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The Use of UTAUT and Post Acceptance Models to Investigate the Attitude towards a Telepresence Robot in an Educational Setting

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Abstract: (1) Background: in the last decade, various investigations into the field of robotics have created several opportunities for further innovation to be possible in student education. However, despite scientific evidence, there is still strong scepticism surrounding the use of robots in some social fields, such as personal care and education. (2) Methods: in this research, we present a new tool named the HANCON model, which was developed merging and extending the constructs of two solid and proven models—the Unified Theory of Acceptance and Use of Technology (UTAUT) model used to examine the factors that may influence the decision to use a telepresence robot as an instrument in educational practice, and the Post Acceptance Model used to evaluate acceptability after the actual use of a telepresence robot. The new tool is implemented and used to study the acceptance of a double telepresence robot by 112 pre-service teachers in an educational setting. (3) Results: the analysis of the experimental results predicts and demonstrate a positive attitude towards the use of telepresence robot in a school setting and confirm the applicability of the model in an educational context. (4) Conclusions: the constructs of the HANCON model could predict and explain the acceptance of social telepresence robots in social contexts.

Keywords: acceptance; telepresence robots; UTAUT model; post acceptance model

1. Introduction

A robot is defined by the International Organization of Standardization (ISO) as "a programmable device that can move and perform tasks in its environment" [1]. This meaning includes robotic devices ranging from fully autonomous robots to remote-controlled robots such us telepresence robots. Currently, no consensual definition of robots exists, due to the rapid evolution of this technology.

However, the term "robotics" includes a variety of research sub-areas: social robotics, involving robots that engage in social interaction with humans through speech, gestures, or other means of communication; assistive robotics, which generally involves robots that assist people with physical and neurodevelopmental disabilities. Another sub-area of robotics is Socially Assistive Robotics (SAR), a fast-emerging field that has developed from the intersection of these two and involves robots that are designed to help through advanced interaction which is driven by user needs via multimodal interfaces [2].

Technological advances in the last decades have boosted the area of robotics and resulted in fast growth of possible applications, with a consequent solid impact on people's daily lives. Thanks to evidence from various studies and the use of new robotic platforms concerning applications in social contexts, education [3] and care [4] have received particular consideration. However, notwithstanding the extensive work done in human-robot interaction and technology acceptance, suggest that advances in robotics require supplemental research [5].

Based on the above, this study was conducted using the Double robot, a telepresence robot in an educational setting. To evaluate the acceptability of the participants we used a questionnaire inspired by the Unified Theory of Acceptance and Use of Technology (UTAUT) model [6], while the Post acceptance model [7] was used to evaluate attitudes to the continued use of the robot after its initial use. Currently, recent literature in the field of human-robot interaction reports a higher frequency of use of a single questionnaire than two or more, to investigate the participant's acceptability or aptitude towards robotic technology. Usually, the questionnaire used is based on a single theoretical model (e.g., UTAUT, TAM, etc.), and is filled out in the final part of the experiment, after the interaction with the social robot [8]. In this way, important information about the "before" of the interaction could be inexorably lost.

In this study we used two different models, UTATUT and PAM, highlighting the clear difference between before use and after the actual use of the robot. The innovative aspect of the research is given by the use of a robust model such as the PAM model to evaluate post acceptance in the robotics field, because often the model used "before" and "after" the interaction is the same. The purpose of our research was to confirm the reliability of the proposed model using a questionnaire inspired by two solid models, UTAUT and PAM, and its applicability in an educational context. In this paper, we proposed an analysis of the perception of a telepresence robot as an instrument for their future use in an actual educational setting. However, we would remark that the application to education is offered as a proof-of-concept, whereas the fundamental aim of the research presented in this article was to develop a new acceptance model that could be applied in many other social settings.

2. Related Work

In the last decades, robots are starting to become a part of working life in many sectors including journalism, agriculture, the military, medicine such as surgery, and education [9]. A factor influencing the attitude toward robots may be a concern over the risk of unemployment caused by robots, considering certain occupations are even at risk of being replaced by robots or other technology [10].

Europeans interviewed in a recent Eurobarometer survey (n = 26.751) generally showed a positive view of robots, although they do not feel comfortable with robots in some specific areas, such as the care of children, the elderly, and the disabled. In detail, the survey stated that 60% of Europeans surveyed thought robots should be "banned" from such care activities [11]. In a study conducted by Taipale et al. [12] the participants showed reluctance to use the robot in various areas, including childcare, care for elderly, leisure and education. In another recent European survey [13] only 26% of respondents showed that they were comfortable "with having a robot to provide services and companionship to the infirm or elderly" or "with having a medical operation performed on them by a robot". This result could be linked to the common perception that people have of robots. Robots are considered as dangerous and technically powerful machines, which could be mainly useful in those activities where humans are not available, for example: in military applications, in space exploration, and industries. For this reason, the purposes of current robotics research focus on adapting the robot's appearance and behaviour to improve end-user acceptance [14,15]. In another recent study with an Italian sample, the authors compared the acceptance of practitioners and students who would be future practitioners. They reported that as experienced practitioners they felt sceptical and perceived the assistive robot as an expensive and limited tool, although the sample showed an overall positive attitude towards the use of the robot [4].

In recent decades, extensive researches on the factors that can influence the acceptance by possible users and on how such acceptance can be increased have been conducted. Examining technology acceptance is closely related to research fields of social acceptance and attitudes in general. In detail, the deployment of new technology about social and human factors has been studied within the concept of technology acceptance [16], and based on the theory of reasoned action [17]. In general, attitudes refer to fairly constant positive, negative, and neutral evaluations of an object or concept [18]. Some studies have shown that attitudes could be defined as “a type of knowledge structure stored in memory” [19], where other studies have also connected attitudes more tightly to neurological processes [20]. Additionally, the acceptability of robots to people is an important matter which depends on several variables, where the acceptance is described as the “robot being willingly incorporated into the person’s life” and implies long-term usage [21].

