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Robotic Question Support System to Reduce Hesitation for Face-to-Face Questions in Lectures

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Abstract

Encouraging students to actively ask questions during lectures is a formidable challenge that can be addressed through innovative use of information technology. We developed a robotic system that allows students in a lecture to collaboratively decide questions to be asked by a humanoid robot. To verify whether the system reduces hesitation to ask questions during lectures, 62 university students were divided into two groups, and each attended two different mock lectures on the Nobel Prize in Physics. The two lectures were conducted with and without the proposed system in counterbalanced order. Results suggested that students who were usually hesitant to ask questions during lectures became less hesitant to ask questions face-to-face when they could use the proposed system. Moreover, the perceived activeness in the lectures increased when using the system. Multiple regression analyses revealed that certain student actions, particularly tweeting and showing agreement with the questions posted by others, were correlated with increases in perceived activeness.

Keywords: human-robot interaction, question support system, education technology, audience response system, lecture participation support

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Introduction

In lectures attended by large numbers of students, encouraging students to actively ask questions is considered a formidable challenge. Asking questions in class has an important role in enhancing complex knowledge construction (A. King, 1994) as well as the ability to think critically (Gray, 1993). Psychological factors such as shaming can create hurdles for students who are reluctant to participate in classes (Crozier, 2005; Doyon, 2000; Lund, 2008; Qashoa, 2006). In particular, in schools in Japan and other parts of East Asia, the perceived in-class passivity of students is regarded as a problem (Harumi, 2011; J. E. King, 2011; Liu and Littlewood, 1997). The possibilities of using information and robot technologies to address such passivity problems have attracted the attention of researchers; for example, in trials, robots have been used as teaching assistants (Alemi, Meghdari, and Ghazisaedy, 2014, 2015; Hong, Huang, Hsu, and Shen, 2016; Kanda, Shimada, and Koizumi, 2012), tutors (Han, Jo, Jones, and Jo, 2008; Hashimoto, Kobayashi, Polishuk, and Verner, 2013; Saerbeck, Schut, Bartneck, and Janse, 2010), learning partners (Iio et al., 2019; Kory and Breazeal, 2014; Mazzoni and Benvenuti, 2015; Wang, Young, and Jang, 2013), and a schoolmate taught by students (Tanaka and Matsuzoe, 2012).

It has been reported that audience response systems such as Clicker promote the active participation of students by providing another means of asking questions or presenting ideas (Lantz and Stawiski, 2014; Mayer et al., 2009). However, there is a trade-off in using audience response systems: their simple interfaces limit the degree of freedom available to students for presenting questions or ideas, and reduces the flexibility of teacher-student communication. For example, Clicker, a device for selecting given options via clicking, only allows students to submit short, simple responses to the teacher. Although there exist other audience response systems with more complex input methods such as typing or flicking (Scornavacca, Huff, and Marshall, 2009), they have mainly been used for communication in the question-and-answer format, and still cannot flexibly construct the sequences needed for teacher-student communication. Further, it is sometimes difficult to prepare lecture content that enables students to participate in the lectures using an audience response system (Beatty, Gerace, Leonard, and Dufresne, 2006). Therefore, it is worth developing a novel system that enables students to freely compose their questions and also initiates seamless teacher-student communication that can dynamically cover a wider range of topics that interests them both.

Considering the following findings in the studies on virtual experiences (Kumazaki et al., 2019; Nishio, Taura, Sumioka, and Ishiguro, 2013; Rosenberg, Baughman, and Bailenson, 2013), encouraging active participation with response system is conjectured to provide merits not only in the current attendance but also in future one without it. Virtual experiences that simulate flying as a superhero virtual reality technology have been shown to promote prosocial behaviour in users (Rosenberg et al., 2013). When a user controls a humanoid robot via a teleoperation system, and the robot occasionally exhibits facial expressions without being prompted by the user, the feelings of the user are influenced to reflect the given facial expressions (Nishio et al., 2013). It was reported that adolescents with Autism Spectrum Disorders realized the importance of using gestures in communication after engaging in virtual communication experiences with an android robot, whose voice and gestures were controlled to mimic a role of an interviewer (Kumazaki et al., 2019). These studies imply that avatar or robotic technology can support enhanced communication experiences that change user behaviour to reflect a given behaviour. Therefore, by providing students a robotic system that allows them to freely present questions and ideas in class while sensing that they have contributed to the learning experience, the students are expected to change their behaviour to reflect the enhanced experience of active participation with the system; in other words, their hesitation to present questions and ideas in class is expected to decrease.

