Telepresence Robots for Remote Participation in Higher Education

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ABSTRACT

Telepresence robotics enable people to synchronously communicate and interact at a distance. The Covid-19 pandemic caused in-person teaching and research activities to migrate online in almost all society sectors (including higher education). In hybrid learning environments, telepresence robots have the potential to increase the effectiveness of distance learning by enhancing user presence, allowing students to remain physically embodied and socially connected. However, to be accepted, trusted, and adopted in higher education, more work is needed to investigate the specific requirements of telepresence robotics in these settings. In this paper, we present the results of a mixed methods study exploring how the use of a telepresence robot in a simulated learning and research environment affects trust in and user experience of telepresence robots used in higher education. We aimed to understand users' attitudes and requirements for the use of telepresence robots in academic teaching and research. Our findings suggest that the level of trust is contingent upon the user, the performance of the robot, and the credibility of the developing organisation. We additionally map out the current challenges encountered by the use of telepresence robots in these settings and provide suggestions to improve user experience by highlighting new software and hardware capabilities.

CCS CONCEPTS

• **Computer systems organization → Robotics**; • **Human-centered computing → User studies**.

KEYWORDS

Human Robot Interaction, Distance Education, Higher Education, Telepresence Robot, Mobile Robotic Telepresence

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1 INTRODUCTION

Telepresence robots are increasingly employed in a variety of settings, including offices [29], healthcare [15, 17, 33], and museums [23] due to the social benefits of remote mobility and the capacity to communicate in real time. They can also provide opportunities to enable people to engage in education activities, supporting individuals in working and learning at a distance. Besides transmitting the user's live video and voice across the Internet to the intended destination, a person (i.e. 'remote user') can utilise the robot to move in the space (i.e. 'local setting') and interact in real time with others (i.e. 'local users'). Compared to other conference videos, telepresence robots can improve the user's physical presence and attract more attention. In particular, they are framed as capable of moving and communicating without the assistance of another person [33]; however, it has been shown that telepresence robots require substantial help from the local users (e.g. when navigating obstacles or going through doors) [2].

Although telepresence robots have the advantage of being able to facilitate communication across geographical boundaries and provide additional functionality such as scanning QR codes (for example, to open websites) and multiple levels of zoom to improve readability[1], they still face many obstacles in the higher education sector [5, 9, 12]. Particularly, because various stakeholders in higher education have varying academic requirements, specialisations, and occupations, they require a higher level of software capabilities and hardware facilities to satisfy their specific needs. The incomplete application scenarios and defective functions of telepresence robots in higher education can also result in a decline in user experience and trust, thereby diminishing the popularity of telepresence robots.

To explore these issues, we sought to invite stakeholders to explore the challenges and opportunities with these new technologies, different use cases, and the responsible design and deployment of this in the educational and research context. Consequently, a mixed methods experiment was designed to examine 1) attitudes towards robots in general in terms of fear, anxiety, expectation, and hope; 2) stakeholders' trust in telepresence robots in education and research activities, and the factors that influence the level of trust; and 3) stakeholders' satisfaction with the usability of telepresence robots in our use case. The proposed research questions are:

RQ1: How do different approaches to inform and educate people about the use of telepresence robots for educational and research activities affect self-reported trust and user experience? RQ2: What are the factors that influence stakeholders' level of trust in and acceptance of telepresence robots in education and research activities?
RQ3: What technological expectations do stakeholders have for telepresence robots in educational and research activities?

Our overarching objective of answering these questions is to contribute to discussions related to the responsible design and development of telepresence robots within education and research.

2 RELATED WORK

2.1 Distance Education and Research

Distance learning and some research activities can be synchronous, asynchronous, or blended. Asynchronous engagement utilises email, message boards, audio, and video recordings. Thus, participants have the flexibility to access course or presentation materials according to their schedules; however, lack of supervision can affect the quality of learning or research progress due to a lack of interaction with lecturers, supervisors and peers [6], and the institution must provide technical support to the instructor. Synchronous engagement allows people to communicate in real time [20], enables learning or research activities in a synchronous environment via the internet, and strengthens relationships between stakeholders. Commonly used synchronisation devices include videoconferencing [3] and Virtual Reality (VR) environments [30]. For instance, several research conferences have been held online or in a hybrid format since the Covid-19 pandemic, using a mix of synchronous and asynchronous platforms (e.g. Zoom and Slack). Nonetheless, a number of studies have demonstrated that remote users continue to struggle with remaining motivated, receiving feedback, or being able to meaningfully participate in the intended activities. Specifically, difficulties in contacting instructors, interacting with others, and missing out on campus life or research events are some of the reasons why people are hesitant for enrolling in distance education and research activities [7].

2.2 Robotic Telepresence

Originally, the telepresence robots were designed to enable adults to work remotely [29]. These are controllable from a computer, tablet, or smartphone and employs a camera, screen, speakers, and microphone for audiovisual interaction. The body of the robot consists of a rod that connects the head to wheels with self-balancing capabilities (see Figure 1) [1, 13]. They usually have a tablet-like interface with the person's live video feed displayed on it, and have locomotive capabilities. The wheels at the bottom of the telepresence robot allow the user to move in the space, so users no longer have to travel to visit patients or wait for workers to hold teleconferences [26]. In addition, a number of features have been added to telepresence robots to enhance their efficacy. In the case of Double3 robot, for instance, it has been equipped with 3D sensors and automatic obstacle avoidance, providing semi-autonomous navigation functionality. Moreover, the added zoom function enables the user to conduct detailed observations and near readings [1].

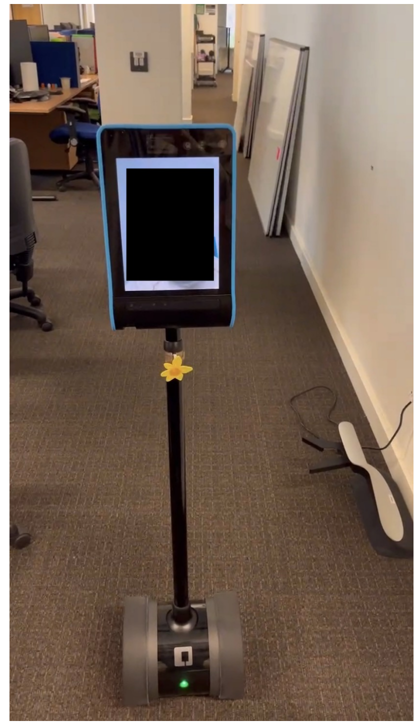

Figure 1: A telepresence robot: Double 3 by Double Robotics https://www.doublerobotics.com/.