The literature suggests that individual users’ psychological variables could influence the person’s acceptance process [22], and their social and physical environment [23]. Heerink [24], suggested that participants with a higher level of education were less open to perceiving the robot as a social entity. The implication that adults can respond to technology differently than young people has been shown by Scopelliti et al. [25]. While the effects of age and anxiety on robots have been studied by Nomura et al. [26]. The results showed that young people who experienced humanoid robots directly or through the media had higher levels of anxiety towards robots than those aged 50 to 60. Women were more sceptical about using robots than men, as also reported by Arras and Cerqui [27]. Gross et al. [28] found that the sample, although initially negative, started to appreciate the benefits and found the robot more acceptable after spending one day using it. The novelty effects may initially improve Perceived Enjoyment (PE) but then decrease over time, potentially resulting in lower acceptance of the robot in the longer term. Specifically, De Graaf’s [29] and Torta et al. [30] suggest that PE reduced over six to eight months. Considering that it is easier to form a clear vision of robots if there are already previous encounters in the individual’s life, the literature suggests that attitudes based on direct experience are more extreme and less ambivalent [31]. In fact, before a subject has his first direct experience with robots, he forms a mental perception that conditions subsequent responses and attitudes towards robots.

The past personal experience and second-hand sources of information external to the individual, such as science fiction and the media, influence these mental models. In a recent study, Savela et al. [32] found that when the participants did not have actual experiences with the robot in question, negative attitudes were more likely to be reported in the studies. For this reason, the lack of first hand or direct experiences forces people to resort on their social representations or mental images of robots. These seem to influence attitudes towards them, as confirmed by attitudes theories [31]. Currently, the research focused on technology that already exists around automated robotic devices and telepresence robots, instead of emerging technology such as autonomous service robots. Telepresence robots were highly approved by patients [33] and workers [34], especially regarding home care.

Recently Benitti [35] examined the scientific literature on the use of robotics in schools, concluding that appropriate use of educational robotics can act as an element that improves learning. In particular, robotic assistants have the potential to overcome concerns about the physical effects of a student’s use of computer-based tools, because they encourage the scholar to be active during a play [36]. Additionally, the robot can be a practical learning partner that motivates students, arousing learning performance naturally [37]. In a recent article, the authors specified that in educational settings robots are accepted in work tasks related to education, and attitudes toward educational robots were neutral and robots could be imagined in subjects such as science, technology, engineering, and mathematics [38]. However, respondents were reluctant to participate in teaching provided by a robot and could not imagine a robot in subjects such as social sciences or art [38].

In recent years, robotics research has shown numerous benefits of using robot in the treatment of children with special needs and neurodevelopmental disorders, such as autism spectrum disorder (ASD) [39], in particular a new direction is to create partially automatic robots in combination with machine learning strategy [40].

3. Materials and Methods

3.1. Technology Acceptance Model (TAM)

The Diffusion of Innovations model (DoI) [41], the Technology Acceptance Model (TAM) [42], and the Theory of Planned Behaviour (TPB) [43] have examined variables that motivate individuals to accept new Information Systems (IS), and how they do it. These attitude theories suggested that "intention" is the strongest and most immediate predictor of individual behaviour [43]. The theoretical association comes from Cognitive Dissonance Theory (CDT), which suggests that users may experience cognitive dissonance or psychological tension if their pre-acceptance usefulness perceptions are disconfirmed during actual use [44]. Rational users may try to remedy this dissonance by distorting or modifying their usefulness perceptions in order to be more consistent with reality. Davis et al. [45], and Taylor and Todd [46], empirically validated a strong correlation between intentions and behaviours in IS usage contexts.

In an empirical analysis conducted by Bhattacherjee [47], attitude theories hold that human behaviours are influenced by subjective perceptions, though such perceptions are biased or inaccurate; consequently, perceived rather than objective assessment (e.g., third party) usefulness is relevant. Specifically, the first studies on technology acceptance modelling can be traced back to Davis with the Technology Acceptance Model (TAM) [42]. This model, used for different types of technology, states that the user's perception of the usefulness and ease of use of a system determines the intention and subsequently the actual use of the system itself.

Frequently consumers show unrealistically low or high initial expectations of new innovative services because they are unsure what to expect from them. Although low initial expectations are easily confirmed, these expectations themselves may be adjusted upwards as a result of their usage experience, if customers realize that their initial expectations may have been unrealistically low. Similarly, unreasonably high initial expectations may be lowered throughout a service's initial use, as some of those expectations are unconfirmed [48]. The higher or lower level of expectations obtained may then serve to motivate or demotivate further usage intentions and defined continuance. Results of Bhattacherjee's study [47] support that satisfaction and Perceived Usefulness (PU) are strong predictors of consumers' intention to continue IS services. Specifically, PU was identified as a secondary determinant of continuance intention, and loyalty incentives did not have any significant effect on continuance intention. PU refers to users' subjective probability that IS use will improve their performance [45], and therefore captures the instrumentality or rational component of their usage decision. Satisfaction is conceptually distinct from the attitude in that satisfaction is a transient, experience-specific affect, while attitude is a relatively more enduring affect transcending all prior experiences [49]. Tse and Wilton [50] have shown that satisfaction and attitude differ in their predictive abilities, while Oliver [48] suggested that satisfaction temporally and causally precedes post-purchase attitude in a path-analytic model. Hunt [51] argues that attitude is an emotion, but satisfaction is an evaluation of that emotion. As described earlier, drawing from TAM, PU captures the instrumentality of IS use, while ease of use taps into the self-efficacy dimension. Because PU and FC are the primary motivators of IS acceptance, it is plausible that they can also influence subsequent continuance decisions.

In another research, Venkatesh et al. [6] published an inventory of current models and factors and presented a model called the Unified Theory of Acceptance and Use of Technology (UTAUT). The UTAUT was developed as a model of general technology acceptance that aims to unify eight existing models of technology acceptance and usage behaviour. In the UTAUT model proposed by Heerink et al. [52], they defined the constructs represented by a few questions and the scores for the constructs can be mapped and interrelated.

3.2. Post Acceptance Model

While existing studies have tended to investigate individuals' decisions to initially adopt an Information Technology (IT), there is less attention paid to the post-adoption environment where individuals decide on the continued or discontinued use of an IT. Contrarily, in consumer behaviour literature, research into consumers' satisfaction and re-purchase decisions shows the expectancy–confirmation paradigm as a dominant theme (e.g., [53,54]). The Expectation–Confirmation Theory (ECT) is widely used in consumer behaviour literature to study consumer satisfaction, post-purchase behaviour (e.g., repurchase, complaining), and service marketing in general [50].

