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Effects of an intercultural seminar using telepresence robots on students' cultural intelligence

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ABSTRACT

Student exchanges have been demonstrated to increase students' Cultural Intelligence (CQ). However, global problems in recent years, such as the Coronavirus pandemic, have highlighted the need for digital alternatives to traditional in-person visits. One such alternative could be intercultural seminars using telepresence robots, which allow students to experience particularly realistic intercultural interactions in their real environments. In this research, we evaluated the effects of two semi-virtual intercultural seminars on diversity and intercultural competence that integrated telepresence robots to enable interactions between students located in Germany and Kenya. We conducted quantitative and qualitative analyses using data from $N = 135$ college students. One half of these students actively participated in one of the seminars. The other half did not participate in the seminars or participated only passively (without using the robots), and formed the control group. In line with our expectations, active participants in the seminars showed significant increases in metacognitive CQ, cognitive CQ, and behavioral CQ, likely due to the particular combination of seminar contents and methods. In contrast, no changes in CQ were found in the control group. Our evaluation of the telepresence robots reveals a mixed picture: Although the students showed high acceptance of using telepresence robots in intercultural seminars, this acceptance did not change during the seminars. Moreover, several technical problems hindered the smooth operation of the robots. Nevertheless, the concept of the seminars under examination proved to be promising for enhancing students' CQ in an efficient manner.

1. Introduction

Cultural Intelligence (CQ) describes the ability to function effectively in intercultural contexts (Earley & Ang, 2003). In today's globalized world, this ability has become an increasingly important skill. For example, numerous studies have documented the benefits of high CQ for intercultural adjustment (e.g., Malek & Budwar, 2013), job performance (e.g., Chen et al., 2012), leadership effectiveness (e.g., Rockstuhl et al., 2011), and other outcomes (see Ang et al., 2020, for an overview). Given such findings, it is understandable that universities around the world have put it on their agenda to help their students develop CQ (e.g., Lin & Shen, 2020).

However, in recent years the Coronavirus pandemic has made it challenging to have intercultural encounters between students from different countries and to advance international collaborations between partner universities through in-person visits. This problem was explicitly addressed in the "Robots for cooperation in teaching between Koblenz and Nairobi" (RoKoNairo) project, funded by the German Academic Exchange Service (DAAD). In this project, two joint seminars were conducted in cooperation between the German University of Koblenz and two Kenyan partner universities, the University of Nairobi and the United States International University – Africa. Based on findings showing that intercultural experiences can enhance CQ (Raver & Van Dyne, 2017), a central goal of these seminars was to promote CQ among the participating students by means that did not entail travel or physical meeting.

A special feature of the seminars was the integration of telepresence robots. These robots, which do not appear to have been used in any other intercultural seminar up to this point, are mobile videoconferencing devices controlled via the Internet. They are designed to provide particularly realistic and human-like digital interactions, between the person operating the robot and those within range of the robot (see Fig. 1). By integrating the telepresence robots into the seminars, it was

Abbreviations: CQ, Cultural Intelligence; CQS, Cultural Intelligence Scale; DAAD, German Academic Exchange Service; EQ, Emotional Intelligence; IQ, Cognitive Intelligence; RoKoNairo, Robots for cooperation in teaching between Koblenz and Nairobi; T1, First measurement point; T2, Second measurement point.

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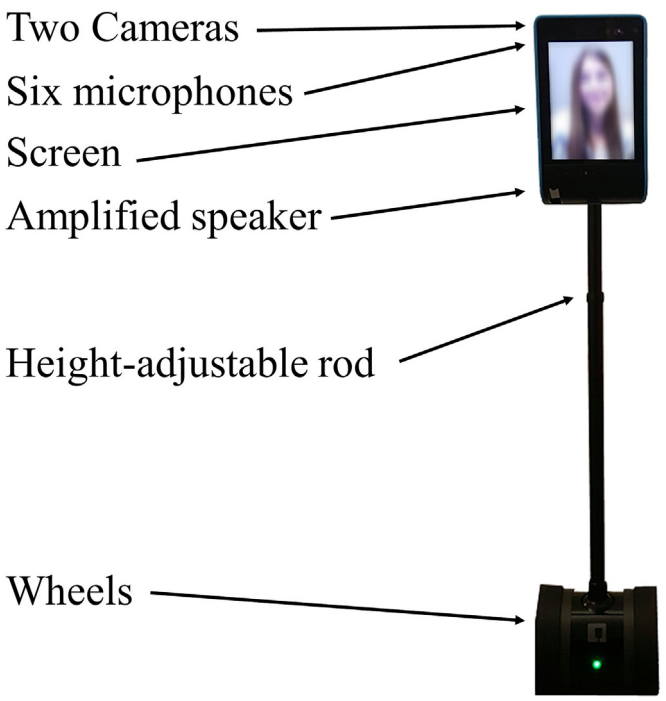

Fig. 1. Telepresence robot (type Double 3).

possible to conduct intercultural group discussions, where participants could talk to each other in a real environment instead of using a purely virtual platform (e.g. Zoom). Moreover, the telepresence robots allowed the students to move autonomously around the grounds of the partner university and to explore it virtually with their fellow students.

The aim of the present study was to evaluate whether the seminars conducted within the RoKoNairo project were indeed suitable for promoting students' CQ. More generally, we pursued the question whether students' CQ can be enhanced by a seminar in which intercultural exchange takes place predominantly via the Internet. Furthermore, we aimed to investigate how students would assess the use of telepresence robots in intercultural seminars, how participation in an intercultural seminar with telepresence robots would change students' attitude towards this technology, and whether students' experiences with the use of telepresence robots in intercultural seminars could explain their CQ development during these seminars. The findings of this study could have important implications for the planning of future intercultural seminars, as the didactic concept of the examined seminars could be adopted in other universities or institutions of higher education, to realize joint seminars with partner institutions from different countries. In addition, our findings provide valuable insights into the potential and limitations of using telepresence robots in the educational context, and so advance a line of research that has received increasing attention in recent years (e.g., Chen, Xie, et al., 2020; Chen, Zou, et al., 2020; Leoste et al., 2022).

2. Literature review

2.1. Cultural intelligence and its development

In 2003, Earley and Ang introduced the construct of CQ to explain why some individuals adapt to a new culture more easily, quickly, and thoroughly than others. Defined as the ability to function effectively in intercultural contexts, essentially CQ can be understood as a synonym for what is widely termed intercultural competence (e.g., Lin & Shen, 2020). However, while there is still no consensus on how intercultural competence is defined, as numerous intercultural competence definitions exist side by side (e.g., Gelfand et al., 2008; Leung et al., 2014), CQ has the advantage that it offers a well-defined and theoretically grounded framework, based on Sternberg's (1986) theory of multiple loci of intelligence. Inspired by this theory, Earley and Ang (2003) developed CQ as a new form of nonacademic intelligence that complements other known forms of intelligence, such as cognitive intelligence (IQ) or emotional intelligence (EQ). This background also explains the derivation of the acronym CQ (see also Ang et al., 2020).

More specifically, Earley and Ang (2003) have described CQ as a multidimensional construct composed of four facets. First, *metacognitive CQ* refers to an individual's mental ability to acquire, assess, and understand cultural knowledge. It allows individuals to have a certain degree of control over their cognitive processes about cultural differences ("thinking about thinking"). For example, individuals with high metacognitive CQ use higher-order cognitive strategies to plan intercultural interactions, maintain awareness of cultural differences, and develop new heuristics for social interactions in novel cultural environments. Second, *cognitive CQ* describes an individual's knowledge about cultures, as well as cultural differences and similarities. It includes both culture-general and culture-specific knowledge, which can refer, for example, to norms, conventions, practices, and social systems in different cultures. Third, *motivational CQ* reflects the ability to direct and sustain attention and effort toward functioning in intercultural situations. It is based on the expectancy-value theory of motivation (Eccles & Wigfield, 2002) and considers an individual's intrinsic motivation, extrinsic motivation, and self-efficacy for functioning effectively in culturally diverse settings. More generally, it can be understood as an approach versus avoidance motivation (Elliot & Covington, 2001), as individuals with higher motivational CQ are more likely to approach, rather than avoid, intercultural situations. Finally, *behavioral CQ* describes an individual's ability to exhibit flexibility in verbal and nonverbal behaviors in intercultural interactions. Individuals with high behavioral CQ are likely to overcome the natural human tendency to exhibit habitual behaviors that do not fit the cultural context. Accordingly, behavioral CQ also enables individuals to minimize misperceptions and misattributions in intercultural encounters (see also Ang et al., 2020; Raver & Van Dyne, 2017).

Since its introduction, the construct of CQ has attracted much interest and led to a large body of research. One reason for this success may be that Matsumoto and Hwang (2013), in a rigorous review of instruments for measuring intercultural competence, attested good psychometric properties to the Cultural Intelligence Scale (CQS), whereas they assessed many other examined instruments as rather insufficient in terms of reliability and validity. For example, Matsumoto and Hwang (2013) highlighted that the CQS had a stable factor structure and that there was "considerable evidence for [its] concurrent and predictive ecological validity … with samples from multiple cultures" (p. 856).

Another aspect of CQ that has made it particularly interesting for research and practice may be the fact that Earley and Ang (2003) conceptualized CQ as a malleable set of intercultural abilities that are susceptible to development. In line with this conceptualization, numerous studies have found that CQ can be increased through training/education and intercultural experience. Raver and Van Dyne (2017) provided a comprehensive overview of these studies. They summarized that for both kinds of intervention, the strongest impacts on CQ development were found for metacognitive and cognitive CQ (e.g., Eisenberg et al., 2013; Hodges et al., 2011; Varela & Gatlin-Watts, 2014). However, some studies have also found positive effects on the other CQ facets following CQ training (e.g., Bücker & Korzilius, 2015; MacNab, 2012) or intercultural experience (e.g., Engle & Crowne, 2014; Tarique & Takeuchi, 2008). In particular, such effects might occur when training consists not only of imparting information but also of incorporating experiential learning opportunities, as in intercultural simulations and role plays, and when intercultural experiences are particularly deep and rich (Raver & Van Dyne, 2017; Van Dyne et al., 2019). In line with this, Lin and Shen (2020) found that intercultural contacts in informal settings (e.g., residential communities, interest groups, or sports activities) had stronger effects, especially on students' motivational and behavioral CQ, than did

formal activities (e.g., classroom discussions, group works, or other events in an academic context). Nevertheless, increases in all four CQ facets following interventions have been observed only rarely so far (Raver & Van Dyne, 2017).

McCrea and Yin (2012) compared the effectiveness of classroom-based trainings and international study tours on students' CQ development within one study. Their preliminary findings suggested that classroom-based trainings are more effective for developing a wide level of metacognitive and cognitive CQ (e.g., knowledge of multiple cultures), whereas international study tours are more effective for developing a deep level of metacognitive and cognitive CQ (e.g., knowledge of one culture) as well as motivational and behavioral CQ. According to Van Dyne et al. (2019), this implies that "classroom-based and experiential learning interventions are complementary and that both contribute to holistic development of CQ" (p. 20). On the basis of this argument, which can also be found elsewhere in the literature on intercultural competence (e.g., Wolff & Borzikowsky, 2018), in our seminars we aimed to combine classroom-based intercultural training/education with experiential learning/intercultural experience. For this purpose, students in our seminars received both professional input and opportunities for personal exchange with students from another culture via video conferencing, especially by telepresence robots, in both formal and informal settings. To the best of our knowledge, there is no study to date that has examined how such an approach affects the development of CQ.

In respect of research on CQ development, our study thus addresses at least two research gaps. First, it addresses the question of whether a combination of intercultural training and virtual intercultural experience can enhance all four CQ facets. Second, it examines for the first time how the use of telepresence robots in intercultural seminars (which, compared to other digital alternatives, should provide students with particularly rich intercultural experiences) affects students' CQ development.