Currently, telepresence robots are used in a variety of applications [10, 18, 27]. Gallon's research from 2019 demonstrated that telepresence robots can be used to effectively reduce interaction distances and assist users with team duties [9]. In a 2011 investigation, telepresence robots were utilised for office meetings. Experiments have demonstrated that using telepresence robots can increase user's presence and attention, and they can even make eye contact with individuals in the room. The mobility and interactivity of telepresence robots can facilitate the completion of post-conference meetings, particularly in distributed offices and hallway conversations [29]. In addition, the social benefits of telepresence robots can also be applied to long-term care, as Joey Wong et al. demonstrated that telepresence robots can help family members overcome geographical barriers to look after patients and reduce their anxiety and concerns. Moreover, telepresence robots do not require any other assistance, which helps to establish an independent space for private conversations and safeguards the patient's privacy [33]. In the sphere of healthcare education, it is advantageous in courses with subject prerequisites, such as nursing courses. Telepresence robots and the videoconferencing technology they possess can provide telemedicine and tele-simulation, thereby enhancing students' confidence and familiarity with telemedicine practise [15]. Nicolas et al. also indicate that senior adults are receptive to telepresence robot-supervised physical activity as a means of achieving healthy ageing[17].To summarise, telepresence robots have already proven their worth in a variety of applications, ranging from assisting with remote work to facilitating medical treatment. Next, we look deeper into their role in higher education.

2.3 Robotic Telepresence in Higher Education

The use of telepresence robots in higher education is primarily motivated by the realisation of education in particular situations, such as bridging geographical distances [4]. Social presence [24], better integration into practical activities [9], and physical presence within them are three characteristics that give telepresence robots an advantage over other mediated devices. However, the telepresence robot may require additional features to support a wider range of teaching and research activities. Not being able to read the whiteboard or presentation materials, how to quietly request to speak, and how to present their work to others are examples [9]. All of these concerns must be investigated and addressed in greater depth. At the same time, technical concerns, user concerns[12], and educational concerns [5] are the three primary reasons why telepresence robots are not utilised in education. According to Lei, Clemente, and Hu's research, students' use of the robot is primarily based on conversation without fully employing the entire capabilities of its replacement robot body. In addition, problems with network technology, such as latency, can disrupt the classroom and even make other students uncomfortable [12]. Corsby and Bryant investigated the perceptions of PhD students regarding telepresence robots; participants reported some functional limitations of the telepresence robots, such as a small screen size and difficulty viewing materials such as PowerPoint slides. In addition, they were unable to engage in informal interactions with other students during breaks, resulting in a diminished sense of belonging. [5]. Likewise, although telepresence robots were found effective to provide access to remote conference attendees, social encounters were difficult [19].

In conclusion, despite the advantages of telepresence robots to overcome geographical limitations and communication, there are still a number of obstacles to the implementation of telepresence robots in higher education. In particular, the public trust in scientific research. The use of telepresence robots for lab visits facilitates public participation in university research and can overcome the problems posed by health, safety, and distance. But it can also face a range of ethical and privacy issues, including how researchers interact with robots. They may also experience anxiety and fear when dealing with robotic visitors.[31] To explore the better application and potential of telepresence robots in higher education, we need a wider range of stakeholders to convey their feelings and opinions regarding telepresence robots. Similarly, future improvements to telepresence robots should be more pertinent to the specific requirements of higher education, allowing users to utilise additional features to enhance the remote academic experience.

3 METHODS

3.1 Mixed Methods

In this study, we used a mixed-method approach, whereby a series of questionnaires were nested within a group interview and discussion, as done in related work [28]. The aim of this study is to understand the opportunities and challenges of telepresence robots in education. We recruited people working in different positions in the higher education sector to understand users' attitudes towards telepresence robots. We explored three main areas: 1) General Attitudes Towards Robots (Stage 1 and Stage 3), 2) Trust attitudes towards telepresence robots used in higher education teaching and research activities (Stage 2 and Stage 3); and 3) Usability of telepresence robots used in this context (Stage 2 and Stage 3). Because we considered that not every participant had previous experience or even had an opportunity to see a telepresence robot in use, we aimed to study how different approaches to inform and introduce people to telepresence robots impact user trust and experience.

3.2 Study Design

We divided the study into three stages (as shown in Figure 2) to investigate general attitudes towards robots and people's perceptions of trust and usability related to telepresence robots (room layout presented in Figure 3).

Stage 1 - Pre-study questionnaire: First, we distributed the General Attitudes Towards Robots questionnaire to each participant. Upon completion of the questionnaire, a brief interview was administered to ascertain the participants' prior encounters with robots, their views towards robots, and the deeper reasons for their points.

Stage 2: Experimental User Study: We designed a user study to investigate the use of telepresence robots in academic communication or socialisation tasks, as well as the effect of these various methods of engagement on the user's trust in the robot, usability, and their level of confidence when using it. Participants were instructed to envision themselves participating in a remote activity via using telepresence robots. We provided telepresence robots for participants to view academic posters in three conditions: C1: Participants are seated with a laptop and view an introductory video about telepresence robots with instances of their use in education, conversation, etc. C2: The participants operate a Double 3 with a laptop with the user interface to control the robot via the keyboard and mouse to investigate the laboratory for 10 minutes. C3: Participants use a Double 3 to engage in an academic discussion. There are two participants in each condition. One participant is involved in a meeting in the laboratory next door, and the other participant is required to use a computer and user interface to drive the robot into the meeting room next door and complete academic tasks. The tasks involved in scholarly communication included engaging in conversation with others, discussing a scholarly poster, using a robot to read the poster, and deciphering the QR code information on the poster. Participants were prompted to engage in additional scholarly activities on their own initiative.

In each instance, participants were able to expand on their initial experience with the robot. Our working hypothesis was that by increasing exposure with the robot and how it could support scholarly communication, participants would feel more comfortable using the different features and would be willing to accept or use the robot for scholarly communication and remote socialising in each situation. After each situation, participants were asked to fill out two questionnaires with five- and seven-point Likert scale statements to assess their level of trust (adapted from [21]) and the robot's usability[14]. C1 was a baseline condition to establish perceived trust and usability based on a video about the robot. C2 was to test the effect of initial, unconstrained (as in, without a specific task) user experience on perceived trust and usability. C3 was to test the effect of participation in a collaborative task via telepresence on perceived trust and usability.

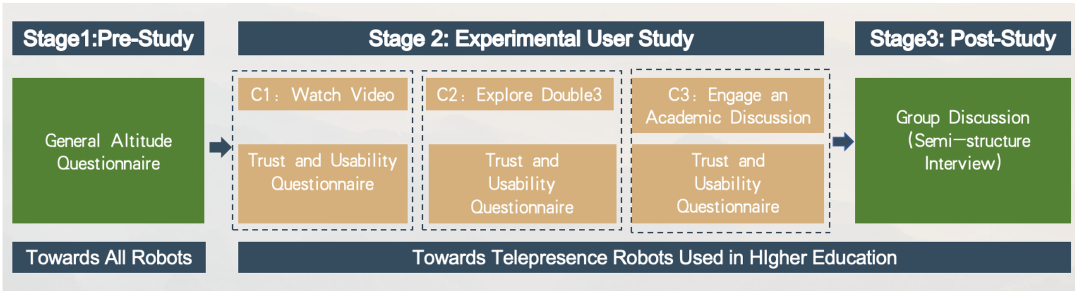

Figure 2: Study Procedure. Stage 1 involved a pre-study questionnaire focused on measuring participants general attitudes towards robots; Stage 2 was the experimental part of the study where participants learned about and tried the telepresence robots; Stage 3 was a post-study group discussion (semi-structured interview).