Specifically, Oliver's process [48] where consumers reach repurchase intentions in an ECT is as follows: consumers initially form an expectation of a specific product/service before purchase. They subsequently accept and use that product/service, but only after an initial consumption period they manage to form perceptions about its performance. They assess its perceived performance vis-a-vis their original expectation and determine "Confirmation 2", namely the extent to which their expectation is confirmed. Finally, consumers form a satisfaction or affect, based on their confirmation level and expectation on which that confirmation was based and form a repurchase intention, while dissatisfied users discontinue subsequent use. Churchill and Surprenant [53], added that the consumer's expectations are confirmed when the product/service performs as much as expected; negatively disconfirmed when it performs worse than expected, and positively disconfirmed when it performs better than expected.

In the Information Technology (IT) literature, Bhattacherjee [7] proposes an Expectation-Confirmation Model (ECM) of IT continuance based on the congruence between individuals' continued IT usage decisions and consumers' repeat purchase decisions. The purpose of Bhattacherjee's studies [7] was to understand continued use or "continuation", in contrast to initial use or "acceptance". Continuance in Information Systems (IS) research has been examined variously as "implementation" [55], "incorporation" [56], and "routinization" [57] in IS literature. IS and IT are often considered synonymous, but IT is a subset of IS. Hence, the ECM suggests that post-adoption expectations are the relevant determinants of a user's level of satisfaction with an IT, instead of pre-adoption expectations. In the expectancy-confirmation paradigm, the expectation is commonly defined as individual beliefs or a sum of beliefs about the levels of attributes possessed by a product/service (e.g., [49]). Since, among the various beliefs in IT adoption research, Perceived Usefulness (PU) is the most consistent antecedent of a user's Intention To Use (ITU), and consequently, IT is the logical choice as a surrogate for post-adoption expectations (e.g., [58]). Moreover, the ECM does not include the performance variable, as it presumes that the influence of performance is already accounted for by the confirmation variable [7].

Pioneering studies [59,60] attempted to integrate variables from different adoption perspectives (e.g., TAM, TPB, Innovation Diffusion) into a single framework in order to improve the explanation of the initial adoption behaviour. Consistent with the view in ECM that post-adoption expectations refer to users' beliefs about the attributes possessed by an IT [7], the post-adoption expectations in the proposed model are represented by PU, perceived Facilitating Conditions in their use (FC) and Perceived Enjoyment (PE). Previous empirical evidence has shown that perceived FC is one of the major cognitive beliefs in determining users' affect (attitude) towards technology adoption (e.g., [45]). Specifically, in motivation research, there are two types of motivation: intrinsic and extrinsic [61]. PE can be described as an intrinsic motivation, whereas perceived usefulness in TAM is an example of extrinsic motivation [62].

Considering that the process of confrontation in disconfirmation judgments requires the deliberate processing of information, Oliver confirms that the expectancy disconfirmation paradigm is mainly cognitive [48]. The cognitive and affective responses in post-purchase judgments may be seen as distinct components in response to environmental events, and each would appear to introduce its own influence on the consumption process.

3.3. Overview of Construct Interrelations

The model inspired by UTAUT includes the following constructs: Anxiety (ANX), Attitude Towards Technology (ATT), Facilitating Conditions (FC), Intention to Use (ITU), Perceived Adaptiveness

(PAD), Perceived Enjoyment (PENJ), Perceived Ease of Use (PEOU), Perceived Sociability (PS), Perceived Usefulness (PU), Social Influence (SI), Social Presence (SP), Trust, and Use [4,52]. Instead, the constructs of the post acceptance model are: IS continuance intention, Satisfaction, Perceived Usefulness, and Confirmation [7].

From the combination of parts of these two models, we identified 15 constructs as potential direct determinants of intention to use and post-acceptance use. We selected only those constructs that were in adherence with the objectives of the present research. Specifically, in the first part of the questionnaire we did not investigate the constructs: PEOU, which is the degree to which one believes that using the system would be free of effort, and USE, which is the actual use of the system over a longer period in time. We decided to insert the PEOU construct in the second part of the questionnaire, after the real use of the telepresence robot. Furthermore, in the second part of the questionnaire we inserted all constructs of the post acceptance model but in some cases we modified the name, but not the meaning, of the construct (e.g., IS continuance intention as Post Intention To Use (PITU); Satisfaction as User Satisfaction (US); and Confirmation as Met expectation (ME).

Of these constructs, we theorize six to play a significant role as direct determinants of intention to use (ITU): perceived usefulness (PU), gender, perceived enjoyment (PENJ), trust technology (TTrust), attitude (ATT), and social influence (SI). Whereas perceived adaptivity (PAD), anxiety (ANX), perceived sociability (PS), social presence (SP), and facilitating conditions (FC) are theorized but not direct determinants of intention to use (ITU).

Furthermore, intention to use (ITU) determines met expectation (ME). We identify perceived ease of use (PEOU) as directly determined by met expectation (ME) but determines for user satisfaction (US) and post intention to use (PITU).

Figure 1 visualizes this model, featuring the following hypothetical construct interrelations that will be tested in our experiments.

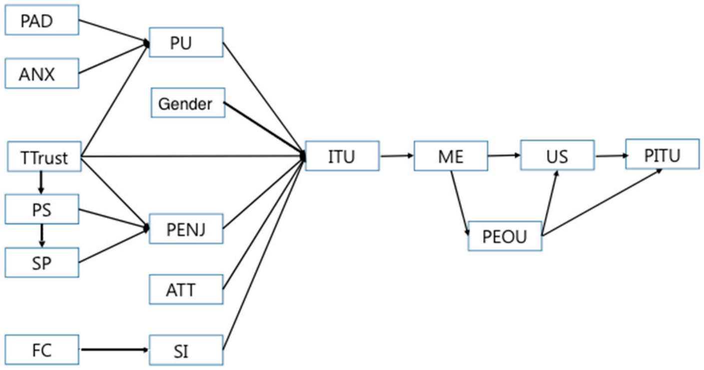


Figure 1. Hypothetical construct interrelations for the HANCON model.

The hypotheses considered were:

- **H1**—Intention to use (ITU) is determined by (a) perceived usefulness (PU), (b) perceived enjoyment (PENJ), (c) attitude (ATT), (d) trust of technology (TTrust), (e) social influence (SI), and (f) gender.
- **H2**—Perceived usefulness (PU) is influenced by (a) perceived adaptability (PAD), (b) anxiety (ANX), and (c) trust of technology (TTrust).
- **H3**—Perceived enjoyment (PENJ) is influenced by (a) social presence (SP), (b) perceived sociability (PS), and (c) trust of technology (TTrust).
- **H4**—Perceived sociability (PS) is influenced by trust of technology (TTrust).
- **H5**—Social influence (SI) is influenced by facilitating conditions (FC).
- **H6**—Social presence (SP) is influenced by perceived sociability (PS).
- **H7**—Post-intention to use (PITU) is determined by (a) user satisfaction (US) and (b) perceived ease of use (PEOU).