2.2. Telepresence robots and their use in education

As noted in the Introduction, telepresence robots are mobile videoconferencing devices controlled via the Internet. They are equipped with a webcam, microphone, screen, and speaker, and enable virtual interactions between the person operating the robot (shown on the screen of the robot) and other persons within range of the robot (shown on the screen of the device used to operate the robot). Thus, telepresence robots allow users to participate actively in an event taking place in the real world without the need to be physically present at that site.

In the educational context, telepresence robots so far have been applied mainly in schools, where they are used in particular by students who are unable to attend school for a longer period of time for health reasons. The robots are intended to help these students to participate interactively in school life again. Among other things, this should be achieved by the fact that the robots provide the students with a higher degree of autonomy and flexibility in their behaviors compared to immobile videoconferencing devices (e.g., notebooks with a web conference). For instance, students who go to school via robot can decide for themselves where they want to 'be' during class and with whom they want to spend their break. Furthermore, telepresence robots are characterized by high visibility, so that students connected to the robot are noticed by their classmates and teachers despite their physical absence, and conversations can be held that are relatively close to natural human interaction (e.g., Cha et al., 2017; Newhart & Eccles, 2020; Reis et al., 2019).

Empirical findings support that telepresence robots are a promising medium to enable homebound students to participate interactively in class and maintain social relationships with their classmates and teachers. For example, Newhart et al. (2016) pointed out the high potential of telepresence robots in terms of socio-emotional benefits, including social acceptance and overcoming isolation. Similarly, Weibel et al. (2020) found that telepresence robots were perceived to be facilitative of social interaction processes between classmates and inclusion in learning activities. Page et al. (2021) reviewed several studies that examined the impact of telepresence robots on students who missed school because of illness. They concluded that telepresence robots can enable positive experiences in education and foster the social development of homebound students. However, the authors also noted that technical shortcomings, such as problems maintaining reliable communication or having stable Wi-Fi connections in schools, sometimes impeded maximization of the educational and social benefits of the robots (see also Weibel et al., 2020).

In addition to homebound students, studies have investigated the use of telepresence robots with students who were able to attend school. For example, Tanaka et al. (2013) examined elementary school students from Japan and Australia who were connected via telepresence robot. They found that the students communicated with each other through the robot, although they spoke different languages. Tanaka et al. (2014) conducted a study with students who used either a telepresence robot or immobile videoconferencing to communicate with their English teacher. They showed that student-teacher interactions were more intense when the students used the robot. Furthermore, some studies examined telepresence robots at school used by teachers (e.g., Kwon et al., 2010; Zhang et al., 2019). Overall, these studies also demonstrated the great potential of such robots to support distance learning. For example, Yun et al. (2011) found performance gains among students who participated in English lessons taught by a native-speaking teacher connected by robot.

In contrast to schools, telepresence robots have for a long time not received much attention in higher education. However, initial studies suggest that they can also be integrated successfully into university teaching (see Leoste et al., 2022, for an overview). For example, Lei et al. (2022) examined the acceptance of telepresence robots in higher education within a sample of college students, faculty members, and other professionals, most of whom had prior experience with telepresence robots. Overall, these participants reported high intention to use telepresence robots in higher education, which was predicted in particular by perceived usefulness of the robots. Lei et al. (2019) investigated a hybrid seminar in which some students participated via telepresence robot. Among other things, they found that the students using the robots reported high perceptions of social presence, embodiment, and engagement, and that they used nonverbal communication as the predominant form of interaction. However, the engagement of students taking part via robot was also affected by contextual factors. For example, the students showed higher engagement in small-group than in whole-class discussions. Moreover, they reported higher cognitive engagement the more they perceived the robot to be an extension of their own body.

Edwards et al. (2016) compared the use of human instructors using a telepresence robot with the use of autonomous social robots in higher education. They found that students perceived the human instructor to be more credible. Wolff and Möller (2021) conducted a longitudinal quasi-experiment in which students participated in seminars temporarily via a telepresence robot and via an immobile videoconference. They found that students' acceptance of telepresence robots as a medium of university teaching was significantly higher at the end of the seminars than at the beginning. In contrast, students' acceptance of immobile videoconferencing as a medium for university teaching did not change over the course of the seminars.

Although these initial findings on the use of telepresence robots in higher education are promising, overall there is little research on this topic. This is especially true with respect to longitudinal studies, which are necessary to examine the development of students' attitudes towards telepresence robots and to understand the mechanisms that influence their attitudes towards these devices in higher education (Leoste et al., 2022). Furthermore, there is a lack of studies examining the application of telepresence robots in various educational contexts. In particular, we are not aware of any study in which telepresence robots have been used in an intercultural seminar to enhance students' CQ. As noted above, there are a few studies in which telepresence robots have been applied in a school context to enable students to communicate with other students

or teachers from another country. However, these applications aimed to increase students' language skills, rather than their intercultural competences. In the present research, therefore, we conducted a longitudinal study in which we investigated the use of telepresence robots, presumably for the first time, in an intercultural seminar in higher education. Specifically, we focused on the questions of how students assess the integration of telepresence robots into intercultural seminars, and how their experiences with the robots affect their CQ development.

3. The present study

On the basis of the research gaps outlined in the previous section, our study addressed three main research questions:

1. Can students achieve increases in CQ by participating in an intercultural seminar in which intercultural exchange occurs mainly via the Internet?
2. How do students assess the use of telepresence robots in intercultural seminars in higher education?
3. To what extent can students' CQ change during an intercultural seminar with telepresence robots be explained by their experiences with the robots?

To investigate these questions, we evaluated the effects of two newly developed intercultural seminars that integrated telepresence robots, apparently for the first time, to help students increase their CQ. Each seminar was conducted simultaneously in Germany and Kenya, and was similar in terms of contents and methods. Specifically, we examined three groups of students: (1) students from Germany and Kenya who actively participated in one of the seminars (seminar group), (2) students from Germany who did not take part in any seminar (German control group), and (3) students from Kenya who participated purely digitally and passively (i.e., without being present in the seminar room or connected via robot) in one of the seminars (Kenyan control group). In our main analyses, we combined the data of the students from Germany and Kenya and distinguished between one seminar group and one control group. However, we also conducted additional analyses that included only students from one country.

3.1. Overview of the seminars

The general topic of the seminars was diversity and intercultural competence. Diversity can be defined as the presence of difference between individuals or social groups, which can refer to various dimensions, such as age, gender, or culture. The word has a similar meaning to "variety" or "heterogeneity" with a positive connotation that implies richness through differences (Blaine & McClure Brenchley, 2022; Quaiser-Pohl, 2013). Intercultural competence, in its broadest sense, can be described as a heterogeneous construct involving multiple dimensions that are necessary for interacting with individuals from other cultures adequately and effectively (Wolff & Borzikowsky, 2018). Thus, it can also be understood as a synonym for CQ. For students, knowledge about diversity and intercultural competence, as well as skills in dealing with diversity and individuals from different cultures, can be helpful, for example, when they are faced with heterogeneity in their later professional life. Furthermore, raising awareness of diversity (including cultural differences) is of great social relevance in countering stereotyping and discrimination.

In the seminars, the topics of diversity and intercultural competence were addressed in the form of presentations given by the lecturers and students. Moreover, there were various small-group and whole-class discussions about these topics. Specifically, the seminars focused on the six internal diversity dimensions of the four layers of diversity model (Gardenswartz & Rowe, 2003): (1) age, (2) gender, (3) sexual orientation and identity, (4) ethnicity and nationality, (5) disability, and (6) religion and ideology. In the course of the seminars, students from Germany and Kenya gave short presentations on each dimension, in which they presented that dimension from the perspective of their own country. Subsequently, they discussed selected issues related to the respective dimension in intercultural small groups, using the telepresence robots. In addition, the telepresence robots were used in the seminars to conduct informal activities in which students showed each other around their campuses (see section 4.2, for a detailed description of the seminars).

3.2. Hypotheses

In line with our research questions, we distinguished between three groups of hypotheses.

The *first group* of hypotheses referred to students' CQ development during the seminars. In accord with the goal of our seminars to promote all four facets of CQ, we expected increases in metacognitive CQ (*Hypothesis 1.1*), cognitive CQ (*Hypothesis 1.2*), motivational CQ (*Hypothesis 1.3*), and behavioral CQ (*Hypothesis 1.4*) in the seminar group, all of which should be stronger than in the control group. In particular, the increase in metacognitive CQ should result from the lecturers' presentations about intercultural competence and from students' experience of preparing a presentation about diversity from the perspective of their own country. The increase in cognitive CQ should result from the new knowledge imparted in the seminars. The increase in motivational CQ should result from the various opportunities given to the students in the seminars to have face-to-face contact with students from another culture, to pose their own questions to them, to have fun with them during the informal activities, and to experience a sense of self-efficacy in the intercultural interactions. The increase in students' behavioral CQ should result from students' experience of giving a presentation to students of another culture, and their various opportunities to have personal intercultural interactions in formal and informal settings.

The *second group* of hypotheses referred to students' attitudes towards the telepresence robots. First, we assumed that students would show high acceptance of using telepresence robots in intercultural seminars (*Hypothesis 2.1*). Second, we assumed that the acceptance of using telepresence robots in intercultural seminars among the students in the seminar group would increase during the seminar, and that this increase would be stronger than in the control group (*Hypothesis 2.2*). Third, we assumed that acceptance of the robots among the students in the seminar group would be stronger, the more that these students felt that they were actually in the seminar room abroad when using the robots (*Hypothesis 2.3*). We expected that the students would show high acceptance of the robots because they would perceive the integration of the robots into intercultural seminars as useful (e.g., to achieve particularly realistic interactions between students in a real-world setting and to move independently around the campus of the other university). The seminar group students should increase their acceptance of the robots during the seminar because their own positive experiences with the robots should further demonstrate the benefit of these devices for intercultural seminars. Furthermore, their acceptance of the robots should depend on their feeling of self-location while moving the robots, as this feeling should be a crucial added value of telepresence robots compared to immobile videoconferences.

The *third group* of hypotheses related students' experiences with the telepresence robots to their CQ development during the seminars. We expected that the students in the seminar group would show a stronger increase in metacognitive CQ (*Hypothesis 3.1*), cognitive CQ (*Hypothesis 3.2*), motivational CQ (*Hypothesis 3.3*), and behavioral CQ (*Hypothesis 3.4*), the more they felt that they were actually present in the other seminar room when using the telepresence robots. These hypotheses

were based on the assumption that the telepresence robots would allow for particularly intense intercultural experiences when students experience high self-location in the seminar room abroad.

4. Method

4.1. Sample

Our sample consisted of $N = 135$ students (age: $M = 22.52$, $SD = 3.71$; 85.9% female) from the German University of Koblenz ($n = 80$) and two Kenyan universities (University of Nairobi: $n = 40$; United States International University – Africa: $n = 15$). Of these, $n = 43$ students (Germany: $n = 16$; Kenya: $n = 27$) participated actively and were physically present in one of the intercultural seminars (seminar group). The other $n = 92$ students did not participate in the intercultural seminars (Germany: $n = 64$) or participated purely passively via a web conference, without giving a presentation, participating in the discussions, or attending the informal activities (University of Nairobi: $n = 28$). Thus, these students formed the control group.

Most students were majoring in psychology (Germany: 93.8%; Kenya: 100%). However, in Germany, the intercultural seminars were offered as part of the elective subject Diversity Management. In this subject, the students could choose whether to attend one of the intercultural seminars or an alternative seminar dealing with heterogeneity and its consequences. In contrast, in Kenya the seminars were offered within the psychology curriculum. At the University of Nairobi, one of the lecturers decided which students were to be the active and passive participants of the seminar.

Participation in evaluation of the seminars was voluntary for all students. Nevertheless, all seminar participants took part in the evaluation. Moreover, most students who filled out the pre-questionnaire also filled out the post-questionnaire (Germany: 87.5% in the seminar group, 79.7% in the control group; Kenya: 88.9% in the seminar group, 50.0% in the control group). The relatively lower number of students from the Kenyan control group who filled out both questionnaires can be explained by the fact that some students from the Kenyan control group were not present for the entire time during the second formal session, as this session took place during a Kenyan public holiday (see section 4.2).

