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# 원격로봇학습과 원격화상학습에 대한 아동 반응 비교

# Is a Robot better than Video for Initiating Remote Social Connections among Children?

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**Abstract:** Videoconferencing technology is increasingly used in classrooms to introduce children to people from other countries and cultures in order to provide a wider learning experience. However, with traditional screen-based video conferencing technology, research has shown that it is easy for students to miss non-verbal cues that play a key role in developing human relationships. To investigate how children interact differently when their interactions are mediated through screen-based video communication versus robot-mediated communication, we conducted a study with elementary students in Korea, comparing the use of both technologies to introduce classroom students with peer-aged individuals in America. Our findings show that the children displayed more positive emotions during certain tasks and exhibited more interest and intimacy to remote participants in the context of robot-mediated communication than with video-mediated communication.

**Keywords:** tele-communication; robot-mediated communication; video-mediated communication; non-verbal communication, robotic technology in classroom

## I. INTRODUCTION

Non-verbal exchanges are an important aspect of all communications, but they are particularly important in the *initiation* of communications. People are familiar with the everyday patterns of non-verbal greetings—shaking hands or hugging—wherein the physical interaction plays a large part in conveying emotion and demonstrating affiliation and friendship. Sociologists such as Edward Hall have pointed out that these embodied rituals and spatial patterns are particularly important factors in *culture contact* when people from one culture are introduced to another [1].

When we teach people how to interact with people from other cultures, it is important to explicitly address tacit understandings of non-verbal behaviors. However, these types of non-verbal cues can be easily lost in the use of traditional video-conferencing technologies such as Skype, VSee, or Google Hangouts. In this paper, we explore how using robot-mediated communication can improve the quality of social connection, particularly in the case of cultural contact, by supporting non-verbal communication. We present a study in which elementary classroom students in Korea are introduced to and interact with a child in America using video-mediated communication and robot-mediated communication. This research highlights the potential for tele-operated robots to play a valuable role in distance communication, and also illustrates the educational potential of such communication robots in the classroom.

(a) Robot-mediated.

(b) Video-mediated communication.

그림 1. 원격화상 수업과 원격로봇수업 장면.
Fig. 1. Classroom children interacting with a remote student using.

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## II. BACKGROUND

Research has shown that non-verbal exchanges play a critical role in human interactions [1-5]. Non-verbal communication such as gestures, spatial behavior, gaze, facial and bodily expression of emotion, as well as touch and bodily contact functionally helps people to express emotions, to communicate interpersonal attitudes, to accompany and support speech, to affect self-presentation and to perform rituals [2]. Sociologists have found that this type of communication is particularly important at moments when people are interacting for the first time: when people are uncertain in initial interactions, they are more actively looking for signs of emotional expression and affiliate behavior to establish what kind of interaction and relationship are being started [3,4]. In fact, the content of non-verbal communication can have a stronger effect on people than verbal communication. Argyle et al., found, for example, that in experiments where participants were asked to rate videotaped performers reading friendly, neutral, and hostile messages with friendly, neutral, or hostile non-verbal presentations, the non-verbal cues had greater effects on the participants' ratings of the performers' friendliness or hostility. When the verbal and non-verbal signals were inconsistent, the performer was rated to be insincere, unstable, or confusing [5].

In computer-mediated communication, early developers were enthusiastic about the ability of videoconferencing technology to augment distance communication with gestural and other non-verbal signals [6]. Video could augment audio communication by providing cognitive cues (such as head-nods or direction of visual attention), turn-taking cues (such as eye-gaze, head turning and posture), and social or affective cues (which relate emotional state) and help to coordinate conversational content and process [7]. However, video only communicates some aspects of non-verbal communication. In particular, aspects of a remote actor's physical gesture, proximity, and spatial orientation are often not conveyed or mis-conveyed in the local meeting spaces. These issues can cause people to have lower trust in one another [8]; particularly, if they have never met face-to-face [9].

