* (ISS) (2000), and items for assessment of declarative knowledge regarding the dimensions of culture adopted from Hofstede's cultural dimensions theory. Participants then experienced the 45-minute VR simulation individually. The same online survey (excluding demographic information) was sent to them as a posttest (Time 2) two weeks after the intervention. We merged data collected specifically for this study with previously existing data before de-identifying the dataset for analysis. For example, many STEM students at this university complete the IDI assessment in their first semester. We were able to extract the IDI scores for 46 participants from that institutional data set and triangulate them with study data for a deeper understanding of students' intercultural growth and development. Qualitative learner artifacts, including reflection in response to prompts during and after the VR simulations, and non-invasive biometric data such as heart rate and skin responses (i.e., in temperature and moisture) were collected in this study as well. However, these data sets were analyzed and triangulated with quantitative data in a separate research report due to space limitations.

### *Instruments*

*The Miville-Guzman Universality-Diversity Scale* (MGUDS-S) (Miville et al., 1999) was adapted in this study to measure participants' universal-diverse orientation – a spectrum indicative of gravitation towards and comfort with similarity as opposed to difference. This validated instrument utilized a 5-point Likert scale (1= strongly disagree to 5=strongly agree) and contained 15 items, for example, "I can best understand someone after I get to know how he/she is both similar to and different from me". The reliability of the scale in this study was $\alpha = .779$.

We employed the *Tolerance for Ambiguity Scale* (TAS developed by Herman et al. (2010) to measure tolerance for ambiguity. A sample item for the TAS included "I can enjoy being with people whose values are very different from mine". The Cronbach's alpha of the 5-point Likert scale in our data was $\alpha = .678$.

We also adapted the short form of Chen and Starosta's (2000) *Intercultural Sensitivity Scale* into four items. For instance, "I tend to wait before forming an impression of culturally-distinct counterparts". The reliability of the ISS scale in our study was $\alpha = .701$.

*The Intercultural Development Inventory* (IDI) assessment contained 50 items to assess intercultural sensitivity. It yielded three normed scale scores: perceived orientation (PO), developmental orientation (DO), and orientation gap (OG). Perceived orientation indicates individuals' self-evaluation (usually considered aspirational rather than realistic) of their perspective when interacting with culturally diverse individuals. The development orientation reflects a more objective measure of participants' actual orientation towards cultural differences. The orientation gap is the difference between these two scores: the perceived orientation, which is almost invariably higher, minus the developmental orientation (Hammer et al., 2003).

The assessment of declarative knowledge regarding the dimensions of culture used 14 questions to measure knowledge of the cultural dimensions of uncertainty avoidance, power distance, individualism and collectivism, monochronic and polychromic mindset, long and short term orientation, and masculinity and femininity. The items in this scale were primarily based on Hofstede's (1997) Dimensions of Culture theoretical model.

### *Data analysis*

Paired sample t-tests were conducted to examine how the universality-diversity dimension, tolerance of ambiguity, intercultural sensitivity, and cultural knowledge changed from directly before (T1) to two weeks after (T2) the VR intervention. Then, to understand the specific relationship of IDI scores to these pre-posttest measures, additional analyses were performed using linear regressions with these variables' changes over time among the 46 participants for whom we could obtain previously collected IDI data. The change scores for each measure were computed by subtracting pre-intervention scores from post-intervention scores. Demographic variables such as gender, ethnicity, international student status, and travel and life history were controlled in the linear regression.

**Table 1**
Correlation table of all study variables (N = 101).

| Variables | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Gender | 1 | −.116 | −.062 | .180 | .175 | .148 | .244* | .155 | .264** | .157 | .193 | .163 | .116 |
| 2. Ethni-city | | 1 | −.316** | −.117 | −.058 | .027 | .149 | .197* | −.050 | .019 | .185 | .147 | −.003 |
| 3. Inter-national | | | 1 | −.309** | −.535** | −.164 | .098 | .004 | .105 | −.075 | .073 | .116 | .123 |
| 4.Travel History | | | | 1 | .503** | .239* | .106 | .023 | .070 | .216** | .054 | −.042 | .081 |
| 5.Life History | | | | | 1 | .256** | .036 | .034 | .013 | .213** | .028 | .076 | −.027 |
| 6. T1-MGUDS | | | | | | 1 | .487** | .491** | .132 | .811** | .456* | .398** | .035 |
| 7. T1-TA | | | | | | | 1 | .491** | .152 | .401** | .809** | .455** | .019 |
| 8. T1-IS | | | | | | | | 1 | .088 | .489** | .542** | .708** | −.033 |
| 9.T1-CK | | | | | | | | | 1 | .198* | .106 | .214* | .536** |
| 10.T2-MGUDS | | | | | | | | | | 1 | .491** | .548** | .153 |
| 11.T2-TA | | | | | | | | | | | 1 | .530** | .044 |
| 12.T2-IS | | | | | | | | | | | | 1 | .102 |
| 13.T2-CK | | | | | | | | | | | | | 1 |

