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► To cite this version:

Xiaoxuan Hei, Valentine Denis, Pierre-Henri Orefice, Alia Afyouni, Paul Laborde, et al.. Evaluating students' experiences in hybrid learning environments: A comparative analysis of Kubi and double telepresence robots. Lecture Notes in Computer Science, 2023, Special Robotics, ICSR 2023, 14454, pp.148-159. 10.1007/978-981-99-8718-4_13 . cea-04526303

HAL Id: cea-04526303

<https://cea.hal.science/cea-04526303v1>

Submitted on 29 Mar 2024

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Evaluating Students' Experiences in Hybrid Learning Environments: A Comparative Analysis of Kubi and Double Telepresence Robots

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Abstract. Amidst the Covid-19 pandemic, distance learning was employed on an unprecedented level. As the lockdown measures have eased, it has become a parallel option alongside traditional in-person learning. Nevertheless, the utilization of basic videoconferencing tools such as Zoom, Microsoft Teams, and Google Meet comes with a multitude of constraints that extend beyond technological aspects. These limitations are intricately linked with human behavior, psychology, but also pedagogy, drastically changing the interactions that take place during learning. Telepresence robots have been widely used due to their advantages in enhancing a sense of in-person. To investigate the opportunities, the impact, and the risks associated with the usage of telepresence robots in an educational context, we conducted an experiment in a real setting, in the specific use case of a design school and a project-based class. We are interested in the experience of a classroom and the relationships between a distance student, his/her peers, and the professor/instructor. This study employed two types of robots: a Kubi robot (a semi-static tablet-based system) and a Double robot (a mobile telepresence robot). The primary objective was to ascertain the perceptions and experiences of both remote and in-person students during their interaction with these robots. The results of the study demonstrate a marked preference among students for the Double robot over the Kubi, as indicated by their feedback.

Keywords: Telepresence robot · Distance learning · Human-robot interaction.

1 Introduction

In recent years, technological advancements have revolutionized the landscape of education, going beyond traditional limits and opening up new opportunities for

learning [1]. One such innovation is the integration of telepresence robots within the classroom environment [2]. Telepresence robots can serve as a solution to address the limitations in mobility faced by students due to a variety of reasons such as weather, disability and illness [3]. Compared to conventional distance learning tools, with telepresence robots, students are empowered to navigate the robot’s movements, select viewing angles, and even engage with the surrounding environment. This technology facilitates their seamless integration into a social learning environment, allowing them to interact with peers and educators in real time [4].

A recent project implemented by French Ministry of National Education, Youth and Sports, called TED-i ⁴, just concluded by deploying 4000 of these robots in French schools. This endeavor is designed to address the challenges faced by students who are absent due to various reasons, particularly hospitalization, and to facilitate their seamless reintegration into the classroom environment. The ultimate goal is to support their learning journey and ensure genuine inclusion and socialization upon their return.

The central aim of our ongoing research is to explore the potential of telepresence robots in enhancing the realm of distance learning. This entails a comprehensive evaluation of several key factors, including the perception of information assimilation, the quality and quantity of knowledge acquisition, the engagement levels and responsiveness of remote students, the overall user experience, as well as the amplification of interactions among students participating from a distance, those physically present in the classroom, and collaborative partnerships.

In this paper, we delve into an examination of the practical utilization of telepresence robots, specifically focusing on the Kubi and Double robots. Our primary focus is to gain an understanding of how students perceive and engage with these robots within a real setting of a university classroom. To accomplish this, we employ a combination of quantitative data analysis and qualitative insights to provide a comprehensive overview between a distance student, his/her peers, and the professor/instructor.

The rest of the paper is structured as follows: Section 2 discusses previous related work about telepresence robots in education; Section 3 presents our experimental design; Section 4 shows the results and section 5 concludes this work.

2 Related Work

Lately, there has been a growing interest in researching telepresence robots due to their promising utility in the field of distance education.