Table 1 describes the sample and the different subsamples in terms of demographics and the initial values in CQ and acceptance of the robots. It shows that the students from the seminar and control groups did not differ significantly with regard to most characteristics examined. However, the students of the seminar group had higher initial levels of metacognitive CQ, motivational CQ, and acceptance of using telepresence robots in intercultural seminars. These differences, which we discuss in detail in section 6.5, were mainly due to differences between the German seminar and control groups. No student had worked with telepresence robots prior to the seminar.

4.2. Procedure

The two seminars were conducted in April 2022 (in cooperation with the University of Nairobi) and May 2022 (in cooperation with the United States International University – Africa) in the context of the RoKoNairo project (DAAD, 2021). Each seminar was attended by 5–15 actively participating students (April: $n = 11$ students from Germany, $n = 12$ students from Kenya; May: $n = 5$ students from Germany, $n = 15$ students from Kenya) as well as two lecturers from each of the two universities involved. These individuals were all located at their home institutions during the seminars. Moreover, three interns supported the lecturers: two students from the University of Koblenz, one student from the Kenyan university involved in the respective seminar. Of these, one German intern was located at her home institution, whereas the other two interns were located at the corresponding partner university during the seminars. A guest lecturer from another German university also participated temporarily in the seminars at the University of Koblenz. Finally, $n = 28$ students of the University of Nairobi followed parts of the April seminar passively from home via an ongoing web conference. The language spoken in the seminars was English. Fig. 2 provides an overview of the procedure, which is explained in the following subsections.

4.2.1. Formal sessions

Two formal sessions constituted the main part of the seminars. They took place on two full days at the interval of one week. During these sessions, the students and lecturers from each university were in a seminar room at their home institution (the interns being in the seminar

Table 1
Description of the sample.

Characteristic	Entire sample				German sample				Kenyan sample			
	All students ($n = 135$)	Seminar group ($n = 43$)	Control group ($n = 92$)	Subgroup comparison	All students ($n = 80$)	Seminar group ($n = 16$)	Control group ($n = 64$)	Subgroup comparison	All students ($n = 55$)	Seminar group ($n = 27$)	Control group ($n = 28$)	Subgroup comparison
Age	22.52 (3.71)	22.84 (2.98)	22.37 (4.01)	$t(133) < 1$, $p = .50$	21.38 (2.93)	21.88 (2.31)	21.25 (3.07)	$t(78) < 1$, $p = .45$	24.18 (4.10)	23.41 (3.21)	24.93 (4.74)	$t(53) = 1.39$, $p = .17$
Gender (0 = *male*, 1 = *female*)	0.86 (0.35)	0.84 (0.37)	0.87 (0.34)	$t(133) < 1$, $p = .62$	0.86 (0.35)	0.81 (0.40)	0.88 (0.33)	$t(78) < 1$, $p = .52$	0.85 (0.36)	0.85 (0.36)	0.86 (0.36)	$t(53) < 1$, $p = .96$
Citizenship (0 = *local*, 1 = *other*)	0.04 (0.21)	0.02 (0.15)	0.05 (0.23)	$t(133) < 1$, $p = .42$	0.08 (0.27)	0.06 (0.25)	0.08 (0.27)	$t(78) < 1$, $p = .84$	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	–
Years lived abroad	1.00 (3.31)	1.09 (2.56)	0.96 (3.62)	$t(133) < 1$, $p = .82$	1.40 (4.01)	1.69 (2.70)	1.33 (4.29)	$t(78) < 1$, $p = .75$	0.42 (1.76)	0.74 (2.46)	0.11 (0.42)	$t(27.44) = 1.32$, $p = .20$
Metacognitive CQ (T1)	5.48 (0.91)	5.73 (0.89)	5.37 (0.90)	$t(133) = 2.17$, $p = .03$	5.23 (0.91)	5.53 (0.87)	5.16 (0.91)	$t(78) = 1.49$, $p = .14$	5.85 (0.79)	5.84 (0.90)	5.85 (0.68)	$t(53) < 1$, $p = .98$
Cognitive CQ (T1)	4.32 (1.02)	4.32 (0.98)	4.33 (1.04)	$t(133) < 1$, $p = .96$	4.39 (0.92)	4.65 (0.82)	4.32 (0.93)	$t(78) = 1.28$, $p = .21$	4.24 (1.15)	4.12 (1.02)	4.35 (1.27)	$t(53) < 1$, $p = .48$
Motivational CQ (T1)	5.66 (0.85)	6.00 (0.70)	5.50 (0.87)	$t(133) = 3.36$, $p < .01$	5.60 (0.80)	6.20 (0.53)	5.45 (0.79)	$t(78) = 3.62$, $p < .01$	5.75 (0.92)	5.89 (0.77)	5.61 (1.04)	$t(53) = 1.13$, $p = .26$
Behavioral CQ (T1)	5.17 (0.93)	5.25 (0.88)	5.14 (0.95)	$t(133) < 1$, $p = .52$	5.22 (0.88)	5.49 (0.83)	5.15 (0.88)	$t(78) = 1.37$, $p = .18$	5.11 (1.00)	5.11 (0.90)	5.11 (1.04)	$t(53) < 1$, $p = .99$
Acceptance robots (T1)	5.47 (1.15)	5.94 (0.76)	5.26 (1.24)	$t(123.63) = 3.93$, $p < .001$	5.03 (1.20)	5.60 (0.85)	4.88 (1.24)	$t(78) = 2.22$, $p = .03$	6.12 (0.68)	6.14 (0.64)	6.11 (0.73)	$t(53) < 1$, $p = .88$

Note. The table depicts the means and standard deviations (in parentheses) of the different subgroups. The four CQ facets and students' acceptance of the use of telepresence robots in intercultural seminars were measured at the first measurement point (T1) on Likert scales ranging from 1 to 7.

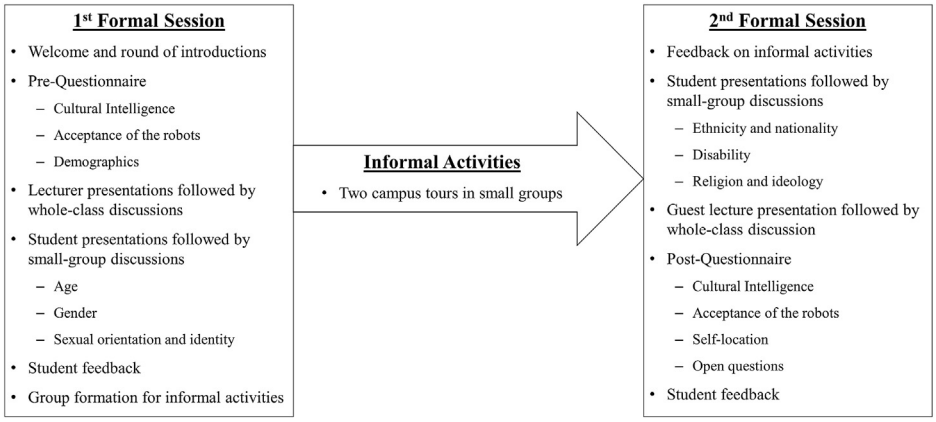

Fig. 2. Overview of the procedure of the seminars.

room either at their home institution or at the partner university). Both seminar rooms were connected with each other via a Zoom conference.

In both seminar rooms, all participants sat around an oblong table. One of the short sides of the table was used by presenters. A room camera was placed in front of the presenters. This camera could be directed either at the presenters or at the rest of the group. Behind the presenters was a screen onto which the video from the room camera in the other seminar room was shown, in addition to slides from PowerPoint presentations (see Fig. 3). One aim of this set-up was to contribute to an apparent reduction of the physical boundaries between the two seminar rooms and to promote a sense of cohesion between the German and Kenyan groups. In particular, this arrangement aimed to give the impression of everyone sitting at a common table when the room cameras were pointed at the groups. In addition, we sought to promote the psychological fusion of the two groups using two telepresence robots placed in each seminar room. These robots were of the type Double 3 (Doublerobotics, 2022). Students from the remote seminar room could log into these robots (via notebooks in their own seminar room) to participate even more immediately in the other seminar room, to navigate around the other seminar room, and to have individual conversations with the students there.

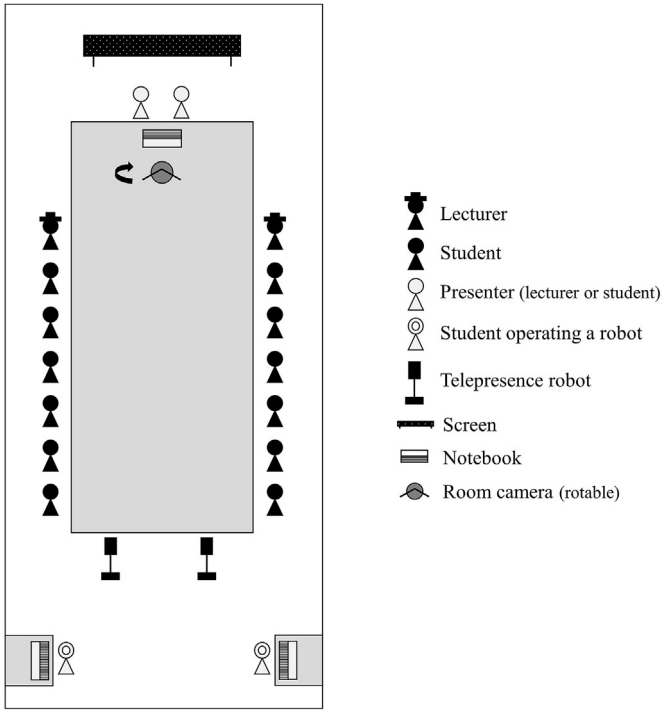

Fig. 3. Setup of the seminar rooms.
Note. The figure shows the setup in one of the two seminar rooms. The setup in the other seminar room was identical.

In terms of seminar content, the six internal diversity dimensions of the four layers of diversity model (Gardenswartz & Rowe, 2003) were at the heart of the formal sessions. In each session, three of these dimensions were covered: First, 1–2 students from Germany and 2–3 students from Kenya (in alternating order) gave 10-min presentations on selected aspects related to the respective dimension from the perspective of their own country (e.g. aging population in Germany; prohibition of homosexuality in Kenya). They ended their presentations with two questions for subsequent discussion (e.g., how the shortage of skilled nursing staff in Germany could be counteracted; how acceptance of same-sex love in Kenya could be increased). Each question from the two presentations was then discussed in one of four small groups, consisting of several students from one university and one student from the other university joining the group via robot (i.e., the discussions took place without further web conferencing). During these discussions, the students also had opportunities to ask questions about the presentations and to talk about the respective diversity dimension, independently of the discussion questions.

In addition to considering the six diversity dimensions, the lecturers gave scientific presentations on the topics of intercultural competence and diversity, followed by subsequent whole-class discussions. The presentations were designed to familiarize the students with the concept of intercultural competence and the four layers of diversity model, to further sensitize them to cultural differences between Germany and Kenya, and to highlight the importance of cultural diversity. Moreover, a round of introductions of all participants took place at the beginning of the first session. At the end of both sessions, the students gave brief feedback about their impressions of the session and had the opportunity to clarify any questions that had remained unanswered up to that point. These conversations took place via Zoom.

It is important to note that the quality of the Internet connection varied considerably in respect of robot use in the seminars. While the connection worked excellently at times, some discussions had to be terminated prematurely because neither image nor sound could be transmitted adequately via the robots. In contrast, no technical problems occurred during the Zoom conference. Furthermore, it is noteworthy that the second formal session of the April seminar could not take place in the seminar room at the University of Nairobi due to the unexpected declaration of a public holiday in Kenya. For this reason, the students from Kenya attended the seminar from home. Thus, the robots could not be used in this session and all discussions took place in the plenary via the Zoom conference.