Note: MGUDS = Miville-Guzman Universality-Diversity; TA = Tolerance for Ambiguity; IS = Intercultural Sensitivity; CK = Cultural Knowledge; $p < .05$ *; $p < .01$ **.

## Findings

Table 1 displays the bivariate correlation relations among all variables. Participants' travel history and living abroad history are positively correlated with MGUDS score prior to ($r = .475$, $p < .01$) and after the VR intervention ($r = .383$, $p < .01$) respectively.

Students' assessment scores before and after VR intervention are shown in Table 2. The measures yielded a small significant decrease in the MGUDS after the VR intervention compared to the prior intervention score (mean difference = −.089, SD = .278), t (100) = −3.23, p = .002. Similarly, intercultural sensitivity also has significant decrease after receiving the intervention with mean difference = −.104, SD = .513, t (100) = -2.04, p = .044. Instead, students' cultural knowledge has an .713 point increase after receiving VR intervention with t (100) = 3.42, p = .001. The results indicate that students tend to self-evaluate as more universal-oriented and less curious about cultural differences after engaging in the VR intervention; at the same time, they significantly increased their knowledge of cultural worldview frameworks.

Table 3 displays the multiple linear regression analyses associating components of intercultural competence with IDI scores. Results support a model with F (14, 30) = 4.623, $p < .001$ in which students' pre-training IDI and cultural knowledge scores were significant predictors of their MGUDS score change. MGUDS can be predicted by all three IDI scores – perceived orientation (b = .249, $p < .01$), development orientation (b = −.229, $p < .01$) and orientation gap (b = −.222, $p < .01$) – as well as by T1 cultural knowledge level (b = .078, $p < .01$). Higher perceived orientation scores on the IDI predicted more change in the MGUDS, whereas higher developmental orientation scores and higher orientation gap scores predicted smaller changes in the MGUDS. Higher initial levels of cultural knowledge predicted larger changes; although still strongly significant, this relationship had the weakest predictive power. Relationships between the IDI and scores on other measures were not statistically significant.

## Discussion

Hypothesis 1 in this study measured whether a VR-based learning environment increases learners' intercultural competence. Table 2 shows that after receiving VR intervention, students' cultural knowledge score significantly improved compared to T1 performance, with a mean difference of .663, $p < .001$. These findings support our first hypothesis that a VR-based learning environment would increase learners' knowledge of cultural worldview frameworks and provides a safe, immersive, and scalable learning environment for intercultural competence development. Immersiveness in the learning environment is considered a key for any intercultural competence development (Zhang & Zhou, 2019). It is one of the main drivers for academic study abroad programs, which typically aim to provide students a venue to immerse in a culturally different environment and target various psychological transformations. including feelings, behaviors, beliefs, and attitudes (Root & Ngampornchai, 2013).

The existing literature explored the impact of immersion in intercultural competence development. Ramirez (2016) examined the impact of studying abroad programs on intercultural competence development and assessed the moderating role of student's personality in the process. He found that semester-long study abroad programs have a significant effect on intercultural competence development. Heinzmann et al. (2015), examined a broad range of linguistic exchange activities at Swiss upper secondary schools to identify the effects of exchange activities on intercultural competence development. He reported participation in a study abroad program increased intercultural competence. In another study designed to determine the extent to which intercultural competence development was achieved through participation in a study abroad program, Cushner and Chang (2015) reported a significant change in participants' intercultural competence levels. They also found that such programs "without a concerted effort to address intercultural growth is insufficient in bringing about a change in intercultural competence" (p. 165). Academic study abroad programs are often considered an effective way to provide direct and natural immersion opportunities to learners.

