



Fig. 1. Photos of Ifbot

lids and neck are controlled by motors, while the mouth shape, eyes, and cheek color are expressed by LEDs, to express various emotions. In this study, nodding is carried out by the neck movement, and verbal hints are given through a built-in speaker.

The Ifbot is remotely controlled in this study by the Wizard of Oz method [16, 17]. In this method, an operator pretends to be the system and carries out conversations or otherwise interacts with the user by a remote control. Although it is easy to implement the control of giving hints and nodding to the robot, it is difficult to properly respond to the learner's questions during learning sessions. Thus, the Wizard of Oz method is adopted, in which the robot does not initiate conversation; instead, the operator selects the robot's verbal responses from those presented in Table 1. It is possible to place the robot in the learning environment without making the learner feel self-conscious by having the robot only responds to the user's utterances and to unify the actions other than giving hints and nodding by avoiding general conversations.

2.2. Use of hints

The Ifbot gives hints to support learning in expression education. The hints must consist of verbal suggestions that stimulate the imagination instead of direct solutions or directions on specific tasks. Thus, the hints are selected by the following procedure. First, five people who did not participate as learners in the present study were recruited in advance, and asked to respond to a questionnaire. They were asked to freely associate from the learning contents of expression education. The minority views among the responses, i.e., hints that are not easily associated, were extracted from the selected hints. The hint selection process was very rigorous and involved multiple researchers in order to confirm and discuss the contents. The learners' imagination can be stimulated by adopting hints that are less easily associated. Hirai et al. [18] divided the learners into two categories: those playing the instructor's role and those playing the learner's role. They observed the manner in which the learner paired with an instructor to tackle a problem, computed the average utterance frequency among pairs who solved the problem, and found that it was 6 min and 30 s. In their experiment, the learner

Table 1. Verbal responses of robot. The name of the learning activity entered in the table in question format [activity name].

Amazing.	Try to think.
It is amazing.	Please try thinking.
That's realistic.	I don't know.
It's cool.	What do you want?
That's cute.	Who knows?
Very nicely done.	I wonder what that is.
You're fast.	I wonder if it is.
You're good.	What's that?
That's wonderful.	Which one?
That's great.	It's for having on hand.
You have good taste.	It's for riding.
That's kind of.	It's for standing.
It's getting better.	It's for listening.
I see.	It's for a sport.
Oh.	That's a tool.
They're in the 2nd and 4th boxes.	Well.
They're in the 2nd and 6th boxes.	Ummm.
They're in the 2nd and 7th boxes.	Right.
They're in the 2nd and 9th boxes.	Uh-huh.
They're in the 4th and 15th boxes.	Yup.
They're in the 5th and 7th boxes.	That's it.
They're in the 6th and 14th boxes.	That's right.
They're in the 8th and 11th boxes.	All right.
They're in the 9th and 15th boxes.	It's fine.
They're in the 14th and 15th boxes.	OK.
It's [task name].	

consults with the instructor when he or she encounters difficulties such as a compiler error or execution error during programming. Encountering difficulty in our present task, that is, in expression education, was thought to be the mind "going blank" when the learner is producing a work. The condition whereby the "mind goes blank" is thought to occur under two conditions: 1) when the learner cannot come up with any ideas on what type of work to produce, and 2) when he or she relies excessively on instructions to produce work. Thus, in order to avoid two conditions, i.e., either no instructions or too many instructions, we felt that proper support can be given by offering hints rather than consulting with the instructor. Based on the results of study by Hirai et al., we set the interval for giving hints at 6 min and 30 s.

2.3. Nodding

The Ifbot nods to evaluate (i.e., express approval) in expression education. Non-verbal communication can be classified into 1) emblem, 2) illustrator, 3) affect display, 4) adapter, and 5) regulator [19]. An emblem is a gesture that replaces words. An illustrator is a gesture that emphasizes a verbal utterance. An affect display expresses emotions. An adapter is a gesture that is associated with the situation. A regulator is a gesture that adjusts or controls the flow of conversation or other forms of communication, such as encouraging the partner to say something.

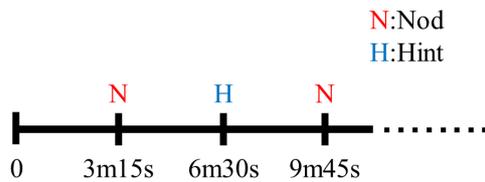


Fig. 2. Timeline of nodding and presentation of hints

For example, nodding (gestural response) and eye movements are regulators. We believe that the learner feels that he or she is being evaluated when the Ibot nods during learning, which contributes to increasing learning motivation or reinforces the support given by hints. Since the robot's nodding motivates the learner to learn, it can be considered to be a regulator.

The nodding action is realized by making the robot's neck move in the pitch-axis direction forward and back twice in a 1-s period. The mechanical sound accompanying the nodding is sufficiently small to avoid causing any problems to the learner during the task. The nodding takes place between hints. The interval between nods is set at 6 min 30 s, the same as the hints, with the first nod taking place 3 min 15 s after the experiment starts. Thus, the nodding gestures and hint-giving alternate as shown in Fig. 2. By alternating the nodding and presentation of hints, we believe that the learner feels that he or she is being evaluated with respect to 1) the act of producing work based on hints, and 2) the self-initiated thinking and act of engaging in producing work without the use of hints, which thus leads to raising the learning motivation. Thus, the nodding serves to express understanding and evaluation of the learner's production process whether or not the hints are used. Moreover, by alternating the nodding gesture and the presentation of hints, the nodding serves the function of an independent regulator apart from the hints.