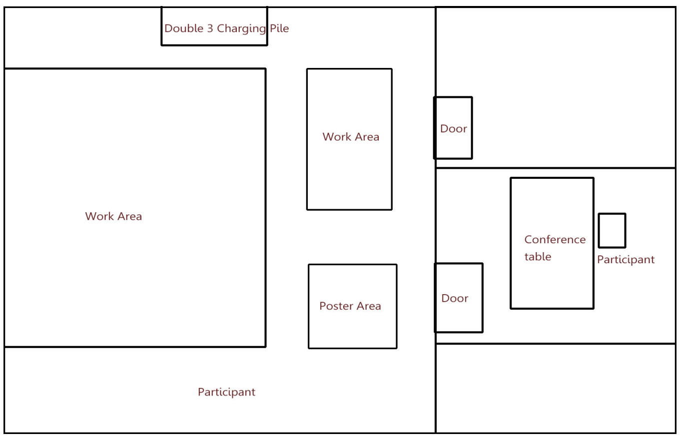

Figure 3: Study Procedure. Condition 1: Participants sat around the conference table and watched videos. Condition 2: Participants sat around the table with a laptop, with the user interface to control the robot via the keyboard, and took turns to drive a Double3 into the main room (next door) and explored it freely. Condition 3: One of the participants sat around the table with a laptop, with the user interface to control the robot via the keyboard, and drove the Double 3 from the charging pile to look for the other participant located in the main room and engaged in an academic discussion.

Stage 3 - Post-study group discussion: The discussion focused on the details of the questionnaire that was filled out in Stage Two. Our objective was to identify the participants' perceptions on each question and their corresponding responses, as well as to comprehend the factors contributing to the fluctuations in their scores following each round. In addition, we wanted to know their opinions on the use of telepresence robots in education, as well as the robots' weaknesses and strengths, additional applications, necessary enhancements, and their willingness to use the robots.

3.3 Participants

Ten individuals participated in this study. Among them was a university professor from the Faculty of Engineering, who specialises in robots and thus has extensive knowledge of using robots. Two PhD students from the Optoelectronics and Media Departments were also recruited to participate. The project also included the participation of 6 students pursuing Master's degrees, primarily from the Faculty of Engineering and the Faculty of Computer Science. Finally we have also recruited one undergraduate student with a background in robotics.

All participants were grouped in pairs and then completed the experiment based on their available time. All participants volunteered to take part in this experiment, conducted at the University of Nottingham. The study was subject to the Computer Science Department and University's ethical procedure. The University of Nottingham provided financial compensation of £5 voucher to each participant.

3.4 Data Collection and Analysis

Our investigations were conducted using a mixed methodology consisting of questionnaires and interviews. The quantitative data included the General Attitudes Towards Robots questionnaire (stage 1), the trust questionnaire and the usability questionnaire after three conditions (stage 2).

For the qualitative data, we sought to investigate the reasons behind the scores and why the scores changed. At the same time, we wanted to know robots' assessment of the strengths and weaknesses of telepresence robots, how they could be improved, whether people would be able to accept the use of telepresence robots for themselves or others, and what domains telepresence robots could be applied to in the future (stage 3). The entirety of the experiment was documented by employing an audio recorder and utilising the transcription feature included in Microsoft Teams.

3.4.1 Quantitative Analysis. The quantitative questionnaire responses were analysed by the researcher using: IBM SPSS Statistics[8]. Considering that the experimental design was used to compare nonparametric statistical methods for the same group of participants across multiple conditions of interest. Therefore, we chose the Friedman test to examine the relationship between groups in the three conditions. And for the pre-experimental test questionnaire, we calculated its mean and median to understand the participants' attitudes.

3.4.2 Qualitative Analysis. We utilised a thematic analysis[16] approach for analysing the data obtained from audio recordings that were transcribed by professional service organisations. The researchers familiarised themselves with the data by listening to all the recordings and correcting the study transcripts; then, they inductively coded the data and extracted the semantics and underlying meanings. The recordings captured two primary aspects: 1) the reasons why participants' scores changed across conditions and 2) the participants' perspectives and comprehension of the queries. We first coded and categorised participants' responses under different questions to capture important features of the data that might be relevant to the research questions. Following categorisation, initial themes were generated based on codes and data. After completing this step, the researchers held meetings to discuss and refine the themes. After defining and naming the themes, the report was written to provide analytical narratives and data excerpts to illustrate the themes.

4 STAGE 1: PRE-STUDY QUESTIONNAIRE

To assess people's attitudes towards robots, we used the General Attitudes Towards Robots Scale (GAToRS) [11]. We quantified feelings of (a) comfort and enjoyment around robots, (b) unease and anxiety around robots, (c) rational hopes about robots in general (at societal level), and (d) rational worries about robots in general (at societal level). After obtaining quantitative data, we used the median and the mean to represent participants' attitudes towards four aspects. On the personal level, we found participants had a positive attitude towards the aspects of comfort and enjoyment around the robot (mean and median above 4.00). The qualitative data revealed that participants trust the robot mainly from the driver, while improvements in the design and organisation of the robot would also increase the feeling of trust. However, regarding commercially available robots, the concerns revolved around the possibility of commercial companies disregarding user needs, especially privacy, in their pursuit of profitability.

> *P2: "To this, like I said before, the robot I saw is used by my professor. Yeah, by the university. So I can trust him."*
> *P9: "Was it companies? I think that maybe sometimes organisations might be more concerned about profit than the customers. Yeah. And maybe this would make them not fully consider their customers needs."*
> *P7: "Wow. I suppose the questions about whether you trust the developers of the. Yeah. So I suppose it's a big question. So yeah, I don't know. I mean, so I put mutual because I, you know, it depends. But device different situation have different answer. Yeah. Don't know quite trust okay."*

Furthermore, while participants reported a sense of relaxation during interactions with the robots, they also highlighted distinctly human traits such as facial expressions and voices. Given that robots cannot replicate these features in a one-to-one manner with humans, this incongruity might evoke a certain level of discomfort.

> *P4: "Because I think even the robot can talk, but like maybe the sounds of the robot is sounds like some robotic sounds. Not like what a human voice. But I think it's a bit weird for me because I can't really talk with someone who has that like normal phones."*

Next, regarding whether robots can generate emotions, participants felt that the integration of emotional applications should be evaluated based on different situations. For instance, in the context of psychotherapy, an emotionally responsive robot could yield positive emotional benefits. However, the question of whether a robot, once endowed with autonomous thinking, shares the same identity and value as humans, emerges for contemplation. This becomes particularly significant when grappling with challenging tasks, as the necessity of considering the robot's preferences becomes a focal point for future discussions. For instance, when confronted with a challenging problem and an emotionally endowed robot expresses an unwillingness to assist people, how should this situation be addressed? Of course, it's worth noting that some participants argued that robots would not genuinely possess emotions, as they operate solely based on programmed codes. Even if they were to simulate emotions, these would remain as calculated projections.