In this study, we examine an advantage of a robotic question support system, representing a brand new audience response system with which students can collaboratively present questions or ideas in class. With this system, students post candidate questions and ideas to be presented by a humanoid robot placed in the class. When a candidate receives a high number of votes or high agreement from other students, it is presented by the robot. Through such a democratic process, it is expected that the sense of contribution to the presentation of questions and ideas can be felt not only by the student who posted it but also by those who voted for it. A previous field study has shown that the robotic question support system can promote the presentation of questions and ideas via the system (Palinko et al., 2018; Shimaya et al., 2020). However, it is still unclear whether and how direct presentations of questions and ideas by students can be encouraged.

In this paper, we report the experimental results of mock lectures designed to investigate the effects of the system: specifically, we investigate whether contributing to the presentation of questions and ideas via the system reduces hesitation to the direct presentation of them without the system and promotes a sense of actively participating in the lecture. To enhance the sense of contribution, visual and haptic feedback is communicated to the interface device in order to inform students that their questions or ideas will be presented in the class. We invited two groups of approximately 30 university students and asked them to participate in two lectures: one with the proposed system and one without it. In the lecture with the system, the students could present their questions and ideas directly by themselves or via the system. In the lecture without the system, questions and ideas needed to be presented directly, without the system. Hereafter, questions presented directly by students are called direct questions, while questions presented via the system are called via-system questions.

We hypothesized that the hesitation to ask direct questions would be lower in the lecture with the system than the one without it. Hesitation was evaluated according to the number of questions asked, as well as subjective reports collected immediately after each lecture.

Method

Participants

Sixty-two first- and second-year Japanese university students were recruited and divided into two groups. Twenty-nine of these students were assigned to Group 1 and first attended an experimental lecture with the proposed system (hereafter referred to as the with-system lecture) and then attended another without it (hereafter referred to as the without-system lecture). The remaining 33 students were assigned to Group 2 and first attended the without-system lecture followed by the with-system lecture. Group 1 consisted of 14 males, 14 females, and one student who did not disclose their gender, while Group 2 consisted of 17 males, 14 females, and two students who did not disclose their genders.

Nine less-hesitant participants, whose ‘hesitation to question in daily lectures’ ratings were lower than the neutral level, were excluded from the subjective measure analysis because they were considered to have less need for the system. One participant who answered the questionnaire only partially was also excluded. The remaining 52 participants (26 in Group 1 and 26 in Group 2) were analysed. The average ages and standard deviations of the ages of the participants were 19.5 and 0.8 (min: 18, max: 21) in Group 1 and 19.4 and 0.9 (min 18, max: 21) in Group 2.

System

The robotic question support system consists of an interface device for posting candidate sentences to be spoken and for voting on posted sentences, and a humanoid robot that speaks the elected sentences. The interface device is used to run a Web application, and can be accessed from smartphones or personal computers via the target URL. Figure 1 illustrates the appearance of the interface.

To post a sentence to be spoken, a student inputs text in the text box and pushes the blue button labelled 'question button'. To post sentences intended to be shared among students, the yellow button labelled 'tweeting button' is pushed instead. The posted sentences are displayed in the interface in the order in which they were posted. The upper section of each post displays text information such as '<tweet>by you @ 2020-03-23 19:13:54,' which indicates the type of post (question or tweet), the proposer of the post, and the timestamp of the post. The proposer displays as 'you' if the sentence was posted by the user of the interface, and displays as 'unknown' otherwise.

The bottom section of each post contains a 'like' button to allow the student to show agreement with the posted sentence. The number next to the like button represents the number of students who agreed with the sentence. For sentences liked by the student, the number is displayed in red; otherwise, it is displayed in grey. The student can cancel his or her action of liking the sentence by selecting the like button again.

In this experiment, the robot could speak only when the lecturer approved it. The lecturer indicated approval by saying 'any questions'? For the simplicity and stability of the experiment, the timing of the approval was recognized by an experimenter. During the approved period, two sentences were randomly chosen from the top-five 'liked' sentences and spoken by the robot.

Although ‘liked’ tweets can be candidates to be spoken when the number of liked questions is less than two, tweets were not spoken in this experiment.