Telepresence robots have emerged as a way to provide physical presence and autonomous mobility to remote participants. Currently, there are a variety of mobile remote presence (MRP) systems on the market, which have a physically embodied audio-video remote collaboration system that remote participants can drive around the local site. Although this configuration of robot, initially pioneered by Paulos and Canny's Personal Roving Presence (PRoP) [10], lacks robotic capabilities beyond the mobile base, early research suggests that the constant physical presence afforded by such systems allow co-workers to feel almost as if distributed coworkers were on-site [11]. Augmenting such systems with more robotic capabilities to steer gaze, gesture, and point is likely to improve such systems: Sirkin and Ju found that physical action along with the on-screen non-verbal signals can improve perceptions of the remote and local participants [12].

Videoconferencing technology is increasingly used in classrooms to promote foreign language and cultural education [13-15]. While robotic technology is far more novel in classroom settings, the early use of robots to enable distance foreign language teaching has shown that such applications may promise to be spread out. There are some tele-operated robots controlled by an English speaking human teacher to communicate with English learners at remote sites [16]. We have previously introduced and described the long-term use of our teaching assistant robot Robosem, an educational service robot for English learning [17], which is used in the following study.

## III. HYPOTHESIS

Based on this body of prior work, we formulated the central hypothesis that using a robot as a medium for distance communication (*robot-mediated communication*) will affect the interpersonal attitudes of classroom students towards a remote participant differently from those who interact with the remote participant over a more traditional screen-based video conference setup (*video-mediated communication*). In particular, we predict the following effects in first encounter interactions between young people:

**Hypothesis 1:** Classroom participants will show more interest in the activity with robot-mediated communication than with video-mediated communication.

**Hypothesis 2:** Classroom participants will show more empathy with media in robot-mediated communication than in video-mediated communication.

**Hypothesis 3:** Classroom participants will show more intimacy with the remote participant in robot-mediated communication than with video-mediated communication.

**Hypothesis 4:** Classroom participants will show more positive emotions in robot-mediated communication than in video-mediated communication in at least one or more tasks given in the class.

## IV. METHOD

To test these hypotheses, we conducted a classroom experiment at CharmSaem Elementary School in Korea. Elementary students from several classes participated as classroom participants in Korea and one American student from the US interacted as a remote participant in each class.

The classes were designed as introductory first-time and second-time meetings between the Korean students and the American student. They were allowed to greet each other and get to know each other using both verbal and non-verbal communications. For the video-mediated communication condition, we used Google hangout on a large-screen display located in the classroom in Korea, and on a laptop located in the remote participant's home in the US. For the robot-mediated communication condition, the children in the Korean classroom interacted with a robot featuring a screen that showed the remote participant. The remote participants again participated on a laptop from their own home in the US, but they were able to connect to the robot and control motions of robot remotely. There was a teacher in the classroom and a research assistant at the remote site helping students with the video conferencing and robot systems. For the purpose of this study, we focused primarily on capturing the responses from

the Korean classroom participants. Participants, task, procedure, measure, analysis of the study are discussed hereafter.

### 1. Participants

Fourteen elementary students in Korea (8 females and 6 males) participated as classroom participants. Twelve students were 7 years old and two students were 8 years old. These students previously studied with the Robosem, an educational service robot, for two hours a week during two months prior to this study. For this reason, we assume that there was no novelty effect associated with robot-assisted learning. Among the three days of the experimental, eight students participated in all of the experiments (three days and 6 classes in total), while six student participated for a shorter session (one day, two classes). We recruited two American students from US as remote participants. Both were male student living in the Palo Alto, California. One student was five years old and the other student was nine years old. They were given instructions to follow and practiced with the researcher in prior to the remote classroom engagement. The remote participants were compensated $15 per hour for their participation.