4.2.2. Informal activities

The informal activities, which took place between the formal sessions, were another key element of the seminars. During these activities, two students from Germany and two students from Kenya met to show each other their campuses (in some cases, the groups were somewhat larger). The students from the university abroad took part via robot. To provide a framework for the informal activities, the students had to solve several tasks on each campus. For example, they had to find out what kind of food was offered in the cafeteria on that particular day, or to take a group photo in front of a certain building. The informal activities were designed to give the students the opportunity to get to know each other in a more casual atmosphere, and to have more private conversations, away from the formal sessions of the seminar. Furthermore, the students should be given the opportunity to gain a relatively rich intercultural experience by being able to autonomously move around the campus of the other university using the robots. At the end of the first formal session, the small groups for the informal activities were formed, and individual time slots were coordinated with the interns, who handed out the robots to the students to perform these activities. At the beginning of the second formal session, the students were asked to report their experiences of the informal activities.

4.2.3. Evaluation

Evaluation questionnaires were completed within the intercultural seminars at the beginning of the first formal session (after the round of introductions) and at the end of the second formal session. In the German control group, most questionnaires were completed during a course on diagnostics. Students' CQ and acceptance of using telepresence robots in intercultural seminars were measured at both measurement points (T1 and T2) in both the seminar group and the control group. Students' demographics were measured at T1, also in both groups. At T2, the students of the seminar group were additionally asked to rate their self-location when using the robots and to respond to some open questions about the robots and the development of their intercultural competence during the seminar. All items of each scale used to measure the constructs examined were presented in randomized order. In order to assign the data from both measurement points, individual identification numbers were generated. If students had not completed the second questionnaire in time, they were asked by mail to do so as soon as possible. Thus, the average interval between the two measurement points was slightly more than one week. However, it did not differ significantly between students of the seminar group ($M = 7.84$, $SD = 2.40$) and the control group ($M = 7.77$, $SD = 2.08$); $t(101) < 1$, $p = .87$. All participants gave informed consent to participate in the study at its beginning. Our local ethics commission declared the study ethically unobjectionable.

4.3. Measures

4.3.1. Cultural intelligence

We used the CQS (Ang et al., 2007) in its original form to measure students' CQ. This scale consists of 20 items that can be assigned to the four facets of CQ. As noted in section 2.1, previous research has shown that the CQS has good psychometric properties. Moreover, it has already been used successfully to measure CQ in different cultures. Example items of the four subscales are "I am conscious of the cultural knowledge I apply to cross-cultural interactions" (metacognitive CQ), "I know the cultural values and religious beliefs of other cultures" (cognitive CQ), "I enjoy interacting with people from different cultures" (motivational CQ), and "I change my verbal behavior (e.g., accent, tone) when a cross-cultural interaction requires it" (behavioral CQ). In line with the original scale, the students in our study responded to all items on a 7-point Likert scale ranging from 1 = *strongly disagree* to 7 = *strongly agree*. For all subscales, higher values indicated higher CQ. On average, the reliabilities were satisfactory and somewhat higher at T2 compared to T1 (metacognitive CQ: $\alpha_{T1} = 0.74$, $\alpha_{T2} = 0.76$; cognitive CQ: $\alpha_{T1} = 0.80$, $\alpha_{T2} = 0.85$; motivational CQ: $\alpha_{T1} = 0.74$, $\alpha_{T2} = 0.83$; behavioral CQ: $\alpha_{T1} = 0.66$, $\alpha_{T2} = 0.80$).

4.3.2. Acceptance of telepresence robots

We slightly adapted and translated three items developed by Wolff and Möller (2021) to measure students' acceptance of using telepresence robots in intercultural seminars: (1) "In principle, I consider the use of telepresence robots to be useful for conducting intercultural seminars", (2) "In the future, more telepresence robots should be used to conduct intercultural seminars", and (3) "I would attend an intercultural seminar (again) with students participating via telepresence robot". We used these items because the original scale had been shown to be a reliable measure to assess students' acceptance of using telepresence robots in higher education ($0.83 \leq \alpha \leq 0.87$). Moreover, the use of these items allowed us to make direct comparisons between our findings and those of Wolff and Möller (2021) regarding the development of students' acceptance of using telepresence robots in higher education. As was the case with the original scale, the students in our study responded to all items on a 7-point Likert scale ranging from 1 = *strongly disagree* to 7 = *strongly agree*. The reliability of the modified scale was also good at both measurement points ($\alpha_{T1} = 0.85$, $\alpha_{T2} = 0.89$).

4.3.3. Self-location

We slightly adapted four items developed by Vorderer et al. (2004) to measure students' self-location while using the robots: (1) "When participating via telepresence robot, I felt like I was actually there in the other seminar room", (2) "When participating via telepresence robot, it was as though my true location had shifted into the other seminar room", (3) "When participating via telepresence robot, I felt as though I was physically present in the other seminar room", and (4) "When participating via telepresence robot, it seemed as though I actually took part in the action in the other seminar room". We chose this scale because the original items could be easily adapted to the context of our study. Furthermore, the original scale had been shown to be highly reliable ($\alpha = 0.92$). In contrast to Vorderer et al. (2004), the students in our study responded to all items on a 7-point Likert scale ranging from 1 = *strongly disagree* to 7 = *strongly agree*, rather than on a 5-point Likert scale, so that we could use the same Likert scale for all the constructs measured. As with Vorderer et al. (2004), the reliability of our modified scale was also very high ($\alpha_{T2} = 0.95$).

4.3.4. Open questions

To examine students' CQ development and experiences with the robots during the seminar in a qualitative manner, we asked them to respond to the following open-ended questions: (1) "To what extent have your intercultural competences changed as a result of participating in this seminar?", (2) "Please describe your experience with the telepresence robots in this seminar in your own words", (3) "Did you encounter any problems during the seminar (technical, content-related or personal)? Please describe them in your own words", (4) "How did you benefit from the use of robots in this seminar?", and (5) "How could the robots be improved for use in future intercultural seminars?". These open-ended questions were designed on the basis of our three research questions: Whereas the initial questions addressed students' CQ development and experiences with the robots in isolation, the following questions were aimed more at relating students' experiences with the robots to their CQ development. In general, however, we paid attention to formulating the questions as broadly as possible and giving the students the opportunity to focus on any aspects that were relevant to them. Accordingly, students could even answer the final questions without addressing the issue of CQ development if preferred.

4.3.5. Demographics

We asked the students to indicate their age, gender, citizenship, and years lived abroad. Moreover, we asked them whether they had had any experience with the use of telepresence robots prior to the seminar and, if this were the case, to describe their experiences.

4.4. Analyses

We tested most of our hypotheses by means of latent change score models (McArdle, 2009) in Mplus 7 (Muthén & Muthén, 2015). For model estimation, we used the robust maximum likelihood estimator (Yuan & Bentler, 2000). First, we calculated separate models for the seminar group, for the control group, and for both groups, to examine whether there were significant changes in the four CQ facets and in acceptance of telepresence robots in these groups. Moreover, we specified correlations between the initial values at T1 and changes between T1 and T2, to investigate how students' change in CQ facets and acceptance of the robots depended on their initial values in these variables. Second, in the models including all students of our sample, we regressed the initial values at T1 and changes between T1 and T2 on the group variable (coded as 0 = *control group*, 1 = *seminar group*) as well as on four covariates: students' age, gender (coded as 0 = *male*, 1 = *female*), citizenship (coded as 0 = *local*, 1 = *other*), and years lived abroad. Thus, a significant positive effect of the group variable on the change score would indicate a stronger increase in the respective variable in the seminar group compared to the control group. Third, we considered only the students of the seminar group and regressed the initial values at T1 and changes between T1 and T2 on self-location as well as age, gender, citizenship, and years lived abroad. Accordingly, these analyses allowed us to test whether students showed a stronger increase in the CQ facets and acceptance of telepresence robots in intercultural seminars, the stronger their perceived self-location in the seminar room abroad while using the robots.

To examine to what extent our results were generalizable across both cultural groups, we also conducted analyses including only the subsample of students from Germany or that of students from Kenya. Due to the relatively small sample size, especially in the analyses including only students from one cultural group, we ran the models with manifest variables and considered only one change variable in each model (Coman et al., 2013). However, our findings on the models including the entire sample were also replicated if latent variables were specified under strong measurement invariance. To test Hypothesis 2.1, assuming that students would show a high acceptance of using telepresence robots in intercultural seminars, we calculated 95% confidence intervals around the mean acceptance scores and examined whether the lower boundaries of the intervals were significantly higher than the midpoint of the Likert scale used (Wolff & Möller, 2021).

Because of the nature of the computer-based data collection procedure, there could be no missing values in the completed questionnaires (except for the open questions). However, some students had only filled out questionnaires at T1. We also included the data of these students in our analyses and used the full information maximum likelihood procedure to deal with the missing values. Compared to traditional missing data treatment methods, such as listwise deletion, this approach is considered superior, as no observations are deleted and a higher power can be achieved (Enders, 2010). Nevertheless, our main findings were also replicated in additional analyses that only included those students who had provided data at both measurement points.

We analyzed students' responses to the open-ended questions using thematic analysis (Boyatzis, 1998; Braun & Clarke, 2006). First, we grouped similar statements into inductively formed categories. Subsequently, we examined which categories were most frequently addressed by the students. Moreover, we looked for some suitable citations to illustrate the key messages of different categories.

5. Results

This section begins with some preliminary analyses examining the correlations between all (quantitative) variables examined. Subsequently, we present our findings according to the three research questions. For each research question, we first report the findings of the quantitative main analyses, examining the entire sample, which we consider central to testing our hypotheses. We then report the most important findings from the quantitative additional analyses, in which the subsamples from Germany and Kenya were considered separately. Finally, we present the findings from the qualitative analyses. All results of the quantitative analyses can be found in Tables 2–5. Table 2 depicts the bivariate correlations. Table 3 shows the change in the CQ facets and students' acceptance of using telepresence robots in intercultural seminars in the different groups. Table 4 presents the results of the regression analyses in which students' initial values and changes in the CQ facets and acceptance of the robots were regressed on the group variable and the covariates. Table 5 presents the results of the regression analyses in which the initial values and changes in the CQ facets and acceptance of the robots in the seminar group were regressed on self-location and the covariates.

5.1. Preliminary analyses

As shown in Table 2, there were strong positive correlations between the same constructs measured at two points in time (all $.62 \leq r \leq .75$, all $p < .001$). The correlations among the different CQ facets were also positive, although three correlations with behavioral CQ were not statistically significant (all $.12 \leq r \leq .64$; all $p \leq .23$). Students' acceptance of using telepresence robots showed substantial correlations, especially with metacognitive CQ, self-location, and age (all $.29 \leq r \leq .54$, all $p < .001$). Age also showed substantial correlations with metacognitive CQ and cognitive CQ (all $.27 \leq r \leq .45$, all $p < .01$). Years lived abroad showed significant correlations, especially with cognitive CQ (all $.31 \leq r \leq .40$, all $p < .01$). Moreover, there was a strong correlation between years lived abroad and gender ($r = .55$, $p < .001$), indicating that female students had spent more time in another country.