3. Experiment

3.1. Objective of experiment

The experiment was conducted to verify the validity of implementing nodding and giving hints to the expression education support robot.

3.2. Experiment method

LEGO Story Starter, shown in Fig. 3, was used as the teaching material.

LEGO Story Starter was developed to improve the communication skills of learners. Educational institutions often conduct expression education by using the curriculum attached to LEGO Story Starter. Five of the LEGO production problems that provided with LEGO Story Starter were selected as the learning activities in the present experiment (Table 2).

In this learning activity, the human who plays the role



Fig. 3. LEGO Story Starter

Table 2. Learning tasks

Free the Tree
Viola the Volcano Pops
Winter Wonderland
A Super Stadium
Breaking Out News

of instructor, or the Ibot, and the learner are seated facing each other. The instructor, or Ibot, gives hints to the learner when the latter is working on the activity. We selected a person who had never met the learner previously for the instructor's role. He or she was trained to carry out the same gestures as the Ibot. Six hints were given while the learner was working on an activity. For instance, the hints given for the first activity "Free the tree" are presented in Table 3.

The first two hints are technical ones. They teach the basic possible combinations of LEGO blocks to minimize the difference in experience with LEGO blocks among learners. The block numbers in the table correspond to those shown in Fig. 3. Each box contains blocks with similar shapes or uses, and it is possible to make a specific object, such as a person or tree, by combining blocks from different boxes. Attention was given to avoid providing a direct solution when providing technical hints.

The learners consisted of 40 students (39 males and one female, age range: 18–23), who were divided into four groups: The first group has a robot that gives hints (Robot with Nod with Hint: Rw/Nw/H). In the second group, the robot is present but does not give any hints (Robot with

Table 3. Hints for first learning task: "Free the Tree"

Hint number	Hint
1	A human can be made of bricks in the 8th and 11th boxes.
2	A tree can be made of bricks in the 14th and 15th boxes.
3	I wonder if money can be used to protect the tree.
4	I wonder what happens if harmful things are thrown away.
5	I wonder if the tree is worth anything.
6	I wonder if anything will change if you recycle.

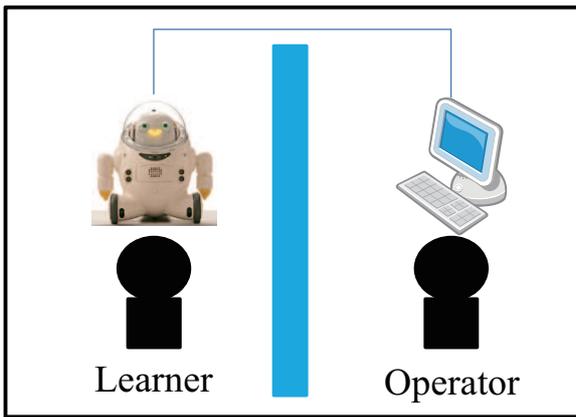


Fig. 4. Experiment setup with a robot instructor



Fig. 5. View of experiment with robot instructor

Nod without Hint: Rw/Nw/oH). The third group has a human instructor that gives hints (Human with Nod with Hint: Hw/Nw/H). While in the fourth group, a human instructor is present but does not give any hints (Human with Nod without Hint: Hw/Nw/oH). Each group consists of ten learners that are randomly selected. The Ifbot nods for both the groups that use the robot as an instructor. The data in our previous study [6] was used to represent groups in which the robot or human instructor does not nod (Rw/oNw/H, Rw/oNw/oH, Hw/oNw/H, and Hw/oNw/oH). Note that there is no overlapping between the learners in the present study and those in the previous study. However, the experiment procedure is the same as in the previous study [6]. The experiment was conducted during a single 1-h session on a weekly basis over a five-week period (i.e., making up five sessions in total). For each activity, the final hint was given 39 min after the session had begun. For each activity, the final hint was given 39 min after the session had begun. No nodding or hints were given thereafter; however, the comments (listed in Table 1) were offered whenever necessary, thus creating an environment in which the learner thinks on his or her own.

3.3. Experiment environment

The experiment was conducted university in classrooms. A schematic illustration of the experiment setting is shown in Fig. 4. The classroom was divided by a partition so as to produce a one-to-one learning environment. Figures 5 and 6 show photos of the learner participating in the experiment in which he appears in a one-to-one situation with the robot and human instructor, respectively. The robot operator and the control computer are thus hidden behind the partition and cannot be seen by the learner.

3.4. Evaluation criteria

Two of the activities provided with the LEGO Story Starter were not chosen as learning activities (activity A: “Circus S’cool” and activity B: “Come on Campfire”), however, they were used as advance and follow-up activities, to be done by the learner on his or her own (i.e.,



Fig. 6. View of experiment with human instructor

without the Ifbot or instructor present). Half of the learners were given activity A as the advance activity and activity B as the follow-up activity, and the other half B as the advance and A as the follow-up activity. The produced pieces were photographed and used in the evaluation. The photos of each piece were taken from eight directions: four from the sides and four from an oblique angle above the piece, as shown in Fig. 7.

The evaluation was carried out by twenty evaluators (20 males, age range: 18–23) who did not participate as learners. First, photos of the 80 pieces (40 advance and 40 follow-up pieces) that produced by the learners were presented one at a time in random order to the evaluators, who graded the “degree of completion” of the piece in a scale from one to five points according to the Likert scale (raw score). “Degree of completion” refers to how successfully the assigned activity has been completed. Next, the scores rated by each evaluator of the ten learners in each group were added up (total score). The maximum and minimum total scores are 50 and 10, respectively. Then, the difference between the total scores for the advance and follow-up activities for each group was obtained, and the average for each group was calculated.