Before a sentence was spoken by the robot, the students who contributed to the content were informed that the sentence they posted or liked was going to be spoken. The interface of the student who posted the sentence displayed an alert message such as ‘Your posted question “Which physicist do you like the best?” was selected because 15 other students liked it’, and the vibrate function on their device was activated three times. The duration of one vibration was 500 milliseconds and the interval between vibrations was 200 milliseconds. The interface of a student who liked the spoken sentence displayed an alert message such as ‘Your liked question “Which physicist do you like the best?” was selected with 14 others also liked it’, and the vibrate function was activated in the same way as above.

A desktop-type humanoid robot called CommU (Vstone, Co. Ltd.)(Figure 2) was used as the robot for the system. CommU is 30 cm tall and has 14 degrees of freedom of movement to express natural, human-like movement in the upper body during conversations (two in the waist, two in the right shoulder, two in the left shoulder, three in the neck, one in the mouth, three in the eyes, and one in the eyelids). The robot speaks through a speaker in its chest while moving its lips synchronously. A commercial software product, AI Talk (AI Inc.), was used for Japanese text-to-speech synthesis. A voice model named *yuuto*, whose voice resembles that of a young boy, was selected in order to match the childlike appearance of the robot.

During lectures, when the robot received no sentence to be spoken, it randomly looked at the lecturer, the blackboard, the students seated on the left, and those seated on the right. The targets being looked at were switched every 6 - 10 s, and the probabilities of the robot looking at the lecturer, the blackboard, the students seated on the left, or those seated on the right were 20%, 60%, 10%, and 10%, respectively. Note that the positions of the targets were predefined. When the robot received a sentence to be spoken, the random gaze transition was stopped and the robot looked at the lecturer. It then raised its right hand and spoke the sentence. After two seconds of speaking, the robot lowered its hand. After 20 seconds of speaking, it restarted the random gaze transition.

To encourage the audience to ask direct questions, in this experiment the robot started to speak a sentence ten seconds after the lecturer said ‘Any questions’? If an audience member asked a direct question within 10 seconds, the robot waited for the next opportunity, i.e. ten seconds after the next time the lecturer said ‘Any questions’?

Apparatus

The lecture scene in the experiment is shown in Figure 3. The experiment was conducted in a standard lecture room at the Graduate School of Engineering Science, Osaka University; the room is approximately 15 [m] x 9 [m] in size. Sixty% of the lecture content had been written on the blackboard. The remaining 40% was added during the lecture. The CommU robot was placed on a table between the participants’ seats and the blackboard. The posted and elected questions from the participants were sent to the robot, and spoken by it. The lecturer was positioned in the same region. Informed consent documents, questionnaires, and the interface devices were placed on the long desks in front of the participants’ chairs before the participants entered the room. ASUS ZenFone Max (M2) smartphones were provided to the participants. They were connected to the server of the proposed system via Wifi. The Wifi environment was constructed using a strong Wifi router with mesh Wifi devices to ensure excellent throughput. The messages sent from or to the smartphones were logged with the user ID, the message type (i.e. question, tweet, or like from participants as well as feedback from the system), the message text, and the timestamp of the message. Video cameras were placed in the front and back of the room to capture the behaviour of the participants and the content from the lecturer, respectively.

Procedure

The experiment was conducted after approval from the Ethical Committee of the Graduate School of Engineering Science, and written informed consent was obtained from all participants prior to the experiment. The experimenter explained the procedure and the rules for behaviour in the experimental lectures. The participants first answered a pre-experiment questionnaire and attended two lectures approximately 40 minutes in length, including Q and A sessions. Immediately after each lecture, they answered a post-lecture questionnaire. The participants read all questionnaire items before the first lecture session. With-system and without-system lectures were conducted, and their order was counterbalanced. Namely, participants in Group 1 first attended a without-system lecture followed by a with-system lecture, while those in Group 2 first attended the with-system lecture followed by the without-system lecture. Before the with-system lecture, the experimenter explained the usage of the system and allowed participants to attempt to use it. Before the lecture, the experimenter ensured that all participants could log in to the Web page for the interface and post test questions. For analysis purposes, the user IDs corresponding to the seats were assigned to the participants.

In both lectures, a lecturer provided an introduction to physics by discussing the Nobel Prize. The lecturer was Mr. Yobinori Takumi, a well-known Japanese lecturer who actively uploads educational material to YouTube to explain such content to general populations of college students. In the first lecture, ten studies that received Nobel Prizes from 1901 to 1910 were described, while nine such studies from 1911 - 1920 were presented in the second lecture. In each lecture, Q&A sessions on the previously discussed Nobel Prize studies were inserted approximately every 10 minutes. The lecturer began the Q&A by saying ‘do you have any questions’? The Q&A sessions ended after approximately three minutes.