> *P6: "Yes, for example, a foreign student is very lonely abroad, if he or she many people will choose to have a pet this kind of, but the robot may also be as a kind of pet existence."*
> *P5: "First of all, you have to look at what your definition of a robot is, what you want to use it for, and what your expectations of it are. If you just want an object that will help you deal with problems, it is ok. However, once it has emotions, it's going to lose its impartiality and objectivity, so I don't think that's a good idea. But if what I need is an item that provides me with emotional value, I would think it's good to have emotions."*
> *P6: "If one day a robot has a mind of its own, does it enjoy the same status or value as a human being? That is to say, do we just define it as a tool and not a thinking life form, right? It's something that has to be considered, so I'm wondering if that happens then isn't it an injustice for robots as well, but all in all I'm okay with them replacing humans to do some of the threatening jobs."*
> *P3: "Ohh, I would think it's just a machine." P10: " I think they can have fake emotions, but the emotions would be like programmed in."*

When exploring users' feelings of unease and anxiety around robots from a personal perspective, participants showed neutrality (mean = 4.10, median = 4.00 SD = 1.197) with respect to question 7 (I worry that robots do not understand my needs). This was due to the fact that all participants had experienced similar situations before. For instance, Participant 7 recounted an experience of utilizing Siri to set an alarm clock; however, due to a recognition error, Siri failed to wake them up at the designated time, leading to a mishap. In addition, the robot's misbehaviour may affect others, such as by generating noise. However, some participants also indicated that expectations could help them to better give commands or use the robots, even though the existing robots were not perfect. Setting reasonable expectations for different robots can also help users interact with them.

> *P7: " But I think that.That is about working out. Again, it's the interaction between the person and machine.*

Questions	Mean	SD
1. I can trust persons and organizations related to development of robots.	4.70	0.948
2. Persons and organizations related to development of robots will consider the needs, thoughts and feelings of their users.	5.30	1.251
3. I can trust a robot.	4.00	1.054
4. I would feel relaxed talking with a robot.	4.00	1.414
5. If robots had emotions, I would be able to befriend them.	4.90	0.737
6. I would feel uneasy if I was given a job where I had to use robots.	3.20	0.788
7. I fear that a robot would not understand my commands.	4.10	1.197
8. Robots scare me.	2.50	1.269
9. I would feel very nervous just being around a robot.	2.50	0.849
10. I don't want a robot to touch me.	3.00	1.333
11. Robots are necessary because they can do jobs that are too hard or too dangerous for people.	5.90	0.875
12. Robots can make life easier.	5.60	0.699
13. Assigning routine tasks to robots lets people do more meaningful tasks.	5.50	0.707
14. Dangerous tasks should primarily be given to robots.	5.70	1.159
15. Robots are a good thing for society, because they help people.	5.20	1.032
16. Robots may make us even lazier.	5.10	0.994
17. Widespread use of robots is going to take away jobs from people.	5.30	0.948
18. I am afraid that robots will encourage less interaction between humans.	4.10	1.197
19. Robotics is one of the areas of technology that needs to be closely monitored.	5.80	1.032
20. Unregulated use of robotics can lead to societal upheavals.	5.60	0.843

Table 1: The quantitative results of the General Attitudes Towards Robots scale [11], divided in four sections: Personal Level Positive Attitudes (questions 1-5), Personal Level Negative Attitudes (questions 6-7), Societal Level Positive Attitudes (questions 11-15), and Societal Level Negative Attitudes (questions 16-20). (7-Point Likert items, where 1 - 7 is from completely disagree to completely agree).

Yeah. And I think that as long as you kind of have the right expectations."

In addition, regarding the level of comfort working with robots, participants felt that robots were useful and could be more productive, but needed to be judged on a case-by-case basis. Regarding the desire for robots to have physical contact, participants' apprehensions revolved around the suitability of the robot's parameter configurations and the intensity of contact. However, overall, there was no strong reluctance to engage in physical interaction with robots.

At a societal level, users exhibited favorable attitudes towards maintaining rational expectations of robots (with means and medians above 5.00). However, users' general rational concerns about robots manifested in more pronounced negative sentiments. The primary apprehension is that robots might supplant human labor and contribute to increased idleness. Nevertheless, should robots prove capable of handling straightforward, monotonous, and repetitive tasks while facilitating time savings, individuals could enjoy more leisure time and seize opportunities for engaging in stimulating activities, all while maintaining or even enhancing productivity.

P3: "Yeah. Like there are cleaning robots. Yeah. Robots. If it there are now delivery robots also. Yeah. So first of all, the delivery guys job has gone and everyone in the future there will be a robot. Yeah then so people will be more lazier yeah."
P4: " I think it depends like it depends on what work people was doing. As the robot was doing some very easy job like cleaning or the money or something, it just like maybe help you to save some time. So I think it won't make you lazy about it to do more effective thing, yeah."
P7: "I suppose I said no, I sort of slightly disagree because I think it obviously the side is that they can help you do more things. Yeah, if if the robots doing the cleaning, you could do something more interesting. Yeah. It doesn't matter."

Furthermore, as the frequency of robot usage increases, concerns regarding a potential reduction in interpersonal communication have arisen. Some participants posit that social media has already contributed to a decline in human-to-human interaction, and thus robots might exacerbate this phenomenon. Nevertheless, other participants contend that this reduction primarily pertains to unnecessary communication, and If users genuinely desire to converse with their friends and family, this phenomenon would not see an increase; the essence of communication remains unchanged, only the form has evolved.

P9: "I think already with technology it's encouraging less interaction between humans like social media. Yeah. Now we talk to people online rather than it. Yes. And I think that the more technology advances, the more this will happen." P10: "But if we are friends or friendship,

> *this kind of relation and I think the robot will not encourage less interaction between humans. Because I can connect each other every time or every night. It's based on my personal wishes."*

Lastly, all participants concur that due to robots' capabilities surpassing those of humans, the necessity for stringent governance and regulations is paramount.

> *P5: "Because I think a robot is a tool, and tools have their pros and cons. And if you use it well and everything is regulated, then you can create a harmonious society. It's actually superior to human beings in some of its capabilities, and it needs to be better regulated."*

5 STAGE 2: USER STUDY

5.1 Quantitative Results

5.1.1 Trust Questionnaire. A Friedman test was run to determine if there were differences in whether various degrees of exposure to the robot influence levels of trust. Pairwise comparisons were performed [25] with a Bonferroni correction for multiple comparisons. The Q3 (I feel the robot is reliable) was statistically significantly different for the different exposure to the telepresence robot, (x^2 = 9.909, p <0.05). Post hoc analysis revealed statistically significant differences in the degree of trust from condition 1 (Mdn = 3.00) to condition 2 (Mdn = 4.00) (p <0.05), but not condition 1 (Mdn = 3.00), and condition 3 (Mdn = 4.00) and not condition 1 (Mdn = 3.00) and condition 3 (Mdn = 4.00).

In addition to Q3, our questionnaire included trust in the responsible use of data collected by the robot (C1 Mean = 3.20, C2 Mean = 3.30, C3 Mean = 3.40), trust in the secure storage of data (C1 Mean = 2.90, C2 Mean = 3.40, C3 Mean = 3.20), trust in fulfilling the intended function (C1 Mean = 3.60, C2 Mean = 3.60, C3 Mean = 3.90), basic trustworthiness (C1 Mean = 3.70, C2 Mean = 3.80, C3 Mean = 3.70), whether or not others will use the robot (C1 Mean = 4.00, C2 Mean = 3.90, C3 Mean = 3.70), trust in deletion of data (C1 Mean = 2.80, C2 Mean = 3.30, C3 Mean = 3.30), and importance of building trust (C1 Mean = 4.30, C2 Mean = 4.30, C3 Mean = 4.10), but differences were not statistically significant.