Fig. 7. Example of a produced piece

The difference can range from zero to 40 points. The score difference was used as the evaluation criterion for the effect of learning. This evaluation criterion is similar to our previous study [6]. After the completion of the follow-up activity, the learners were interviewed about their views or impressions of the human instructor and the robot. The questions “how was it to work under the eyes of the robot (or human instructor)?” (Item 1) and “what is your impression of the robot (or human instructor)?” (Item 2) are the same questions asked in the experiment in the previous study. In the present experiment, we added two questions: “did you notice that the robot (or human instructor) was nodding?” (Item 3) and “how did you feel about the robot (or human instructor) nodding?” (Item 3.1). Item 1 relates to the robot’s presence and Item 2 to the learner’s impression about the verbal hint given by the robot. Item 3.1 was asked to only those learners who answered “yes” to Item 3. Item 3.1 relates to the learner’s impression on the nodding.

4. Results

4.1. Score difference between the advance and follow-up activity

Figure 8 shows the distribution of raw scores of the advance and follow-up activities. The abscissa represents the raw scores while the ordinate presents the frequency. The green bars represent the raw scores of the advance activity, and the light blue bars are for follow-up activity. The average total scores and standard deviations for the advance activity are Rw/Nw/H group = 26.6 ± 4.9 , Rw/Nw/oH group = 27.0 ± 4.5 , Rw/oNw/H group = 30.4 ± 5.3 , Rw/oNw/oH group = 26.7 ± 4.8 , Hw/Nw/H group = 24.6 ± 4.0 , Hw/Nw/oH group = 24.8 ± 4.4 , Hw/oNw/H group = 26.1 ± 4.9 , Hw/oNw/oH group = 29.2 ± 4.0 (Fig. 9). Similarly, the total scores for the follow-up activity are Rw/Nw/H group = 31.9 ± 5.6 , Rw/Nw/oH group = 30.3 ± 5.3 , Rw/oNw/H group = 32.2 ± 5.0 , Rw/oNw/oH group = 26.9 ± 4.8 , Hw/Nw/H

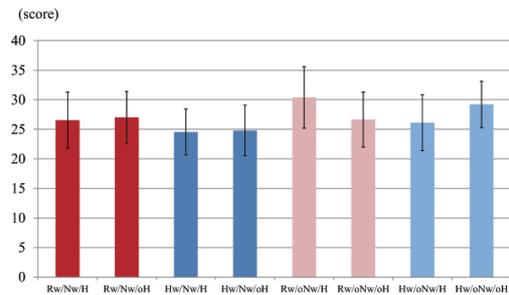


Fig. 9. Total scores of advance activities

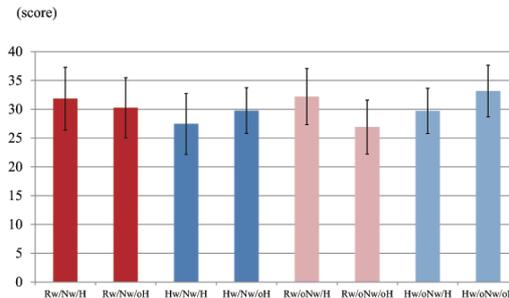


Fig. 10. Total scores of follow-up activities

group = 27.5 ± 5.4 , Hw/Nw/oH group = 29.8 ± 4.1 , Hw/oNw/H group = 29.7 ± 4.1 , Hw/oNw/oH group = 33.2 ± 4.6 (Fig. 10).

In order to verify the effect of providing hints and nodding by the proposed robot (Rw/Nw/H), *t*-tests were carried out between the proposed-robot group (Rw/Nw/H) and the other groups to determine the statistical significance of the differences among the groups’ scores. Paired *t*-tests were used to compare the groups set up in the present study, while unpaired *t*-tests were used to compare the present results with the experiment results of the previous study [6]. Since seven tests are carried out in the present experiment, the issue of multiplicity arises. Bonferroni and Sidak corrections are used in multiple comparisons as conservative methods in which adjustments are made to keep the Type-I error at 0.05 or below. Therefore, Type-II error remains an issue in this case, since the null hypothesis cannot be rejected even when there is a significant difference. One can instead adjust the false discovery rate (FDR), which allows measuring Type-I error while reducing the possibility of Type-II error. FDR refers to the ratio of the true null hypotheses that were erroneously discarded within the discarded hypothesis. Benjamini-Hochberg procedure (BH) [20] is one of the methods to adjust FDR and was employed in in this study.

Figure 11 shows the score differences between the advance and follow-up activities for the groups employing the robot. Significant differences were observed between the Rw/Nw/H and Rw/oNw/H groups with a significance level of 5% ($p = 0.014$), and between the Rw/Nw/H and Rw/oNw/oH groups with a significance level of 1% ($p =$