The participants were informed that they would attend two approximately 40-minute lectures on the Nobel Prize for the experimental purpose of investigating how the proposed system was used during a lecture. The experimenter explained that they could ask the lecturer questions at any time during the lecture. In addition, for the with-system lecture, the experimenter explained the following rules:

- The participants could ask the lecturer any questions at any time during the lecture, even in the with-system lecture
- They could post or vote on questions and tweets at any time during the lecture
- In the Q & A sessions, the robot would randomly choose two questions from the posted questions receiving the many votes, and would use its speech capabilities to ask the questions
- In the Q & A sessions, if only a few questions had received large numbers of votes, the robot might instead convey tweets receiving high vote totals
- The posted questions and tweets were erased after the Q and A session.

Measurement

Behavioural measure. As a behavioural measure, instances of the following behaviours were counted:

- Number of direct questions
- Number of questions, tweets, and likes submitted via the system

The direct questions were counted from the video of the lecture, while the via-system questions, tweets, and likes were counted from the operation interface log.

Subjective measure. As a subjective measure, the answer scores of the following items were obtained from the post-session questionnaire:

- Hesitation (You hesitated to ask direct questions during the lecture)
- Activeness (You actively participated in the lecture)
- Interest (The lecture was interesting)
- Understanding (The lecture was understandable)
- Usefulness of the direct questions[/the via-system questions] (The direct questions[/the via-system questions] were useful in making the lecture understandable)
- Nuisance of the direct questions[/the via-system questions] (The direct questions[/the via-system questions] caused nuisance)

In addition, the following item was included in the pre-experiment questionnaire:

- Daily hesitation (You hesitate to ask questions during lectures in your daily life)

All items were answered using a seven-point Likert scale (1. I strongly disagree, 2. I disagree, 3. I slightly disagree, 4. Undecided, 5. I slightly agree, 6. I agree, 7. I strongly agree)

In addition to the evaluation by participants, the lecturer also evaluated the following aspects of the lecture after each session:

- Lecture quality (You conducted a good lecture)
- Student activeness (The students were active during the lecture)
- Usefulness of the student direct questions[/the student via-system questions] (The direct questions[/the via-system questions] from the students were helpful in facilitating your lecture)

These items were also answered with the same seven-point Likert scale as described above.

Results

Behavioural measure

The via-system questions were presented twice during every Q&A session in the with-system lectures. No direct questions were asked in the with-system lectures, while one was asked in the without-system lectures. Specifically, one direct question was asked in the without-system lecture for Group 2. Although the participants were allowed to ask direct questions outside of the Q&A session as long as they did so without the system, none did.

Subjective measure

The mean answer scores of each questionnaire item were compared using paired t-tests (see Table 1). The mean score of 'Hesitation' was significantly lower in the with-system lectures (M=5.3, SD=1.5) than in the without-system lectures (M=5.8, SD=1.2) ($p=0.038$). The mean score of 'Activeness' was significantly higher in the with-system lectures (M=4.8, SD=1.3) than in the without-system lectures (M=4.2, SD=1.6) ($p=0.014$). No significant differences were shown in the mean scores of 'Interest' or 'Understanding'. Mean scores, their standard deviations, and the results of paired t-tests for each questionnaire item are listed in Table 1.

The impressions ('Usefulness' and 'Nuisance') of the via-system questions were compared with the neutral level 4. The mean score and standard deviation of 'Usefulness of the via-system question' were 5.2 and 1.5, respectively. The one-sample t-test showed that the mean was significantly higher than the neutral level ($t(51)=6.01$, $p<0.0001$, $r=0.64$). The mean score and standard deviation of 'Nuisance of the via-system question' were 3.1 and 1.5, respectively. The one-sample t-test showed that the mean was significantly lower than the neutral level ($t(51)=4.17$, $p=.00011$, $r=0.50$). The impressions of the direct questions were not analysed because very few were asked.

The mean scores of the lecturer’s self-evaluation on ‘Lecture quality’ were 5.5 and 5 for the with- and without-system lectures, respectively. The mean scores of ‘Student activeness’ as rated by the lecturer were 5 and 2 for the with- and without-system lectures, respectively. The mean score of ‘Usefulness of the student via-system questions’ was 6.5.

