Development of a Peer Tutor Support System for Disabled Students Using a Telepresence Robot in South Korea

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Abstract - Peer tutoring was confirmed in various studies that peer tutoring helps increase the academic performance and social interaction of both the peer tutee and the peer tutor. However, there are many problems in applying peer tutoring generally and applying it in all classes due to playing around between the peer tutor and peer tutee, failure to complete assignments, difficulties in preparing to teach, peer tutor of pride corruption, etc. Therefore, this study seeks to produce a system that allows an education expert to implement a peer tutor arbitration technique remotely using a telepresence robot that students recognize as a peer and learn whether peer tutoring can be implemented through the use of the robot. We developed a system whereby an education expert could remotely observe and support students' learning process, behavioral pattern, and emotional change by using a telepresence robot. The system is intended to help disabled or at-risk students by opening up their minds as a peer, and the teacher and student are assisted in the classroom learning through an electronic blackboard, iPad, and Galaxy Tab. We applied the system in an open classroom of a special-learning class of

ten disabled students at an elementary school in 2013, Gyeonggi-do, Korea and surveyed six teachers who observed the class to assess whether peer relationships were successfully formed between the robot and students, whether the robot helped the learning process as a peer tutor, whether there were any mutual interactions between the robot and students, and how the robot peer tutor compared to normal peer tutors. Most of the survey items had a positive response of 4.0 point or higher out of 5 points. These results show that the remote support system for experts using the telepresence robot solved some of the problems that arise in integrated education for disabled students.

Key words: peer tutoring, telepresence robot, assistive technology, special education technology

I. INTRODUCTION

Disabled students require special education and should be provided educational opportunities equal to those offered to normal children (Lee, 2011). The Act on the Special Education for Disabled Persons, etc. ensures that, in order for educational service that fits the educational needs of individual disabled students to be provided, individualized education that fits various types and characteristics of disabilities be provided(Korea Ministry of Government Legislation, 2014).

Individualized education means education that is appropriate for each disabled student's needs and entails supporting his or her learning through teaching methods that fit those needs (Lee, 2011; Jang, Kim, & Kim, 2006). Most disabled students who are given support in special learning locations not only achieve successful academic performance but also receive help in enhancing their self-management capability (Barnard-Brak & Lechtenberger, 2010).

In order to make the individualized education of disabled students successful, teachers play an important role. However, teachers who teach disabled students in Korea experience difficulties in drafting plans necessary for implementing individualized education, as well as in collaborating with other teachers and implementing their plans in the classroom (Lee, Lee, Park, & Yoon, 2012). Also, they experience difficulties because the level of lesson that is appropriate differs from one student to another within a group of disabled students, and there is uncertainty as to which student's difficulty level should be the standard. If the whole class studies a low difficulty level, some students may feel bored, but on the other hand, if the difficulty level is raised, some students will give up trying to learn. Recently, with new developments in information and communications technology (ICT), individualized learning programs based on the use of a PC and smartphones may be used, but individualized classes cannot be taught through digital media only (Seo, 2005; Lee, Kim, Lee, Kim, & Choi, 2011; Hwang, Jin, Shim, Choi, & Kim, 2010; Kim & Kim, 2013; Kang, Kim, & Kim, 2013). This is because the students not only learn knowledge during classes but also form peer relationships through teacher-student and student-student interactions and learn their roles as members of society. Peer tutoring, whereby high achieving students help those who are underachieving in traditional group lessons, is a teaching method that can improve upon such problems and facilitate the advantages of group lessons. Peer tutoring was found in many studies to increase the mutual interaction of everyone involved, including the peer tutee and peer tutor (Baek & Kwean, 2007). Also, peer tutoring can be said to be an appropriate teaching method that can be applied in integrated education for disabled students who are in dire need of leveled education. However, there are many problems in applying peer tutoring generally and applying it in all classes due to playing around between the peer tutor and peer tutee, failure to complete assignments, difficulties in preparing to teach, peer tutor of damage to pride, etc. (Sohn & Kim, 2005). Such problems exist because the peer tutors have not learned professional teaching methods. However, if an educational expert becomes a peer to implement peer tutoring, the problems could be solved. Therefore, this study seeks to produce a system that allows an education expert to implement a peer tutor arbitration technique remotely using a telepresence robot that can be recognized as a peer and learn whether peer tutoring is implementable using the robot.

II. SYSTEM DESIGN PROCESS

A. System design

In case of two-dimensional image, after a DWT transform, the image is divided into four corners, upper left corner of the original image, lower left corner of the vertical details, upper right corner of the horizontal details, lower right corner of the component of the original image detail (high frequency). You can then continue to the low frequency components of the same upper left corner of the 2nd, 3rd inferior wavelet transform.