5.2. Research question 1: change in cultural intelligence

5.2.1. Quantitative main analyses

In line with Hypotheses 1.1, 1.2 and 1.4, we found significant increases in metacognitive CQ ($\Delta M = 0.34$, $p < .01$, $d = 0.40$), cognitive CQ ($\Delta M = 0.65$, $p < .001$, $d = 0.84$), and behavioral CQ ($\Delta M = 0.45$, $p < .001$, $d = 0.65$) in the seminar group, but not in the control group (all $|\Delta M| \leq 0.12$, all $p \geq .17$). Moreover, the increases in these CQ facets were significantly stronger in the seminar group than in the control group (metacognitive CQ: $B = 0.45$, $p < .01$, $\beta = 0.30$; cognitive CQ: $B = 0.56$, $p < .01$, $\beta = 0.28$; behavioral CQ: $B = 0.34$, $p = .02$, $\beta = 0.21$). However, in contrast to Hypothesis 1.3, there was no significant change in motivational CQ either in the seminar group or in the control group (all $\Delta M \leq 0.08$, all $p \geq .49$) and both groups did not differ significantly with regard to change in motivational CQ ($B = 0.07$, $p = .66$). The correlations between students' initial levels and changes in the CQ facets were negative, implying that increases in these variables were stronger for students with lower initial values (all $-.59 \leq r \leq -.27$). Except for the correlation between the initial levels and changes in behavioral CQ in the seminar group ($r = -.31$, $p = .13$), all of these correlations were also significantly negative (all $p \leq .04$). As already noted in section 4.1, at the first measurement point students of the seminar group showed higher metacognitive CQ ($B = 0.31$, $p = .04$, $\beta = 0.16$) and motivational CQ ($B = 0.48$, $p < .001$, $\beta = 0.26$) compared to the control group students. Moreover, older students had higher initial values in metacognitive CQ, cognitive CQ, and motivational CQ compared to younger students (all $0.04 \leq B \leq 0.06$, all $p \leq .03$, all $0.16 \leq \beta \leq 0.26$). Students' metacognitive, cognitive, and behavioral CQ were higher, the more time they had spent abroad (all $0.06 \leq B \leq 0.10$, all $p \leq .04$, all $0.21 \leq \beta \leq 0.35$).

5.2.2. Quantitative additional analyses

In our additional analyses, we were able to replicate most of the key findings from the main analyses. In particular, we also found significant increases in metacognitive CQ ($\Delta M = 0.53$, $p < .01$, $d = 0.90$), cognitive CQ ($\Delta M = 0.63$, $p < .001$, $d = 0.82$), and behavioral CQ ($\Delta M = 0.43$, $p <$

Table 2
Bivariate correlations.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Metacognitive CQ (T1)	1														
2. Metacognitive CQ (T2)	.70***	1													
3. Cognitive CQ (T1)	.41***	.38***	1												
4. Cognitive CQ (T2)	.44***	.63***	.62***	1											
5. Motivational CQ (T1)	.46***	.45***	.39***	.42***	1										
6. Motivational CQ (T2)	.34***	.52***	.30**	.48***	.67***	1									
7. Behavioral CQ (T1)	.41***	.37***	.13	.26*	.12	.26**	1								
8. Behavioral CQ (T2)	.48***	.64***	.23*	.40***	.19	.31***	.68***	1							
9. Acceptance robots (T1)	.42***	.42***	.06	.28**	.29***	.27**	.13	.18	1						
10. Acceptance robots (T2)	.29***	.36***	.04	.25*	.11	.20*	.13	.19	.75***	1					
11. Self-location (T2)	.23	.12	−.17	−.08	−.27	−.09	−.07	.02	.50***	.54***	1				
12. Age	.32***	.40***	.27**	.45***	.20**	.12	.03	.19	.29***	.34***	.01	1			
13. Gender (0 = *male*, 1 = *female*)	.03	.09	.03	.03	−.07	.00	−.04	.04	.06	.16	.02	−.04	1		
14. Citizenship (0 = *local*, 1 = *other*)	.03	.09	.19*	.17	−.01	−.07	.02	.08	−.19	−.13	−.17	.09***	.15	1	
15. Years lived abroad	.24***	.24*	.31***	.40**	.12**	.08	.24**	.30*	.00	.08	−.24	.07**	.55***	.33	1

Note. Asterisks indicate whether values are significantly different from zero. *$p < .05$. **$p < .01$. ***$p < .001$. $N = 135$ (except for correlations including self-location with $n = 43$).

Table 3
Initial values and changes in the CQ facets and acceptance of the telepresence robots.

Sample	Group	Variable	Metacognitive CQ	Cognitive CQ	Motivational CQ	Behavioral CQ	Acceptance robots
Entire sample ($N = 135$)	Seminar group ($n = 43$)	M_{T1}	5.73*** (0.14)	4.32*** (0.15)	6.00*** (0.11)	5.25*** (0.13)	5.94*** (0.11)
		$M_{T2–T1}$	0.34** (0.13)	0.65*** (0.14)	0.08 (0.11)	0.45*** (0.11)	0.15 (0.15)
		$d_{T2–T1}$	0.40**	0.84***	0.11	0.65***	0.23
		$r_{T1, T2–T1}$	−.59*** (0.15)	−.27* (0.13)	−.42** (0.15)	−.31 (0.20)	.02 (0.18)
	Control group ($n = 92$)	M_{T1}	5.37*** (0.09)	4.33*** (0.11)	5.50*** (0.09)	5.14*** (0.10)	5.26*** (0.13)
		$M_{T2–T1}$	−0.10 (0.07)	0.03 (0.11)	0.03 (0.09)	0.12 (0.09)	0.00 (0.10)
		$d_{T2–T1}$	−0.16	0.03	0.04	0.16	0.00
		$r_{T1, T2–T1}$	−.42*** (0.10)	−.42*** (0.10)	−.31** (0.11)	−.34** (0.11)	−.35** (0.10)
	Both groups ($n = 135$)	M_{T1}	5.48*** (0.08)	4.32*** (0.09)	5.66*** (0.07)	5.17*** (0.08)	5.47*** (0.10)
		$M_{T2–T1}$	0.08 (0.07)	0.26** (0.09)	0.06 (0.07)	0.24** (0.07)	0.06 (0.09)
		$d_{T2–T1}$	0.11	0.29**	0.08	0.33**	0.08
		$r_{T1, T2–T1}$	−.39*** (0.10)	−.36*** (0.09)	−.33*** (0.09)	−.33** (0.10)	−.20* (0.09)
German sample ($n = 80$)	Seminar group ($n = 16$)	M_{T1}	5.53*** (0.21)	4.65*** (0.20)	6.20*** (0.13)	5.49*** (0.20)	5.60*** (0.21)
		$M_{T2–T1}$	0.53** (0.16)	0.63*** (0.18)	0.05 (0.08)	0.43** (0.16)	−0.36 (0.33)
		$d_{T2–T1}$	0.90**	0.82***	0.15	0.82**	−0.46
		$r_{T1, T2–T1}$	−.26 (0.33)	−.71*** (0.13)	−.42 (0.24)	−.23** (0.26)	−.01 (0.29)
	Control group ($n = 64$)	M_{T1}	5.16*** (0.11)	4.32*** (0.12)	5.45*** (0.10)	5.15*** (0.11)	4.88*** (0.15)
		$M_{T2–T1}$	−0.05 (0.08)	−0.15 (0.09)	0.05 (0.09)	0.11 (0.10)	0.05 (0.12)
		$d_{T2–T1}$	−0.09	−0.24	0.08	0.16	0.06
		$r_{T1, T2–T1}$	−.43** (0.14)	−.16 (0.15)	−.32* (0.14)	−.28* (0.12)	−.39*** (0.10)
	Both groups ($n = 80$)	M_{T1}	5.23*** (0.10)	4.39*** (0.10)	5.60*** (0.09)	5.22*** (0.10)	5.03*** (0.13)
		$M_{T2–T1}$	0.07 (0.08)	0.02 (0.09)	0.05 (0.08)	0.18* (0.09)	−0.04 (0.12)
		$d_{T2–T1}$	0.12	0.04	0.09	0.28*	−0.05
		$r_{T1, T2–T1}$	−.29* (0.12)	−.14 (0.13)	−.30* (0.14)	−.24* (0.11)	−.33** (0.10)
Kenyan sample ($n = 55$)	Seminar group ($n = 27$)	M_{T1}	5.84*** (0.17)	4.12*** (0.19)	5.89*** (0.15)	5.11*** (0.17)	6.14*** (0.12)
		$M_{T2–T1}$	0.22 (0.17)	0.66** (0.19)	0.09 (0.17)	0.46** (0.16)	0.45*** (0.11)
		$d_{T2–T1}$	0.22	0.81**	0.11	0.61**	0.84***
		$r_{T1, T2–T1}$	−.70*** (0.13)	−.19 (0.15)	−.42** (0.16)	−.34 (0.25)	−.44 (0.23)
	Control group ($n = 28$)	M_{T1}	5.85*** (0.13)	4.35*** (0.24)	5.61*** (0.19)	5.11*** (0.21)	6.11*** (0.14)
		$M_{T2–T1}$	−0.19 (0.19)	0.65* (0.27)	−0.04 (0.22)	0.22 (0.20)	−0.08 (0.15)
		$d_{T2–T1}$	−0.37	0.44*	−0.05	0.24	−0.18
		$r_{T1, T2–T1}$	−.14 (0.27)	−.82*** (0.06)	−.27 (0.16)	−.54*** (0.15)	.07 (0.34)
	Both groups ($n = 55$)	M_{T1}	5.85*** (0.11)	4.24*** (0.15)	5.75*** (0.12)	5.11*** (0.13)	6.12*** (0.09)
		$M_{T2–T1}$	0.11 (0.13)	0.63*** (0.17)	0.07 (0.14)	0.36** (0.13)	0.26** (0.10)
		$d_{T2–T1}$	0.13	0.58***	0.08	0.43**	0.48**
		$r_{T1, T2–T1}$	−.57*** (0.14)	−.51*** (0.11)	−.37** (0.13)	−.46** (0.16)	−.27 (0.18)

Note. Standard errors are shown in parentheses. The effect size d for the mean differences was calculated according to Morris and DeShon (2002). Asterisks indicate whether values are significantly different from zero *$p < .05$. **$p < .01$. ***$p < .001$.

.01, $d = 0.82$) in the German seminar group, but not in the German control group (all $|\Delta M| \leq 0.15$, all $p \geq .12$), and the increases in all three CQ facets were significantly stronger in the seminar group compared to the control group (metacognitive CQ: $B = 0.57$, $p < .01$, $\beta = 0.37$; cognitive CQ: $B = 0.77$, $p < .001$, $\beta = 0.42$; behavioral CQ: $B = 0.42$, $p = .03$, $\beta = 0.24$). In the Kenyan seminar group, significant CQ increases were only found for cognitive CQ ($\Delta M = 0.66$, $p < .01$, $d = 0.81$) and behavioral CQ ($\Delta M = 0.46$, $p < .01$, $d = 0.61$). Nevertheless, in addition to behavioral CQ ($B = 0.52$, $p = .05$, $\beta = 0.29$), there were also stronger increases in metacognitive CQ ($B = 0.56$, $p = .01$, $\beta = 0.32$) in the Kenyan

Table 4
Prediction of initial values and changes in the CQ facets and acceptance of the telepresence robots in the entire/German/Kenyan sample.