Discussion

The results showed decreased hesitation in asking direct questions and increased activeness during the with-system lectures. Thus, the hypothesis that ‘hesitation in asking direct questions will be less in lectures with the system than in those without it’ was supported in the subjective measure. It is regarded that students in the with-system lecture felt that they had actively participated in the lecture and could have had self-confidence to do so even without the system. The latter is consistent with previous findings stating that experiences enhanced with a robot change the user’s mental state to reflect the behaviour of the robot (Kumazaki et al., 2019; Nishio et al., 2013; Rosenberg et al., 2013). This experiment suggests that such a change could occur not only when users operate a robot alone but also when they do so as part of a group.

On the other hand, because few direct questions were asked regardless of lecture type, it is unclear whether the system would contribute to actual behaviour change. The previous field study that tested a prototype system during lectures on a different topic, namely the introduction of recent advances in robotics, obtained approximately 10 direct questions (Palinko et al., 2018). Perhaps it was easier for students to relate a lecture on the recent advances in robotics to everyday life than one on the history of physics. It is also possible that, during the experimental lecture, the participants felt less necessity and curiosity, which are supposed to be felt to a greater degree in lectures in their daily school lives or those on more casual topics; thus, the motivation to ask questions may have been lower than in the previous field experiment. Extending the system to support students in relating lecture content to their potential interests is a possible and important future study topic.

Participant impressions of the via-system questions suggest that these questions did not interfere with the lecture, and were useful in deepening their understanding of the lecture. In addition, the ‘Interest’ and ‘Understanding’ of the with-system lecture were not significantly lower than those of the without-system lecture. On the other hand, the lecturer rated the with-system lecture relatively highly in terms of quality and student activeness. He also felt that the with-system questions were helpful in facilitating the lecture. The with-system lecture was positively evaluated by both the lecturer and the students. The results motivate us to move to the next step, which will involve verifying the usefulness of the system in an actual educational setting.

In order to examine how the system influences changes in the mental states of users, multiple regression analyses using the backward-forward stepwise method were applied, using the amount of change in ‘Hesitation’ and ‘Activeness’ as the dependent variables. The independent variables were the numbers of times system actions such as ‘question’, ‘tweet’, ‘like for question’, and ‘like for tweet’ were logged, and the number of chosen sentence that one posted or liked (i.e. the number of times feedback was received from the system). Table 2 shows the correlation coefficient of each independent variable, standardized partial regression coefficient (SPRC), squared multiple correlation coefficient (R2), adjusted-R2, and total F-value of the stepwise multiple regression when the dependent variable is the amount of change in activeness. The numbers of ‘tweet’ and ‘like for question’ actions are significantly correlated with the amount of change in ‘Activeness’ (adjusted R2=0.3279, $p<0.0001$). The variance inflation factor (VIF) between ’tweet’ and ’like for question’ was 1.07, which was less than 10.

This implies that there was no multicollinearity. The SPRC of ‘tweet’ and ‘like for question’ were both significant at 0.169 and 0.168, respectively. That is, students who invoked the ‘tweet’ and ‘like for question’ actions more often tended to evaluate themselves as relatively more active in the with-system lecture than in the without-system lecture. Our results suggest that even actions that do not directly result in robot speech, such as ‘tweet’ and ‘like for questions’, can contribute to enhancing a sense of participation. Identifying the cognitive processes that exist between these actions and the user’s mental state is an important step in developing more effective systems.

Limitations

It is not clear whether the enhanced participation was caused by the presence of the robot or by the use of the interface, or whether it was caused by a combination of these. Previous research showed that when a robot operated by a third person is included in a dialogue between humans, the amount of dialogue increases (Kim et al., 2013). This implies that robots have the ability to activate human-human conversation. In this experiment, there were scenes in which the robot's comments prompted the participants to laugh and send tweets expressing familiarity with the robot's behaviour. The robot's behaviour and presence itself may have contributed to the ease of asking face-to-face questions.

Concerns about being negatively evaluated by others and lack of confidence in the content of questions are considered to be the reasons for Japanese university students to hesitate in asking questions during lectures (Akita, 1995). On the other hand, being able to check others' posts and likes in advance through the operation interface can reduce the uncertainty of other participants' responses. Thus, the operation interface itself reduced concerns about negative evaluations and increased the ease of asking questions without the system. Therefore, further experiments are necessary to distinguish between the effect of operating the robot and the effect of communicating via the interface.

