Effect of Advances in Wisdom of Robot in Collaborative Learning

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Abstract: This study clarified the effect of advances in wisdom of robot in collaborative learning. The robot learns while solving a problem issued by a English vocabulary learning system with a human learner. The robot was designed to solve the problem in the same was as learners and could not solve it correctly at the beginning. However, the robot changed the solving method to a more effective one and could solve the problem correctly as the learning progressed. Ten college students with low level English learned using a learning system with robot for two months and took exams. We found that learners came to imitate the learning method of the robot and change their way of learning to the more effective one. This suggest that the robot, which changes the question-solving method to a more effective one and increases its accuracy rate as learning progress, prompts learners to change their learning method to the more effective one.

1 Introduction

With the growth of robot technology, more robots are supporting learning. For example, one robot supports the school life of students [1]. Another robot helps students to learn English better [2]. Interaction between robots and humans promotes a more realistic learning experience. This could lead to helping as make learners more interested in learning [3]. Moreover, a robot's recommendations are more often taken seriously that those of a screen agent. One such situation is when a robot describes an object that exists in real space to a human [4]. Another is when a learner solves a task that is highly difficult psychologically [5]. Therefore, a robot's body has a beneficial effect on a learner by teaching how to learn and helps to solve problems.

Many learning systems that utilize robots induce effective learning or teach the content to be learned. However, collaborative learning, such as discussions between learners, is more effective than induction and teaching. The collaborative learning helps learners to understand the content on a deeper level and improve substantiality, and applicability of knowledge [6]. Therefore, recent studied have examined relation building with which a robot can promote and help the learning and looked at how humans and robots can learn together [7]. For example, Kanda et all. used a series of Lego-block building classes run by a robot to promote spontaneous collaboration among children. Robots not only manage collaborative learning between children but also have positive social relationships with children by praising their efforts. This experimental results suggest that robots promote spontaneous collaboration among children and improve their enthusiasm for learning [8]. However, in most existing studies, robots are interposed to promote effective collaborative learning between many learners, and few existing studies have examined collaborative learning between robot and humans. Therefore, we do not know how the behavior of robot affects the collaborative learning with human.

This study proposes a robot advances in wisdom in collaborative learning. The robot learns while solving a problem issued by a English vocabulary learning system with a human learner. The robot was designed to solve the problem in the same was as learners and could not solve it correctly at the beginning. However, the robot changed the solving method to a more effective one and could solve the problem correctly as the learning progressed. Therefore, learners can change their way of learning to more effective one of the robot and progress their English ability.

2 Overview of learning system

2.1 EFL vocabulary learning system with support function

This study uses an English as a Foreign language (EFL) vocabulary learning system for Japanese students. It has been suggested that in second language acquisition, vocabulary is learned effectively by seeing it used in example sentence and though reading [9][10]. However, English words are still hard to learn by using example sentence because it is difficult for learners to guess the meaning of the English word in the example sentence. Therefore, the system presents words in example sentences and uses an support function that helps the learner guess the meaning of English words in the example sentence upon a user request [11] (Figure 1). This function is called "Hint Translation." When a learner uses this support function, it presents a Japanese translation of the example sentence expect for the target words.