The system designed in this study allows an education expert to remotely observe and support the learning process, behavioral pattern, and emotional change by using a telepresence robot to teach disabled students by opening up their minds as a peer, and the teacher and students are assisted in the classroom learning through the use of an electronic blackboard, iPad, and Galaxy Tab. The remote education expert can communicate with the students by controlling the robot placed in classrooms through the system shown in Fig. 1 and support the teacher's lesson.

To ensure that the remote system can see the overall circumstances of the classroom at one glance and enable participation in lessons, it is composed of a video system that can monitor the entire space, a two-way

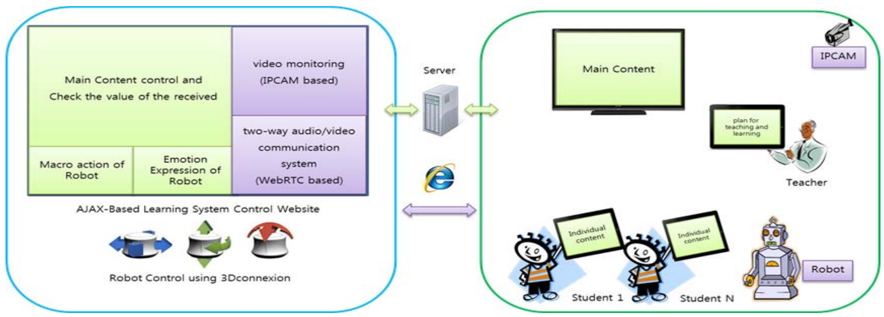

Figure 1. System overview

voice/image transmission system for the remote expert to communicate with the robot, a voice conversion microphone system to convey the voice of the robot (not in a human voice but in a robotic voice), a 3D mouse that allows the remote expert to control the robot's movements with one hand, a robot movement control system, a contents verification/adjustment system for a large screen used to transmit remote lessons smoothly, and a system in which students can enter responses on an academic pad to be verified later.

In classrooms where the smart education support system using the telepresence robot is applied, the teacher may receive assistance in lessons, as seen in Fig. 1, in the form of teaching suggestions or lesson contents through a personal smart pad or smartphone. Also, the students can receive the digital learning papers necessary for classes through their smart pad. Here, the robot plays the role of a student who participates in the lesson, communicates with other students as a peer, and encourages appropriate reactions from students while class is being conducted. The remote expert observes the situation at one glance through a separate webpage that is linked with the IPCAM site system that allows the confirmation of the classroom situation, while adequately engaging through the telepresence robot.

B. Commencing the system

The system designed in this study was produced using HTML5 so as to maximize its web accessibility, and in an app format where students and teachers can use the webserver conveniently through smart devices. The digital learning paper provided in every lesson was made as seen in Fig. 2.

The teacher can receive assistance from the teacher app, which provides lesson contents and leveled teaching suggestions for each lesson, as seen in Figs. 3 and 4. The teacher app was produced so that the teachers could learn about the contents needed in lessons at one glance using xml parsing information and provide them through the app from a server.

C. Commencing the system

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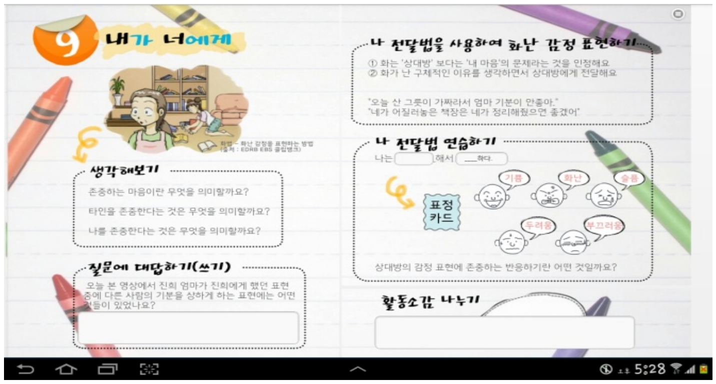

Figure 2. The student digital learning paper produced using HTML5

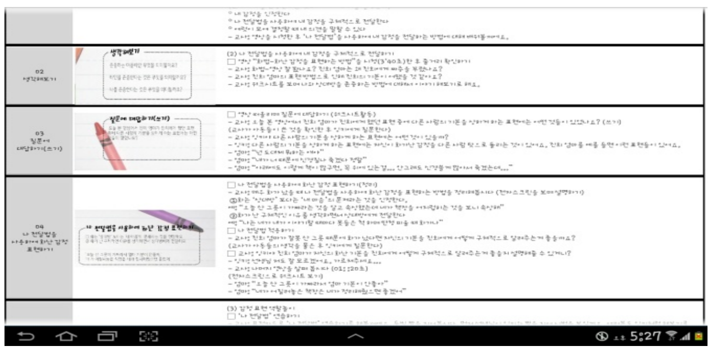

Figure 3. App providing teaching suggestions for teachers

The webpage produced for the remote expert is supplied in the format shown in Fig. 4, and the WebRTC (web with real time communication) technique was used for two-way telecommunication using the robot. Moreover, the screen used by the remote expert was produced as seen in Fig. 5 so that the contents entered through the student digital learning paper could be verified, and HTML5 AJAX telecommunication was used so that the contents of individual students' work could be verified and controlled. Also, in order to allow the remote expert to understand the entire situation, the internet controllable IP Webcam was used.