5.1.2 Usability Questionnaire. In the usability questionnaire, we explored three main areas: system usefulness (Q1-Q6), information quality (Q7-Q12), and interface quality (Q13-Q16). A Friedman test was run to determine if there were differences in whether various degrees of exposure to the robot influence levels of usability. Pairwise comparisons were performed [25] with a Bonferroni correction for multiple comparisons. The Q5 (It was east to learn to use this system.) was statistically significantly different for the different exposure to the telepresence robot (x^2 = 11.385, p <0.05). Post hoc analysis revealed statistically significant differences in the degree of usability from condition 1 (Mdn = 5.00) to condition 2 (Mdn = 6.00) (p <0.05), and from condition 1 (Mdn = 5.00) to condition 3 (Mdn = 6.00)but not condition 2 and condition 3.

A Friedman test was run to determine if there were differences in whether various degrees of exposure to the robot influence levels of usability. Pairwise comparisons were performed [25] with a Bonferroni correction for multiple comparisons. The Q7 (The system gave error messages that clearly told me how to fix problems.) was statistically significantly different for the different exposure to the telepresence robot, (x^2 = 9.538, p <0.05). Post hoc analysis revealed statistically significant differences in the degree of usability from condition 1 (Mdn = 4.50) to condition 2 (Mdn = 3.50) (p <0.05), but not condition 2 (Mdn = 3.50), and condition 3 (Mdn = 4.00) and not condition 1 (Mdn = 4.50) and condition 3 (Mdn = 4.00).

A Friedman test was run to determine if there were differences in whether various degrees of exposure to robot influence levels of usability. Pairwise comparisons were performed [25] with a Bonferroni correction for multiple comparisons. The Q12 (The organisation of information on the system screen was clear.) was statistically significantly different for the different exposure to the telepresence robot, (x^2 = 7.913, p <0.05). Post hoc analysis revealed statistically significant differences in the degree of usability from condition 1 (Mdn = 5.00) to condition 2 (Mdn = 6.00) (p <0.05), but not condition 2 (Mdn = 6.00) and condition 3 (Mdn = 6.00), and condition 1 (Mdn = 5.00) and condition 3 (Mdn = 6.00). The rest were not statistically different.

5.2 Qualitative Results

5.2.1 Reason for Changes. During the interviews, we focused on the factors that contributed to the disparate scores of the participants. The majority of participants responded that they were unable to obtain a complete understanding of the telepresence robot from the video and, as a result, scored low or in the middle of the scale. The majority of the participants' scores in condition 1 were based on their own expectations and imagination. In C2, however, after the participants actively manipulated the robot through free exploration, they were able to use basic functions such as walking, reading, etc. Consequently, their evaluations of the robot improved. In C3, however, participants were required to independently operate the robot, use combination functions, and collaborate with other participants to complete the task, thereby increasing the difficulty of the task. Because it was the first time that the majority of participants utilized the telepresence robot, their ratings were similar, in that the differences were not statistically different.

5.2.2 Trust in Telepresence Robots. 1) The organization's correct structure contributes to users' confidence in data management. The organization's correct setting contributes to users' confidence in data management. Participants mentioned on multiple occasions that their trust in telepresence robots from the driver and institutions behind them, as well as the associated safeguards. *"If it's a university telepresence robot, I wouldn't be concerned because the university or professor won't use my information."* A portion of the participants stated that their mistrust of the telepresence robot from the absence of privacy information or ethical consent. *"Because there is an ethics form, I believe that even if the company is for-profit, they will comply and protect my information."* Another participant stated that she determines whether or not her data is being recorded by the illumination next to the camera, which provides her with a reliable indication. A participant also stated that the telepresence robot did not intrude personal privacy excessively, and that there were already too many devices recording data such as faces or voices, so he did not mind that such data could be accessed. There were also participants who agreed with the view and stated that information is gathered for the purpose of completing a task, and that the most

Question	C1	C2	C3
1. I trust that the data collected by the robot is used responsibly.	3.20	3.30	3.40
2. I trust that the data collected by the robot is stored securely.	2.90	3.40	3.20
3. I feel that the robot is reliable.	2.80	3.80	3.60
4. I trust that the robot will do what it is supposed to do.	3.60	3.60	3.90
5. I think the telepresence robot is basically trustworthy.	3.70	3.80	3.70
6. I think that other people will use the robot.	4.00	3.90	3.70
7. I trust that my data will be delated when the robot says it will.	2.80	3.30	3.30
8. It is important to me that I trust the robot in order to use it.	4.30	4.30	4.10

Table 2: Means for the eight questions on trust [21] towards telepresence robots after each conditions, where 1 - 5 is from strongly disagree to strongly agree (5-Point Likert items).

Question	C1	C2	C3
1. Overall, I am satisfied with how easy it is to use this system.	4.60	4.90	5.40
2. It was simple to use this system.	4.80	5.40	5.40
3. I was able to complete the tasks and scenarios quickly using this system.	4.40	4.80	4.70
4. I felt comfortable using this system.	4.60	5.10	4.90
5. It was easy to learn to use this system.	5.10	6.00	6.10
6. I believe I could become productive quickly using this system.	4.70	4.00	4.40
7. The system gave error messages that clearly told me how to fix problems.	4.20	3.30	3.60
8. Whenever I made a mistake using the system, I could recover easily and quickly.	3.90	4.20	4.50
9. The information (such as online help, on screen message, and quickly documentation) provided with this system was clear.	4.20	5.10	4.90
10. It was easy to find the information I needed.	4.30	5.20	5.00
11. The information was effective in helping me complete the tasks and scenarios.	4.20	5.00	5.20
12. The organization of information on the system screens was clear.	4.50	5.50	5.60
13. The interface of this system was pleasant.	5.00	4.60	4.80
14. I liked using the interface of this system.	4.40	4.60	4.90
15. This system has all the functions and capabilities I expect it to have.	3.80	4.10	4.20
16. Overall, I am satisfied with this system.	4.30	4.80	4.90

Table 3: Means for the sixteen questions on usability [14] of telepresence robots after each conditions, where 1 - 7 is from completely disagree to completely agree (7-Point Likert items).

important factor is to determine on a case-by-case basis what type of data will be gathered and what will occur when it is gathered. Therefore, increasing the organization's credibility and providing numerous proofs that the data is secure helps users to trust the robot.

> *P8: "Okay so I didn't trust the the information. I don't have much like secret. So I think it's OK. Me. Yeah as well."*
> *P7: "It depends on what it's doing. Yeah. With the data. Cause if it's just doing it to to do its task correctly like. And you know the the cleaning everyone needs to know what the shape of your house is like. It's not necessarily personal information."*

2) Safety, convenience, and independence are crucial factors in determining the robot's reliance. Participants' primary safety concerns centred on whether the robot might come crashing down and injure others by accident. The main question in this scenario was whether the robot could effectively avoid obstacles and resist being pushed by others when entering a crowded area. During the experiment, participants attempted to push the robot by hand, but the robot rotated substantially. Even though it did not collapse, it was still possible that someone could have been injured by accident. A large number of participants reported that the robot was very convenient and could enhance the user experience in the educational field. A PhD participant provided the example of attending an academic exhibition. She remarked that if she used the telepresence robot to attend the conference, she could freely join academic discussions and was in charge of her own behavior. Moreover, a number of participants indicated that using the robot was sufficient to grant them independence. This was demonstrated by the fact that they did not require the assistance of others and were free to communicate with others.