The study was initially designed as a within subjects study, so that three classes, each consisting of five or six students, would participate first in the video conferencing set up, and on the following day, in the robot-mediated conference setup (or the other way around). However, as these were actual classes, some of the classroom participants were not present both days, so an additional session was added. In total, there were eight students who participated in both the video and robot-mediated conditions. Two subjects were left out of the analysis; one that responded with straight-lined answers, and another that stated his preference was based solely on the size of the screen. This resulted in small number of participant to size of six (n=6) for analysis of the paired T-test.

### 2. Activities

During the class, students were asked to participate in two types of icebreaking activities: a verbal icebreaking activity and a non-verbal icebreaking activity. Both tasks included greetings and social exchanges between the local classroom participants and the remote participant.

We chose to divide the activities into verbal and non-verbal icebreaking tasks for several reasons. First, research indicates that people tend to communicate more with non-verbal language when they meet others for the first time in face-to-face communication [1-3]. Second, non-verbal communication has been reported as the limitation of telecommunication in previous mediated communication studies [7-9].

During the experimental classes, two researchers were observing and taking notes on the behaviors of the students participating in classroom. Also we collected video footages from one camera positioned in the classroom. The paragraph below provides more detail on each task:

1) *Verbal icebreaking activity*: Verbal icebreaking activities included exchanging greetings, introducing oneself by name, and asking for the other person's name. Also they asked each other where they lived, what animals they liked, what their favorite color was, and what cartoon characters they enjoyed.

표 1. 원격 화상과 로봇간의 비언어적 첫 만남 활동 비교.

Table 1. A comparison of the non-verbal ice-breaking activities in the video- and robot-mediated conditions.

| **Non-verbal icebreaking activity** | **Video** | **Robot** |
|---|---|---|
| Performing high-fives | Performing *high-fives* in the air towards camera in the right position as the child sees in the screen | Performing *high-fives* slowly with the hand of the robot. |
| Giving a hug | Hug in the air with you arm as if you were hugging your friend | Hug with the robot |
| Putting arms around each others | Put your arm in the air as if you were putting your arm around your friend | Put your arm the robot's shoulder |
| Giving postcard | Handed in to camera then teacher will take hand it to the participants | Handed in to robots arm |
| Hooking their pinky finger | Hook finger in the air in front of the camera | Hook finger with the robot |

The classroom teacher introduced the experimental activities by first telling students that they would meet a new friend from America and asking them to greet him by saying, "Hi" and asking, "What is your name?." Then teacher gave instructions to the students to take turns talking with remote participant shown on either the video display or the robot.

In order to facilitate the process promptly and complete desired tasks within the class period of 40 minutes, the conversational topic was provided to the students. Throughout the class, the teacher facilitated the conversation and language issues when Korean student had difficulty in English.

2) *Non-verbal icebreaking activity*: Non-verbal icebreaking activities included performing *high-fives*, giving a hug when they said good bye at the end of class, putting arms around each others' shoulders for a photo shoot, giving postcard to the remote participant, and hooking their pinky finger as a promise for the following meet-up. The remotely participating students were given instructions how to reproduce these physical actions in the classroom. Table 1 shows instructions given to the Korean students in the classroom.

### 3. Measures

We developed a questionnaire to measure the classroom participants' interest, empathy with media, and intimacy towards the remote participant as well as how they felt overall about this activity. Participants were given post-experiment questionnaires after the two classes. The questionnaire consisted of three parts: four-point scale (1- strongly disagree, 2- disagree, 3- agree, 4- strongly agree) questions, an emotional journey map, and several open-ended questions. The four-point scale questionnaire consists of a total of five items: two items on interest, one item on empathy with media, and two items on intimacy towards remote participant.