In their study, Bell et al. [5] conducted a comparison of different types of telepresence robots within an educational setting. These categories encompassed videoconferencing (referred to as 2D telepresence), “table” telepresence robots (referred to as 2.5D telepresence), and mobile telepresence robots (referred to as 3D telepresence). The outcomes of the research revealed that 3D telepresence,

⁴ <https://www.education.gouv.fr/ted-i-des-robots-de-tele-presence-destines-aux-eleves-hospitalises-326458>

involving mobile robots, generated a heightened sense of immersion for students participating remotely.

Thompson et al. [4] studied the perception of a telepresence robot in a classroom. Initial findings focused on the experiences of students within a physical classroom where face-to-face interactions involved both students present in person and those participating remotely through a telepresence robot. These findings underscored the necessity for educators to devise and implement innovative instructional approaches to foster a positive classroom experience that caters to the needs of both in-class attendees and remote learners.

Fitter et al. [6] examined the experiences of college students taking classes in three formats: in-person, via a telepresence robot, and through distance learning tools such as live streaming, recorded lectures, and class calls with questions. The findings revealed a student preference for a blend of distance learning tools and in-person attendance. In contrast, teachers expressed a preference for telepresence robots over conventional distance learning tools, with students highlighting the robots' effectiveness in maintaining their engagement.

Moreover, a comparison between a student interaction via a telepresence robot with the mediated student interaction supported by videoconferencing was made by Shouten et al. [7]. The results showed that students who used the robot, compared to videoconferencing, experienced stronger feelings of social presence, but also attributed more robotic characteristics to their interaction partner (i.e. robomorphism). The study also showed that while robomorphism had negative impacts, these effects were mitigated by the sense of social presence.

Gallon et al. [8] analyzed the motivation of students while using telepresence robots. The study proposed the idea of improving robot interactions as a means to maintain student engagement and motivation. Past research consistently confirms that telepresence robots contribute to fostering a sense of presence among individuals who cannot attend lectures in person.

The primary aim of this study is to explore students' perspectives while engaging in small group activities through the utilization of telepresence robots, especially within the context of a design school and a project-based class, a scenario that has not been explored in previous studies.

3 Methods

3.1 Experimental Setup

The study took place within the actual classrooms of Strate Ecole de Design, a five-year higher education institution that delivers a recognized diploma in industrial design. Specifically, the experiment was conducted within a second-year class as part of a month-long module on *Introduction to interaction design*. This module extended from April 12th to May 10th, 2023, with one session scheduled per week.

Within this specific class, students worked in groups of 3 to 4 persons on a design brief. The allocated assignments consistently required cooperative efforts,

usually carried out within groups. Each group project encompassed collaborative activities such as brainstorming, jointly exploring ideas, conducting benchmarking exercises, and participating in feedback sessions. The learning environment fostered extensive dialogues, complemented by practical tasks such as sketching, intermittent interviews, experimentation, filming, video editing, and presentations. This educational framework routinely demanded considerable mental and physical engagement, emphasizing practical applications, while traditional academic lectures were relatively infrequent.

3.2 Robotic Systems

- Kubi⁵ robot (see Figure 1) is a telepresence solution designed specifically for 7-10 inch tablets. Remote users can command the Kubi's 300° pan and +/- 45° tilt capabilities, allowing them to virtually look around the room and engage with their surroundings.
- Double3⁶ robot (see Figure 2) consists of a mobile base with wheels and a tablet or screen that displays the user's face, allowing them to see and communicate with others as if they were physically present.



Fig. 1. Kubi robot



Fig. 2. Double3 robot

3.3 Procedure

During the first session, the research team introduced the project and provided guidelines on how to operate the robots. The participants endorsed the informed

⁵ <https://www.kubiconnect.com/e-commerce/kubi-classic.html>

⁶ <https://www.doublerobotics.com>

consent form regarding their image rights and their involvement in the experiment. Additionally, they completed three pre-questionnaires.