3) The source of execution power is the different functions that robots have. Participants reported that the Double 3 robot allowed them to engage in conversations with others and was able to use auto-guidance to help them navigate, and that the robot's zoom function and image quality modification feature helped them read academic posters more effectively. Meanwhile, QR code detection assisted users in reading academic content more thoroughly, and the robot's height could be adjusted at any time. However, participants still encountered some issues when using the robot, such as an excessive reliance on the internet and navigation that was not entirely precise; these issues will be discussed in the post-study interview. However, according to one of the participants, the configuration of multiple methods to use the same feature worked exceptionally well. "Mouse clicks or auto-navigation are not particularly effective when moving. However, I can use the keyboard to navigate, and I'm able to do so more efficiently, which I prefer."

4) Trust is not the first consideration in using a product. Some participants stated that trust is important, but not the most important. *"When the product is useful to a certain extent, you will use it even if you don't trust it."* Other participants pointed out that the three points of usability, operability, and convenience are more important than trust. Robots were originally designed to serve people. Participants preferred to use products that make them feel convenient and efficient in a trusting environment, rather than choosing to use a product because they trust it.

> *P5: "Since you're going to create these robots, right? Then you must be based on human needs, otherwise you won't blindly create it."*
> *P6: "I believe in robots because I believe that they can bring me benefits and then I but as for big data nowadays, like companies secretly collecting your data and so on, I don't believe in that aspect."*

5.2.3 Usability Questionnaires. We explored three main aspects of usability: System Usefulness, Information Quality, and Interface. We summarised the strengths and weaknesses of these three aspects based on participants' responses.

1) System Usefulness: All participants reported that the robot's system was very simple and easy to understand and learn. They were able to grasp the basic functions and apply them flexibly in C2. For instance, *"I see the camera icon on the screen, it can capture a screenshot. I enjoy that. If I use my phone to take a screenshot while conversing with someone, I feel disrespectful, but this feature prevents me from doing so."* Similarly, participants stated that the benefit of usability is that it corresponds to human utilisation. Regarding the productivity of robots, some participants believed that using telepresence robots instead of instruments such as mobile phones might speed up the production of something useful. For instance, *"If I want to find my friend in the corridor, I can drive there immediately."* However, because the system was too simplistic, the robot was not as effective as anticipated and did not appear to be a commercial product. During the experiment, the robot didn't move as fast as the participants expected, so they thought that some things would follow more efficiently if they did them by themselves.In addition, many of the features lacked introductory text, such as "3D Construction," so the participants were unable to experience them. Lastly, the robot's system is evidently overly dependent on the WiFi network; during the experiment, problems such as unclear audio and delayed video diminished the experience for the participants.

> *P1: "On the 3D mode we just used, we didn't know what the heck it was and there was no help. "*
> *P9: "I think the robot is slow. I think that I wasn't able to complete them quickly."*

2) Information Quality: We focus mainly on error messages, blunder recovery, and display information.Error message refers to whether the user receives error feedback while controlling the automaton. All participants reported that they did not receive error message feedback during the experiment. When they came across an obstruction that barred them from moving, for example, the robot simply stopped in position without emitting a warning message. Similar circumstances occurred with Mistake recovery. No adjustments were indicated when the robot encountered troubles; only a halt in movement and in operation were indicated. No indication of obstacles, no indication of impassibility, no indication that the screen had reached its magnification limit, and an error in the auto-navigation that did not indicate that the robot could be controlled using the keypad are examples of specific instances of this. However, participants reported that the telepresence robot possessed all the expected fundamental features. The screen was lucid and its clarity could be adjusted. In addition, when using the QR code scanning function, the screen displayed a distinctive icon that indicated to participants that there was additional information to peruse.

> *P2: "Because it didn't give me any l message at all from start to finish."*
> *P6: "I didn't experience this question and I don't know if I did anything about mistake. It also doesn't say what happens with recovery, it just doesn't have that. I don't feel like I've experienced this, so I'm giving it a no."*
> *P7: "Yeah. I think similar. I think it would be better if it could. And to tell you more about what it's. It's trying to do and whether it's achieved or not?"*
> *P9: "The first question I was before we used the perhaps the programme. Yeah. So I I assumed that we would get error messages, but then once I tried it I gave it a four because I didn't get any error messages. OK."*

3) Interface Quality: The main problem with the interface quality was that it was too primitive and did not meet the requirements of commercial robot users. Participants expressed a desire to redesign the interface with a new set of UI (User Interface), as certain elements were obscure and difficult to comprehend. For instance, the icon for "adjust robot height" is a slider bar. Participant 10 believed that it should be made clearer. In addition, the participants did not feel comfortable using the interface.

> *P3: "And about the interface as well, because the interface here was very basic, but it was easy to understand, but it could be better. Yeah, it it should be improvement."*
> *P4: "In my first time when I use this interface, it's not really user friendly like I don't know what's the buttons about like."*
> *P6: "The UI is a bit ugly, like a graduation design like me feels, not like a commercial company made it. I feel that one of the information organisation is relatively brief all squeezed on this, and then especially monotonous, and then the UI is not very good-looking, I feel that kind of free icon randomly paste a few up, give me a feeling is not very good."*

> *P8: "There are some cases very like simple. So there are only few buttons on the top and then there is a park button and the battery and power. But if you want to try to find another, you have to explore by yourself, such like zoom function. "*

6 STAGE 3: POST-STUDY GROUP DISCUSSION

We discussed the current difficulties and future directions with participants through a panel discussion.

6.1 Deficiencies of telepresence robots

6.1.1 Navigating and driving the telepresence robot. Participants typically stated that the robot didn't move as quickly as expected, which was one of the main reasons they were concerned about efficiency. This was primarily demonstrated by the fact that when participants used the keyboard to control the robot, they were required to manually steer and turn it. Due to a lack of skill in manoeuvring, participants frequently made steering errors, resulting in longer driving times and diminished efficiency. Additionally, auto-navigation was not always effective. When the robot enters a new area, it is unable to instantly navigate and may make errors when planning routes. Participant 8 drove the robot into a meeting room, for example, the robot was unable to autonomously navigate the turn into the room, and frequently made computational detours into other rooms. Lastly, participants were required to assist the robot in entering the room by manoeuvring.

6.1.2 Telepresence of the robot's voice and video screen. During the investigation, we discovered that the robot was overly reliant on the WiFi network, as unexpected disconnections between the robot and the computer were possible. In addition, when the WiFi signal was feeble, both audio and video transmissions were delayed. Due to the audio latency during the C3, Participant 3 and Participant 4 were unable to understand what the other was saying.They reported that the experience was very poor, especially since they were from different countries and spoke non-native languages, making communication even more difficult. To supplement this, we can equip the bot with language translation and subtitle conversion. Language translation allows the user to communicate in a second language, while the other party can read the translated text. Through subtitles, users speaking' contents can also be displayed on the screen. This decreases the anxiety induced by voice latency and improves user satisfaction. The video delay occurred when the picture quality was adjusted to 1080 so that the text on the academic posters could be read more clearly, but the delay caused a lengthy wait.

