Deployment of a Social Robot into a Classroom of Remote Teaching by Elderly People to School Children: a Case Report

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***Abstract*— A humanoid robot combined with a classroom SNS (social networking service) was introduced into a classroom of remote teaching by elderly persons (aged 78, 83, and 91 years) to school children (aged between 12 to 15 years). The goal was to carry out an ethnographic participatory development of an education support system for elderly teachers and school children. The development formed part of a weekly club activity in an elementary school over the course of six months and consisted of iterating three phases (the experience, reflection, and implementation phases). Through this ethnographic participatory development, we aimed to reveal potential utility and issues in using a social robot combined with a classroom SNS to support remote educational activities between elderly people and children. In addition, the significance of leveraging elderly people in aging societies, especially in education, is highlighted.**

I. INTRODUCTION

Telecommunication technologies are becoming important tools for education. Not to mention standard video-conferencing, telepresence robots have been introduced in classrooms and other educational venues [1], [2], [3]. It is noteworthy that these technologies not only help existing teachers but also create new teachers. For example, senior people who are retired but have certain knowledge or skills can teach from their homes by using these telecommunication technologies. In fact, many schools in Japan invite local senior people to their schools for teaching purposes. In most cases, the senior people find this teaching experience rewarding, and the schools also benefit from having diverse classes. In aging societies, leveraging the knowledge and skills of senior people effectively is a significant social challenge. With telecommunication technologies, senior people become able to teach from their homes, reducing their physical burden in commuting to schools.

However, traditional video-conferencing has several limitations in its use for remote teaching. Particularly, in case of one-to-many teaching in which a remote teacher talks to multiple students in a classroom, the teaching tends to be one-sided, i.e., the remote teacher keeps talking and few question comes from the students side. As a consequence, the class becomes less active and students are going to get distracted. Telepresence robot was expected to provide a solution for this issue. The robot placed in the classroom side serves as an avatar for the remote teacher, presenting a real-time facial image with audio on a screen mounted on the robot. The remote teacher can operate the avatar robot so that it moves around the classroom. Due to its physical embodiment property, students can feel more presence of the remote teacher than the case with video-conferencing. Telepresence robots have been introduced into classrooms for educational purposes (Section II). The results overall show advantages over video-conferencing; however, it was also reported that sometimes the operation of telepresence robot could be troublesome for remote teachers, particularly for senior users [3]. This issue is essential for our target described in the previous paragraph. There have been made efforts in improving the user interface of telepresence robot, including cases targeting senior users [3]; however, they did not deal with remote teaching for children in classrooms.

Therefore, we decided to explore another approach of complementing video-conferencing by introducing an autonomous robot which supported remote teaching by senior people. The basic concept is to make use of physical properties of the robot and supplement the lack of physical presence of remote teachers, while maintaining the ease of the use of video-conferencing. Because we could not find existing knowledge about this style of remote teaching, we decided to conduct an exploratory study involving senior people and school children as well as school teachers. This paper documents the process of this participatory development that formed part of a weekly club activity in an elementary school in Japan, conducted over the course of six months in 2017. Through observations, we aimed to reveal important issues existed in this setting and discuss potential merits of using a social robot combined with a classroom SNS.

II. RELATED WORKS

The use of social robots for education has been actively studied in human-robot interaction and social robotics research fields [4]. Social robots can serve as teaching assistants [5], [6], [7], teachers [1], [8], facilitators [9], companions or peers [10], [11], [12], [13]. Most of these robots are autonomous robots. They have also been used as telepresence robots, remotely controlled by human operators, for educational purposes for children [1], [2], [14]. For elderly users, telepresence robots have been used to facilitate their collaborative works between remote locations, including learning activities about the use of tablet PCs [3]. For inter-generational use cases, a teleoperated android called Telenoid was successfully introduced to connect school children with elderly people including those with dementia [15]. Although in this study the elderly people did not act as

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teachers, it provided us with insights on the use of robots for intergenerational situations.

The recent growth of online communication technologies has led to the introduction of computer-mediated communication in education [16], [17]. SNSs and the use of tablet PCs were also studied to realize their effects on students' engagements in learning activities [18], [19]. However, at the same time, the real-world presence of teaching agents has been re-evaluated. Comparative studies between virtual and physical agents revealed several benefits of physical agents over virtual agents (we will discuss this topic in detail in Section V-D.2). A survey of 33 experimental works concluded that the physical presence led to positive perceptions and performance of learners [20]. Combining methods such as an SNS or a messenger with robot having physical presence [21] could provide further value with education.