- A general questionnaire was employed to gather demographic details, including age, gender, prior experience with distance learning, and interactions with robots.
- Big-Five [9] questionnaire assesses participants' personality traits based on the Five Factor Model, i.e. *Extroversion*, *Conscientiousness*, *Agreeableness*, *Neuroticism* and *Openness*. It includes 45 questions with a 5-point Likert scale.
- Situational Motivation Scale (SIMS) [10] questionnaire measures an individual's motivation in a specific situation or context. It assesses different types of motivation, including *Intrinsic Motivation* (engaging in an activity for personal enjoyment or satisfaction), *Identified Regulation* (engaging in the activity because it aligns with one's personal values and goals), *External Regulation* (engaging in an activity for external rewards or pressures), and *Amotivation* (lack of motivation). It includes 16 questions with a 7-point Likert scale.

Each class session lasted three hours, during which the students collaborated in groups. During all the sessions, the teacher gave a brief introduction before visiting each group to assess their progress and offer guidance. In one group, only one student interacted with the Kubi robot, while the other attendees were physically present. In a different group, a single student engaged with the Double robot, while the remaining participants joined in person (see Figure 3). After each session, participants completed two questionnaires.



Fig. 3. Experimental scenarios with Kubi robot (left) and Double robot (right)

- Godspeed [11] questionnaire assesses human perceptions in interactions with robots. It evaluates dimensions such as *Anthropomorphism*, *Animacy*, *Likeability*, *Perceived intelligence* and *Perceived safety* to provide insights into how people perceive and evaluate robot interactions. It includes 24 questions with a 5-point Likert scale.

- Engagement [12] questionnaire assesses participants’ engagement from a multidimensional perspective, including *Emotional and cognitive dimensions* (how one feels and thinks about the activity), *Social dimension* (interactions and connections with others), *Behavioral dimension* (observable actions and behaviors). It includes 20 questions with a 7-point Likert scale.

Furthermore, both students and the professor in charge of the class took part in individual interviews led by the research team to collect their opinions following each session. The interview inquiries were customized depending on whether the participants engaged in the study through physical presence or remote involvement. Distance students were required to respond to 21 questions, whereas on-site students had 11 questions to answer. The teacher also answered 5 questions, after the first session and also after the last session.

In the 21 questions addressed to the remote participants, it was discussed how employing a telepresence robot differs from using a standard videoconferencing application or physically attending the class. Other questions focused on the tasks that participants completed in class, their level of familiarity with the robot’s user interface, the overall user experience, flexibility, and technical challenges. The other questions were on how they interacted remotely for three hours with their colleagues, how they produced work together, and how they were integrated into the group.

The on-site students responded to 11 questions about their main class group tasks, their interactions with the remote peer, and the differences between interacting through a traditional videoconferencing system and being present all together in the class. Other questions also investigated the technical aspects of the interaction with the Kubi robot and with the Double robot.

The teacher was questioned about whether the robots disrupted the lesson, whether he thought that remote students using Kubi or Double were more engaged than those using a traditional videoconferencing system, and whether and how this engagement differed from that of students who were physically present.

4 Experimental Results

4.1 Participants

Our experiment involved 16 participants; however, one of them did not complete the initial questionnaires. Among the remaining 15 participants (4 female, 11 male; mean age = 20.67, SD = 2.21), one participant did not respond to the Big-Five questionnaire. Out of these, 7 participants took part in the experiment on two occasions, with one of them not answering the SIMS questionnaire. Therefore, we obtained 21 valid sets of data for the Big-Five questionnaire and 20 valid sets for the SIMS questionnaire. All 15 participants had prior experience with online courses conducted through videoconferencing. Additionally, over half of them (8 out of 15) had engaged with robots before. Details regarding participant distribution can be found in Table 1 and Table 2.