Predictors		Metacognitive CQ		Cognitive CQ		Motivational CQ		Behavioral CQ		Acceptance robots	
	Coefficient	M_{T1}	M_{T2-T1}	M_{T1}	M_{T2-T1}	M_{T1}	M_{T2-T1}	M_{T1}	M_{T2-T1}	M_{T1}	M_{T2-T1}
Group	*B*	**0.31**/0.33/−0.02	**0.45/0.57/0.56**	−0.04/0.28/−0.13	**0.56/0.77**/0.14	**0.48/0.72**/0.34	0.07/−0.02/0.27	0.08/0.28/−0.15	**0.34/0.42/0.52**	**0.61/0.65**/0.10	0.16/−0.41/**0.54**
(0 = *control*,	*SE*	**0.16**/0.22/0.23	**0.14/0.18/0.23**	0.17/0.22/0.30	**0.18/0.19**/0.38	**0.14/0.16**/0.24	0.15/0.13/0.28	0.16/0.22/0.26	**0.14/0.19/0.26**	**0.16/0.24**/0.19	0.17/0.34/**0.19**
1 = *seminar*)	*p*	**.04**/.13/.95	**<.01/<.01/.01**	.82/.19/.65	**<.01/<.001**/.72	**<.001/<.001**/.16	.66/.87/.34	.61/.20/.56	**.02/.03/.05**	**<.001/.01**/.61	.35/.22/**.01**
	β	**0.16**/0.15/−0.01	**0.30/0.37/0.32**	−0.02/0.12/−0.06	**0.28/0.42**/0.06	**0.26/0.37**/0.19	0.04/−0.01/0.15	0.04/0.13/−0.08	**0.21/0.24/0.29**	**0.25/0.22**/0.07	0.09/−0.17/**0.45**
Age	*B*	**0.06**/0.03/0.03	0.02/0.01/**0.06**	**0.05**/0.02/**0.09**	0.06/0.00/0.04	**0.04**/0.01/**0.05**	−0.01/−0.02/0.02	−0.02/0.03/−0.04	0.03/−0.07/**0.11**	**0.09**/0.08/0.02	0.02/0.04/0.01
	SE	**0.02**/0.04/0.02	0.02/0.03/**0.03**	**0.02**/0.05/**0.02**	0.03/0.03/0.04	**0.14**/0.03/**0.03**	0.02/0.03/0.02	0.03/0.03/0.04	0.02/0.04/**0.04**	**0.03**/0.06/0.02	0.02/0.04/0.02
	p	**<.01**/.48/.21	.22/.68/**.04**	**.02**/.66/**<.001**	.06/.91/.40	**.03**/.72/**.04**	.60/.58/.73	.58/.20/.30	.15/.08/**<.01**	**<.001**/.19/.39	.27/.36/.52
	β	**0.26**/0.09/0.13	0.11/0.06/**0.29**	**0.19**/0.08/**0.31**	0.24/0.01/0.14	**0.16**/0.04/**0.23**	−0.05/−0.07/0.08	−0.06/0.12/−0.17	0.16/−0.28/**0.50**	**0.31**/0.19/0.10	0.10/0.11/0.09
Gender	*B*	0.10/0.16/−0.04	0.24/−0.09/**0.81**	0.06/−0.06/0.26	0.05/−0.08/0.28	−0.13/−0.16/−0.06	0.20/−0.33/**1.09**	−0.15/−0.02/−0.30	0.31/0.20/**0.54**	0.34/0.28/0.37	0.48/0.62/0.12
(0 = *male*,	*SE*	0.20/0.28/0.20	0.24/0.20/**0.36**	0.26/0.24/0.48	0.31/0.31/0.60	0.21/0.24/0.36	0.26/0.17/**0.41**	0.19/0.29/0.26	0.18/0.20/**0.26**	0.21/0.30/0.24	0.31/0.36/0.36
1 = *female*)	*p*	.62/.58/.82	.31/.65/**.03**	.83/.79/.59	.86/.79/.64	.53/.50/.86	.44/.05/**.01**	.45/.95/.25	.08/.31/**.04**	.11/.35/.12	.13/.09/.74
	β	0.04/0.06/−0.02	0.12/−0.05/**0.33**	0.02/−0.02/0.08	0.02/−0.04/0.09	−0.05/−0.07/−0.03	0.10/−0.19/**0.44**	−0.06/−0.01/−0.11	0.14/0.10/**0.21**	0.10/0.08/0.19	0.19/0.22/0.07
Citizenship	*B*	−0.48/−0.38/—	0.37/0.35/—	0.14/0.14/—	−0.39/−0.45/—	−0.25/−0.25/—	−0.24/−0.23/—	−0.67/−0.65/—	0.06/0.06/—	**−1.34/−1.34**/—	0.03/0.11/—
(0 = *local*,	*SE*	0.59/0.62/—	0.20/0.22/—	0.20/0.20/—	0.36/0.27/—	0.21/0.23/—	0.23/0.25/—	0.38/0.42/—	0.33/0.26/—	**0.49/0.57**/—	0.25/0.28/—
1 = *other*)	*p*	.43/.55/—	.07/.11/—	.49/.47/—	.28/.10/—	.25/.28/—	.30/.36/—	.08/.12/—	.86/.82/—	**.01/.02**/—	.90/.68/—
	β	−0.11/−0.11/—	0.11/0.15/—	0.03/0.04/—	−0.09/−0.16/—	−0.06/−0.08/—	−0.07/−0.10/—	−0.15/−0.20/—	0.02/0.02/—	**−0.24/−0.30**/—	0.01/0.03/—
Years lived abroad	*B*	**0.06/0.08/0.08**	−0.03/−0.04/**−0.12**	**0.07/0.08/0.07**	0.02/0.05/−0.06	0.03/0.03/0.03	−0.01/−0.00/−0.07	**0.10/0.07/0.14**	0.02/0.04/−0.01	0.01/0.04/**−0.06**	−0.00/−0.01/0.01
	SE	**0.03/0.03/0.03**	0.02/0.02/**0.03**	**0.03/0.03/0.04**	0.04/0.03/0.08	0.02/0.02/0.02	0.03/0.04/0.05	**0.02/0.02/0.06**	0.03/0.04/0.04	0.04/0.05/**0.03**	0.03/0.04/0.03
	p	**.04/.02/.01**	.15/.14/**<.01**	**.01/.02/.04**	.64/.15/.44	.13/.09/.20	.74/.91/.15	**<.001/<.01/.02**	.57/.42/.91	.84/.38/**.05**	.98/.86/.70
	β	**0.21/0.36/0.17**	−0.15/−0.23/**−0.23**	**0.23/0.34/0.11**	0.07/0.26/−0.10	0.10/0.17/0.05	−0.05/−0.03/−0.13	**0.35/0.31/0.25**	0.08/0.20/−0.01	0.02/0.15/**−0.16**	−0.00/−0.03/0.04

Note. Significant values are highlighted in bold. $N = 135/n = 80/n = 55$.

seminar group compared to the Kenyan control group. The increase in cognitive CQ did not differ significantly between the Kenyan seminar and control groups ($B = 0.14$, $p = .72$), because students of the control group also showed a significant increase in cognitive CQ ($\Delta M = 0.65$, $p = .02$, $d = 0.44$). However, these students showed no significant change in metacognitive and behavioral CQ (all $|\Delta M| \leq 0.22$, all $p \geq .28$). Moreover, and similarly to the main analyses, no significant change in motivational CQ was found in either the German or Kenyan seminar or control groups (all $|\Delta M| \leq 0.09$, all $p \geq .49$), and the changes in motivational CQ did not differ significantly between the seminar and control groups (all $|B| \leq 0.27$, all $p \geq .34$).

5.2.3. Qualitative analyses

Students' responses to the question to what extent their intercultural competences had changed as a result of participating in the seminar underlined the finding from the quantitative analyses that students' CQ had increased during the seminar. In fact, all students of the seminar group reported that their intercultural competences had improved during the seminar. For example, one Kenyan student noticed that her intercultural competence had changed "to a great extent" and explained: "I get to appreciate, accommodate and understand culture that is not my own. I appreciate the differences we have as well as the similarities that we share." A German student wrote that she "got a closer look at different realities and how they come together. This helps for an intercultural understanding". Many students emphasized the knowledge they had gained about the other culture. For instance, one Kenyan student wrote that she had "been able to learn so much information in terms of German culture and how they operate in their day to day lives". Similarly, a German student noticed that she "gained more knowledge about Kenyan culture and realized which German characteristics are not self-evident in intercultural conversations". However, some students also referred to the behavioral aspect of CQ, such as a Kenyan student who noted that she had "learnt a lot about how to interact with people from different cultures" or a German student who stated that although she "already had a lot of intercultural skills before, now it has intensified".

5.3. Research question 2: assessment of the telepresence robots

5.3.1. Quantitative main analyses

Hypothesis 2.1was supported, as students' mean acceptance of using telepresence robots in intercultural seminars was significantly higher than 4 ($M_{T1} = 5.47$, 95% CI [5.28, 5.67]; $M_{T2} = 5.54$, 95% CI [5.30, 5.77]). However, in contrast to Hypothesis 2.2, we found no significant change in acceptance of the robots in either the seminar group or the control group (all $\Delta M \leq 0.15$, all $p \geq .32$), and both groups did not differ significantly with regard to changes in acceptance of the robots ($B = 0.16$, $p = .35$). The correlation between students' initial levels and changes in acceptance of the robots was significantly negative in the control group ($r = -.35$, $p < .01$), but close to zero in the seminar group ($r = .02$, $p = .90$). Nevertheless, in accord with Hypothesis 2.3, we found a stronger increase in acceptance of the robots in the seminar group, the more students had felt that they were actually in the other seminar room when using the robots ($B = 0.24$, $p < .01$, $\beta = 0.41$). As noted in section 4.1, students' acceptance of the telepresence robots at the first measurement point was higher in the seminar group than in the control group ($B = 0.61$, $p < .001$, $\beta = 0.25$). Moreover, the acceptance of the robots at the first measurement point was higher for older students compared to younger students ($B = 0.09$, $p < .001$, $\beta = 0.31$) and for local students compared to foreigners ($B = -1.34$, $p = .01$, $\beta = -0.24$).

5.3.2. Quantitative additional analyses

In line with the main analyses, we found high acceptance of using telepresence robots in intercultural seminars in both the German subsample ($M_{T1} = 5.03$, 95% CI [4.77, 5.29]; $M_{T2} = 4.99$, 95% CI [4.69, 5.28]) and the Kenyan subsample ($M_{T1} = 6.12$, 95% CI [5.94, 6.30]; $M_{T2} = 6.38$, 95% CI [6.15, 6.62]). However, acceptance was significantly

Table 5
Prediction of initial values and changes in the CQ facets and acceptance of the telepresence robots in the seminar group (entire/German/Kenyan sample).