Other intercultural competence learning efforts include various pedagogical interventions such as formal education materials based on cultural contexts (Rodríguez & Carranza, 2017; Shayakhmetova et al., 2017), in-class group activities and role plays (Arshavskaya, 2018; Worawong et al., 2017), engaging students in critical self-reflection (Feng, 2016; Williams, 2017), and service learning

(Dziedziewicz et al., 2014; Liu, 2018). These approaches also reported intercultural competence improvement at varying levels. In this study, the objective measure shows an increase in knowledge while the subjective self-report measure shows a slight but significant decrease in attitudes and skills, indicating a change in constructs via the VR intervention.

Hypothesis 2 of the study, on the other hand, tested whether the VR-based learning environment encourages learners to have a more realistic self-assessment of their level of intercultural competence. A commonly noted issue in self-report measures such as those used in this study, which rely on subjective assessment of skills and attitudes and are thus often influenced by social desirability bias, response shift bias, and other confounds, is that participants often overestimate their capacities. This happens especially before an intervention or learning experience when they may not have a realistic sense of how challenging they may find situations that demand them to perform the skills being assessed (Pratt et al., 2010). This research phenomenon frequently occurs when assessing intercultural competency and intercultural sensitivity (Jackson, 2015). For this reason, the Intercultural Development Inventory (Hammer et al., 2003) offers both subjective (Perceived Orientation) and objective (Developmental Orientation) scores to emphasize the over-estimation of intercultural development. Other instruments such as the Cultural Intelligence Scale (Van Dyne et al., 2009) rely on 360 assessment with data from people other than the participants to counteract the self-evaluation overestimation effect.

It should be noted that it is not unusual for a groups' pretest self-report measurement of intercultural competence to decrease in a posttest measurement after a challenging intercultural learning experience (Almeida et al., 2012). Because participants have recognized their previous over-estimations and corrected it in the posttest, their subsequent self-evaluation can be considered more accurate. This is one manifestation of response-shift bias, where participants' understanding of the meaning of items shifts over time in response to an intervention or life experiences, so that they are interpreting the same items within a different framework of reference (Pratt et al., 2010). Because of this tendency to inaccurately self-evaluate before intercultural training, Hypothesis 2 predicted that learners would develop a more realistic self-assessment of their levels of intercultural competence as a result of engaging in VR-based learning - that is, that their subjective self-reported levels of intercultural competence could go down rather than up, resulting in score decreases on measures such as the MGUDS and ISS.

As illustrated in Table 2, data did in fact demonstrate this trend, with decreases in both self-reported universal-diverse orientation and intercultural sensitivity. The significant decrease in these self-evaluations does not necessarily reveal actual reductions in intercultural competencies. Their knowledge of worldview frameworks as objectively measured by the cultural knowledge items increased overall even as their subjective self-assessment decreased. As noted in previous studies, this decrease in scores on self-report measures and negative correlation of objective and subjective measures likely reflects more realistic self-perceptions after the intervention. In the VR-simulated training, students experienced virtual interaction with people from a different cultural background, realizing as a result of the challenging nature of these interactions that their actual skill level was less well-developed than they previously judged it to be. Thus, it makes sense that, after the intervention, these participants tended to score lower on the MGUDS and IS scales yet higher on cultural knowledge items.

Moreover, when we introduced participants' IDI scores into our model, we found a statistically significant positive relationship between IDI Perceived Orientation and MGUDS change as well as a significant negative relationship between IDI Developmental Orientation and MGUDS change. The positive relationship between IDI PO and MGUDS change in the model indicates that the higher participants subjectively evaluated their intercultural development on the IDI pre-intervention, the larger changes in MGUDS score they had after they experienced the VR simulation. One explanation for these findings is that both perceived orientation and MGUDS scale are self-reported evaluations of one's orientation of intercultural difference subject to the tendency to over-estimation. With higher initial overestimation levels, several manifestations of change are likely, including that some participants would have larger decreases as they became more accurate in their self-perceptions. At the same time, however, high POs indicate aspirational capacity (the level of intercultural sensitivity that participants would like to have), and this internalized ideal could stimulate high motivation to develop more intercultural competence, sometimes resulting in larger increases in MGUDs scores. This explanation is further supported by the relationship between IDI PO and the objective assessment of cultural knowledge, in that the IDI PO is positively related to changes in cultural knowledge scores from pretest to posttest. The more students overestimated their capacity in understanding cultural differences in pretests, the larger the gap between their scores in cultural knowledge tests before and after the intervention.