III. Ethnographic Participatory Development

Following the background explained in the previous section, we decided to study the use of a humanoid robot combined with a classroom SNS to observe its potential utility to support remote teaching by elderly teachers to school children. Since we could not find previous attempts nor existing knowledge about this style of remote teaching, we opted for an exploratory study to gain a better understanding to clarify requirements by using an ethnographic participatory development approach.

Ethnographic methods have been employed with social robots for use in human society such as homes [22], companies or hospitals [23] or educational sites [24]. The main focus is on observing and understanding people's interactions with robots in detail "in the wild." To reflect stakeholders' opinions and suggested improvements to the system design, we incorporated a participatory design approach. Participatory design has also been introduced in the study of social robots [25], [26]. The approach we used followed the method proposed by [27], which comprised four elements of iterative prototyping: (1) identifying anticipated and desired change; (2) specifying anticipated change; implementing prototype/system; (3) exposing prototype to real use, enabling emergent and opportunity-based change; and (4) evaluating use, experienced change and fostering new desired change. On this basis, our approach involved iterating three distinct phases: an *experience* phase in which students experienced the system, which corresponded to the previously-mentioned element (3); a *reflection* phase in which they reflected on their experiences (elements (1) and (4)); and an *implementation* phase in which we improved the system (element (2)). The experience phase not only involved the students experiencing the system but also incorporated the ethnographic element of observing their behavior.

IV. Field Study

In 2017, we conducted a field study involving the ethnographic participatory development explained in the previous section at a junior high school in Japan.

A. Participants

14 students (two females and 12 males, aged between 12 and 15), one junior high school teacher, and three senior persons (aged 78, 83, and 91) participated in this study. The students were members of an after-school science club at the junior high school. This project formed part of the club's activities and was conducted weekly over the course of six months in 2017. The senior participants were recruited from a senior community called Smart Seniors Association in Japan. This association was established to promote "active seniors" who utilized the latest technologies as well as their skills and knowledge actively to participate in several activities in society even after their retirement. Before we started this field study, we conducted a pilot study [28] within the senior community and gathered their opinions for planning for this field study. Then, we recruited new three senior participants (who did not participate in the pilot study) for this study. They participated in this study from their homes. All the participants had no previous knowledge of robot technology or any prior programming experience. The study was approved by the ethical committee of University of Tsukuba (2015R109-3) and conducted based on informed and written consent obtained from the participants (for the students the consent was obtained from their parents). We also obtained informed and written consent for the publication of identifiable/non-identifiable images from the participants. If some of the participants have only given consent for use of non-identifiable images, those participants are de-identified in all publications.

B. Method and Procedure

In collaboration with the students, we first set a common goal: *Let's make a robot that makes remote educational activities enjoyable.* Specifically, we aimed to develop a robot system that encouraged students to participate in one-to-many remote educational activities involving senior teachers.

As explained in Section III, we used an ethnographic participatory development approach, based on [27]. This involved iterating three distinct phases: an experience phase, in which the students experienced the system; a reflection phase, in which they reflected on their experiences with it; and an implementation phase, in which we improved the system. We repeated these three phases twice in this study.

Since all participants had little programming experience, they were involved mainly in the first and second phases and left researchers to actually implement the system. To further enable the students to come up with novel ideas to improve the system during the second phase, we gave them opportunities to gain technical and robot programming experience during the study.

1) First experience phase: A remote educational activity via video calling and programming experience.: First, we conducted a one-to-many remote educational activity using a video calling system (Skype), in which a senior person taught the participating students. The goal was to make it easier for students to come up with ideas for the planned system based on their experience of an actual remote educational

Fig. 1. Exchanging ideas with students during the first reflection phase.