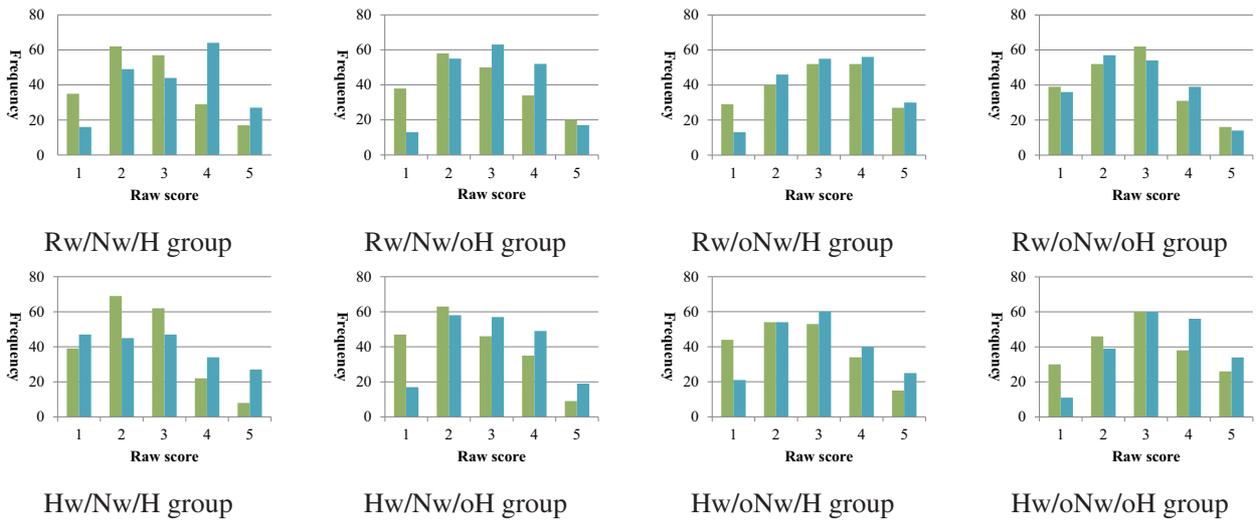


Fig. 8. Distribution of raw scores for advance (green) and follow-up (light blue) activities

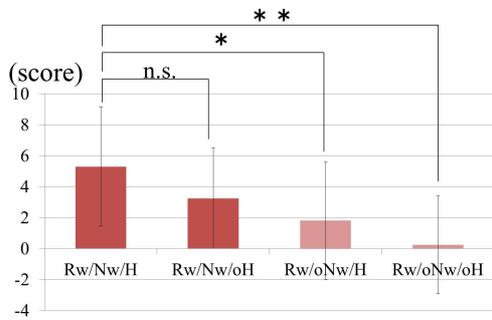


Fig. 11. Comparison of the four groups with robot instructor

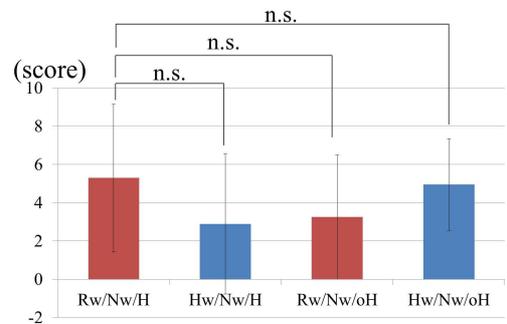


Fig. 12. Comparison of the four groups with nodding

0.0014). Figure 12 shows the score differences between the advance and follow-up activities for the four groups in which nodding took place. There was no significant difference between the proposed-robot group and the other groups. Figure 13 shows the score differences between the advance and follow-up activities for the proposed-robot group and human-instructor groups (Hw/Nw/H and Hw/Nw/oH as displayed in Fig. 12). There was no significant difference between the proposed-robot group and the human-instructor groups.

4.2. Interview results

4.2.1. Item 1 (Fig. 14)

First, we discuss the groups in which the robot nods (Rw/Nw/H and Rw/Nw/oH) (see the attached Tables A.1 and A.2). The views expressed by the Rw/Nw/H group participants indicate that the learners were conscious of the robot's presence, such as "I was greatly helped by the advice I received," and "I was helped when I received accurate advice, but sometimes I got distracted" (three of ten). However, many responses similar to "I didn't mind

it" or "I felt nothing in particular" were obtained from the two groups (16 of 20).

Next, we discuss the groups with the robot that does not nod (Rw/oNw/H and Rw/oNw/oH) [6] (see the attached Tables A.3 and A.4). The views expressed by the Rw/oNw/H group participants reveal that they were conscious of the robot's presence, such as "It was not as lonely as working by myself," were obtained (three of ten). However, there were many responses from both groups stating that "(the robot) did not bother me" or "(I) was not conscious of it." (17 of 20).

These results indicate that many learners in the robot groups stated that they were not conscious of the robot's presence whether it nodded or not.

Then, we discuss the groups with the human instructor who nodded (Hw/Nw/H and Hw/Nw/oH) (see the attached Tables A.5 and A.6). The majority of the Hw/Nw/H group participants stated that they were "(I) wasn't particularly bothered." (eight of ten) although a few expressed views of being conscious of the human presence, such as "(I) felt like I was being watched" and "(I) felt pressure because I was being watched" (two of ten). Meanwhile, many of the Hw/Nw/oH group partic-