- **H8**—User satisfaction (US) is influenced by (a) met expectation (ME) and (b) perceived ease of use (PEOU).
- **H9**—Perceived ease of use (PEOU) is influenced by met expectation (ME).
- **H10**—Met expectation (ME) is influenced by the intention to use (ITU).

We decide to name the model "HANCON", as part of the authors' surnames.

3.4. The Instrument

The questionnaire used includes 45 items, takes from the models UTAUT and PAM models. In details, items 1 to 34 were administered before the actual participants use of the telepresence robot, and items 35 to 45 were administered only after the real interaction.

The questionnaire was completed anonymously by the participants and the answers were given on a Likert five-point scales: (1) Strongly Disagree, (2) Disagree, (3) Neither Agree nor Disagree, (4) Agree and (5) Strongly Agree, taking into account variables that can be influenced after use of the telepresence robots.

The questionnaire was based on studies by Heerink et al. [52] and Conti et al. [4]. Considering that these studies refer to social robots, we have replaced in the questionnaire the term "robot" with "telepresence robots" in order to promote a better understanding of the participants. Furthermore, we have modified and added some elements, to attempt to stay as close to the original form as possible: for the PS, we replaced two items "I feel the robot understands me" and "I think the robot is nice" with three items "I consider the student via the telepresence robot a pleasant conversational as much as the other students in my class", "I find the student via the telepresence robot pleasant to interact in the classroom with the other students", and "I feel the tele-operating student via telepresence robot can well interact with me as a teacher". On behalf of SP, we replaced three items "I can imagine the robot to be a living creature", "I often think the robot is not a real person", and "Sometimes the robot seems to have real feelings", with "I felt like the tele-operating student via the telepresence robot to be in the classroom". Finally, we decide to rename the "Trust" construct with "TTrust" which indicates the Trust Technology that is the belief that the system performs with personal integrity and reliability. We decided to replace the following two items: "I would trust the robot if it gave me advice" and "I would follow the advice the robot gives me", with three items "I think that the head image quality and reliability visible on the telepresence robot screen is not good", "I think that the sound quality and reliability the telepresence robot is good" and "I think that the movement quality and reliability of telepresence robot is not good". These items TTrust have been verified in a pilot test with nine Korean participants [63], where the clarity of the items was confirmed. See the Appendix A for a complete view of the questionnaire.

3.5. Experimental Setup

3.5.1. The Telepresence Robotic Platforms

The telepresence robot used for the experiment was a Double robot and a remote-control platform with a notebook PC equipped with a video communication camera. This robot had a 9.7-inch tablet PC and a visual effect that realizes an anthropomorphic upright posture. It could move around on two wheels using a gyro sensor and park. It was connected to the school Wi-Fi or LTE network and showed sufficient performance for video call and robot manoeuvring. It had a built-in speaker and could communicate clearly with participants in the classroom. As shown in Figure 2, the Double robot wore a t-shirt to personify it as a student because people are inclined to interact with the robots whose personalities conform to the robot's occupational role [64], and the LED circle light on the center of the t-shirt was turned on to make it easy for a participant to recognize when his/her voice was transmitted into robot platform. Considering that when people interact with robots, they have impressions of the robots in terms of perceived robot personality [65], we made these changes with the aim of promoting a social aspect in the setting.

Figure 2. Double telepresence robot with t-shirt used in the experiment.

3.5.2. Participants

A total of 112 undergraduate students (n = 112, Males = 34, Females = 78, M-age = 21.5 years, range = 20–23, SD = 1.06) were recruited as pre-service teachers with teaching experience in South Korea schools. Specifically, with "pre-service teachers" we mean university students with educational curricula who carry out the apprenticeship in educational settings, while "teachers" are those who work as teachers in schools. The recruitment had been conducted through posting on the university board from October 2018. The participation in the experiment was voluntary, and all personal information obtained was anonymized except for the participant's gender and age. The participant was free to withdraw the experiment at any time, for whatever reason.

We did not consider the influence of age by adopting the pre-service teachers with an average age of 21.5 years. The female proportion of pre-service teachers was of 69.5%, and this gender imbalance reflects the population ratio, as being a teacher is a very popular occupation for women in South Korea. In order to test the methodology proposed in the experiment, we carried out a pilot experiment with seven pre teacher students (n = 7, Males = 2, Females = 5). Only for this occasion did we use a KUBI telepresence robot. In conclusion, excluding seven participants who had previously participated in the pilot experiment, the participants were a total of 105. All the participants we included had no previous experience of interaction with telepresence robotics platforms, nor had the use of robots been previously presented to them as an instrument of support for teachers and learners.

Ethical approval was obtained by the Ethical Committee of the Cheongju National University of Education. Informed consent to participate and to use data for scientific research was obtained from all participants prior to the study. The methods were carried out in accordance with the relevant guidelines and regulations for human subjects.

3.5.3. Experimental Procedure

The experiment was conducted at the university building for four weeks, where a total of 16 slots were planned. The participants were assigned to a group with less than six people in a randomized manner.

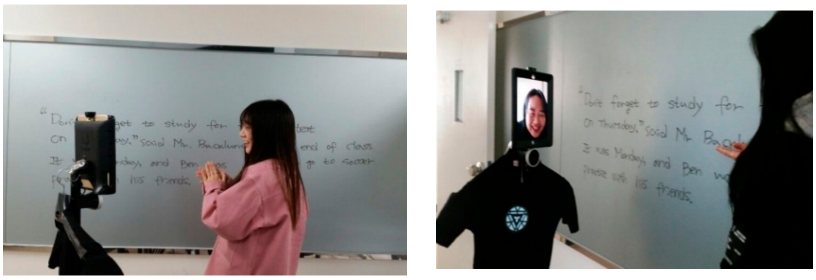
The Double telepresence robot base could move in forward, backward, right, and left directions, and it was remotely controlled by detecting the gestures of the participants. For example, the telepresence robot could easily look at a student who called his name and move to the corresponding position, thanks to features such as camera image recognition, microphone voice recognition and interaction based on various sensors. The teacher should be close to individual pupils or the classroom as a whole to be more effective [66]. For this reason, robot mobility during the instruction was a learning benefit for the experiment.