Table 1. Distribution of participants

Distance-Kubi	Presence-Kubi	Distance-Double	Presence-Double
4	8	4	7

Table 2. Distribution of participants for Big-Five

	Extroversion		Agreeableness		Conscientiousness		Neuroticism		Openness	
	Low	High	Low	High	Low	High	Low	High	Low	High
Distance-Kubi	2	2	1	3	1	3	3	1	0	4
Presence-Kubi	3	3	2	4	3	3	1	5	1	5
Distance-Double	1	3	2	2	1	3	3	1	2	2
Presence-Double	4	3	1	6	4	3	2	5	1	6
Total	10	11	6	15	9	12	9	12	4	17

4.2 Quantitative results

Godspeed In our experiment, only participants who were physically present had the opportunity to interact with the robots. As a result, we employed a t-test to compare the Godspeed questionnaire results between the “Presence-Kubi” group and the “Presence-Double” group. The outcome is displayed in Figure 4. Among the five scales, the Anthropomorphism score for Kubi ($M = 2.2$, $SD = 0.3$) was significantly higher than that for Double ($M = 1.6$, $SD = 0.15$), as indicated by $t(13) = 2.43$ and $p = 0.03$. This discrepancy can be attributed to the presence of a wheel and a long straight bar on the Double robot, which imparts a more mechanical appearance and reduces its anthropomorphic quality. We also attempted to analyze variations in perception among different personality traits; however, no statistically significant results were observed.

Engagement questionnaire We applied a One-way ANOVA to analyze the data from the four groups (Distance-Kubi, Presence-Kubi, Distance-Double, Presence-Double), taking into account all three dimensions of the engagement questionnaire. Despite this analysis, no statistically significant results were identified.

Other results Based on the collected data, by using Pearson Correlation analysis, we observed a positive correlation between behavioral engagement and identified regulation ($r(20) = 0.595$, $p = 0.006$). This relationship becomes evident as individuals are more inclined to actively participate, invest effort, and sustain engagement with an activity when they perceive its value and alignment with their personal values.

Furthermore, students with low extroversion ($M = 5.25$, $SD = 0.84$) demonstrate significantly higher levels of intrinsic motivation compared to students with high extroversion ($M = 3.67$, $SD = 1.77$) with $t(17) = 2.53$, $p = 0.022$.

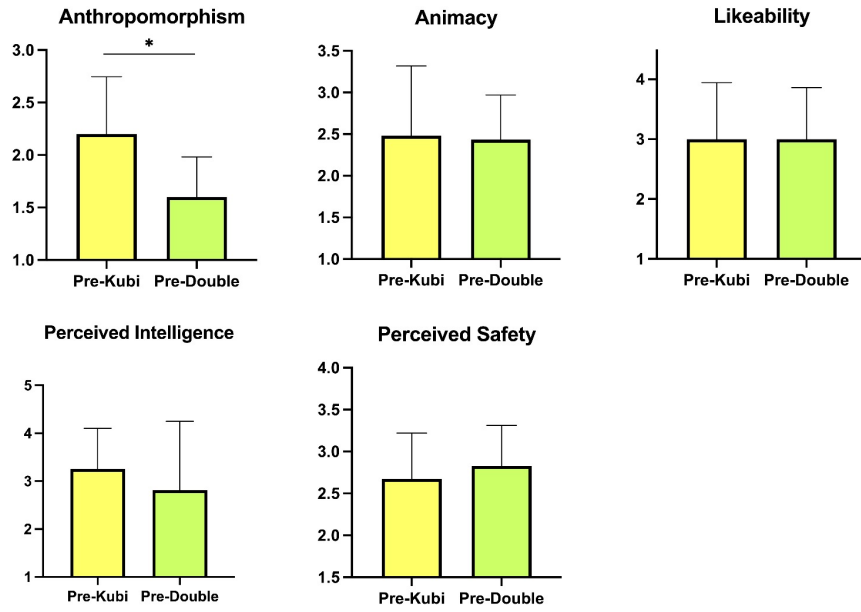


Fig. 4. Results for t-test of Godspeed questionnaire between Presence-Kubi and Presence-Double. Error bars show Standard Deviation, * indicates significance at the 0.05 level.