Meanwhile, as illustrated in Table 3, IDI DO indicates the primary orientation towards differences and commonalities in cultural interaction. The higher DO predicts smaller changes in MGUDS: when the actual level of intercultural sensitivity is high, the MGUDS score is more stable. In other words, as people who already demonstrate high capacity, they have less room to grow (less tendency to increase scores) as well as more realistic self-evaluations (less tendency to decrease scores). Again, the same correlation was echoed for IDI DO and the measure of cultural knowledge, with the IDI DO negatively related to cultural knowledge changes; higher initial IDI DO scores meant less change in CK over time. Thus, the relationships of IDI PO and DO scores to MGUDS change and CK change, while predictive in opposite directions, both support the second hypothesis that participants would grow more realistic in their self-

**Table 2**
Paired sample test (N = 101).

| | Mean | Std. Deviation | t | df | Sig |
|---|---|---|---|---|---|
| Paired 1 T2-MGUDS– T1-MGUDS | −.089 | .278 | −3.225 | 100 | .002 |
| Pair 2 T2-Tolerance for Ambiguity – T1-Tolerence for Ambiguity | .020 | .327 | .608 | 100 | .544 |
| Pair 3 T2-Intercultural Sensitivity – T1-Intercultural Sensitivity | −.104 | .513 | −2.038 | 100 | .044 |
| Pair 4 T2-Culture Knowledge – T1-Culture Knowledge | .663 | 2.099 | 3.176 | 100 | .002 |

**Table 3**
Multiple regression analyses results (N = 46).

| | MGUDS Change | | TA Change | | IS Change | | CK Changes | |
|---|---|---|---|---|---|---|---|---|
| | Step 1 b | Step 2 b | Step 1 b | Step 2 b | Step 1 b | Step 2 b | Step 1 b | Step 2 b |
| Gender | −.008 | −.182 | .051 | .106 | .054 | .057 | −.175 | .164 |
| Ethnicity | −.004 | −.051 | .016 | −.002 | −.002 | −.020 | .288* | .257* |
| International | −.049 | .274 | .168 | .169 | .307 | .259 | .581 | .649 |
| Travel History | .090 | .100 | .060 | .065 | −.090 | −.091 | .015 | .019 |
| Living History | −.003 | −.034 | −.009 | .000 | .192* | .195 | .282 | .254 |
| T1-MGUDS | −.588** | −.885** | | | | | | |
| T1-TA | | | −.275** | −.313** | | | | |
| T1-IS | | | | | −.286* | −.327* | | |
| T1-CK | | | | | | | −.835** | −.813** |
| IDI-PO | | .235* | | .107 | | .171 | | .845* |
| IDI-DO | | −.191* | | −.120 | | −.188 | | −.878* |
| IDI-OG | | −.173 | | −.126 | | −.193 | | −.883 |
| T1-MGUDS | | | | .058 | | −.094 | | .515 |
| T1-TA | | .283 | | | | .110 | | .480 |
| T1-IS | | .143 | | .126 | | | | −.550 |
| T1-CK | | .053 | | .009 | | .034 | | |
| Model $R^2$ | .283* | .612** | .259 | .422 | .250 | .316 | .477** | .554** |

Note: IDI = Intercultural Development Inventory; PO = Perceived Orientation; DO = Development Orientation; OG = Orientation Gap; MGUDS = Miville-Guzman Universality-Diversity Scale; TA = Tolerance for Ambiguity; IS = Intercultural Sensitivity; CK = Cultural Knowledge. $p < .05$ *; $p < .01$ **.

assessment after they experienced the VR simulation.