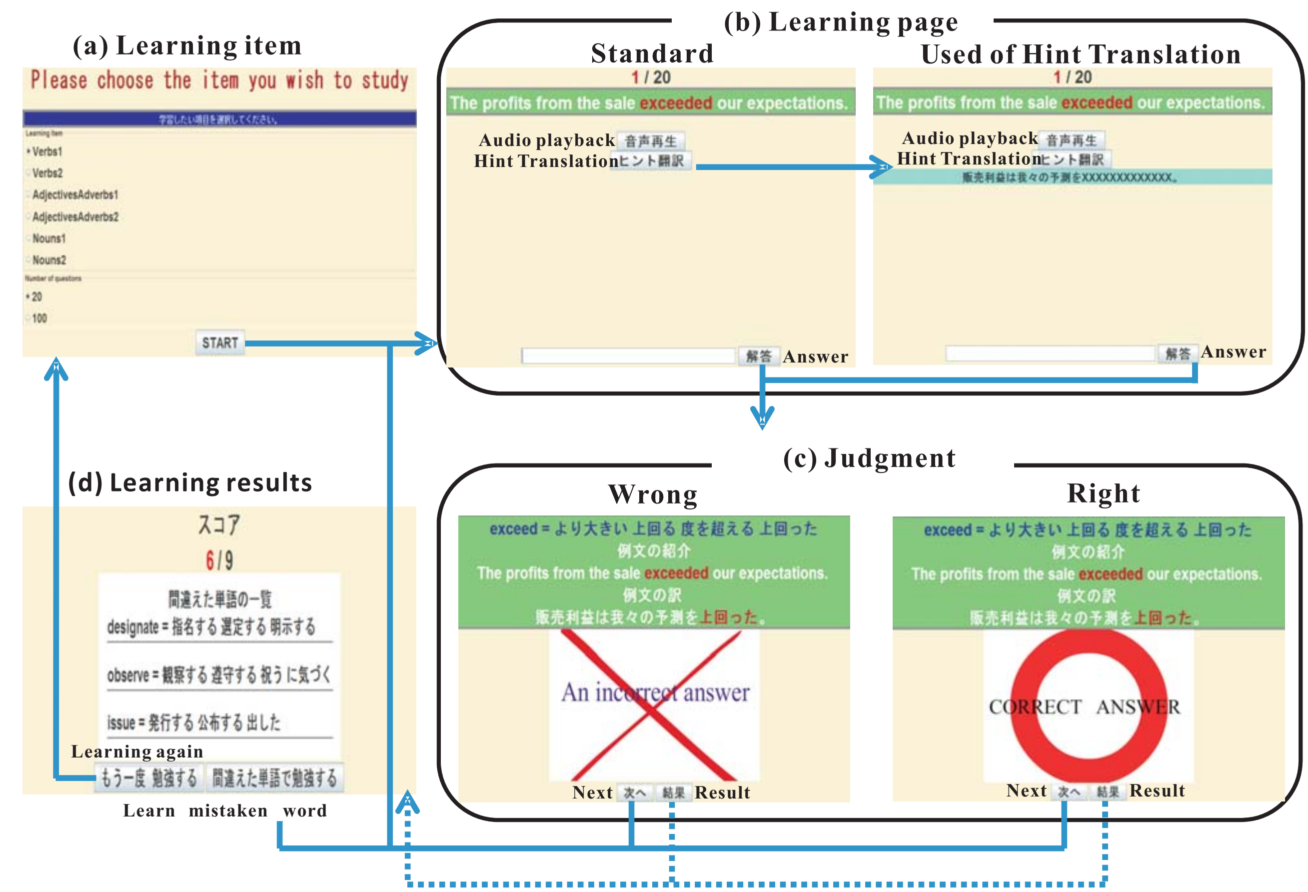


Figure 1: EFL vocabulary learning system with Hint Translation

Jimenez and Kanoh [11] reported five college students of lower to intermediate ability used the system for fourteen days and then took exams. The result of exams and usage rate of Hint Translation (Figure 2) indicate that intermediate learners phased out their use of Hint Translation as learning progressed, and their learning ability improved such as they learned target words while guessing the target words' meanings in presented sentences. On the other hand, lower level learners depended on Hint Translation and paid attention to only the Japanese that was presented. This is thought to be why they could not learn the target words.

This study focus on the lower level learners and attempts to make lower level learners change their question-solving method the same way intermediate learners do. Therefore, the robot that changes its question-solving method in this ways learns with the lower level learners in the learning system.

2.2 Operation of the learning system

Learners enter their accounts number on the login page. A menu of learning items is shown (Figure 1(a)). There are six learning items to choose form : Verbs 1 and 2, Adjectives, Adverbs 1 and 2, and Nouns 1 and 2. The leaner selects a learning item from the list. Also, the column from which the number of questions is chosen is shown under the learning items. Then, the learning screens (Figure 1(b)) appears and the learning process starts. The learner provides an answer for the meaning of the word (target) that is shown in red text in the example sentence (Figure 1(b)). When a learner uses "Hint Translation," the system presents the Japanese translation of the example sentence expect for the target (Figure 1(b) light). When a learner uses "Audio playback," the system reading out the example sentence in a native English-speaker's voice. After the answer is given, the system displays whether it is correct or not, as shown in Figure 1(c). When the learner selects "NEXT" (Figure 1(c)), the system moves on to the next target. When the learner selects "RESULT" (Figure 1(c)) or solves all of the problems, the system moves on to the results page (Figure 1(d)). This page presents the number of correct and incorrect words. When the learner selects "Learning again," a menu of learning items is shown (Figure 1(a)). When the learner select "Learn mistaken words," the leaning page presents questions consisting of words previously mistaken (Figure 1(b)).