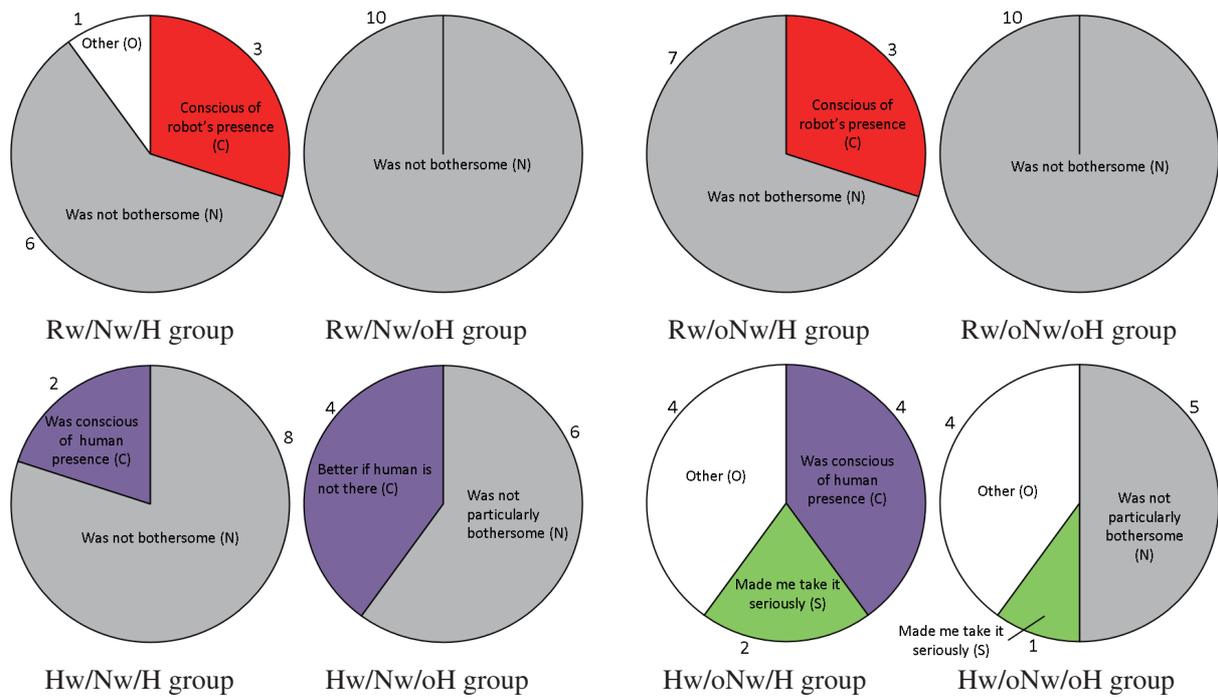


Fig. 14. Interview responses for Item 1. The letters in parentheses correspond to the categories in the attached Tables A.1–A.8.

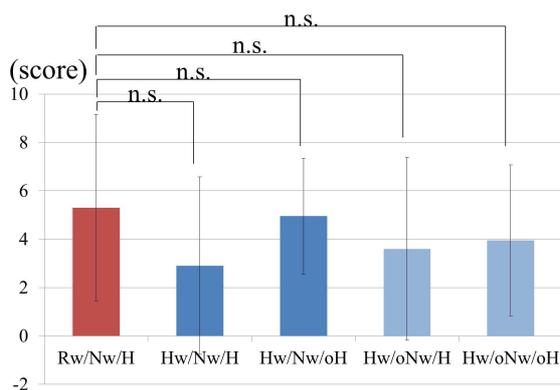


Fig. 13. Comparison of proposed-robot group (Rw/Nw/H) and the human-instructor groups

participants stated that they were “not bothered.” (six of ten). However, some expressed negative views of the presence of a human, such as it would have been “better if (the person) was not there” or “it was awkward” (four of ten).

Lastly, we discuss the groups with the human instructor who does not nod (Hw/oNw/H and Hw/oNw/oH) [6] (see the attached Tables A.7 and A.8). The expressed views of the Hw/oNw/H group participants state that they felt the presence of a person, such as “I didn’t like it” or “I felt pressure” (four of ten), while the Hw/oNw/oH group participants state that “it became less bothersome with the passing of time” or “I wasn’t particularly conscious (of his presence)” (five of ten). Some of the views are common among the participants of both the Hw/oNw/H

and Hw/oNw/oH groups including “his presence made me take the task seriously” or the “(instructor’s) presence made me take the task seriously.” (3 of 20).

These results indicate that, among the groups with the human instructor, two learners of the Hw/Nw/H group and about half of the learners of the remaining groups voiced views that they felt psychological pressure due the human presence.

4.2.2. Item 2 (Fig. 15)

First, we discuss the groups with the robot that gives hints (Rw/Nw/H and Rw/oNw/H) (see the attached Tables B.1 and B.2). The expressed views of the Rw/Nw/H group participants reveal that they felt no negativity against the robot, such as “I didn’t feel any stress from the robot” or “It was easy to work with the robot” (four of ten). Meanwhile, half of the learners responded that they “(I) didn’t feel anything in particular.” or “(the robot) was not bothersome.” (five of ten). On the other hand, the expressed views of the Rw/oNw/H group participants [6] indicate that they perceived favorable impressions about the hints given by the robot, such as “I had a good impression of the robot because it gave me good advice” or “The robot taught me different ideas from the ones I had” (five of ten). However, some participants had little or no impression about the robot, as in “I have no comment” or “I felt as if the robot wasn’t there” (three of ten).

Next, we discuss the groups with the robot that does not give hints (Rw/Nw/oH and Rw/oNw/oH) (see the attached Tables B.3 and B.4). Many of the Rw/Nw/oH group participants mentioned that the robot did not bother them “I didn’t pay any attention to the robot at all” (seven