## Implications for theory and practice

The findings in this study suggest several important implications for both scholarly work and practitioner best practices. In terms of research design, among the open-access instruments used in this study, the MGUDS and IS proved the most useful for identifying pre-/posttest changes in participants' perspectives, with the MGUDS findings more significant. Because this instrument is also prevalent in literature on intercultural competence development, the MGUDS may therefore be a compelling choice for scholars and intervention facilitators, such as classroom instructors, study abroad leaders, and professional development trainers, who may not have an assessment budget to fund the use of a fee-for-use proprietary instrument. However, the true strength of the analysis here lies in the triangulation of the MGUDS and IS with multiple other data sources. Without this rich dataset, drawing conclusions would have been much more difficult, and findings would not have been as useful. In fact, it was especially beneficial to merge data collected specifically for this study with pre-existing institutional data. While this methodological choice could present ethical and logistical challenges such as additional human subjects board review and the need for cooperation from the keepers of institutional data, and while its success does, of course, depend on the existence of matchable data, the advantages of pursuing such opportunities are clear in terms of cost and time savings.

Perhaps the most important implication for researchers in these findings is the risk of response shift bias in traditional pre-/post-test study design when using self-report instruments. One solution would be to employ retrospective pre-testing rather than a traditional pretest (Pratt et al., 2010). Essentially, in a retro pretest design, after an intervention, the participant reports on their current knowledge, skills, or attitudes, and then immediately completes the same self-evaluation a second time in reference to their pre-intervention state. In this way, "response shift bias is avoided because participants are rating themselves with a single frame of reference on both the posttest and retrospective pretest" (p. 343). Many studies have documented that this study design is as or even more accurate than pre-post testing (Levinson et al., 1990). An added benefit of the design is practicality, since data collection occurs only once (Bhanji et al., 2012).

Practitioners who mentor others' intercultural growth and development can also glean insights for best practice in these findings. If these results prove generalizable over time as more VR simulations are evaluated for effectiveness, the widespread use of VR for intercultural learning may be justified, especially in cases where mobility is not possible and local communities are not diverse. Time spent abroad, either as a student or an expatriate employee or volunteer, has previously been upheld as the gold star method of intercultural competence development. These experiences present learners with various challenges such as "language difficulties, difficulties adjusting to the academic culture, misunderstanding, and complications in communication with faculty and peers; stress, anxiety, feeling of isolation, social experiences, culture shock, financial hardships, lack of appropriate accommodation, isolation and loneliness, and any adaption in their daily life" (Wu et al., 2015). In the current (and perhaps future) reality where many such opportunities are prohibited, VR offers some of those same challenges while safeguarding participants' personal safety.

Even when mobility is a viable option, VR could prove to be the most scalable solution for large groups of participants, whether in higher education institutions or in corporate, government, or NGO lifelong learning settings. Today, the costs of VR equipment has significantly lessened as compared to when the technology was newly available. Initial investments per learner represent only a fraction of typical short-term educational or professional development programs that involve international travel. The true cost-

effectiveness of the technology comes into play after that initial investment, though, since the equipment can be reused time and again for new cohorts of learners. On the other hand, the scalability of VR will still be limited not only by the number of headsets on hand for simultaneous deployment but also by the number of trained personnel to manage simulation implementation. Moreover, development expenses for VR simulations themselves (or the time and expertise to develop them in house) may prove necessary if open-access resources appropriate to the context are not already in existence. Despite these remaining challenges, VR offers great potential as a scalable alternative to training and educational programs that require mobility.

VR could also effectively supplement more traditional training methods, for example in pre-departure orientation or as an asynchronous assignment for a course. Finally, because VR provides a safe environment for intercultural skill development that allows for experimentation by participants without fear of social stigma or discomfort, this medium may be a way to enable personal and professional development in polarized times when people are wary of causing conflicts or giving offense to others as they learn. In sum, VR presents a new vision in intercultural learning, offering unrivaled opportunities compared to or in conjunction with traditional approaches.

To take full advantage of the potential of VR for intercultural learning, best practices stemming from research on education abroad and intercultural competence development need to be transferred and applied to this learning platform. For example, recent studies have demonstrated the importance of pairing reflection with an authentic experience for intercultural learning (Pederson, 2010). VR simulations designed for intercultural outcomes should therefore not rely on the immersive experience of the simulation alone to stimulate learning but must embed opportunities for reflection throughout and following the training. Other scholars have documented that the length and/or rigor of the experience (Vande Berg et al., 2009), effective preparation for or framing of the experience (Deardorff, 2011), individualized guidance by a mentor (Jones et al., 2019), and a variety of other program-level characteristics impact the achievement of intercultural learning outcomes. Each of these findings has implications for the VR environment. Intercultural VR simulations would be best leveraged as a series of interventions rather than a single, isolated activity. Before a VR program, learners should reflect on their learning goals and motivations for engaging, and afterward they should be encouraged to connect their takeaways from the simulation to their past experiences and future plans. VR simulations should maximize their capacity for differentiation to meet the needs of diverse learners by utilizing artificial intelligence and machine learning techniques to adapt to learners as they make choices within the simulations. In essence, as we move towards a future in which VR is in common use, we need to leverage the scholarship of teaching and learning to ensure it is used well.