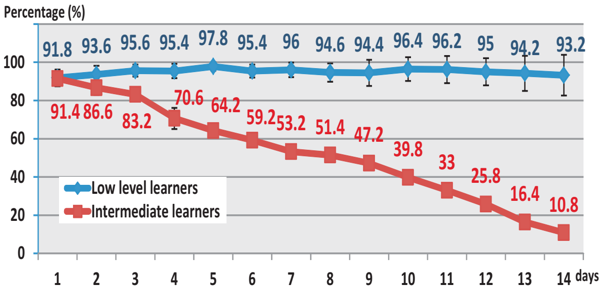


Figure 2: Usage rate of Hint Translation of existing study

Figure 3: Appearance of Ifbot

3 Overview of robot

3.1 Using the robot

This study use a Ifbot (Figure 3). Ifbot can express various expression. We implement the learning system inside Ifbot. Therefore, Ifbot and the student can face a monitor and learn together as shown in Figure 4.

3.2 Definition of a mark

The following things are defined to explain the robot's action.The learning items are defined as i ($i \in$ {Verbs1, Verbs2,...,Nouns2}). A set of target words among a learning item is defined as S_i. A set of answered target words among S_i is defined as $A_i(t_i)$. A set of target words which that uses Hint Translation among $A_i(t_i)$ is defined as $H_i(t_i)$. t_i is the number of times i is learned. When learners solve all questions among S_i, t_i is counted up, i.e. when $|A_i(t_i)| = |S_i|$, $t_i = t_i + 1$. The number of questions that a learner tackles is defined as M. If learners select "100" in the menu of learning items (Figure 1(a)), M becomes $M = 100$. If learners select "20" in the menu of learning items (Figure 1(a)), M becaomes $M = 20$. If learners select "learn mistaken words" on the result page (Figure 1(d)), M becaomes $M =$ the number of incorrectly answered questions.

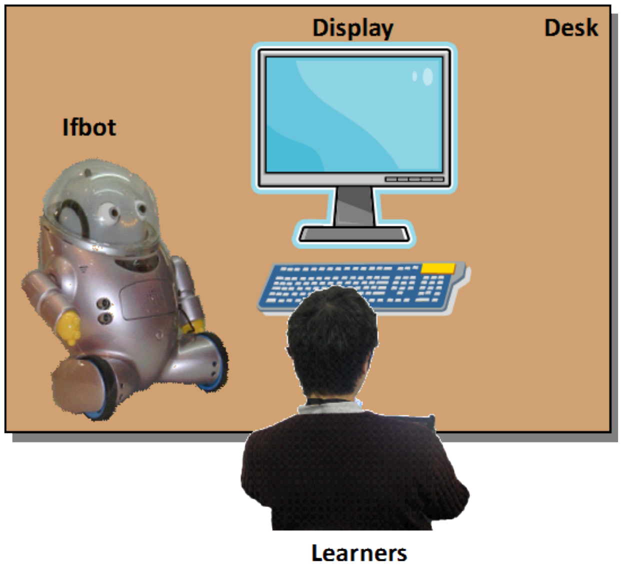


Figure 4: Learning state

3.3 Robot's action

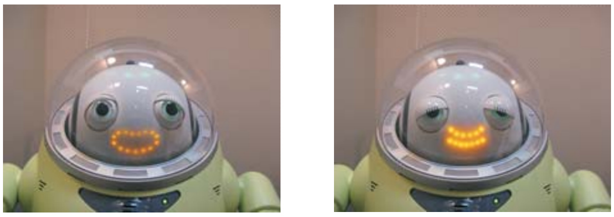
This study examine whether learners can learn from a robot's actions in collaborative learning. Therefore, the robot does not use a function that can enable it to interact with human directly, such as voice recognition. The robot acted in accordance with the screen of the learning system and the usage rate of learner's Hint Translation. The robot incorporated "Answer motion" and "Think motion" into its actions to make learners feel that they were answering questions along with a robot and thinking about answers to questions along with a robot.