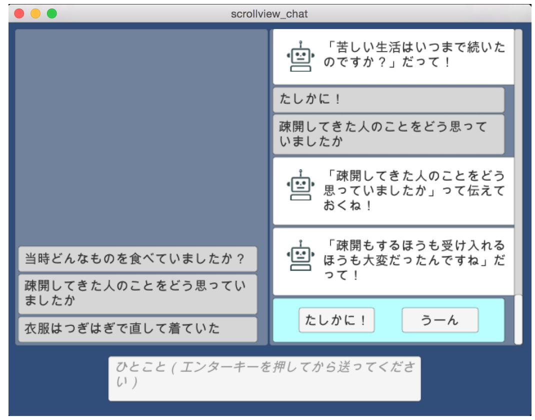

Fig. 2. Classroom SNS: The right side shows comments posted on a public timeline. The English translations from the top: "(Robot) A student is asking how long did the hard life last?," "Indeed!," "What did you think about those people evacuated?," "(Robot) A student is asking what did you think about those people evacuated?," and "(Robot) A student is commenting that both sides must have had really a hard time." The left side shows comments (notes) added by the current user. The English translations from the top: "What kind of foods did you eat during the wartime?," "What did you think about those people evacuated?," and "Clothes were all patchwork."

activity using an existing system. The subject of the remote class was to talk about the senior's war experiences[1]. For about 40 min, the senior talked to the students about his own war experiences over Skype. At this phase, no robot was introduced into the classroom. Instead, the first author of this paper acted as a substitute for the robot and participated in the lesson, talking to both the students and the senior. The lesson was recorded using a video camera for use in the following reflection phase.

After this lesson, we divided the students into groups of four or five and invited them to weekly sessions to experience robot programming for a month. This was to encourage them to gain experience with the robots and programming, making it easier for them to come up with specific ideas. For these sessions, we used Choregraphe, a robot programming tool provided by SoftBank Robotics. We distributed laptop computers with Choregraphe installed to each group and taught the students how to use it.

2) First reflection phase: Exchanging ideas with the students based on the first experience phase.: After the remote class, we exchanged ideas with the students while they were gaining programming experience during the first experience phase (Fig. 1). The goal was to identify problems with the remote class and generate system development ideas based on the experiences of the students who participated in the lesson. In conducting participatory research, it was important to create an environment where users could easily express their opinions [29], and therefore we first asked the students to speak openly about what they noticed while watching a video of the first experience phase.

This process identified that it was difficult for the students to express their opinions or ask questions during the lesson. They suggested that it was not enough to just listen to the senior's story and that a way to enable greater student participation in classes was necessary. To achieve this, they suggested taking notes during the lesson or distributing a tablet PC to each student so they could use them to ask questions. In other words, it was necessary to improve the communication between the students and seniors during lessons. In addition, the students felt that having a physical agent such as a robot involved in the lesson was a good way to keep their attention. They also felt that the agent should move around the classroom during the class and make remarks to deepen their understanding.

3) First implementation phase: Prototype robot system combined with a classroom SNS.: In order to improve the communication between the students and seniors, we developed a classroom SNS so that the students could freely express their opinions during the class. Then, so that the classroom robot could make remarks that deepened the students' understanding during the class, it (acting as an agent intervening in the class) read out the opinions that the students expressed using the SNS. Tablet PCs with the classroom SNS application installed were distributed to each student, and a humanoid robot (Pepper, by SoftBank Robotics) was deployed in the classroom. The classroom SNS's interface is shown in Fig. 2. On the basis of the students' suggestions from the first reflection phase, we implemented the following SNS functions: (1) comments were posted on a public timeline, visible to the other students (Fig. 2, right), and (2) notes could be added to comments (Fig. 2, left). To prevent students from chatting about other, irrelevant topics on the timeline, we also implemented the ability to (3) rate other students' comments on the timeline. Four main behaviors were implemented for the robot, which was linked to the classroom SNS: (1) moving around the students randomly; (2) reading out their comments on the timeline in order; (3) reading out the comments that were most highly rated by other students; and (4) asking students to put questions to the senior.

4) Second experience phase: Field tests using the robot linked to the classroom SNS.: Then, we conducted again field tests to obtain the students' opinions and observe their SNS activity and how they reacted to the robot's behavior. This tests involved three seniors talking about their most

[1]Currently in Japan, fewer people remain who have actually experienced the war, and schools sometimes invite senior people to hear their stories.

Fig. 3. Classroom environment.