## Conclusion

In this study, we addressed a gap in the literature by examining the effectiveness of virtual reality in developing intercultural competence. The dearth of literature on VR and ICC is especially troubling in the current pandemic era when traditional means of developing intercultural competence are so constrained. The VR platform provides an interactive, immersive learning environment for both technical and nontechnical outcomes; this environment allows for experimentation in authentic scenarios and reflection on the consequences of choices made within the simulation. With recent advances in computer science, VR technology can provide personalized learning experiences that address each learner's unique learning and pedagogical needs. Thus, the VR platform provides a customizable, safe, and cost-effective learning environment that is not only highly suitable for developing intercultural competence but also scalable to large numbers of learners.

Our findings on the effectiveness of the VR environment as a learning platform for intercultural competence development lay the foundation for future training design and research in intercultural learning. Because the over-estimation of intercultural competence in self-report measures is a common phenomenon, especially before interacting in an unfamiliar cultural context, the capacity of VR simulations that surfaced in this study to support more realistic self-evaluation is important. Perhaps most importantly, the discussion of the merits of the VR learning environment for building intercultural competence answers the current pressing need to move beyond traditional learning and education approaches, and to consider innovative new technologies that will allow trainers and educators to continue their work of supporting the intercultural competence development of others despite limitations on travel, face-to-face interactions, funding, and time.

The study is not without limitations, of course. First, the research design leveraged a convenience sample, which resulted in imbalances in some demographic categories: more male students than female, for example, and few who self-identified as black or of African descent. The convenience sample also impacted the merge with previously collected data, resulting in a mixed group of participants, some matchable with institutional data and others not. In this case, a more careful recruitment process (with the existence of institutional data as criteria for inclusion) combined with an experimental design using randomly assigned treatment and control groups would have been most effective. A second limitation relates to generalizability. While the STEM context is of great value, given the current push by STEM accrediting bodies such as ABET toward embedding more intercultural competence development in tertiary education (see abet.org/accreditation), it is unclear whether the findings of this study apply to students in other disciplines, or older adults in a variety of professional sectors. Finally, the simulation used in this study did not utilize the most cutting-edge VR approaches. While the use of artificial intelligence or advanced application of algorithms would allow for maximum customizability to individual learners, they can be costly and time-consuming to create and test. This is simply the nature of new frontiers in technology; however, the recent decreases in the cost of VR equipment and increases in its uses in various settings bode well for its future accessibility for designers of intercultural learning materials.

In conclusion, beyond demonstrating the effectiveness and utility of a new learning medium to intercultural researchers and educators, this paper puts forth a call for further study of VR and intercultural learning. As a scholarly community, we need to develop more nuanced theories of how and why the platform is effective. Likewise, we need data on when and for whom VR works best. For

example, it would be useful to know if learners' orientations towards difference (as measured by the IDI on the Intercultural Development Continuum), experience with immersive technologies, motivation to learn, or other individual variables shape their experiences with IC learning in the VR platform. Perhaps the most compelling direction for future research lies in the applying new technologies beyond the learning intervention itself, for instance, in data collection and analysis. Exciting new methods of AI-based and computer-assisted analysis of large quantities of qualitative data emerge regularly, and a wide range of biometric data can now be collected non-invasively – that is, with external sensors alone. These emerging methods seem particularly well-suited to research on VR learning. The study reported in this paper is, in fact, part of a much larger exploratory project that will eventually triangulate all of these data types with more common self-report measures.

In the end, the current study prompts a number of important questions, even as it provides preliminary evidence of VR's potential in the area of intercultural competence development. Incorporating rapidly advancing technologies is a clear gap in our literature, and we hope to see the field adapting by more fully embracing technology in our teaching and research practices.

## Funding

This project was partially funded by the Purdue Research Foundation and a grant (award number: 2000779) funded by the National Science Foundation.

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