(1) Answer motion

First, robot displays a consideration expression like in Figure 5 (e) (f). When a consideration expression is expressed, the robot shakes its head horizontally or leans it forward. Simultaneously, the robot uses Hint Translation to present a Japanese translation of the example sentence expect for the target words and say things such as "I use a Hint Translation." Next, the robot displays a speaking expression like in Figure 6 (g) (h). When displaying a speaking expression, the robot moves its mouth. Simultaneously, the robot says the answer of a question; for example "The answer of this is ..." However, the robot produces not only a correct answers but also wrong answers. The number of times a robot correctly answers by learning a word once is $\min(n(t_i+1), \frac{M}{2})$ times, and this increases as learning progresses. The "n" is a fixed number and is defined by M. If $M = 100$, n is defined as "5". If $M = 20$, n is defined as "2". Otherwise, n is defined "3". Similarly, the number of times the robot uses Hint Translation is

(e) Consideration expression 1 (f) Consideration expression 2

Figure 5: Example of expression robot uses to show consideration



(g) Speaking expression 1 (h) Speaking expression 2

Figure 6: Example of expression robots uses to when speaking

$\max(\frac{M}{2} - nt_i, 0)$ times, and this decreases as learning progresses. When the robot does not use Hint Translation, it only displays a speaking expression. Then, the robot says things such as "I'll focus on the example sentence" and says the answer to a question, such as "The answer is ..."

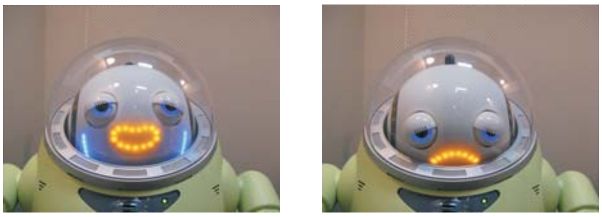
(2) Think motion
Robot displays a consideration expression and says things such as "I'll look at the Japanese translation" or "I'll use Hint Translation." However, robot says different things such as "I'll focus on the example sentence" or "I'll consider the situation of the example sentence." This change in proportion to the number of times the robot uses Hint Translation during answer motion.

These two motions indicate how the robot learns. Here, the robot show learners that robot phases out using Hint Translation as learning progress and learns targets while guessing the target's meaning in presented sentences. Moreover, if the robots answers each time, learners may be not bother learning and instead depend on the robot's answer. Therefore, answer motion and think motion are alternated.

However, if the robot performs only answer motion and think motion, the two problems will occur. One is that learners will not adequately learn [12] and just depend on using Hint Translation and guessing the Japanese vocabulary from the Japanese sentence. The other is that learners become less interested in the robot as learning progresses [8] so the learning effect is minimal. To solve these problems, the robot is added with "hint avoidance motion" and "same action avoidance motion."

(i) Happy expression 1 (j) Happy expression 2

Figure 7: Example of expression robot uses to show happiness



(k)Unhappy expression 1 (l)Unhappy expression 2

Figure 8: Example of expression robot uses to show unhappiness

(3) Hint avoidance motion
The robot displays a speaking expression and says things such as "Let's solve this without using a hint." Alternatively, the robot displays a happy expression like in Figure 7 (i) (j). When displaying a happy expression, the robot has a smiling face and says things such as "This question is easy, so let's solve it without using a hint." These prompt learners to focus on example sentence without using Hint Translation. This motion is run when learner's usage rate of Hint Translation increased.

(4) Same action avoidance motion
The robot displays an 'unhappy expression like in Figure 8 (k) (l). When displaying an unhappy expression, the robot begins to shed tears and says things such as "I can't answer this question." Alternatively, the robot displays a consideration expression and says things such as "This question is difficult." This motion prompts learners to feel that the robot cannot answer the question. Therefore, even if this motion is run irregularly, it does not cause trouble in learning. Additionally, the robot can avoid that performing the same action patterns.

These four motions are the robot's action and are performed when the learning screens (Figure 1(b)) are shown. Another action is to sympathize with learners when the learning system show whether the answer is correct or not (Figure 1(c)), because an agent's sympathy is reported to improve the motivation of learners to learn[13]. Therefore, when the learning system shows the answer to be correct as in Figure

promote	( )
inspect	( )

Figure 9: Word test

My father was an <u>ordinary</u> company employee.
(   )
A plant will <u>wither</u> and die without water.
(   )

Figure 10: Assumption test

1(c), the robot displays a happy expression and says things such as "Yes, the answer was right." When the learning system shows the answer to be incorrect as in Figure 1(c), the robot displays an unhappy expression and says things such as "Oh, well. Better luck next time."

4 Examination

4.1 Method

This experiment was conducted to compare how effectively learners were able to learn English words in two groups. In one group, learners learned with Ifbot. This group is called the Robot Collaboration Group. In the other group, learners learned using only the learning system. This group is called the Single System Group. The learners consisted of twenty college students of lower ability based on TOEIC scores (210-230). They learned English vocabulary by memorization and leaning word meanings without using example sentences. Moreover, the questions of the learning system were created by consulting the "TOEIC TEST English word speed master" [14], which is the level expected of a final-year high school student. Both the Robot Collaboration Group and Single System Group were allotted ten lower level learners. The learners learned the English word for 45 minutes, twice a week for two months. They studied English vocabulary a total of 18 times.