Establishing the external validity of the questionnaire, items were achieved by means of literature review of relevant articles [12,15-17] and collaborative work with a group of early childhood education experts, preschool teachers,

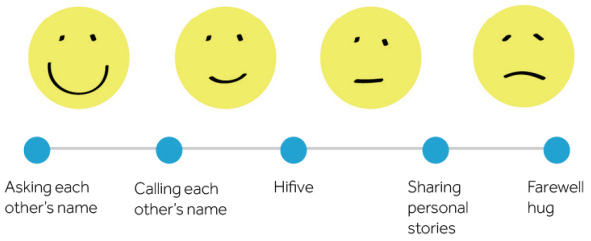


그림 2. 활동 타임라인에 따른 아동의 감정변화 표현 그래프.
Fig. 2. A Smiley scale and line graph given to students to mark their emotional response during activities.

educational technology engineers, and robotics engineers. The questionnaires that participants were given included following statements:

- meeting with Edward/Justin via video/robot was fun,
- I'd recommend my friends to try meeting friends via video/robot,
- I felt Edward was next to me,
- and I felt close to Edward.

It is methodologically challenging to measure perceptions of young children who generally have limited vocabulary to express their feelings or opinions, as well as, to accurately interpret the meanings of written scale descriptions. In our previous studies, we observed that children tend to select a middle point of 5 scales in the survey and prefer to use the face symbols. Thus we employed two approaches to address this methodological challenge.

First, on a four-point scale in the questionnaire, each point was represented with a smiley face (☺), a numeric value and textual information to increase children's accuracy of indicating feelings or opinions for each item asked. Second, in order to measure participants' emotions during the class, we designed emotional journey graph during the non-verbal activities. Following the four-point scale questionnaire, classroom participants were asked to mark their feelings in the choice of four faces; smiley face, subtle smiley face, neutral face, and sad face. Students were asked to pick one of the faces that represent their emotions best among four faces in the time of doing specific non-verbal activities written on the graph. We designed it as a four-scale questionnaire mapping: smiley face = 4, subtle smiley face = 3, neutral face = 2, and sad face = 1. Third, while classroom participants were answering the questionnaires, two researchers was there to explain the questions to help them understand the meaning of the questionnaire items and allow the children to ask questions if they did not understand certain meanings or terms. To control for response interpretations among the researchers, they were trained not to force the children to make any particular choices and remained neutral throughout the process. The researchers assisted the children only when they asked for help.

### 4. Procedure

This experiment was designed as a class activity. The teacher guided students in the classroom and moderated the conversations to give all the students time to talk with the remote participants. One of our researchers was with the remote participant at his home in the US during the study.

표 2. 실험 날짜별 참가자들 및 수업 조건.
Table 2. Participants and conditions.

| | | Day 1 | Day 2 | Day3 |
|---|---|---|---|---|
| **Remote participant (US)** | | Edward | Edward | Justin |
| **Classroom participant in classroom (Korea)** | **First medium** | Video | Robot | Video |
| | **Second medium** | Robot | Video | Robot |

Also the researcher informed the remote participants in advance about the experiment and their role in the study. The remote participants were given instructions to follow the scenario for the experimental class in advance. This included learning to talk looking at the camera and how to reproduce some non-verbal gestures, as well as the fact they needed to repeat the activity for several times with each students in classroom in Korea. The researcher and the participants practiced prior to the class. Each class was 40 minutes long and we had three days of experimental classes. Two classes were conducted in a row in one day and students were given post-experiment questionnaire right after the two classes were finished. In total 3 days and 6 experimental classes were conducted. Following Table 2 shows the detail of the experimental class.

### 5. Analyses

For data analysis, both descriptive and inferential statistics were used to analyze the collected data. Paired T-tests were conducted to examine whether there were any significant differences in the classroom participants' interest, empathy with media, and intimacy to the remote participant in the condition of video-mediated communication and robot-mediated communication. We used thePaired Wilcoxon signed-rank test to examine the difference of classroom participants' emotions in the class at the non-verbal communication since the data set was not normally distributed.

Due to the small sample size, we decided not to further break down the participants for comparing number of participation.

## V. RESULTS

The analysis of data from post-experiment questions and observation notes showed that classroom participants showed significant differences in positive emotions-- the robot was favored over video--and in interest and intimacy to the remote participant between the video-mediated communication and robot-mediated communication while no significant difference was not found in empathy with media as shown in Table 3. Although our results found no significant difference in Hypothesis 2 the mean of difference all showed negative showing that overall factor figure was high in robot-mediated communication.