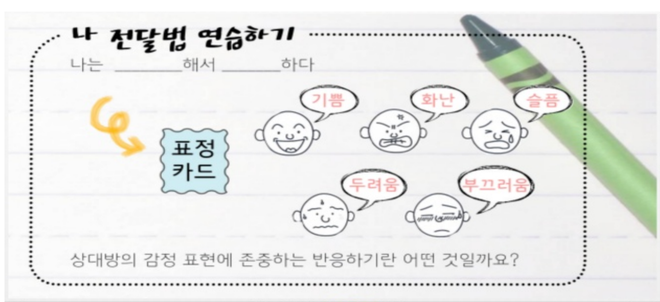

Figure 4. Produced contents for lessons

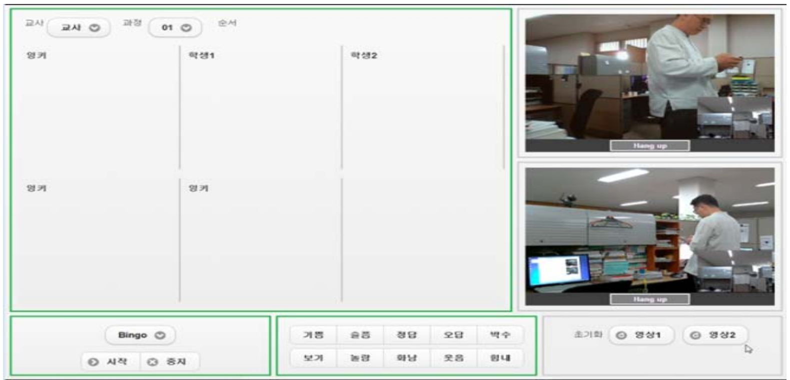

Figure 5. Produced remote system

III. SYSTEM VERIFICATION

The peer tutoring for the individualized education of disabled students has been studied for a long time, and its effectiveness has been sufficiently proven. However, there are many problems in applying peer tutoring generally and applying it in all classes due to playing around between the peer tutor and peer tutee, difficulties in preparing to teach, etc. As a means of resolving such limitations, this study seeks to establish a system that can apply peer tutoring utilizing a telepresence robot that can be controlled by an expert who has majored in special education and learn whether peer tutoring utilizing this system is an appropriate substitute for normal peer tutoring, as was the case in prior studies. For this, this study developed the telepresence remote control system and contents needed for lessons utilizing the telepresence robot. We applied the developed system in an open classroom of a special learning class of ten disabled students in an elementary school in Gyeonggi and surveyed six teachers who observed the class regarding whether peer relationships were formed between the robot and students, whether the robot helped the learning process as a peer tutor, whether there were any mutual interactions between the robot and students, and how the robot compared to normal peer tutors.

A. Students who participated in the lesson

Ten students participated in the open classes: 8 cognitively disabled students, one autistic student, and one emotional/behavioral disorder student. Their characteristics are summarized in Table 1.

Table 1 Students in the open class

Student	Grade	Gender	Degree of disability
Student A	Special class	M	Cognitive disability, 3rd degree
Student B		F	Cognitive disability, 3rd degree
Student C		M	Autistic
Student D		F	Cognitive disability, 3rd degree
Student E		M	Cognitive disability, 3rd degree
Student F		F	Cognitive disability, 1st degree
Student G		F	Cognitive disability, 3rd degree
Student H		F	Cognitive disability, 3rd degree
Student I		M	Cognitive disability, 3rd degree
Student J		F	Emotional/behavioral problems

B. *Lesson plan*

The lesson plan used in the open classes was drafted as Table 2 by the teachers in charge of special classes. It is composed of three stages consisting of passion for learning, which is the preparatory stage; learning activity, where actual learning takes place; and a review stage, where what was learned is reviewed. The robot's role was set so that it would participate in the classes just like the students and follow the teacher's instructions. The robot's other roles were to encourage students' proactive participation in learning and simultaneously follow the learning stages in order to assist in the individual lessons as a peer tutor. In simultaneous reading, when students failed to find expressions, the robot was given the role of finding "gam, gam, gam(persimmon of onomatopoeic words)" and "bam, bam, bam(chestnut of onomatopoeic words)" and individually helping the children who needed assistance in writing, which may be a part of individualized lessons depending on the child's learning level. Also, in the stage where the students were writing down the poem and drawing, the robots were given the role of providing the advice and assistance needed to fold chestnuts and persimmons with colored page.