Fig. 4. Environment on the senior's side.

memorable war experiences and what they wanted to pass on to current junior high school students. Three seniors took turns as teachers (one per day), talking with 14 students. The experimenter met with each senior in advance to discuss what they were going to talk about. As a guideline, the experimenter asked the seniors to discuss four topics in their lessons and to spend about 3 min on each one before asking the students if they had any questions. The experimenter also visited the school once before the activities took place to explain how to use the classroom SNS and how the robot would behave. Before each lesson, summaries of the stories that each senior was going to tell were distributed to the students, and they were also asked to prepare questions so that they could ask the seniors about as much as possible. Fig. 3 and 4 show images taken during the field tests. The robot was remotely controlled by an experimenter from an adjacent room. Each lesson took around 40 min, and then, the experimenter distributed an open-ended questionnaire composed of four question items[2] to the students. They filled out separate questionnaires on each of the three days. The experimenter also interviewed the seniors, either on the telephone or in person, on the day after the class. The interviews were conducted in unstructured ways by asking about the overall feeling of their participation to the tests and any difficulty they found during the tests.

5) Second reflection phase: Exchanging ideas with the students based on the second experience phase.: Three days after finishing the lessons, we visited the school to exchange ideas about the lessons with the children who participated. This was to find out how they felt about using robots for remote lessons and listen to their suggestions about both the system's merits and areas for improvement. We divided the students into three groups, distributed laptops with videos of the three days of lessons to each group, and explained that they were free to watch these videos during the discussion. The exchange of ideas took about 40 min. First, we made time for the students to think alone about the good points of the robot and areas for improvement and to write their ideas on tags. After that, they exchanged their ideas with the other members of their group using these tags. Experimenters also participated in the students' discussions.

[2](Q1) What did you think good/bad about the classroom SNS?, (Q2) What did you think good/bad about the robot?, (Q3) What was the teacher's story which you were interested in the most?, and (Q4) What was the teacher's story which was the most difficult for you to understand?

V. Results and Discussions

A. Feedback on SNS

On the questionnaires, most students commented positively about the system's usability concerning the classroom SNS: *(SNS-01) "I felt free to talk on the classroom SNS because it was anonymous," (SNS-02) "I was able to use it without any problems,"* and *(SNS-03) "I could ask more questions than usual."* These comments suggest that most students found the classroom SNS easy to use and felt free to express their opinions. However, there was a student who was not good at typing commenting that *(SNS-04) "Because I am not good at typing, it was hard for me to follow the senior's story."*

The SNS had a function of notes (the left side in Fig. 2). For that function, there were comments such as *(SNS-05) "Since I can save my opinion as a note, I can review what I wrote,"* and *(SNS-06) "I can take notes so I can adjust the timing to say my opinion from my notes."* The former comment indicates that the student appeared to use this function to record notes and use them for learning, and the latter comment implies that the student adjusted when they posted comments on the timeline based on what the senior was saying or other students' comments on the timeline.

About rating comments in the SNS, a student proposed that *(SNS-07) "I think it would be better to introduce someone to judge which comments to read out."* This could be a good role for students who were shy or did not speak out questions. We will discuss the idea in Section V-D.7.

The classroom teacher made an important observation as to an over-reliance on SNS in making questions: *(TEA-01) "Some of the students were not motivated to speak out. That may be because they felt that just posting comments to the timeline was enough."* Also, the teacher gave us an important comment to improve our system: *(TEA-02) "It's a pity that not all comments were sent to the remote seniors. Sometimes students can be shy and they don't have courage to speak their thought out even if they put many comments/memos in the SNS. I wish those students had a chance to speak* *out their comments/memos."* We will discuss this topic in Section V-D.4.

B. Feedback on Robot

Comments for the robot were divergent. The positive comments arising from the students' discussion of the robot part were as follows: *(ROB-01) "When the robot comes to a student's side it motivates them, so it is good that the robot roams around the students," (ROB-02) "The robot's walking gives the impression that it is somehow teacher-like," (ROB-03) "It was good that the robot could express things that were difficult to say,"* and *(ROB-04) "I could express myself more easily because the robot spoke instead of me."* When the robot spoke to the senior during the lesson, the students looked at the robot or the screen of the classroom SNS and then looked at the senior. In addition, they sometimes posted comments containing words from the senior's replies to the robot. The latter two comments indicate that the students were more active in expressing their opinions because they did not have to say them out loud.