The experimentation took place in two different rooms (no. 1 and no. 2) on the same floor and were 50 m apart. Specifically, classroom 1 was used for interaction with the telepresence robot, while classroom no. 2 for remote control. During all the sessions in each class, a research assistant was present. In the experiment procedure, the first part was conducted by the research assistant K, who explained the experiment purpose, and gave an example of robot-assisted learning (Figure 3), and provided a brief description of the robot hardware configuration. Only for the pilot session the KUBI telepresence robot was used, as an example. This is shown in Figure 4.

Figure 3. Examples of robot-assisted learning with KUBI telepresence robot.

Figure 4. KUBI telepresence robot.

Simultaneously, in room no. 2 the research assistant B remotely controlled the Double telepresence robot in the classroom. The research assistant B via a telepresence robot was in front of the participants' desks and blackboard, as shown in Figure 5a,b.



(**a**) (**b**)

Figure 5. (**a**,**b**) Examples of interaction with the Double robot.

The research assistant K as a teacher, and the robot by research assistant L as a student, showed teaching and learning demonstration of mathematics problem-solving (Figure 6).

Figure 6. Demonstration of mathematics problem-solving.

After 5 min of class demonstration, one of the participants moves to the remote-control room (Figure 7). In this phase, the participant controls the robot by himself and interacts with the other participants for 5 min (Figure 8). In this stage, all the participants were expecting the direct remote control of the telepresence robot. In the final part of the experiment, and after the administration of the second part of the questionnaire, the debriefing phase took place. At this stage, the experimenter disclosed to the participant the purpose and nature of the experiment and to answer any questions that the participant asked about the experiment.

Figure 7. Participants interaction for robot-assisted learning.

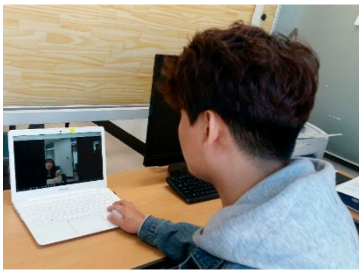


Figure 8. A participant controls the robot interacting with the other participants.

The total session time was 40 min. One ticket for coffee was provided for each participant at the end of the experiment.

3.6. Data Analyses

The data from questionnaires were analysed using statistical package R. To validate the questionnaire, Cronbach 's Alpha for each variable was calculated.

The average and standard deviation of each variable were calculated, and Shapiro-Wilk normality test was performed. Since the assumption of normality is rejected, hypotheses were tested with correlations (exploratory analysis) and linear regression analysis (confirmative) by the nonparametric methods. The Mann-Whitney test was conducted for gender, Spearman's rho analysis was used to examine correlations between variables, and Kendall-Theil Sen Siegel nonparametric regression analysis was used for the correlations.

The Statistical Package for Social Sciences (SPSS) version 24 was used for statistical analyses.

4. Results

The results showed that the use of the HANCON model with telepresence robots reported a Cronbach Alpha of = 0.509 for FC and 0.443 for PAD. This result was lower than in a recent study [4] on the acceptance of robotics were the Cronbach alpha values of ANX, FC, and PAD constructs were below 0.6. The authors [4] imputed the Cronbach's alpha of FC as a result of limited experience and use of a social humanoid robot. In this study, we found that pre-service Korean teachers considered FC (item 8-network infra, average = 3.21) to be slightly better than the FC (item 9-facility condition, average = 2.88) for telepresence robots. Table 1 shows the questionnaire structure with the number of items and Cronbach's alpha for each construct. The two items of FC were removed, while PAD was improved from 0.443 to 0.681, removing item no. 14, used in [4]. Cronbach's Alpha of FC was 0.427. Moreover, Cronbach's Alpha of PAD with items no.13, no.14, and no.15 was 0.384. For this reason, we removed items no.13 and no.14 of PAD because the Cronbach's Alpha was 0.526 without item no.13 and 0.594 without items no.13 and no.14.

Table 1. Constructs Cronbach's alpha.

Code	Construct	No. Items [4]	No. Items HANCON	Cronbach's Alpha
ANX	Anxiety	4	4	0.626
ATT	Attitude	3	3	0.887
FC	Facilitating Conditions	2	2	0.509
ITU	Intention To Use	3	3	0.827
PAD	Perceived ADaptability	3	3→2	0.443→0.681
PENJ	Perceived ENJoyment	5	5	0.869
PS	Perceived Sociability	4	4	0.868
PU	Perceived Usefulness	3	3	0.701
SI	Social Influence	2	2	0.737
SP	Social Presence	5	3	0.803
TTrust	Trust Technology (Reliability)	2	3	0.619
PEOU	Perceived Ease of Use	-	3	0.610
US	User Satisfaction	-	3	0.878
ME	Met Expectation	-	3	0.901
PITU	Post Intention To Use	-	2	0.614

We conducted the Shapiro-Wilk test of normality, as shown in Table 2. Furthermore, we used the nonparametric statistical analysis since all the variables were not assumed to be normally distributed. In the case of gender construct, Mann-Whitney U = 1024 was not significant by p-value = 0.312 for ITU.

Table 2. Shapiro-Wilk test of normality.

Code	Average	Shapiro-Wilk Statistic	Df	p-Value
ANX	3.34	0.973	105	0.030
ATT	3.71	0.931	105	0.000
FC	3.05	0.966	105	0.008
ITU	3.36	0.967	105	0.009
PAD	3.38	0.966	105	0.008
PENJ	3.77	0.949	105	0.001
PS	3.33	0.943	105	0.000
PU	3.84	0.927	105	0.000
SI	3.32	0.907	105	0.000
SP	3.20	0.961	105	0.003
TTrust	3.24	0.973	105	0.028
PEOU	3.38	0.961	105	0.003
US	3.63	0.932	105	0.000
ME	3.63	0.918	105	0.000
PITU	4.05	0.902	105	0.000

The nonparametric Spearman rho correlation is shown in Table 3. Correlations were not significantly correlated in only a few other cases and were highly relevant. This supported the hypotheses (H1 to H10) for UTAUT and PAM models.

Table 3. Correlation matrix for the participants among the scales of the questionnaire (N = 105).