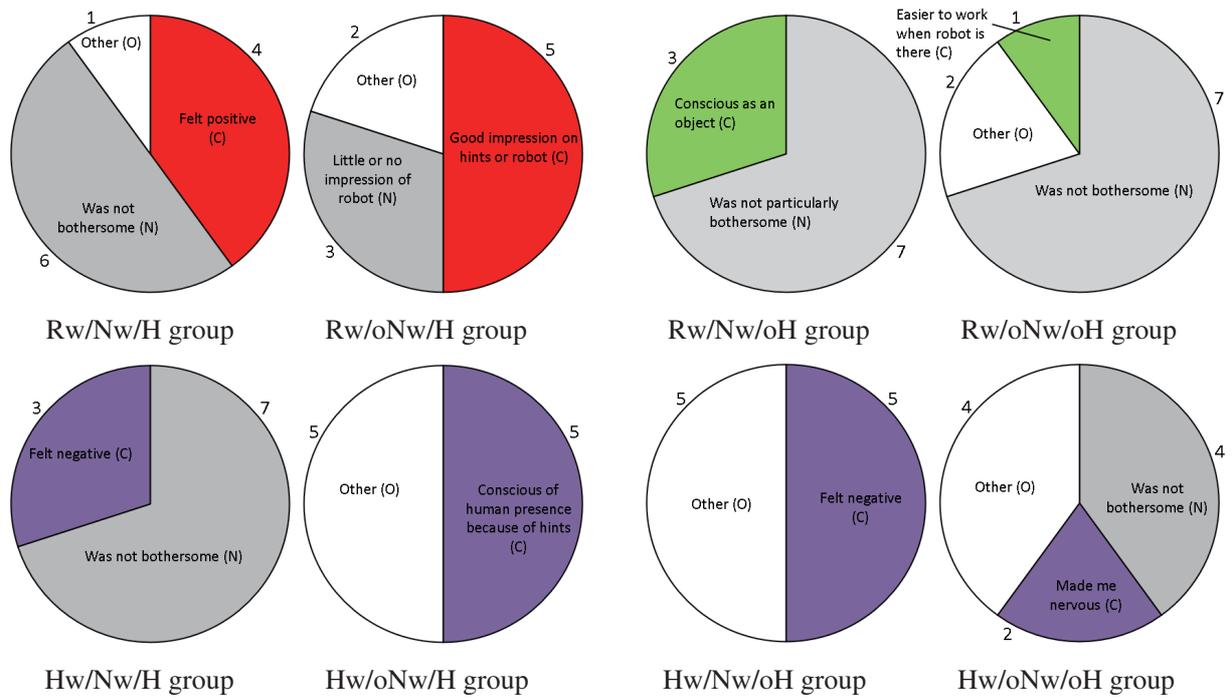


Fig. 15. Interview results responses for Item 2. The letters in parentheses correspond to the categories in the attached Tables B.1–B.8.

of ten). Additionally, some participants expressed views that indicate they were conscious of the robot as an object, such as “The robot was like a figurine” or “I was feeling relaxed because a robot is not a human but a thing” (three of ten). Meanwhile, the majority of the Rw/oNw/oH group participants [6] felt that “I didn’t have an image of the robot” or mentioned that “I didn’t pay any attention to the robot at all” (seven of ten), although one participant stated that “I could make works well because the robot was there” (one of ten).

Based on the above discussion, the study results indicate that about half of the learners in the group with the robot that gave hints voiced positive views about the robot, while in the group with the robot that did not give hints, some expressed views indicating that the robot was perceived as a mere object.

Then, we consider the group with the human instructor who gave hints (Hw/Nw/H and Hw/oNw/H) (see the attached Tables B.5 and B.6). Many learners who participated in the Hw/Nw/H group shared the view that “although it made me conscious in the beginning, it ceased to be bothersome with the passing of time” or “it was not bothersome at all” (seven of ten). However, some expressed negative views against the human presence such as “it was awkward to carry out the task” or “it made me nervous” (three of ten). In addition, the views expressed by half of the learners who participated in the Hw/oNw/H group [6], suggested that they were conscious of the person since he gave hints, such as “I felt strongly that I was being watched.” or “it made me nervous” (five of ten).

Lastly, we consider the group with the human instructor who did not give hints (Hw/Nw/oH and Hw/oNw/oH) (see the attached Tables B.7 and B.8). Half of the learners,

who participated in the Hw/Nw/oH group, mentioned that they “felt nothing” or the human instructor “did not bother me at all” (five of ten). The remaining half gave views that expressed their negative impressions against the human presence, such as “it made it awkward” or “it made me nervous” (five of ten). On the other side, some of the Hw/oNw/oH group participants [6] expressed views that “it was not bothersome” (four of ten), while few participants stated that it “made me nervous” (two of ten).

The above results indicate that some learners who participated in the groups with the human instructor (including three in the Hw/Nw/H group, two in the Hw/oNw/oH group, and half of the learners in the remaining groups) voiced views that they felt psychological pressure.

4.2.3. Items 3 and 3.1

First, we discuss the groups with the robot that nods (Rw/Nw/H and Rw/Nw/oH). Only two of the ten learners participated in the Rw/Nw/H group noticed the nodding. These two expressed views that indicated their interest in the nodding, such as “I was interested in the robot’s nod timing” or “I wondered why the robot nodded”, while, half of the learners participated in the Rw/Nw/oH group noticed the nodding. However, all five of them expressed views indicating that they were not interested in the nodding, such as “I didn’t feel anything.”

Next, we discuss the groups with the human instructor who nodded (Hw/Nw/H and Hw/Nw/oH). Only one of the ten learners who participated in the Hw/Nw/H group noticed the while none of the participants in the Hw/Nw/oH group noticed the nodding. The learner who noticed the nodding in the Hw/Nw/H group felt that “the response was interesting.”

5. Discussion

First, Fig. 11 shows that significant difference among the groups scores were found between the group with the proposed robot (Rw/Nw/H) and the groups with the robot that does not nod (Rw/oNw/H and Rw/oNw/oH). The interview views of the learners in the Rw/Nw/H group that “I was greatly helped by the advice I received” (Item 1) or “It was easy to work with the robot” (Item 2) indicate that they accept the robot presence. Meanwhile, learners who undertook the task with the robot which only nodded (Rw/Nw/oH) voiced views indicating that they perceived the robot as an object, such as “The robot was like a figurine” or “I was feeling relaxed because a robot is not a human but a thing” (Item 2). Although the responses to Item 3 of the interview indicate that two of the Rw/Nw/H group and five of the Rw/Nw/oH group noticed the nodding, there was no significant difference between the two groups regarding the learning effect. This shows that nodding alone does not give the robot a sufficient presence, and that it is important to employ nodding along with the verbal hints.