On the other hand, the negative comments were as follows: *(ROB-05) "When I am surprised suddenly by something behind me, I am afraid that the robot is nearby,"* and *(ROB-06) "When the robot was moving around me, I couldn't concentrate on typing."* These comments indicate that the robot's presence imposed psychological stresses on the students.

During the second half of the third day's lesson (in the second experience phase), the robot called on two students by name. These students had not been told in advance that the robot knew their names, so the first student called was too surprised to ask any questions out loud. In addition, it so happened that, just before this student was called, the robot had read out one of their comments. As a result, this student commented that *(ROB-07) "Even though I had asked questions on the classroom SNS, the robot called me."* After this, the robot called on a student seated next to the first student. Although the second student seemed surprised, he soon asked the senior a question. Then, another student, seated next to the second student, raised his hand and voluntarily asked the senior a question. Regarding this "chain reaction" of making questions by multiple students, there were comments as: *(ROB-08) "It was effective in making it easier for students to speak out when there were a few different questions from the class,"* and *(ROB-09) "I felt a sense of tension."*

There was another comment related to tension/pressure students felt: *(ROB-10) "When I was gazed at (by the robot), I thought I'd be called and felt pressure."* About their feelings of tension/pressure, the classroom teacher commented that *(TEA-03) "Although the students were more surprised to be called on by a robot than by a human, I think the atmosphere become lighter. When it came to the children speaking, being seen by the robot was better than being seen by a human, because robots do not have emotions."*

Other comments, generally positive, expanded in the students' discussion were as follows: *(ROB-11) "This is good because students who have many questions but cannot ask them verbally can ask them more easily," (ROB-12) "No one knows who will be called, so it is thrilling and exciting," (ROB-13) "Because the remarks become closer to the computer, it increases the opportunity to speak oneself," (ROB-14) "It is good for classes where students do not speak much," (ROB-15) "Even when I encouraged students who put many questions in the notes to ask questions, they refrained. So it is better if the robot calls more students,"* and *(ROB-16) "I want the robot to call students more because that will show whether they are thinking or not."*

C. Feedback from Senior Participants

All senior participants expressed that they were very motivated to talk about their stories to the classroom students. However, two seniors commented that *(SEN-01) "Students were quiet,"* and *(SEN-02) "I anticipated more questions would come from students."* In fact, there had been many questions coming from the students. However, the seniors could not see all those questions but they could hear only a part of the questions (from Pepper) chosen by the system. We designed the system in that way because we thought that presenting all questions would be messy for seniors. *(SEN-01)* and *(SEN-02)* suggest that at least the system should have notified the seniors the number of questions came from the students. Another related comment, *(SEN-03) "I wish there were more oral questions"* pointed out a very important issue. It appeared that many students had been satisfied with asking their questions through the system, without speaking them out in front of the seniors. The classroom teacher mentioned exactly the same issue at *(TEA-01)*. In Section V-D.4, we will discuss this issue in detail.

Although not mentioned explicitly during interviews, it was observed that senior participants sometimes found difficulty in moving the lesson forward. It appeared that, due to the limited perception they had through a PC monitor and a speaker, they lost a feeling of "where they were" in the ongoing lesson. There were related comments such as *(SEN-04) "Hearing students' voices was still difficult"* and *(SEN-05) "I wish I had a clearer view of students."* In Section V-D.8, we will discuss potential solutions for these issues.

D. Discussions

1) The robot gave moderate tense and humor to the classroom.: The feedback comments show that the students overall found the robot effective for controlling the classroom's atmosphere. As raised initially in Section I, remote teaching using traditional video-conferencing tended to be one-sided, i.e., few question came from the student side and the students could easily become distracted. In contrast, both the students *(ROB-08)* and the classroom teacher *(TEA-03)* found introducing the robot valuable. The robot's calling on students was felt with a sense of tension *(ROB-09)* but received positively *(ROB-12) – (ROB-16)*. In the lesson, after the robot called on some students, it was observed that some students laughed and became active in participating in the lesson, involving other students. These comments and observed events show that this robot gave moderate tense and humor. The teacher's comment *(TEA-03)* also support this dual characteristics, implying that social robots could be used to control the classroom's atmosphere so that students can well participate in lessons.