	ANX	ATT	ITU	PAD	PENJ	PS	PU	SI	SP	TTrust	PEOU	US	ME	PITU
ANX	1													
ATT	−0.234 *	1												
ITU	−0.250	0.673 ***	1											
PAD	−0.145	0.561 ***	0.627 ***	1										
PENJ	−0.207 *	0.626 ***	0.582 ***	0.574 ***	1									
PS	−0.212 *	0.594 ***	0.564 ***	0.452 ***	0.695 ***	1								
PU	−0.193 *	0.595 ***	0.583 ***	0.633 ***	0.642 ***	0.605 ***	1							
SI	−0.121	0.509 ***	0.504 ***	0.476 ***	0.543 ***	0.582 ***	0.554 ***	1						
SP	−0.215 *	0.414 ***	0.479 ***	0.370 ***	0.564 ***	0.628 ***	0.553 **	0.681 ***	1					
TTrust	−0.310 **	0.351 ***	0.409 ***	0.234 ***	0.394 ***	0.502 ***	0.421 ***	0.460 ***	0.569 ***	1				
PEOU	−0.262 **	0.244 *	0.288 **	0.269 ***	0.425 ***	0.485 ***	0.274 **	0.284 **	0.383 ***	0.485 ***	1			
US	−0.237 *	0.435 ***	0.460 **	0.499 ***	0.587 ***	0.562 ***	.571 **	0.408 ***	0.454 ***	0.527 ***	0.568 ***	1		
ME	−0.186	0.481 ***	0.401 ***	0.440 ***	0.579 ***	0.512 ***	.453 ***	0.330 **	0.392 ***	0.486 ***	0.550 ***	0.780 ***	1	
PITU	−0.140	0.398 ***	0.486 ***	0.549 ***	0.516 ***	0.459 ***	.621 ***	0.389 ***	0.463 ***	0.314 **	0.415 ***	0.663 ***	0.547 ***	1

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

The results of the nonparametric regression analysis in Table 4 show significant results except for hypothesis H6. In other words, the students' PS connected via a telepresence robot does not affect the SP. Nevertheless, PS and SP have a significant impact on PENJ.

Table 4. Linear regression analyses.

Models	Hypothesis	Independent Variable	Dependent Variable	Intercept	Beta	Tau	*p*-Value
TAM	H1	PU	ITU	−0.232	0.971	0.470	<0.001 ***
		PENJ		0.759	0.714	0.462	<0.001 ***
		TTrust		1.83	0.500	0.323	<0.001 ***
		ATT		0.662	0.752	0.566	<0.001 ***
		SI		1.03	0.660	0.414	<0.001 ***
	H2	PAD	PU	1.36	0.660	0.538	<0.001 ***
		ANX		4.37	−0.124	−0.150	<0.05 *
		TTrust		2.76	0.340	0.324	<0.001 ***
	H3	TTrust	PENJ	2.41	0.448	0.309	<0.001 ***
		PS		1.77	0.606	0.560	<0.001 ***
		SP		1.81	0.600	0.441	<0.001 ***
	H4	TTrust	PS	1.46	0.602	0.401	<0.001 ***
	H6	PS	SP	0.670	0.777	0.521	0.222
PAM	H7	US	PITU	1.91	0.599	0.558	<0.001 ***
		PEOU		2.88	0.373	0.327	<0.001 ***
	H8	ME	US	0.060	0.985	0.689	<0.001 ***
		PEOU		1.73	0.599	0.461	<0.001 ***
	H9	ME	PEOU	1.39	0.571	0.449	<0.001 ***
	H10	ITU	ME	2.68	0.330	0.329	<0.001 ***

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

In addition to this, to obtain a further solidity of the study, we compare the results obtained in this study (left), with results of a Korean teacher sample (N = 110) (right), as shown in Table 5. We show the descriptive statistics of the constructs: the minimum (Min) and maximum (Max), standard deviation (SD), and the percentage of positive (POS), and negative (NEG) perception of the participants.

Table 5. Comparison between pre teachers and teachers: constructs analysis. Highest percentages and significant differences are in bold.

Construct	Pre-Service Teachers (Students)						Teachers						Mean Difference
	Mean	Max	Min	SD	POS (%)	NEG (%)	Mean	Max	Min	SD	POS (%)	NEG(%)	
ANX	3.34	5.00	1.00	0.75	**62**	23	3.28	5.00	1.00	1.15	**57**	32	0.07
ATT	3.71	5.00	1.00	0.90	**77**	15	3.18	5.00	1.00	1.15	45	45	**3.11** **
FC	3.05	5.00	1.00	0.97	42	34	2.69	5.00	1.00	1.06	31	**51**	**2.18** *
PAD	3.38	5.00	1.00	0.76	**82**	9	4.17	5.00	1.00	0.91	**80**	5	**−2.90** **
PENJ	3.77	5.00	1.00	0.79	**77**	12	3.75	5.00	1.00	0.90	**83**	12	0.11
PS	3.33	5.00	1.00	0.90	**61**	29	3.35	5.00	1.00	0.99	**54**	29	0.21
PU	3.84	5.00	1.00	0.70	**85**	5	3.68	5.00	1.00	0.93	**75**	15	0.94
SI	3.32	5.00	1.00	0.85	**58**	19	3.28	5.00	1.00	1.04	**51**	25	0.55
SP	3.20	5.00	1.00	0.92	**56**	34	3.34	5.00	1.00	1.06	48	31	0.72
TTrust	3.24	4.67	1.00	0.76	**55**	29	3.17	5.00	1.00	0.82	43	29	0.99
ITU	3.36	5.00	1.00	0.86	**60**	22	3.26	5.00	1.00	0.96	**55**	31	0.67
PEOU	3.38	5.00	1.67	0.78	**62**	27	3.20	5.00	1.00	1.04	46	28	1.12
US	3.63	5.00	1.00	0.83	**71**	17	3.53	5.00	1.00	0.94	**60**	20	0.83
ME	3.63	5.00	1.00	0.81	**71**	11	3.62	5.00	1.00	0.99	**68**	15	0.05
PITU	4.05	5.00	1.00	0.72	**86**	3	3.70	5.00	1.00	1.10	**69**	20	1.68

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Finally, in Figure 9 we reported the final model, where interrelations were confirmed by regression scores for the experiments, while the dotted line indicated that it is not confirmed by any regression analysis.