Next, Fig. 12 shows that there was no significant difference among the four groups with nodding. We speculate that the reasons why the scores of the groups with the robot and those with the human instructor are not greatly different because of 1) psychological pressure due to the human presence and 2) the effect of noticing the nodding. With regard to the first cause, the responses to interview items 1 and 2 indicate that many learners felt psychological pressure due to the presence of the human instructor. Although the psychological pressure can exert a positive effect as in “(the human instructor) made me take the task seriously” (Item 1: Hw/oNw/H and Hw/oNw/oH), it had a negative effect in many cases, as expressed by “it was awkward” or “it made me nervous,” which lowered the learning effect. With regard to the second factor, almost all learners who participated in the groups with the human instructor (Hw/Nw/H and Hw/Nw/oH) failed to notice the nodding. This indicates that the nodding by itself had no effect. We speculate that it was due to these two factors that nodding failed to increase the learning effect in the groups with the human instructor, and produced results of about the same level as the groups with the robot.

Finally, Fig. 13 shows that there was no significant learning effect difference between the group with the proposed robot and those with the human instructor. Since nodding has no effect on the groups with the human instructor, as discussed above, we only need to consider the learning effect of the verbal hints. In our previous study [6], we pointed out the possibility that learning was promoted by imposing human presence and that the learners felt pressure from the hints. We speculate that similar psychological effects were experienced at work in the Hw/Nw/H and Hw/Nw/oH groups in the present experiment.

Based on the above results, we think that it may be possible to achieve a similar learning effect as a human instructor in an expression education learning setting by us-

ing a robot that not only offers verbal hints but also nods as well to indicate approval (i.e., being subjected to evaluation).

6. Conclusion

In this paper, we proposed implementing the function of nodding and providing verbal hints to an expression education-support robot. In addition to providing support by giving verbal hints, the robot nods and gives the impression that it is evaluating the learner’s expression activity in order to improve his or her learning motivation. In the experiment, we examined the learning effect due to the presence or absence of hints and nodding. The results displayed significant difference among the learning effect scores of the group with the proposed robot when compared to the group with the robot that gives hints but does not nod and the group with the robot that neither provides hints nor nods. Furthermore, no significant difference was found between the group with the proposed robot and those with the human instructor. Thus, the results suggested that there is the possibility that a learning effect similar to that of a human instructor can be achieved when the robot used to support expression education provides not only hints to support the learner but also nods to express evaluation. In the present experiment, however, the nodding gesture is not linked to verbal utterances. Accordingly, the future research in the field needs to investigate the effect of explicitly communicating to the learner the fact that he or she is being evaluated. Furthermore, a few learners expressed views that indicated that they were unable to understand the intent behind nodding. These learners may have been affected by factors other than the perception of being subjected to evaluation. Thus, in future research, we further need to investigate the intent and effect of the nodding gestures within the context of expression education.

Acknowledgements

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Appendix A. Interview Item 1

Responses for interview Item 1 of all learners are shown in the attached Tables A.1–A.8. The letters of the category in the tables correspond to the letters accompanying each classification in the pie chart of Fig. 14.

Appendix B. Interview Item 2

Responses for interview Item 2 of all learners are shown in attached Tables B.1–B.8. The letters of the category in the tables correspond to the letters accompanying each classification in the pie chart of Fig. 15.

Table A.1. Rw/Nw/H group

Comment	Category
I was greatly helped by the advice I received.	C
I was thankful, since an idea came into my mind when the robot gave a hint.	C
I was helped when I received accurate advice, but sometimes I got distracted.	C
Felt nothing.	N
Felt nothing.	N
I didn't mind it.	N
Did not bother me much.	N
Did not bother me much.	N
Did not bother me much.	N
Irritating, in the way.	O

Table A.2. Rw/Nw/oH group

Comment	Category
Wasn't bothered.	N
Didn't feel anything.	N
Was not a problem at all.	N
I felt nothing in particular.	N
I felt nothing in particular.	N
Didn't feel like I was being watched.	N
Did not feel any awkwardness in particular.	N
Did not feel particularly different from ordinary times.	N
Wasn't particularly bothered, I felt like I was on my own.	N
Although I looked (at the robot) when I heard some sound, it did not bother me.	N

Table A.3. Rw/oNw/H group

Comment	Category
I relied on it.	C
It was not as lonely as working by myself.	C
Did not feel like I was being watched, but felt insecure without it.	C
Did not bother me.	N
Was not conscious of it.	N
Did not feel like I was being watched.	N

Table A.4. Rw/oNw/oH group

Comment	Category
Did not bother me.	N
Did not bother me.	N
Did not bother me.	N
Was not conscious of it.	N
Didn't think anything of it.	N
Did not feel like I was being watched.	N
Did not feel like I was being watched.	N
Did not feel like I was being watched.	N
It did not bother me since I was concentrating.	N
Did not feel like I was being watched, it was like a figurine.	N

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Table A.5. Hw/Nw/H group

Comment	Category
Wasn't particularly bothered.	N
Wasn't particularly bothered.	N
There was nothing in particular.	N
There was nothing in particular.	N
It did not bother me since I was concentrating.	N
It ceased to bother me since I was concentrating.	N
Didn't feel anything in particular. Wasn't bothered by anything.	N
Didn't see (the human instructor) much since I was concentrating so much.	N
Felt like I was being watched.	C
Felt pressure because I was being watched.	C