Hypothesis 1 posited that classroom participants will show more interest in robot-mediated communication than video-mediated communication. Our results showed support for this hypothesis. We found that classroom participants showed more interest when they interacted with participants through

표 3. 요인별 집단간 차이 T-검정.

Table 3. Study results showing the difference in each factor.

| Factor | Video Mean (SD) | Robot Mean (SD) | Mean of difference | T | Df | p |
|---|---|---|---|---|---|---|
| **Interest** | 2.50 (1.1) | 3.0 (0.8) | -0.5 | -1.936 | 5 | 0.055* |
| **Empathy with media** | 2.83 (2.167) | 3.0 (1.6) | -0.1667 | -.0542 | 5 | 0.305 |
| **Intimacy to the remote participant** | 2.583 (1.242) | 3.167 (0.567) | -0.5833 | -2.907 | 5 | 0.017** |

the robot M=3.00, SD=0.80 than when they interacted with participants through the video M=2.50, SD=1.10, T(5)= -1.936, $p$= 0.055 (< 0.1) as shown in Table 3.

We found no support for Hypothesis 2, that classroom participants will show more empathy with media in robot-mediated communication than video-mediated communication. We found that classroom participants showed a slight more empathy with media when they interacted with participants through the robot M=3.00, SD =1.60 than when they interacted with participants through the video M=2.83, SD=2.17, T(5)= -.0542, $p$= 0.305 as shown in Table 3. We found no significant effects of medium or either video or robot on the participant's empathy with media.

Hypothesis 3 predicted that classroom participants would show more intimacy to the remote participant in robot-mediated communication than video-mediated communication. Our results showed strong support for this hypothesis. We found that classroom participants expressed more intimacy to the remote participant when they interacted with participants through the robot M=3.167, SD =0.57 than when they interacted with participants through the video M=2.58, SD=1.24, T(5)= -2.907, $p$= 0.017 (< 0.05) as shown in Table 3.

### 1. Emotional journey graph

The analysis of the emotional graph from the post-experiment questionnaire, in which classroom participants marked their feelings in the choice of four faces; smiley face, subtle smiley face, neutral face, and sad face. We found that classroom participants showed significant difference in emotions: the participants preferred robot at the time of sharing personal stories $W = -1.89 < W_{\alpha=0.05,5}$, $p$=0.03(<0.05). This result showed support for Hypothesis 4 that classroom participants would show more positive emotions in robot-mediated communication than video-mediated communication during at least one or more activities conducted in the class.

We speculate that proximity between classroom participants and remote participants on robot or video screen as well as the height of screen of video and robot might have influences on the participants response, as reported in previous robot-mediated communication studies (e.g., [5,6]) Communicating via robot, classroom participants had easy access to adjust their physical distance with the robot during interaction. The video screen in the classroom was installed on the wall higher than student's eye level while the robot was free standing providing 360-degree directional approach at eye level.

### 2. Open-ended questions

In open-ended questions of explaining which method among video and robot they would chose if they were to meet another new friend and the reason for their answers, five participant answered that they would choose robot and one answered that he would chose either one. The students who chose robot gave following reasons for their choice:

- because it moves,
- because it felt like really hugging,
- because they could touch the hand of the robot to high-fives,
- and because we can see the body whereas we can only see the face via video.

The student who responded that he would choose either explained that neither of them were 'that' fun**.**

### 3. Summary of Results

The results provided support for Hypothesis 1: classroom participants will show more interest in robot-mediated communication than video-mediated communication. We found no support for Hypothesis 2: classroom participants will show more empathy with media in robot-mediated communication than video-mediated communication. The results provided enough support for Hypothesis 3: classroom participants in classroom will exhibit more intimacy to the remote participant in robot-mediated communication than video-mediated communication. Classroom participants showed more positive emotion in robot-mediated communication than video-mediated in a certain activity during class, providing support for Hypothesis 4.