4.2 Evaluation

The evaluation consisted of three criteria. One was the difference in pre-test and post-test scores between the Robot Collaboration Group and Single System Group. Each pre-test and post-test was presented as a word test, as in Figure 9, with the English words on the left and the answer space on the right. The word test was based on the words in the learning system and consisted of 500 questions. Another was the comparing usage rates of Hint Translation for each Robot Collaboration Group and Single System Group learner and to see which learners decreasingly used Hint Translation. The other was the difference between the scores of the Robot Collaboration Group and the Single System Group in an assumption test,

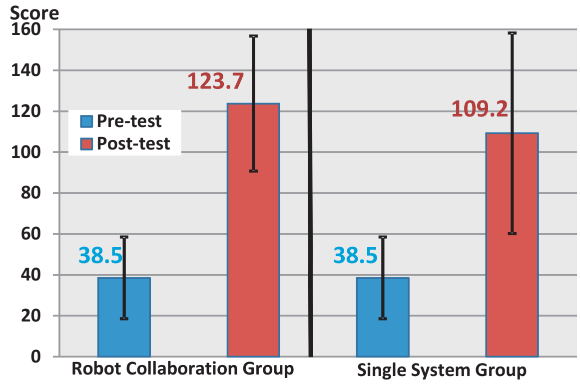


Figure 11: Averages for Pre and Post-tests of each group

as in Figure 10. The assumption test consisted of 20 questions in which they had to translate an underlined English into Japanese. These targets were not in the system. This test was created by consulting "TOEIC TEST English grammar and vocabulary Basic master" [15] and "TOEIC TEST Reading Basic master" [16].

The analysis method used a t-test. A significant difference is admitted if p value is under the significance level 1%. The significance level is regulated at $p < 0.005$ by using the method of Sidak [17] [18].

4.3 Results

The average pre-test and post-test scores are shown in Figure 11. The average learning gains scores are shown in Figure 12. The learning gains are obtained by subtracting the pre-test score from the post-test score. This indicates the number of words that learners leaned. Both Figure 11 and Figure 12 show the scores of the Robot Collaboration Group on the left and those of the Single System Group on the right. We investigated the confidence interval in pre-test scores of each group's learners to check the homogeneity of each group's learners' English ability. The results indicate that the 95% confidence interval of the Robot Collaboration Group learners is 23.04-53.96, and 95% confidence interval of the Single System Group is 22.98-54.02. These indicate the each group's learners' English ability is the same level. Next, we conducted a t-test to determine how effectively learners learn English words by using the learning gains scores of each group, as shown in Figure 12. The results indicate that there was no significant difference $(t = 0.8, df = 18, p = 0.28)$. Therefore, there was no difference in learning effect between the Robot Collaboration Group and Single System Group.

Although there was no difference in learning gains, we investigated the usage rate of Hint Translation of all Robot Collaboration Group and Single System Group learners to check whether the difference was due to changing the learning method. The results are