Predictor		Metacognitive CQ		Cognitive CQ		Motivational CQ		Behavioral CQ		Acceptance robots	
	Coefficient	M_{T1}	M_{T2-T1}	M_{T1}	M_{T2-T1}	M_{T1}	M_{T2-T1}	M_{T1}	M_{T2-T1}	M_{T1}	M_{T2-T1}
Self-location	*B*	**0.16**/0.11/0.36	−0.12/0.08/−0.05	−0.06/0.12/**0.38**	−0.01/0.03/0.11	−0.10/−0.13/−0.00	0.05/0.12/0.35	0.01/0.10/0.27	0.04/0.24/**0.32**	**0.20**/−0.28/**0.41**	**0.24**/**0.38**/0.10
	SE	**0.07**/0.20/0.26	0.06/0.16/0.15	0.09/0.53/**0.13**	0.07/0.35/0.11	0.07/0.38/0.12	0.05/0.15/0.21	0.07/0.25/0.17	0.05/0.18/**0.12**	**0.05**/0.24/**0.07**	**0.09**/**0.18**/0.15
	p	**.03**/.58/.16	.06/.63/.73	.52/.82/**<.01**	.91/.93/.33	.14/.73/.97	.31/.43/.10	.92/.68/.11	.42/.19/**<.01**	**<.001**/.24/**<.001**	**<.01**/**.03**/.49
	β	**0.31**/0.11/0.38	−0.24/0.06/−.05	−0.11/0.04/**0.34**	−0.01/0.04/0.10	−0.25/−0.24/−0.01	0.13/0.17/0.38	0.01/0.11/0.29	0.09/0.25/**0.33**	**0.47**/−0.27/**0.58**	**0.41**/**0.11**/0.18
Age	*B*	0.03/−0.11/0.04	0.04/**0.36**/0.04	0.08/0.03/**0.16**	0.01/0.14/0.01	0.03/−0.03/0.06	0.01/0.13/0.03	−0.06/0.03/−0.04	**0.12**/0.22/**0.16**	0.02/−0.30/0.05	0.02/0.19/−0.02
	SE	0.03/0.18/0.03	0.05/**0.14**/0.05	0.05/0.29/**0.05**	0.06/0.19/0.06	0.04/0.18/0.05	0.04/0.09/0.04	0.03/0.22/0.04	**0.06**/0.14/**0.06**	0.03/0.17/0.03	0.05/0.23/0.04
	p	.31/.56/.16	.42/**.01**/.48	.10/.92/**<.01**	.84/.47/.82	.50/.89/.27	.75/.13/.43	.11/.90/.35	**.03**/.11/**<.01**	.47/.07/.12	.66/.41/.66
	β	0.11/−0.26/0.14	0.14/**0.68**/0.13	0.24/0.08/**0.49**	0.04/0.39/0.05	0.11/−0.11/0.23	0.06/0.44/0.12	−0.18/0.08/−0.13	**0.47**/0.56/**0.56**	0.08/−0.68/0.22	0.07/0.13/−0.11
Gender (0 = *male*, 1 = *female*)	*B*	0.14/0.28/0.05	**0.60**/**0.78**/0.62	0.08/−0.30/0.59	0.58/0.50/0.78	−0.02/−0.09/0.08	0.38/0.15/**0.78**	−0.23/0.55/−0.60	0.28/0.01/**0.68**	0.41/**0.75**/0.21	0.64/**1.86**/−0.07
	SE	0.35/0.64/0.29	**0.30**/**0.35**/0.45	0.51/0.33/0.73	0.32/0.42/0.44	0.39/0.25/0.65	0.24/0.19/**0.28**	0.34/0.50/0.37	0.28/0.34/**0.28**	0.26/**0.23**/0.36	0.44/**0.39**/0.41
	p	.68/.66/.88	**.05**/**.03**/.17	.88/.37/.42	.07/.23/.08	.95/.71/.90	.12/.44/**.01**	.50/.27/.10	.32/.98/**.01**	.11/**<.01**/.56	.15/**<.001**/.86
	β	0.06/0.12/0.02	**0.26**/**0.26**/0.25	0.03/−0.15/0.20	0.24/0.25/0.29	−0.01/−0.07/0.04	0.20/0.09/**0.32**	−0.10/0.26/−0.24	0.14/0.01/**0.26**	0.21/**0.30**/0.12	0.23/**0.23**/−0.05
Citizenship (0 = *local*, 1 = *other*)	*B*	0.42/1.55/—	0.30/−2.03/—	−0.32/−0.33/—	0.64/−0.50/—	**−0.67**/−0.36/—	−0.53/**−2.44**/—	−0.71/−1.48/—	−0.96/−2.30/—	**−1.31**/0.80/—	−0.55/**−9.12**/—
	SE	0.28/1.60/—	0.42/1.78/—	0.46/2.36/—	0.47/2.04/—	**0.31**/1.45/—	0.44/**0.88**/—	0.38/1.83/—	0.59/1.80/—	**0.23**/1.51/—	0.85/**2.98**/—
	p	.13/.33/—	.48/.26/—	.48/.89/—	.17/.81/—	**.03**/.81/—	.23/**.01**/—	.06/.42/—	.10/.20/—	**<.001**/.60/—	.52/**<.01**/—
	β	0.07/0.42/—	0.05/−0.42/—	−0.05/−0.10/—	0.11/−0.15/—	**−0.15**/−0.17/—	−0.11/**−0.91**/—	−0.12/−0.44/—	−0.19/−0.63/—	**−0.27**/0.20/—	−0.08/**−0.70**/—
Years lived abroad	*B*	**0.08**/0.04/**0.09**	**−0.12**/−0.13/**−0.09**	**0.12**/0.16/0.07	**−0.16**/−0.13/**−0.11**	0.05/0.06/0.06	−0.00/0.15/0.02	**0.14**/0.12/**0.15**	0.05/0.13/0.70	−0.02/−.01/**−0.05**	0.15/**1.25**/0.06
	SE	**0.03**/0.07/**0.04**	**0.04**/0.15/**0.04**	**0.06**/0.09/0.07	**0.04**/0.20/**0.05**	0.04/0.06/0.05	0.05/0.08/0.05	**0.05**/0.07/**0.05**	0.07/0.21/0.05	0.03/0.06/**0.01**	0.11/**0.30**/0.04
	p	**.02**/.55/**.02**	**<.01**/.38/**.03**	**.05**/.08/.35	**<.001**/.51/**.03**	.15/.31/.27	.94/.07/.68	**<.01**/.12/**<.01**	.46/.53/.18	.48/.87/**<.001**	.18/**<.001**/.11
	β	**0.21**/0.12/**0.25**	**−0.35**/−0.29/**−0.23**	**0.33**/0.53/0.16	**−0.44**/−0.43/**−0.27**	0.18/0.31/0.07	−0.01/0.60/0.06	**0.40**/0.37/**0.41**	0.17/0.39/0.18	−0.07/−0.03/**−0.20**	0.36/**1.04**/0.25

Note. Significant values are highlighted in bold. $n = 43/n = 16/n = 27$.

higher in the Kenyan subsample ($d_{T1} = 1.08$; $d_{T2} = 1.27$). Moreover, there were some differences between the two subsamples concerning development of acceptance of the robots. Whereas students' acceptance of using telepresence robots in intercultural seminars did not change significantly in the German seminar group and in the two control groups (all $|\Delta M| \leq 0.36$, all $p \geq .27$), there was a significant increase in the Kenyan seminar group ($\Delta M = 0.45$, $p < .001$, $d = 0.84$). In line with this, our regression analyses also revealed a stronger increase in acceptance of the robots in the seminar group compared to the control group in the Kenyan subsample ($B = 0.54$, $p = .01$, $\beta = 0.45$), but not in the German subsample ($B = -0.41$, $p = .22$). The positive effect of self-location on change in acceptance of telepresence robots in intercultural seminars was only found in the German seminar group ($B = 0.38$, $p = .03$, $\beta = 0.11$), and not in the Kenyan seminar group ($B = 0.10$, $p = .18$).

5.3.3. Qualitative analyses

The evaluation of the open questions about the use of the telepresence robots provided a mixed picture. Overall, 52.8% of the students described their experiences with the robots during the seminar as positive (e.g., "It was a really amazing and fascinating experience that we are so far away from each other but we are able to converse and have a conversation and an exchange to learn about each other's culture"), 11.1% as mainly positive (e.g., "It's been a great experience, though felt strange as it was the first time"), 27.8% as neutral (e.g., "As long as the Internet connection worked it was a lot of fun driving around the other campus"), and 8.3% as mainly negative (e.g., "When the connection worked it was an interesting experience, but unfortunately the technical problems were too much"). In line with the findings from the quantitative analyses, the Kenyan students reported much more favorable experiences with the robots during the seminars (73.9% positive, 17.4% mainly positive, 8.7% neutral, 0.0% mainly negative) compared to the German students (15.4% positive, 0.0% mainly positive, 61.5% neutral, 23.1% mainly negative); $\chi^2(3) = 21.3$, $p < .001$. The students who did not assess their experience with the robots as positive criticized technical problems in particular (e.g., "Basically, this is certainly a good idea, but there would have to be a much better Internet connection and volume elaboration"). Moreover, some students experienced the use of the robots as a bit strange, especially at the beginning of the seminar (e.g., "I was nervous at first but eased up with time").

The technical problems with the robots became even more apparent when the students were asked directly if they had experienced any problems during the seminar. In this context, 94.4% of the students noted technical problems with the robots. Accordingly, when asked how the robots could be improved for use in future intercultural seminars, 83.3% of the students indicated that technical improvements were necessary, especially with regard to Internet connectivity, sound transmission, and motion characteristics (better control over movement, more stability on uneven terrain, higher navigating speed, possibility of control via a touch pad dedicated to that purpose).

However, despite the technical problems with the robots, 91.7% of the students stated that they had benefited from using the robots in the seminar. In particular, many students noted that the robots were helpful for conducting the intercultural interactions, during which some students even felt as if they were in the other place (e.g., "I felt like I was physically in University of Koblenz interacting with the students"). Furthermore, several students described the robots as helpful in acquiring new digital skills (e.g., "I learned to adapt to a different system very fast"). Some students also highlighted the importance of the robots in conducting the informal activities (e.g., "The virtual tour in Koblenz was really fun and interesting"). Nonetheless, there were also students who felt that the personal conversation could just as easily have taken place via conventional web conferences. For example, a German student found that it would have been "more straightforward and less nerve-wracking to just hold the seminar via video conferencing". Similarly, another German student summarized her experiences with the robots as follows:

It was an interesting experience to use the robots in order to connect with Kenyan students and discuss about various topics of diversity. It's great that the robots enable this, however sometimes it might be frustrating when the robots set limits by not functioning as expected. So it has been disappointing sometimes, when there was a good conversation or discussion, that the robot's technical issues set limits to continue with the interactions. That's why I think that the technology should be advanced more, so that the intercultural experience can take place limitless and without interruptions because of the robots. This, however has led to the thought sometimes, that without robots it would be less complicated.

5.4. Research question 3: change in cultural intelligence through experience with the robots

5.4.1. Quantitative main analyses

Unlike our predictions in Hypotheses 3.1 to 3.4, students' self-location did not predict their change in the four CQ facets (all $|B| \leq 0.12$, all $p \geq .06$). Instead, students' age predicted change in behavioral CQ ($B = 0.12$, $p = .03$, $\beta = 0.47$), female gender predicted change in metacognitive CQ ($B = 0.60$, $p = .05$, $\beta = 0.26$), and students' years lived abroad predicted changes in metacognitive CQ and cognitive CQ (all $-0.16 \leq B \leq -0.12$, all $p \leq .01$, all $-0.44 \leq \beta \leq -0.35$) in the seminar group. Students' years lived abroad also predicted their initial values in metacognitive CQ, cognitive CQ, and behavioral CQ (all $0.08 \leq B \leq 0.14$, all $p \leq .02$, all $0.21 \leq \beta \leq 0.40$). Local students had higher initial values in motivational CQ compared to foreigners ($B = -0.67$, $p = .03$, $\beta = -0.15$). Self-location was also a predictor of initial values in metacognitive CQ ($B = 0.16$, $p = .03$, $\beta = 0.31$).

5.4.2. Quantitative additional analyses

Similarly to the main analyses, the subgroup analyses usually revealed no significant effects of self-location on change in the CQ facets (all $|B| \leq 0.35$, all $p \geq .10$). The only exception was a positive effect of self-location on change in behavioral CQ found in the Kenyan subsample ($B = 0.32$, $p < .01$, $\beta = 0.33$).

5.4.3. Qualitative analyses

As noted in section 5.3.3, many students highlighted the usefulness of telepresence robots for conducting intercultural interactions. With this in mind, it can be assumed that the robots may have contributed to students' CQ increase during the seminars. In particular, it is worth noting that some students described the robots as useful for building close relationships with their fellow students abroad (e.g., "[The robots] allowed us to have closer contact and more direct exchange in small groups"). However, regarding the question to what extent students' CQ increase in the seminars can be explained by specific experiences that they had when operating the robots (such as the feeling of self-localization), no conclusions can be drawn due to a lack of statements.

6. Discussion

In this study, we evaluated the effects of two semi-virtual intercultural seminars that combined classroom-based training and intercultural experience through telepresence robots. Overall, these seminars proved to be very successful: Although the participants attended the seminars from their home university and thus had no physical contact with the participants from the other university, our study revealed significant increases in different CQ facets among the participants from both countries. Furthermore, it provides important information on the integration of telepresence robots in intercultural seminars.

6.1. Research question 1: change in cultural intelligence

Our study showed that the (active) participants of our seminars achieved significant increases in three CQ facets during the seminars: metacognitive CQ, cognitive CQ, and behavioral CQ (see section 5.2.1). This finding was predicted in Hypotheses 1.1, 1.2, and 1.4. Nevertheless, the increases in the various CQ facets are particularly remarkable, at least for three reasons: First, the increases in CQ are not only of statistical significance, but also of practical relevance. This is especially true for the strong increase in cognitive CQ, which was found in the entire sample as well as in the two culture-specific subsamples (all $0.81 \leq d \leq 0.84$; see Table 3). Second, the increases in the CQ facets are particularly noteworthy given the relatively short length of the seminar. Considering that the seminars included only two block events and the informal activities, our approach can be attested to be highly efficient. Third, the increase in behavioral CQ in particular can be seen as encouraging. As noted in section 2.1, a number of other CQ interventions have also yielded increases in metacognitive CQ and cognitive CQ (e.g., Eisenberg et al., 2013; Hodges et al., 2011). In contrast, increases in behavioral CQ often have not been found in such interventions. In our study, it is likely that the moderate to strong increase in behavioral CQ (all $0.61 \leq d \leq 0.82$; see Table 3) resulted from the presentations, discussions, and joint activities during the seminars, which gave students many opportunities to try out their intercultural behavior in practice.