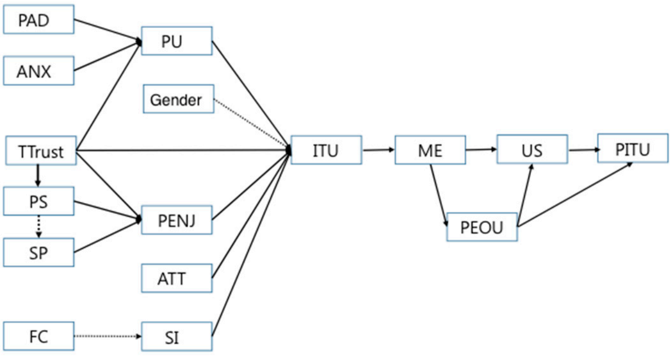


Figure 9. Final model: interrelations confirmed by regression scores for the experiments. Dotted line: not confirmed by any regression analysis.

5. Discussion and Conclusions

In this article, we presented the development and validation of a new acceptance model, named HANCON, to study robotics applications in social context. In a proof-of-concept study, we used a Double telepresence robot that could move and get closer to the student, to make learning more effective. Considering the comparison between robots and computers with students, the literature showed results more effective with a robot in learning of a second language compared to computer [67]. Additionally, Hyun et al. [68] showed a robot's media effectiveness compared to computers in word recognition in reading, story building, vocabulary, and understanding activities in a kindergarten setting.

Obviously, there are preservice teachers, teachers or educators who have a negative view of robot-assisted learning, which is currently being studied in various fields. The development of robot technology and robot-assisted learning must be an objective of technology acceptance that may soon be found. Currently, the literature shows the results of the UTAUT model using humanoids robots. In this study, we used a telepresence robot and a new model, named by us as the HANCON model, which integrates two already solid models (UTAUT and PAM). This model was used here for assisted learning from a robot connected remotely based on a video call.

The HANCON model showed a predictive force and solid constructs. These findings suggest that in general this model could be used to predict and explain the acceptance of social telepresence robots in different contexts. Specifically, the variables that significantly influence the intention to use were: perceived usefulness, attitude, social influence and perceived enjoyment. However, social presence is not influenced by perceived sociability although it has an important role for social enjoyment.

Finally, several limitations need to be considered. First, the sample of participants who participated in the research, pre-service teachers and teachers, could be considered small in order to define the solidity of a model. Second, the sample came from the same university. We cannot know if this could influence the evaluation of the system and the answers given by the participants. Third, we cannot evaluate the personal system experience of the participant before the study. Fourth, we used only a telepresence robot. It would be interesting to see the results of other studies that use different types of robots with different characteristics. In future works we may have a larger sample of participants, use different telepresence robots, and investigate different cultural contexts with different types of robots.

In conclusion, this research has shown that the possibilities of future empirical investigations to further develop this field of study are varied and increasingly interesting. However, the impact of acceptability variables requires further and in-depth examination with the involvement of larger samples, with different robots, with applications in real-life conditions, with robust longitudinal study designs that also evaluate the context differences (e.g., clinical-rehabilitative setting), and possible intercultural components. Finally, it may be important to know how psychological factors can impact users' perceptions of how easy robots would be to use.

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Conflicts of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Ethical Approval: All procedures performed in studies involving human participants were in accordance with the ethical standards by the Ethical Committee of the Cheongju National University of Education (number 1301-201810-HR-0001-01) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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