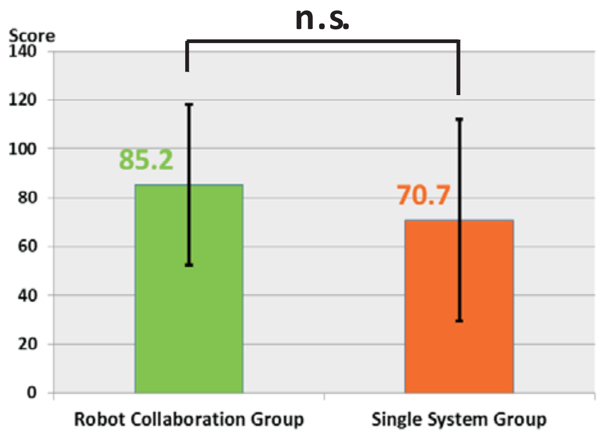


Figure 12: Averages for learning gains of each group

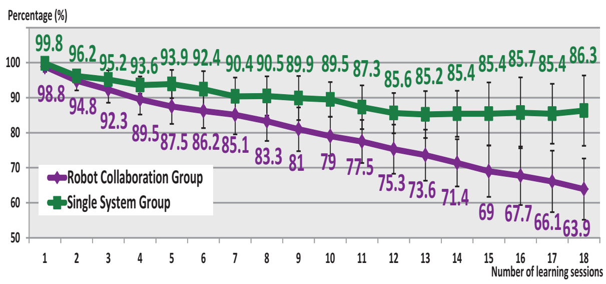


Figure 13: Usage rate of Hint Translation in this study

plotted in Figure 13. Figure 13 indicates that when the Single System Group learners used the learning system for a few days, they tended to always use Hint Translation. On the other hand, the Robot Collaboration Group learners reduced their use of Hint Translation as their learning progressed. Therefore, we consider that the Robot Collaboration Group learners phased out their use of scaffolding in the form of Hint Translation and learned targets by guessing their meanings in the example sentences presented by the learning system.

If the Robot Collaboration Group learners learned targets by guessing their meanings in the example sentences presented by the learning system, we consider them to have improved ability to guess the meaning of English words in the English sentences. Therefore, we compared the score of the assumption test for each group. The average scores of the assumption test are shown in Figure 14. The scores of the Robot Collaboration Group are on the left, and those of the Single System Group are on the right. The assumption test scores for the Robot Collaboration Group learners are shown in Figure 15. Figure .14 indicates that the scores for the Robot Collaboration Group were better than those for the Single System Group. Moreover, to understand the significant difference in the assumption test, we conducted a t-test in the assumption test. The t-test results indicate

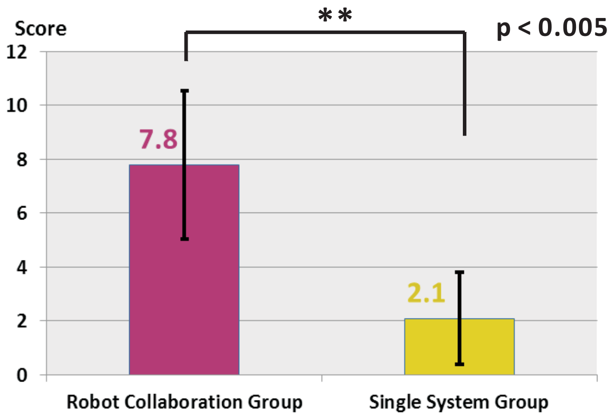


Figure 14: Average scores of assumption test for each group

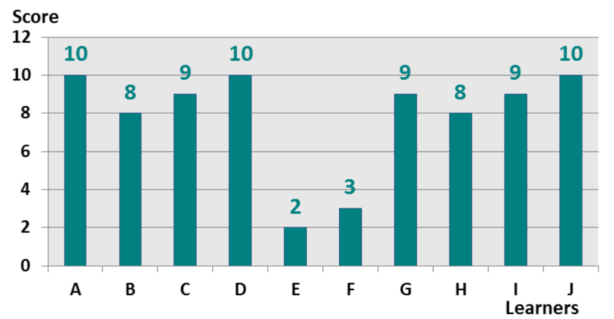


Figure 15: Robot Collaboration Group scores in assumption test

that there was a significant difference between the Robot Collaboration Group and Single System Group ($t = 5.38, df = 18, p = 0.00$). Therefore, the ability to guess the meanings of English words in English sentences of the learners in the Robot Collaboration Group was better than that of those in the Single System Group. However, Figure 15 indicates that the scores of learners E and F in the Robot Collaboration Group were no different to the average scores of learners in the Single System Group. This suggests that learners E and F did not improve in their ability to guess the meanings of English words in English sentences.

5 Discussion

This result of the study suggest that robot, which changes the question-solving method to a more effective one and increases its accuracy rate as learning progress, prompts learners to change their method to the more effective one. Moreover, learners who learning with robot progressed in their ability to guess the meaning of English words in the English sentences. However, the some learner who learning with robot did not improve in ability to guess the meaning of English words in the English sentences. Additionally, there is no difference in the learning gains between learners who learning with robot and without robot.

6 Conclusion

This study proposed a robot advances in wisdom in collaborative learning. The robot learns while solving a problem issued by a English vocabulary learning system with a human learner. The robot was designed to solve the problem in the same was as learners and could not solve it correctly at the beginning. However, the robot changed the solving method to a more effective one and could solve the problem correctly as the learning progressed. Results of this study suggest that learners who learning with robot can change their way of learning to more effective one of the robot and improve their English ability.

We are now working on converting a robot that has voice recognition into a robot that can interact with humans on demand in different learning situations. We infer that this will help the learners have to feeling more comfortable and maintain their interest in the robot.

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