Table A.6. Hw/Nw/oH group

Comment	Category
Wasn't bothered.	N
Didn't feel anything.	N
Wasn't bothered much.	N
Wasn't particularly unpleasant.	N
Wasn't particularly different from ordinary.	N
Wasn't particularly bothered. Felt like I was working on my own.	N
It was awkward.	C
I didn't like it.	C
It made it difficult.	C
It was awkward. Somewhat unpleasant. Better if (the person) was not there.	C

Table A.7. Hw/oNw/H group

Comment	Category
It was awkward.	N
I felt pressure.	N
I didn't like it.	N
It felt a little awkward.	N
I felt like I had to do the task.	S
(Instructor's) presence made me take the task seriously. I was able to take it seriously.	S
I was resigned (to his presence).	O
I was nervous at first, but it didn't bother me.	O
Since I was concentrating on the task, it didn't bother me.	O
Although it felt awkward in the beginning, I stopped being conscious of the person as I was doing the task.	O

Table A.8. Hw/oNw/oH group

Comment	Category
Wasn't particularly bothered.	N
I wasn't particularly conscious (of his presence).	N
It didn't make it more difficult that I was being watched.	N
I was able to do the task without particularly being bothered.	N
It became less bothersome with the passing of time.	N
His presence made me take the task seriously.	S
It was awkward.	O
It felt awkward.	O
It made me nervous.	O
I didn't know what the person was thinking, and it bothered me in the beginning.	O



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Table B.1. Rw/Nw/H group

Comment	Category
Felt no pressure.	C
Did not make me feel unpleasant.	C
It was easy to work with the robot.	C
I didn't feel any stress from the robot.	C
Wasn't bothered at all.	N
Wasn't bothered at all.	N
(The robot) was not bothersome.	N
Didn't feel anything in particular.	N
(The robot) was not bothersome at all.	N
It distracted me. I could not concentrate.	O

Table B.2. Rw/oNw/H group

Comment	Category
It was useful.	C
The robot occasionally said helpful things.	C
The robot taught me different ideas from the ones I had.	C
I had a good impression of the robot because it gave me good advice.	C
It was interesting since the robot taught me things that I didn't think of.	C
Didn't bother me.	N
I have no comment.	N
I felt as if the robot wasn't there.	N
I felt that the robot was going to interfere.	O
Made me nervous thinking about when the robot was going to say something.	O

Table B.3. Rw/Nw/oH group

Comment	Category
Didn't think about it too much.	N
Don't have any (impression) in particular.	N
Don't have any (impression) in particular.	N
Don't have any (impression) in particular.	N
I didn't notice that the robot was moving.	N
I didn't pay any attention to the robot at all.	N
Don't have any (impression) in particular. Same whether the robot was there or not.	N
The robot was like a figurine.	C
It's just there. It's surprisingly big.	C
I was feeling relaxed because a robot is not a human but a thing.	C

Table B.4. Rw/oNw/oH group

Comment	Category
I wasn't conscious of it.	N
I wasn't conscious of it.	N
I didn't have an image of the robot.	N
I didn't pay any attention to the robot at all.	N
It didn't create any problems for carrying out the task.	N
Since it didn't say anything, it didn't leave any impression.	N
Although it bothered me in the beginning, it wasn't bothersome when I was working on the task.	N
It was cute.	O
It made me feel relaxed.	O
I could make works well because the robot was there.	C

Table B.5. Hw/Nw/H group

Comment	Category
Didn't bother me at all.	N
It was not bothersome at all.	N
Didn't bother me in particular.	N
It didn't bother me since I was concentrating.	N
No impression in particular. It didn't bother me.	N
Although it made me conscious in the beginning, it ceased to be bothersome with the passing of time.	N
Wasn't particularly conscious of the person once the task began. It was bothersome in the beginning.	N
It made me nervous. I was embarrassed.	C
It made me nervous. I was a bit embarrassed.	C
I didn't like it. It was awkward to carry out the task.	C

Table B.6. Hw/oNw/H group

Comment	Category
It made me nervous.	C
It was awkward being observed.	C
It made me nervous being watched.	C
I felt strongly that I was being watched.	C
I was conscious of the movements and sound he made.	C
It didn't bother me.	O
No impression in particular.	O
The hints made the task easier.	O
It didn't bother me. It was bothersome only in the beginning.	O
No impression in particular. Since I was immersed in my own world, I didn't pay much attention to his presence.	O

Table B.7. Hw/Nw/oH group

Comment	Category
It made me nervous.	C
It made it awkward.	C
Better if he is not there.	C
Better if he is not there. It is awkward at first.	C
I didn't like the fact that someone was right in front of me.	C
I felt nothing.	O
It did not bother me at all.	O
Wasn't particularly bothered by it.	O
Since I was concentrating on the Lego task, I wasn't conscious of his presence.	O
His presence disappeared when I concentrated. It was bothersome in the beginning.	O

Table B.8. Hw/oNw/oH group

Comment	Category
It was not bothersome.	N
The presence of a human was not bothersome.	N
It was not particularly bothersome.	N
At first, I was conscious of being watched, but midway through I was able to concentrate without being conscious.	N
Made me nervous.	C
It was awkward. It made me nervous being watched.	C
It felt lonely since he said nothing.	O
I tried to concentrate by handling things.	O
I was nervous at first, but got used to it.	O
The short distance between us made me conscious.	O