Appendix A

Code	Construct	Definition		Questionnaire ENG	Questionnaire KOREAN
ANX	Anxiety	Evoking anxious or emotional reactions when using the system	1	I (as a teacher) should use or manage the telepresence robot, I would be afraid to make mistakes with it.	나(교사)는 원격로봇을 사용하거나 관리할 때 실수를 할까봐 두렵습니다.
			2	If I should use the telepresence robot, I would be afraid to break something.	나(교사)는 원격로봇을 사용할 때 망가뜨릴까봐 걱정됩니다.
			3	I am afraid of privacy problem by the telepresence robot in my classroom.	나(교사)는 내 교실에서 원격로봇으로 인한 교실내 프라이버시 침해 문제가 염려됩니다.
			4	I'm afraid of problems that might occur in my classroom with the telepresence robot.	나(교사)는 교실에서 원격로봇이 발생시킬 수 있는 사고에 대해서 걱정됩니다.
ATT	Attitude	Positive or negative feelings about the appliance of the technology	5	I think it's a good idea to use the telepresence robot.	나(교사)는 원격로봇을 사용하는 것이 좋은 생각이라고 생각합니다.
			6	The telepresence robot would make my job more interesting.	나(교사)는 원격로봇이 내 업무를 더 흥미롭게 할 것으로 생각합니다.
			7	It's good to make use of the telepresence robot.	나(교사)는 원격로봇을 사용하는 것이 좋습니다.
FC	Facilitating conditions	Objective factors in the environment that facilitate using the system	8	My school will be able to provide me Wi-Fi in order to make good use of the telepresence robot for my class.	내가 근무하는 학교(교생실습을 했던 학교)는 수업에 원격로봇을 사용하기 좋은 Wi-Fi 환경을 제공할 것입니다.
			9	In order to make good use of the telepresence robot my school will provide adequate building facilities (e.g. threshold, scale, etc.).	내가 근무하는 학교(교생실습을 했던 학교)는 바퀴형 원격로봇을 사용하기에 좋은 환경(문턱, 복도 등)을 가지고 있습니다.
ITU	Intention to use	The outspoken intention to use the system over a longer period in time.	10	I think I'll use the telepresence robot in the near future.	나(교사)는 원격로봇을 향후 사용할 것으로 생각합니다.
			11	I am not certain to use the telepresence robot in the near future.	나(교사)는 원격로봇을 향후 사용하는 것에 대해서 확신하지 않습니다.
			12	I'm planning to use the telepresesnce robot in the near future.	나(교사)는 원격로봇이 지원이 된다면, 이를 향후 사용할 계획이 있습니다.
PAD	Perceived adaptability	The perceived ability of the system to be adaptive to the changing needs of the use.	13	I think the telepresence robot can be adapted to what I need.	나(교사)는 원격로봇이 내가 필요로 하는 것에 맞게 개발될 것이라고 생각합니다.
			14	I think the telepresence robot will only do what I need at that particular moment.	나(교사)는 원격로봇을 특수한 상황에서 필요할 때만 사용할 것이라 생각합니다.
			15	I think the telepresence robot will help the tele-operating student when he/she considers need it.	나(교사)는 원격로봇이 접속한 학생이 필요로 할 때 그 학생을 도울 수 있다고 생각합니다.
PENJ	Perceived enjoyment	Feelings of joy or pleasure associated by the user with the use of the system	16	I enjoy the tele-operating student via telepresence robot talking or approaches me or other students in classroom.	나(교사)는 원격로봇과 접속한 학생이 교실에서 말하거나 다가오는 등의 상호작용을 하면 나뿐만 아니라 학생들도 즐거움을느낄 것 같습니다.
			17	I enjoy doing things with the student via telepresence robot.	나(교사)는 원격로봇과 접속한 학생과 뭔가를 하는 것이 좋습니다.
			18	I find the telepresence robot enjoyable to the other students.	나(교사)는 원격로봇이 다른 학생들에게도 즐거운 경험을 줄 수 있다고 생각합니다.
			19	I find the telepresence robot fascinating to the tele-operating student.	나(교사)는 원격형 로봇 접속학생에게도 흥미로운 경험을 줄 수 있다고 생각합니다.
			20	I find the student via telepresence robot feels boring in the classroom.	나(교사)는 원격로봇 접속학생이 수업에 참여할 때 지겨워할 것이라고 생각합니다
PS	Perceived sociability	The perceived ability of the system to perform sociable behavior	21	I consider the student via the telepresence robot a pleasant conversational as much as the other students in my class.	나(교사)는 원격로봇 접속학생이 수업 중에 다른 학생들과 똑 같은 수준으로 즐거운 대화를 할 것으로 생각합니다.
			22	I find the student via the telepresence robot pleasant to interact in the classroom with the other students.	나(교사)는 내 수업 중에 원격로봇 접속학생이 다른 학생들과 즐겁게 상호작용할 수 있을 것이라 생각합니다..
			23	I feel the tele-operating student via telepresence robot can well interact with me (teacher).	나(교사)는 원격로봇에 접속한 학생이 나와 잘 상호작용할 수 있을 것이라고 생각합니다.
PU	Perceived usefulness	The degree to which a person believes that using the system would enhance his or her daily activities	24	I think the telepresence robot is useful to the tele-operating student.	나(교사)는 원격 로봇이 접속한 학생에게 유용할 것이라고 생각합니다.
			25	It would be convenient for me to have the telepresence robot.	나(교사)는 원격 로봇을 보유하는 것이 편리할 것이라고 생각합니다.
			26	I think the telepresence robot can help a tele-operating student with many things at remote area.	나(교사)는 수업에 참여 못하는 학생이 원격로봇에 접속하여 많은 도움을 받을 것으로 생각합니다.
SI	Social influence	The user's perception of how people who are important to him think about him using the system	27	I think the staff would like me using the telepresence robot.	내(교사)가 원격로봇을 사용하는 것을 다른 교사들이 좋아할 것이라 생각합니다.
			28	I think it would give a good impression to students and parents if I should use the telepresence robot.	내 (교사)가 원격로봇을 사용하는 것이 학생과 학부모에게 좋은 인상 줄 수 있을 것이라 생각합니다.
SP	Social presence	The experience of sensing a social entity when interacting with the system	29	When interacting with the telepresence robot I felt like I'm talking to the real student at remote area.	원격로봇과 상호작용할 때 나(교사)는 접속 학생과 진짜로 이야기하는 것처럼 느낄 것 같습니다.
			30	It sometimes felt as if the telepresence robot was really looking at me.	원격로봇이 정말 나(교사)를 쳐다보는 것처럼 느껴질 것 같습니다.
			31	I felt like the tele-operating student via the telepresence robot to be in the classroom	나(교사)는 원격로봇을 통해 접속학생이 진짜 수업에 출석한 것으로 느껴질 것이라 생각합니다.
TTrust	Trust Technology (Reliability)	The belief that the system performs with personal integrity and reliability	32	I think that the head image quality and reliability visible on the telepresence robot screen is not good.	나(교사)는 원격로봇 얼굴영상의 질과 신뢰성이 좋지 않다고 생각한다.
			33	I think that the sound quality and reliability the telepresence robot is good.	나(교사)는 원격로봇의 음성의 질과 신뢰성이 좋다고 생각한다.
			34	I think that the movement quality and reliability of telepresence robot is not good.	나(교사)는 원격로봇의 이동성이 좋지 않다고 생각한다.
After the participant used the robots, (로봇을 직접 조종하고 사용한 후 설문)					
PEOU	Perceived easy of use	The degree to which one believes that using the system would be free of effort	35	I think the quality and reliability of head image on the screen of telepresence robot was good.	나(교사)는 원격로봇 얼굴 영상의 질이 좋았다고 생각한다.
			36	I think the quality and reliability of sound from telepresence robot was not good.	나(교사)는 원격로봇 음성의 질이 좋지 않았다고 생각한다.
			37	I think the quality and reliability for movement of telepresence robot was not good.	나(교사)는 원격로봇의 이동성이 좋지 않았다고 생각한다.
US	User satisfaction	The opinion of the user about a specific system application, which they use.	38	I am satisfied with this telepresence robot.	나(교사)는 이 원격로봇에 만족한다.
			39	I think this telepresence robot is enough to be used in the school.	나(교사)는 이 원격로봇이 학교에서 충분히 사용 될수 있다고 생각한다.
			40	The students are satisfied with this telepresence robot.	나(교사)는 학생들이 원격로봇에 대해 만족했다고 생각한다.
ME	Met expectation	Performance consistently met expectations.	41	The usage of this telepresence robot is what I as a teacher expect from it.	나(교사)는 원격로봇의 활용성이 기대와 같은 수준이었다고 생각한다.
			42	This telepresence robot has satisfied expectation of the tele-operating student.	나(교사)는 원격로봇이 연결학생의 기대를 만족시켰다고 생각한다.
			43	I think this telepresence robot can satisfy the expectations of my students.	나(교사)는 원격로봇이 내 학생들의 기대를 만족시켰다고 생각한다.
PITU	Post intention to use	The post- outspoken intention to use the system over a longer period in time	44	I'll use the telepresence robot in the near future.	나(교사)는 원격로봇을 향후 사용할 것이다.
			45	In the near future, if it is provided to school I will adopt the telepresence robot for the remote student out of the classroom.	나(교사)는 향후 원격로봇이 학교에 제공된다면, 교실에 올 수 없는 먼 곳에 있는 학생을 위해서 채택할 것이다.

Figure A1. Questionnaires in Korean (used in this study) and for comparison in English, code, constructs, definition, and items.

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