2) The robot's physical properties mattered.: An important discussion topic in this study was about the physical properties of the robot. Studies had revealed that physical robots had several advantages in their uses for education compared with virtual agents. For example, physical robots increased cognitive learning gains [30]. For tutoring systems, physical robots yielded more compliance to the requests than a video representation of the same robot [31]. Physical robots elicited important social behaviors from humans in learning [32], and were more engaging and perceived positively than virtual agents [33]. A survey of 33 experimental works concluded that the robot's physical presence led to positive perceptions when compared with robots displayed on screens or virtual agents [20]. Because most of those studies were conducted in controlled laboratory settings, in this study, we were interested in finding evidence in real classroom settings.

Comments *(ROB-01)* and *(ROB-02)* directly concern physical properties of the robot. The students acknowledged the merit of the robot's approaching behavior towards them with respect to their concentration into the lesson. This is consistent with a social facilitation effect in which mere presence of others (robots) leads to an enhancement of simple task performance and to an impairment of performance on complex tasks [34]. In our case, the effect might have strengthened because the robot not only stood up but also was moving around on the side of the students and sometimes was approaching towards the students. In fact, the negative comments *(ROB-05)* and *(ROB-06)* also show a power of this approaching behavior, suggesting that the robot should have stopped its movement when the students were engaging in some specific tasks other than listening to the lesson.

Students often commented during the lesson that they were being gazed by the robot. The robot's gaze made students felt pressure *(ROB-10)*. As discussed in the previous section, both the students and the classroom teacher appreciated the moderate tense that the robot had offered to the students. The robot's gaze could be used for the purpose of keeping students' concentration. It could be used against students who get distracted or become sleepy. In fact, it was observed during a test that by combining the robot's gaze with its approaching behavior, a student stopped his chat and prepared for being called by the robot (Fig. 5). As suggested by the negative comments, *(ROB-05)* and *(ROB-06)*, because those robot behaviors can have strong influence on humans, they have to be carefully designed. For the robot's gaze, managing responsive control [35] was particularly required in our cases.

3) The robot triggered a bandwagon effect.: We made an interesting observation which related to a psychological phenomenon known as the bandwagon effect [36], in which people did something just because other people were doing it. On that day, during the time when the robot was moving around the classroom, the robot stopped by the side of a student, and called two students in a row in order. Then, another student who was seated on next to those two students voluntary raised his hand and asked a question to the senior. It appeared that the third student was encouraged by (or motivated to act the same way as) the previous two students, and also received some kind of pressure directed towards the student from the robot. This implies that the robot could utilize this bandwagon effect to stimulate students to speak through encouragement from students who were more likely to speak up. For example, to encourage a shy student, the robot could search nearby active students and call them first. It is unclear if this bandwagon effect requires the physical presence of the robot or not. From the impression we had during the field test, we hypothesize that the physical presence of a robot can be a significant factor. Follow-up studies are needed to gain further knowledge.

Fig. 5. The robot's gaze combining with its approaching behavior was particularly effective in getting students' attention.

4) Robots could facilitate human actions such as oral questions in the real world.: As mentioned in Section V-C, both the classroom teacher and senior participants preferred the students to ask their questions orally. In that sense, the system we tested was not good because it had made some of the students satisfied with posting their questions through the classroom SNS, without speaking them out to the seniors *(TEA-01)*. Depending on the situation, this tendency can be beneficial. In fact, such benefit due to anonymity had been discussed in computer-mediated communication (CMC) researches [37], [38]. However, in our situation, we have to note that both the classroom teacher and senior participants preferred the students to make oral questions.

On the other hand, we also had observed cases in which the robot facilitated the students' oral questions. Therefore, a role for robots which support remote teaching may be to facilitate these human actions (such as oral questions) in the real world which tend to be weakened in the setting of remote teaching. For example, by using the classroom SNS, the robot could identify students who potentially ask oral questions, and then "push" the students to speak out their questions. Sometimes students can be shy and don't have courage to speak out even if they post a lot of comments in the SNS. Judging from comments such as *(TEA-01)*, *(TEA-02)*, *(ROB-11)*, and *(ROB-14)*, both the classroom teacher and the students agreed that encouraging those shy students were important and the robot could trigger their actions.