Students with low conscientiousness ($M = 3.83$, $SD = 1.26$) demonstrate significantly higher levels of Amotivation compared to students with high conscientiousness ($M = 2.58$, $SD = 1.01$) with $t(17) = 2.41$, $p = 0.028$. This supports a study indicating that conscientiousness is strongly and negatively correlated with Amotivation [13].

4.3 Qualitative results

The research team transcribed the recorded interviews conducted for the study. The text was analyzed using Grounded Theory coding [14]. The material was divided into concepts, which are standalone phrases, and each concept was given a code (1-3 words that summarize the topic). We eventually came up with 420 concepts and corresponding codes. The codes were then organized into seven distinct themes: *Sense of presence*, *Students' engagement*, *Classroom experience and relationships*, *Learning quality and productivity*, *Ease of operation and comfort*, *Personal feelings*, and *Others* (including comments and improvement suggestions).

The cumulative volume of verbatim content for each theme is presented in Table 3. Additionally, we determined the valence of each code, or whether it showed a positive or negative aspect of the theme. Figure 5 shows the number of positive and negative remarks for each theme.

Table 3. Number of verbatim for each theme

Theme	Count
Sense of presence	37
Engagement	35
Classroom experience and relationships	49
Learning quality and productivity	47
Ease of operation and comfort	107
Personal sentiments	56

Overall, students provided a higher count of positive comments and a lower count of negative comments for the Double robot compared to Kubi (79+ vs. 66+ and 82- vs. 104-), indicating a higher level of satisfaction with the Double robot. Simultaneously, the considerable number of negative remarks for both robots concerning learning quality and productivity emphasizes that the implementation of telepresence robots might not notably improve students' productivity during collaborative tasks.

For the sense of presence, participants mentioned that both robots managed to create a sense of physical presence. This is in accordance with the result presented in [6], which found that robot use made a noticeable impact on students' 'feeling of presence'. Nevertheless, they did acknowledge occasional situations in which remote students were unintentionally neglected. Although the robots displayed greater interactivity than standard videoconferencing, their mobility remained somewhat limited.

Engagement within remote contexts, facilitated by Double and Kubi robots, appears comparable to conventional video conferencing. Despite the robots' modest enhancements, challenges such as participation, group cohesion, and focus endure. Intriguingly, interactions among students utilizing these robots exhibit a superior quality compared to face-to-face interactions, primarily due to the remote format fostering clearer communication and active listening. Remote students express a sense of satisfactory participation during teacher-led sessions. However, individual tasks tend to take precedence subsequently, leading to decreased engagement. In scenarios of this nature, in-person students tend to engage more extensively with their fellow classmates than with their remote peers.

Among both remote and in-person participants, the augmented mobility features contribute to an improved remote group work experience. Nonetheless, there's a prevailing sentiment that the arrangement "isn't well-suited for this class format". This sentiment arises from the combination of hands-on tasks like drawing and modeling, alongside theoretical activities like brainstorming and debates, which seem less compatible with the setup.

Technical issues have been numerous and varied, including setup adjustments, random robot disconnections and reconnections, audio problems like difficulty hearing the remote student or sound being too soft or loud, and video issues such as variable video quality depending on unstable connections or inverted camera views. Battery problems have also arisen, with Double's supposed 4-