6.1.3 Hardware equipment of the telepresence robot: It only has one camera right now, and even though it can turn the lens to see what's going on around it, participants still felt a lot of discomfort when the robot was handled by people who didn't know what they were doing or when they were in a new place. Because they can only see in front of them, it is simple for them to become disoriented. To overcome this issue, we believe we can include a map function, which means we can attach an overhead view of the space we are in on the screen and display the robot's location in real time. Users can click on a room on the map to instantly move to that place. In addition, participants desire Bluetooth functionality to facilitate user communication. Participant 1 stated that her professor previously taught a seminar using a telepresence robot, but the lack of a camera behind him precluded him from signalling to the professor that he wanted to have a group discussion by raising his hand, for example. Moreover, in a chaotic environment, only a few individuals could hear the robot's volume. Therefore, we believe that in such a setting, a chat platform can be constructed to communicate to the robot after students raise their hands on the platform. The hand-raising cursor will appear on the robot's map, allowing the professor to reach the students more swiftly for discussion. Additionally, users can use the Bluetooth system to transmit files and connect wireless headphones to avoid noise interference during meetings.

6.1.4 Telepresence robot's user interface: Remote presentation of the robot's user interface: In the usability survey, we discovered a rudimentary UI on the computer side of the robot, which requires system design because the icons are not clear, there are no corresponding name, and the icons are not aesthetically appealing. In addition, when a system error occurs, there is neither a prompt message nor recovery instructions; the user must decide for himself or restart the device, which diminishes his experience and contentment. But this is just the information we got from the survey. We think there are more parts of the user interface that need to be improved. Therefore, we advise a comprehensive evaluation and enhancement of the telepresence robot's UI.

6.2 Upgradable technology and future applications

6.2.1 Provision of teaching games: There was a lack of professional guidance among users when employing the robot. Participants indicated that they did not fully comprehend how to operate the telepresence robot because they just used some basic functions such as moving and shooting the screen. However, it was difficult to operated group functions such like using the mouse. Participants were required to use the mouse wheel for the magnification function and the right mouse button and drag to rotate the lens. There was no clear instruction manual to help users master these mouse-related functions, despite the fact that many of the functions centred on mouse settings. Consequently, some participants expressed a desire for an assistance manual that would teach users the fundamental functions. When they needed to complete a specific task, they were able to find information by searching for it. We believe that mini-game is a good choice for users to master the robot. Especially, fun should be added to the user experience by providing a guided tutorial through a mini-game. Finally, the game can be displayed on the main interface so that users can learn.

6.2.2 Building a private customisation platform: In addition to being able to participate in teleconferences and seminars, telepresence robots can also assist with data collection. Participants from the optoelectronics major stated that it would be very convenient to be able to collect data outside and transmit them to their computers using a telepresence robot. However, since this would necessitate additional specialisations and software, not all of them would be applicable to everyone. Consequently, we believe we can construct a function platform. To equip their robots, users can choose from various installation packages based on their individual requirements. Simultaneously, functions can be preserved according to their accounts; but the cost of the robots is high and it is impractical to create a set of custom software for each robot. When the user logs in, the function packages can be associated with the account so that they are automatically installed, and then uninstalled and expunged when the user logs out. Thus, higher efficiency and user experience is achieved through personalised telepresence robots.

6.2.3 Hardware upgrades: The telepresence robot's hardware enhancements included both a screen and gesture recognition. Participants wished for bigger screens and for the dialogue companion to be able to view camera content on the screen. This was done not only to enable the other party to observe their physical appearance and social standing, but also to facilitate academic communication. When a user reads a poster by using the robot and states he/she can't see it clearly, they require assistance in locating the content. When the dialogue sees what the camera is capturing, they are better able to assist the user in locating the content. The larger screen also makes it easier to present academic materials such as PowerPoint. Furthermore, we believe telepresence robots could be equipped with robotic limbs and indicator lights. When utilising the robot to complete the act of knocking on a door and raising a hand, users can only do so by raising the volume and asking for assistance from others. However, with a robotic arm, they would be able to knock on the door by themselves, as not all environments permit loud volumes. Lastly, the implementation of indicator lights improves the robot's ability to communicate its actions. People around the robot cannot foresee the robot's behaviour when the user turns; therefore, indicator lights can inform others of the robot's behaviour in a timely manner, increasing the robot's safety and preventing injuries or collisions with others.

6.2.4 Navigation within the campus: Telepresence robots can be utilised for on-campus navigation, such as assisting persons who are unfamiliar with the campus or guiding people with disabilities. Since the robot's screen is touch-screen-capable, the location is entered to assist the robot lock in its coordinates, and then the robot's navigation route is planned automatically. Unlike mobile phone navigation, telepresence machines can have a first-person perspective and are controlled by the user to communicate with visitors. Consequently, telepresence robots are more adaptable and efficient when confronted with unusual routes or inaccurate navigation.

7 DISCUSSION

In this study, we gathered stakeholders from the education sector and used a mixed-methods approach to present the results from both quantitative and qualitative perspectives on the data. From the results, we see an overall positive attitude towards telepresence robots. Simultaneously, we investigated trust and usability. The results indicate that different levels of exposure to the robot influences individuals' ratings. Co-maintaining multiple interests are helpful for public trust to the telepresence robot. Finally, we recapitulated the current disadvantages and benefits of telepresence robots and make suggestions on their future applications.

7.1 Robot exposure builds trust and satisfaction.

When comparing participants' levels of trust and usability across the three conditions, quantitative data revealed that participants rated C2 higher than C1, while the differences between those for C2 and C3 were not significant. We examined this as being influenced by the amount of exposure and familiarity acquired with the robot and the form in which the experience was introduced [28]. Three different experimental conditions were experienced by participants: viewing a video, utilising fundamental functions, and simulating a real-world scenario. The level of exposure to the telepresence robot and their experiences with it varied between the groups. Participants may have struggled to understand the scope and applicability for the telepresence robot after viewing the video, as it lacked specifics. In C2, the participants explored freely and utilised the fundamental functions, and while they did acquire some knowledge, it may have lacked sufficient depth. Participants were required to imagine how the telepresence robot would function in the educational area. As a result, participants in this condition had greater expectations and improved their scores after discovering that the telepresence robot was beneficial. However, participants found that not all features met their expectations in the simulated environment. In particular, they must use multiple functions in combination, which is difficult for beginners; consequently, their scores did not increase in C3. Thus, we propose that robots interacting with the public should be designed and developed with human learnability in mind, catering for different levels of abilities.

7.2 Trust needs to be managed by various parties.

Our findings reveal that the amount of trust is determined by the performance of the robot, the robot's development organisation, and the robot's users [22], not just one area of management. All participants agreed on the need for stronger robot management. Some participants stated that trust is derived from the user, so standardising the robot's operation can increase trust. Second, the organisations developing the robots, including the commercial corporations, must be trustworthy enough to comply to strict data management measures such as privacy inform. It is even possible to assist users in informing what type of information is being used when and where, by installing signalling lights on telepresence robots and adding information deletion prompts. The user's level of confidence can be affected by the legitimacy of the organisation and the pertinent evidence of data security. Lastly, there is the robot's performance. When utilising a telepresence robot, trust is not the primary factor that users consider, according to our research result. In addition to safety, convenience, and independence are also among the primary considerations. Only when all of these aspects are completely developed will people feel more at ease and confident working with robots, using them to complete jobs, or delegating crucial responsibilities to them.