5) Students' help on robots could enrich remote teaching.: There were situations in which students helped the robot. In one situation, due to a communication trouble between the robot and the SNS server, the robot stopped to read out a question to the senior in its middle. Then, some students helped the robot and read out the rest of the question. In another situation, the senior could not listen to the voice of the robot well and then students helped the robot by responding to the senior instead of the robot. It should be noted that in both of the situations, the students who helped the robot were different from the students who made the original questions. These spontaneous actions from the students made the classroom's atmosphere positive. It was reported that teachable/care-receiving robots could facilitate the learning activities of children [11]. As the teacher's comment *(TEA-01)* suggests, over-reliance on the system could discourage individual initiatives of students. The robot under discussion could become a unique educational agent which can offer moderate tense and humor serving as a teaching assistant, but sometimes as a peer for students.

6) Robots could be used as a sandbox.: There was another interesting observation we made in which a student who had posted a comment expressed in an impolite way in the first day changed his way of making questions (in more polite ways) after the second day. It appeared that when the student saw the robot speaking out the initial comment to the senior, the student felt guilty and reflected on his conduct. This observation brought us the idea of using the robot as a sandbox. In fact, most students want to know how to communicate with seniors politely. At the same time, seniors also want to know how to communicate with students effectively. By introducing a sandbox robot, they could test their messages by using the robot, see reactions, and improve/learn themselves. This idea is based on an assumption that people would not be so hurt by robots as by other people. If it stands, we could introduce a robot to fill generation gaps exist between young students and seniors.

At least, we could have let the students tune more parameters in the robot such as the rate, amplitude, and tone of speech. Then, the students could have improved their ways of speech against seniors. At the same time, a better intergenerational interface could have been obtained.

7) The classroom SNS served as a sensor.: There was a rating function in the SNS (each student could rate other students' comments). It turned out that this function had been mainly used by students who made few comments nor made any oral question. Perhaps those students were not good at speaking, either on the SNS or orally, and felt that rating other student's comments was an easier way to participate in the lessons. However, if the students rate positively on a comment, the comment could be used as a trigger for the students to participate in the lessons more actively. The robot could be observing those ratings and then ask for the students' opinions by referring to the question so that the students can participate in the lessons. Through our field tests, we had an impression that the classroom SNS had been serving as a classroom sensor, gathering information about students. The sensor could provide information about shy students, which might have been difficult to obtain from other sensors. Initially, we did not intend to design the classroom SNS for those purposes; however, now we realize that it should be designed with considering shy students.

8) Possible improvements for senior users.: Limited perception has been a major issue in video-conferencing especially for senior users [3]. This was also the case with our participants: *(SEN-04)* and *(SEN-05)*. However, it appeared that the voice of the robot was much easier for them to hear than that of the students. It was likely because the voice of the robot was more stable in its tone and also the speech was often clearer than that of the students. Nonetheless, as reported in Section V-C, sometimes the senior participants seemed to have lost a feeling of "where they were" during the lesson. As an approach to solve this issue, there could be another agent/robot introduced in the side of the seniors. Then, the robot could help seniors to move a lesson forward or tell them "where they were" in the lesson by showing a lesson script that was prepared in advance. Such an assistant robot could also help seniors in case they miss some voice sending from students. For example, the robot can repeat a question coming from the students. It might be even possible for the robot to translate some vocabularies of the students so that the seniors can understand well (and vice versa). Lastly, the robot could tell seniors the status of remote students. In remote teaching, sometimes it becomes not so easy to grasp the status of students compared with face-to-face teaching. If the robot can express, for example, the degree of the students' concentration on the lesson by the side of the seniors, they would have better perception of the students.

In case multiple seniors can participate in a lesson together (even from different remote locations), one of them could take care of controlling the robot that is deployed in the classroom. Then, the robot would be able to support the lesson from the viewpoint of the senior. During the lesson, the robot could bring its camera and microphone into a location in which seniors can have better perception. The robot could also support questions and answers from the senior's perspective.

VI. Conclusion

We reported a field study concerning an ethnographic participatory development on a robot system combined with a classroom SNS to support one-to-many remote educational activities between seniors and schoolchildren. The robot gave moderate tense and humor to the classroom, which potentially contributed to enrich remote teaching. We reported evidence to discuss that the physical properties of the robot mattered. In addition, we explained several implications we got from the study: the robot triggered a bandwagon effect, the robot facilitated the students' oral questions, the students helped the robot, bringing positive classroom atmosphere, and the robot could potentially be used as a sandbox to promote intergenerational communication. In conclusion, the robot could serve as an intelligent interface that fills generation gaps exist between young students and seniors.

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