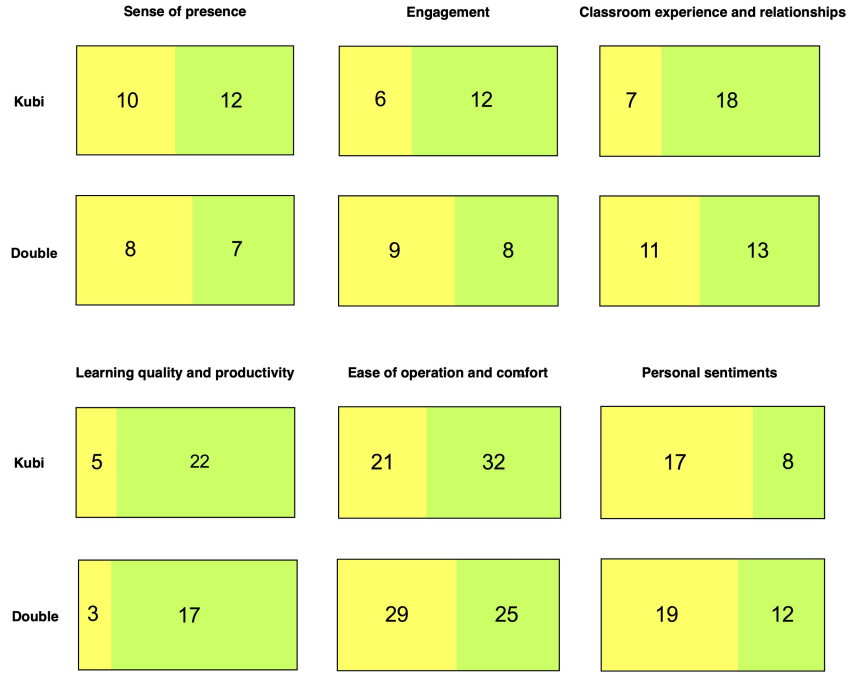


Fig. 5. Participants conveyed positive (yellow/left side) and negative feedback (green/right side) to each of the 6 examined aspects of user experience.

hour autonomy only lasting around 1.5 hours despite full charging, which is also mentioned in [15]. Internet connection posed fewer problems for Double compared to Kubi. Mobility interface was generally found “easy” and “intuitive”, but Double’s obstacle detection was overly sensitive, causing it to stall or halt when people passed by. There was also slight latency in movement tracking. Remote students rarely used mobility features due to these issues, resorting to them “only when truly necessary”.

A range of improvement suggestions emerged from the participants. In terms of handling background noise, some individuals recommended the implementation of “automatic ambient sound volume detection” coupled with the automatic adjustment of Double’s volume. To enhance user-friendliness, alternative approaches could be explored for both robots when remote students need to ask questions, such as utilizing a sound signal. Furthermore, the absence of document-sharing support was noted, often prompting a shift to alternative methods in conjunction with or in lieu of telepresence. One participant highlighted the lack of additional arms to aid in conveying body language, allowing for more unrestricted and clear expression.

5 Conclusion

Throughout this study, our focus revolved around the practical implementation of two distinct telepresence robots, Kubi and Double, within an actual university classroom setting. The core objective was to gain a deeper understanding of students' viewpoints regarding these robotic systems and their broader encounters within the classroom environment. While the experiment did encounter technical challenges and difficulties, it also brought to light a significant level of positive feedback from the participants concerning both robots.

Therefore, students demonstrated a greater level of satisfaction with the Double robot, as evidenced by the higher frequency of positive feedback and fewer instances of negative comments in comparison to Kubi. Nevertheless, the substantial volume of negative comments concerning learning quality and productivity for both robots underscored the notion that integrating telepresence robots might not yield substantial enhancements in students' productivity during collaborative assignments.

This research acts as an initial milestone for our continuous efforts regarding the incorporation of telepresence robots in the classroom environment. Nevertheless, it is clear that there are considerable opportunities for enhancement to fully optimize the practical use of telepresence robots in real classroom situations.

As our society continues to evolve rapidly, the significance of research focused on bridging geographical barriers and connecting individuals across the globe becomes increasingly pronounced. The implications of enabling seamless interactions and learning experiences for all hold substantial importance in this dynamic landscape.

Acknowledgements This work is supported by InterCarnot: Bots4Education project.

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