7.3 Upgrade of hardware equipment and software functions.

According to the participants' accounts, there is still a lot of potential for development in the telepresence robots that are now in use. The first issue is that telepresence robots are overly dependent on network settings. As demonstrated in 2019, a telepresence robot relies heavily on a rapid, dependable, and low-latency internet connection [12]. Particularly, the experience of using a telepresence robot at remote distances will be degraded if the user is unable to move freely, communicate his or her thoughts, and access visual information. Additional equipment or technical support may be considered, if necessary, to enhance the network's stability. Participant 1 stated in the study that their professor used a telepresence robot to participate in classroom discussions, but they could not hear the professor clearly, unless they were in the front row due to excessive background noise. And, when presenting group materials, there was no file transfer function to connect the telepresence robot to the computer, reducing efficiency. As a result, if we can include a Bluetooth option that allows individuals to communicate and transfer data using headphones, the experience will improve.

Discussing other hardware devices, qualitative data revealed that participants felt the current camera's field of view was too limited, and that they would prefer to see both the front and surrounding field of view. The rationale behind this is that in the field of higher education, telepresence robots are certain to encounter novel scenarios if they are utilised in remote conferences, and so different fields of vision and perspectives might help drivers become more comfortable with the conference environment more rapidly. Currently, the auto-navigation function of telepresence robots such as Double3 is dependent on the additional sensors. Consequently, we believe that upgrading the sensors or adding additional sensors to the underneath of the telepresence robot could also increase its safety. Participants also desired more physical interaction with the telepresence robot, such as knocking on doors and raising hands in class, to increase its independence.

In terms of the user interface, the mixed data we used showed that it was not highly evaluated by users, who even said it was "not like the user interface of a commercial product," and that there was no error feedback or ways in place to deal with mistakes when participants encountered them. Although one participant stated that the simplicity of the user interface helped her become familiar with the robot more quickly, it was agreed that the user interface needs to be completely redesigned. The majority of respondents believed that the user interface required a complete overhaul. Specifically, one participant stated that the interface icon was not aesthetically appealing and that some of the logos were not comprehensible. Therefore, we recommend that in future work, the user interface be thoroughly evaluated and a new user interface be developed.

Considering software functionality, our qualitative data indicated that participants provided a large number of suggestions and expectations for future software updates. The first is that receiving too much information at once can affect people's level of trust and satisfaction, as was previously mentioned. Games as a means of instruction could be a viable solution to this problem. By setting levels, the game is able to control the amount of information acquired by the user, allowing users to keep exploring the telepresence robot in-depth as they progress through the beginner tutorials, from the basic functions to the combination of use, which enhances their sense of experience. In addition, the enjoyment of the game can increase user retention. Consequently, some participants expressed a desire for an assistance manual that would teach users the fundamental functions. When they needed to complete a specific task, they were able to find information by searching for it. We believe that mini-game is a good choice for users to master the robot. Especially, fun should be added to the user experience by providing a guided tutorial through a mini-game. Finally, the game can be displayed on the main interface so that users can learn.

When leading a class discussion with more than one small group, an instructor necessarily loses regular visibility into the students' activities behind them. Therefore, using the top view of the room as a map, when other students wish to communicate or raise their hands for discussion, the instructor will immediately perceive the scenario based on the location of the students' red dots. On this basis, it is possible to create question-asking windows, PowerPoint sharing functionality, etc. They can conduct academic discussions with greater efficiency. Finally, based on group diversity, as the participants come from different countries, understanding the communication in the experiment has also become one of the problems we consider. Functions such as subtitle translation and speech-to-text can also help people with different first-languages to understand better. This is also more applicable to academic scenarios such as international remote conferences.

8 LIMITATIONS AND FUTURE WORK

Our research has implications for both HRI and higher education, but it also has some limitations. To begin, despite our efforts to imitate real-life settings, there was a lack of true experiential feeling of people participating in the activities. This was evident in the reduced dialogue and the participants' lack of understanding of the activities that should be completed in this context. In response, we reasoned that assigning modest tasks and providing interactive instructions might be a better method to enable participants interaction with the simulated environment.

Second, the application scenarios in the higher education domain are diverse, and we only simulated remote conferences. In the subsequent experiment, simulation scenarios should be incorporated so that participants can experience a greater variety of features. The third aspect pertains to the participant group. Although we gathered a varied set of stakeholders to help us obtain an initial grasp of the factors required for design and deployment in the education sector, we also identified a number of difficulties. The majority of our participants were Master's students from our University; therefore, our experiment should recruit a broader range of participants.

Also, our quantitative results were affected by the small number of participants, and there was no significant curve change in the data. In order to improve the objectivity of the quantitative data, we may try to boost the number of people taking part in the quantitative experiment in the next experiment and then select representative participants for the qualitative experiment.

9 CONCLUSION

In conclusion, this study offers light on the future of telepresence robots in education. Our research demonstrates that, while telepresence robots offer great promise, there are still issues with usability and user trust.

Responding to RQ 1, we discovered that access to information supports the development of trust and satisfaction. However, excessive detail may result in information oversupply, ultimately decreasing user satisfaction. Games could be a useful instrument for controlling the user's exposure to telepresence robots.

Responding to RQ 2, we found that the main factors affecting users' trust in telepresence robots are the performance of the telepresence robot, the driver, and the development organisation. Additionally, people evaluate the performance of the robot based on safety, independence, and convenience. Secondly, individuals are not repulsed by telepresence robots. They still perceive that they are communicating and interacting with the driver, so the driver's disciplined operation of the telepresence robot becomes a factor in determining the level of trust. Lastly, the creator of a robot is typically an organisation or a business. People are frequently sceptical about whether an organisation will adequately safeguard personal privacy and manage data. As a result, the developing organisation must increase its authority, enhance its data administration systems, and upgrade its robotic equipment in order to address concerns.

In response to question 3, we learned that stakeholders expect the telepresence device to be enhanced based on their requirements. First, the telepresence automaton is too network-dependent. Once the network is delayed, miscommunication and decreased image quality ensue. The hardware equipment and software functions must also be upgraded. This includes the installation of robotic arms, sensors, the design of user interfaces, the creation of training games, the addition of mini-map functions, subtitle translation, and speech-to-text, among other things. At the same time, we support robot privatisation and personalisation to enhance the user experience. Lastly, the deployment of telepresence robotics in other domains is anticipated. The study mentions deployments for in-school navigation and supervision of young children, but we believe that, as science and technology evolve, telepresence robots can be used in more areas.

As a result of Covid-19, an increasing number of institutions are developing distance learning programmes [32]. Our findings will indicate evident design directions for the enhancement of telepresence robots in education and contribute to the exploration and development of systems that provide more user-friendly robots. This research contributes to human-robot interaction and activities in higher education, but it also has limitations. Future research will investigate a broader variety of educational contexts. We intend to construct improved prototypes of the telepresence robot and continue investigating its applicability in additional simulated environments, as well as people's level of trust, reassurance, and expectations.

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