These results were obtained from mock lectures on the Nobel Prize in Physics, attended by approximately 30 first- and second-year university students. It is unclear to what degree the participant group size, participant characteristics, and lecture theme influenced the effects observed in this experiment. In addition, because all participants were new to the system in this experiment, the effects of using it for longer periods of time were not examined. Conducting long-term experiments involving a more varied field of participants and lecture themes are important future work.

Conclusion

We developed a system that enables multiple lecture attendees to collaboratively select sentences to be spoken by a robot, with the goal of enhancing lecturer-student communication. We conducted an experiment to verify that the system can reduce the hesitancy to directly present questions and ideas during lectures. The results of a mock lecture experiment suggested that students who were usually hesitant to ask questions during lectures became less hesitant to ask questions face-to-face when they could use the system. Moreover, the perceived activeness in lectures was increased with the proposed system. As the effect on behavioural aspects was unclear in the experimental setting of the study, it is worth extending the system to support students in finding questions to be asked. Further, future work should be dedicated to clarifying the cognitive model behind student participation engendered by the system, and testing the system in actual educational environments.

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Conflict of Interest

The authors have no conflicts of interest directly relevant to the content of this article.

Ethical Statement

In this study, ethical approval was received from Graduate School of Engineering Science, Osaka University.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Practitioner Notes

What is currently known about the subject matter

- In-class student passivity is a widespread problem at many schools in East Asia.
- Information and robot technologies have focused on addressing student passivity.
- Existing audience response systems are supportive but with limited degrees of freedom.
- It is unclear how these systems can encourage face-to-face student interactions.

What their paper adds to this

- We developed a system for in-class students to ask questions collaboratively via a humanoid robot.
- Japanese undergraduates attended two experimental mock lectures with and without the proposed system.
- Hesitant students felt less hesitation asking questions face-to-face in class with our system

The implications of study findings for practitioners

- Significant effects of the robotic system on lecture participation are shown.
- In particular, it can encourage hesitant students to actively participate in class
- Lecturer-student supported communication expected to promote experiences without it.
- Experiments in real educational settings are recommended to verify system usefulness

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Table 1

Comparison between the questionnaire scores from the with- and without-system lectures: The mean and standard deviation (SD) of the scores from each lecture type, t-value (t), the degree of freedom (df), p-value, and effect size (r) of the paired t-test

	with-system		without-system		paired t-test			
	mean	SD	mean	SD	t	df	p	r
Hesitation	5.3	1.5	5.8	1.2	2.12	51	.038	0.29
Activeness	4.8	1.3	4.2	1.6	2.54	51	.014	0.34
Interest	6.0	1.2	6.0	0.9	0	51	1	0
Understanding	5.7	1.2	5.8	1.0	0.40	51	0.69	0.06

Table 2

Shown are the correlation coefficient of each independent variable, standardized partial regression coefficient (SPRC), squared multiple correlation coefficient (R^2), adjusted-R^2, and total F-value of the stepwise multiple regression when the dependent variable is the amount of change in activeness

			Results of multiple regression analyses with the stepwise method		
Independent variable	Correlation coefficient	SPRC	R^2	adjusted-R^2	Total F-value (df=(2,49))
tweet	0.483	0.169**	0.354	0.328	13.44***
like for question	0.463	0.168**			
question	0.403	-			
like for tweet	0.401	-			
feedback	0.276	-			

Notes. df = degree of freedom

** $p < .01$, *** $p < .001$

名前: jiro, ルーム名: test2

残り60字

質問や呟きを入力(最大60文字)

<呟き> by you @ 2020-03-23 19:13:54
おなかすいた
0

<呟き> by unknown @ 2020-03-23 19:13:04
アインシュタインはどうして相対性理論を思いついたのかな
1

<質問> by unknown @ 2020-03-23 19:12:38
先生が好きな物理学者は誰ですか
1

<質問> by unknown @ 2020-03-23 19:12:26
こんにちは
0

Figure 1. Interface of the robotic question support system.

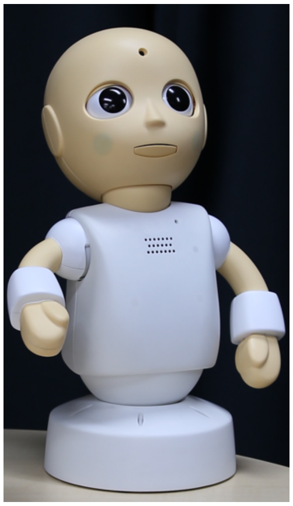

Figure 2. A desktop sized robot CommU.

Figure 3. The scene of the lecture in the experiment.