In contrast to Hypothesis 1.3, we found no change in motivational CQ among the participants of our seminars. However, this finding can be explained by ceiling effects. At the beginning of the seminars, the students in both the German and Kenyan seminar groups were already showing very high values in motivational CQ (all $5.89 \leq M \leq 6.20$; see Table 3), which were also higher than the initial values in the other CQ facets (all $4.12 \leq M \leq 5.84$). Thus, the students had little opportunity to make further gains in motivational CQ during the seminar. Nevertheless, the negative correlations between the initial values and changes in motivational CQ (all $r = -.42$) indicated that students with relatively low initial values in motivational CQ were able to increase in this facet during the seminar.

Although our findings concerning change in the various CQ facets were largely generalized across the German and Kenyan subsamples, it is noteworthy that the change in cognitive CQ did not differ significantly between the Kenyan seminar and control groups (see section 5.2.2). Still, this finding is explicable when it is considered that the students in the Kenyan control group (unlike those in the German control group) participated passively in the seminar, and had the opportunity to make gains in cognitive CQ by receiving information conveyed during the seminar. Thus, it did not seem necessary to be in the seminar room, give a presentation, participate in the small-group discussions, or attend the informal activities to make gains in cognitive CQ during the seminar. In contrast, these differences between the students in the Kenyan seminar and control groups might have been crucial for the increases in metacognitive and behavioral CQ among the students in the seminar group.

6.2. Research question 2: assessment of the telepresence robots

Our overall assessment of the use of telepresence robots is mixed. On the one hand, and as predicted in Hypothesis 2.1, our study demonstrated that the use of telepresence robots in intercultural seminars is not only feasible but is also considered by students to be useful (see section 5.3.1). On the other hand, it became obvious that many technical problems hampered successful implementation of the telepresence robots in this study (see section 5.3.3). Due to these technical problems, it is understandable that we found no increase in acceptance of using telepresence robots in intercultural seminars within the seminar group as a whole (see section 5.3.1). This finding contradicts Hypothesis 2.2, as well as the results of Wolff and Möller (2021), who found significant increases in students' acceptance of telepresence robots as a medium of university teaching over the course of seminars including these devices. Importantly however, no serious technical problems in using the robots were reported in their study. Moreover, with regard to change in the acceptance of using telepresence robots in intercultural seminars, it should be noted that

acceptance of the robots in the present study was already very high among the seminar group students at the beginning of the seminars ($M = 5.94$; see Table 3). Therefore, as with motivational CQ, the scope for further increase in acceptance of the robots was limited. Incidentally, this is another important difference to Wolff and Möller's (2021) study, in which initial values in students' acceptance of telepresence robots on the 7-point Likert scale were significantly less ($M = 5.34$).

It is also worth mentioning that in the present study an increase in acceptance of the robots was shown in the Kenyan seminar group (see section 5.3.2), where the overall evaluation of the robots was significantly more positive compared to the German seminar group (see also section 5.3.3). A possible explanation for this finding is that the Internet connection in Germany was better, so that the robots in Germany were easier to control by the Kenyan students than the robots in Kenya were by the German students. However, it is also conceivable that it is cultural differences that yielded the different evaluations of the robots. For example, it would be possible that the German students had higher expectations of the functioning of the robots and consequently evaluated them more critically than did the Kenyan students. Moreover, the evaluation of the robots in Kenya may have been affected by higher levels of socially desirable responding.

However, regardless of the cultural differences, it should be noted that there were students in both cultural groups who evaluated the robots positively (see section 5.3.3). Thus, it is reasonable to consider that individual differences other than cultural factors may have affected acceptance of the robots. One factor for which we found an impact on the development of students' acceptance of the robots was self-location: Consistently with Hypothesis 2.3, acceptance of the robots increased especially among those students who most felt they were actually in the other seminar room when using the robots. To increase the acceptance of telepresence robots, it thus seems advisable for manufacturers to reinforce the sense of self-location when using the robots. For example, this could perhaps be done through the use of virtual glasses. First and foremost, however, it is important that a stable Internet connection can be guaranteed when using the robots.

6.3. Research question 3: change in cultural intelligence through experience with the robots

In contrast to Hypotheses 3.1 to 3.4, students' perceived self-location while using the robots showed no effect on changes in their CQ facets (see section 5.4.1), except for behavioral CQ in the Kenyan seminar group (see section 5.4.2). Accordingly, our study did not support relating students' CQ increase to their experiences while using the robots during the seminar (see also section 5.4.3). Rather, it seems plausible that the contents of the seminar and the personal interactions, regardless of the medium used, favored the increase in students' CQ in particular. Nevertheless, we believe that it is worthwhile to consider using telepresence robots in future intercultural seminars, provided that the functionality of this technology can be assured. This is especially true for the realization of virtual tours in the remote location, in respect of which several students in our seminars emphasized the importance of the robots (see section 5.3.3).

6.4. Practical implications

The increase in students' CQ found in this study has important practical implications. First of all, we have developed a theoretically-based concept that allows enhancing students' CQ efficiently and without the need for time-consuming, costly and polluting travel. Beyond that, it would also be relatively easy to transfer this concept to other groups (e.g., high school students), content areas (e.g., cultural differences between economic systems), and partner countries (in a similar time zone). Future research would need to test empirically whether our approach actually achieves a similar effect in other settings. However, we consider it very promising for increasing CQ in diverse populations.

It is still an unresolved question to what extent the increase in students' CQ in our seminars depended on the integration of the telepresence robots. Although many students emphasized the importance of the robots for conducting intercultural interactions during our seminars, it is unclear whether our students would not have shown similar development in their CQ if the interactions had taken place via traditional web conferences. In particular, immobile videoconferencing could have been used instead of the robots for the seminar discussions, since students moved around the seminar room very little during the discussions. In addition, mobile videoconferencing on smartphones could have been used to conduct the informal activities. Although students would not have had the opportunity to move around the other university autonomously in that case, reduced technical problems might have offset this advantage of robots. In addition, smartphones would have been a much cheaper alternative to telepresence robots, which currently cost $4499 (Double 3). However, if the technical problems that hindered the use of telepresence robots during our seminar can be solved in the future, telepresence robots should be able to substantially enrich intercultural seminars by offering the possibility of autonomous control for individual participants. Therefore, we believe that the integration of telepresence robots into intercultural seminars—or more generally, into university teaching—should be further advanced in coming years.

6.5. Strengths and limitations

Our study had a number of strengths. In particular, these included (1) the study design, which allowed us to examine development in CQ and the acceptance of telepresence robots in student samples from two cultures longitudinally, and in comparison to two different kinds of control groups, (2) the multi-method approach, which combined quantitative and qualitative analyses, and (3) the relatively large sample size, especially in comparison to previous studies examining the use of telepresence robot in educational contexts, which allowed us to detect changes in students' CQ of practical relevance. Despite these strengths, however, our study also had some weaknesses that should be discussed.

First, we conducted our study with a nonrepresentative and partially selective sample of students, mainly from the field of psychology. Hence, it is unclear to what extent our findings can be generalized to other populations. With regard to the self-selectivity of the sample, it is somewhat problematic that the students from Germany had the choice whether to participate in one of our intercultural seminars or in an alternative seminar. However, since in Kenya the students were assigned by their instructor either to the seminar group or to the control group, the problem of self-selection was less severe in this subgroup at least.

Second, and related to the problem of self-selection, we found some differences between the seminar group and control group students at the beginning of the study. Although both groups did not differ significantly in their demographics, the (German) students in the seminar group had higher initial values in metacognitive CQ, motivational CQ, and acceptance of the robots. Regarding metacognitive CQ, we considered these differences to be less problematic. Rather, we found it somewhat remarkable that the students in the seminar group achieved a stronger increase in metacognitive CQ, compared to the students in the control group, despite their higher initial values. However, it should be noted that the effect of seminar participation on change in metacognitive CQ may have been underestimated, due to the different initial values in the seminar and control groups.

In contrast to metacognitive CQ, our main analyses revealed no effect of seminar participation on change in motivational CQ and acceptance of the robots. Importantly, this finding may partly be due to the higher initial values in these characteristics in the seminar group. Regarding students' change in acceptance of the robots, this assumption is substantiated when considering the results of the additional analyses conducted with the Kenyan students only. These analyses revealed neither statistically significant nor practically relevant differences between students in the seminar and control groups with respect to their acceptance

of using telepresence robots in intercultural seminars. However, students' acceptance increased significantly more strongly in the seminar group than in the control group.

With regard to change in motivational CQ, the additional analyses showed no differences between the seminar and control groups. As discussed in section 6.1, it is possible that this finding is due to ceiling effects. Nevertheless, to draw strong conclusions about the effects of intercultural seminars using telepresence on change in motivational CQ (as well as metacognitive CQ and acceptance of the robots), it would be desirable for future research to have seminar and control groups that do not differ in terms of initial values in these characteristics. To this end, it could be useful to work with a waiting group design where students provide data at two measurement points prior to participating in the seminar. This design may be preferred to the design used in the present research because students who choose to participate in an intercultural seminar with telepresence robots are likely to have higher motivational CQ and show higher acceptance of using telepresence robots in intercultural seminars than students who do not choose to participate.

Third, it can be seen as a limitation of our study that the German lecturers conducted the evaluation of the seminars themselves. For this reason, it is possible that the findings of our study were affected by investigator effects. In fact, the seminar participants were aware that they were taking part in a DAAD-funded project that had the central goal of supporting students in developing their intercultural competence. However, to counteract possible investigator effects, the lecturers explicitly emphasized during the evaluation that the students should fill out the questionnaire honestly and conscientiously. Moreover, the fact that increases in CQ were also found in the Kenyan seminar group, although the Kenyan lecturers were not involved in the evaluation, makes it less likely that our findings were biased by investigator effects.

Fourth, it should be noted that, despite the significant increases in three of four CQ facets, it is still unclear which components of the seminar contributed to these increases. According to our theoretical considerations, several factors (e.g., inputs by lecturers, presentation preparations, small-group discussions) should have jointly supported our students' CQ development. However, to obtain more specific information on the impact of the different components of our seminar, it would be necessary either to evaluate their effects in isolation from each other or to evaluate the seminar without certain components. In particular, an evaluation of our seminar conducted without telepresence robots would be interesting, to better assess the importance of these devices for students' CQ development.

Finally, a shortcoming of our study is that we were not able to investigate whether the increases in CQ that occurred during our seminars, persist in the long run. Since the present study was the first investigation of intercultural seminars using telepresence robots, this question goes beyond its scope. Given that studies have found increases in CQ following interventions to persist months after the intervention (e.g., Erez et al., 2013; Reichard et al., 2014), we consider it plausible that the gains in CQ found in our study would also persist long after the seminars have finished. Nevertheless, future research should examine this question empirically.

7. Conclusion

In times of rapid developments in digital networking on the one hand and global problems such as pandemics, wars, and climate threat on the other, digital student exchanges have become an important alternative to the classic forms of exchange in person. The present study illustrates the high potential of digital student exchanges for intercultural learning. In our seminars, which were apparently the first intercultural seminars using telepresence robots, we found significant increases in metacognitive, cognitive, and behavioral CQ after only one week. Moreover, we found that students from Germany and Kenya showed high acceptance and benefited from the use of the telepresence robots in our seminars. However, many questions about the effects of telepresence robots in intercultural seminars, as well as the factors underlying students' CQ increase in our study, are still unclear. Therefore, we would like to encourage researchers and university teachers to evaluate the approach of our seminars in the future in diverse intercultural settings, with and without integrating telepresence robots, with a focus on the topics of diversity and intercultural competence as well as on other topics, and with systematic inclusion and exclusion of the other components of our seminar, to gain further knowledge about the importance of these components for students' CQ acquisition.

Ethical statement

This study received ethics approval from the affiliated institutional review board (approval number: LEK-447_R). Informed consent was obtained from all participants.

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Competing interests statement

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