## VI. DISCUSSION

On the whole, the results suggested that classroom participants would be more interested in meeting people from different cultures if the remote participant were introduced via a robot-based communication medium rather than with video conferencing technology. The participants seemed to feel more positive, more familiar and less inhibited in interacting with the robot, which is consistent with what was expected based on prior literature review. Based on the previous research and our observation of the interactions that took place in the study, it seems likely that the robot-mediated communication is preferred because the robot gave the classroom participants more of a sense of the remote participants presence (e.g. the feeling like "hanging out."). Since the robot gave the remote participant more of a proportional and relatable use of space and embodiment, the robot embodiment made it easier for the classroom students to gage the interest and attention of the remote participant and to see who was being addressed when the remote participant spoke.

One key contribution of this study is the point that this research explored how children might respond to this application for robot-mediated interaction when novelty is no longer a factor. Since the classroom participants had regular interactions with the Robosem robot prior to this study, the effects have more to do with the use of the robot for this specific application rather than just the novelty of interacting with a robot itself.

### 1. Limitations

The study presented here has several limitations that may decrease the generalizability of our results. First, the number of participants for the study was relatively small. The study was conducted during summer vacation and there was 14 hour time difference between Korea and U.S. These factors made it difficult to gather a large number of students at the scheduled time for the study.

Next, the number of participants in the classroom may have played a role in the response of classroom participants that we didn't take into consideration during study. It is possible that the opinions of a vocal robot enthusiast could strongly sway the emotions of his or her fellow students in one direction or another. In further work, more sophisticated consideration of the role of individual participants would be developed to further disentangle these subjective effects.

Third, there is some variability associated with measuring the emotions of children, because they are young, less literate, and may not necessarily interpret all the points of the scale in the same way. Although we needed to keep our questionnaire short to accommodate the children's limited attentions span, in the future we would like to provide more redundancy in the measurement so that we could be more sure that the we were gaining a stable measure of the children's responses. In addition, we would like to code the behavioral interactions of the students so that we could gain additional measures without necessarily spending more time in interviews and questionnaires.

Lastly, it is possible that the responses of the classroom and remote participants were influenced by the choice of introductory activities we had them engaged in .during this study. While we tried to keep common activities for initiating connection among young people, a more open and naturalistic choice of activities could bring a different dynamic in interactions. Various activities, both verbal and non-verbal, should be explored to further increase the generalizability of our results.

### 2. Future Work

Further studies in this domain may increase the generalizability of our results by examining different activities of social interaction between local users and remote participants with a larger number of participants, with a wider range of activities, and over a longer period of time.

Although many aspects of this study—the setup, the interactions, the media—were well controlled, this study also had many features of a field study. The variability based on the individual students; the swings that one student, one comment, or one action might have on the whole activity; and the evolving nature of sentiment over the course of an initial meeting are challenging to even try to control. Nevertheless, we feel that this study points to the great promise that robotic technologies have in mediating communication, particularly when people are meeting for the first time. Additional work must also be done to further untangle how other aspects of communication might change the interactions between classroom participants and remote participants. Further work in non-verbal language, environment factors in robot-mediated communication, screen size, screen placement and installation may reveal additional factors that influence the design and use of robot-mediated communication.

## VII. CONCLUSION

We found that students in the classroom develop more interests and feelings of intimacy towards remote participants when they interact via the robot compared to traditional screen-based video conferencing. In addition, classroom students showed more positive emotions during certain activity via the robot in comparison to activity with the video.

This paper provides evidence that robot could improve the quality of social connection; particularly, in the case of cultural contact, by supporting non-verbal communication.

Our results highlight the potential of robots in playing a valuable role in distance communication and an educational potential of such communication. As a result, they provide students and teachers with a greater opportunity to explore a new learning environment through wider implications of robot-mediated communication.

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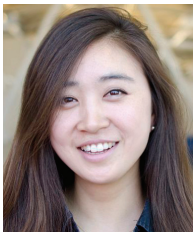

**김 누 리**

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