Table 2 Lesson plan

<table>
<tr><th rowspan="2">Lesson Stage</th><th rowspan="2">Lesson Process</th><th colspan="4">Learning Activity</th><th rowspan="2">Time (Minutes)</th></tr>
<tr><th>Teacher</th><th colspan="3">Student</th></tr>
<tr><td rowspan="2">Passion for learning</td><td rowspan="2">Passion for learning (Response preparation)

Confirmation of the learning objective</td><td>◇ Create a learning atmosphere
T. Lead students in singing the "ga-eul-gil" song
T. Lead a discussion of the color that describes fall in the poem</td><td colspan="3">S. Listen and sing energetically
S. Discuss the color that describes autumn</td><td rowspan="2">5</td></tr>
<tr><td colspan="4">Read the children's poem titled "One Autumn Day" and make their own poem drawings</td></tr>
<tr><td rowspan="8">Learning activity</td><td rowspan="2">Response formation (Reading simultaneously)</td><td>T. Have students listen to the children's poem "One Autumn Day"</td><td colspan="3">S. Listen to the children's poem</td><td rowspan="2">8</td></tr>
<tr><td>T. Read the children's poem with the students</td><td colspan="3">S. Read along with the children's poem
R. Read the children's poem to the students</td></tr>
<tr><td>Enjoyment</td><td>T. Ask the students to find the parts in the poem that are expressed in an interesting manner</td><td colspan="3">S. Find the parts described in interesting manner
R. Find relevant parts of the poem that the children cannot</td><td>8</td></tr>
<tr><td rowspan="5">Generalization (Writing a poem and drawing)</td><td>T. Teach about the fruits in the poem and show the students how to fold colored papers into chestnuts and persimmons</td><td colspan="3">S. Fold the colored paper into chestnuts and persimmons</td><td rowspan="5">15</td></tr>
<tr><td>T. Help students find the color that expresses autumn, make a tree, and stick the chestnuts and persimmons on it.</td><td colspan="3">S. Make a tree using the color that expresses autumn and stick chestnuts and persimmons on it</td></tr>
<tr><td rowspan="3">T. Ask the students to write down the children's poem "One Autumn Day"</td><td colspan="3">S. Write down the children's poem so that it fits the children's level</td></tr>
<tr><td>Level A</td><td>Level B</td><td>Level C</td></tr>
<tr><td>Read and write down the poem</td><td>Read and write down the expressions</td><td>Read and write down the poem, finding chestnuts and persimmons</td></tr>
<tr><td rowspan="2">Review</td><td rowspan="2">Review and evaluation</td><td rowspan="2">T. Ask the students to introduce their autumn poem drawings</td><td>Level A</td><td>Level B</td><td>Level C</td><td rowspan="2">4</td></tr>
<tr><td colspan="2">Students show their drawings about the poem</td><td>Read the target sound in the poem drawings</td></tr>
</table>

C. Participants in the questionnaire and questions

In order to check whether it is possible to teach peer tutoring classes using the telepresence robot, open classes were conducted with 10 disabled students, and the six teachers who observed it completed a questionnaire survey. As can be seen in Table 3, of the six teachers who participated in the survey, two teachers had less than five years of teaching experience. One teacher fell in each of the following ranges of experience: 5 to 10 years, 10 to 15 years, 15 to 20 years, and 20 years or more.

Table 3 Teachers participating in the survey

Teacher	Age	Education level	Experience
Teacher A	30s	Graduate school	10-15 years
Teacher B	50s	University	Less than 5 years
Teacher C	20s	University	Less than 5 years
Teacher D	30s	Graduate school	5-10 years
Teacher E	50s	University	20 years or more
Teacher F	40s	University	15-20 years

The survey was designed so that the teachers who observed the classes with the robot could assess the formation of peer relationships between the robot and students as well as the robot's efficacy as an assistant teacher. It contained questions about the respondents' basic information such as sex, age, education, and experience in teaching, as well as questions about the robot for measuring the peer relationships between the robot and students. In order to learn whether the students recognized the robot as a peer and whether there were any teaching effects, the questions asked about the formation of peer relationships between the robot and students, with reference to the study by Seo, Park, and Park (2012), which classified the role of peer tutors, as well as studies comparing the teaching effect. Also, in order to learn about the role of the robot, who could assist the teacher, questions were added about whether the robot helped in the class; these questions were designed to measure the efficacy of the teacher assistant robot defined in comparative studies about the interactions between teacher assistant robot peers (Yong, Kim, Park, & Hyeon, 2012). As can be seen in Table 4, the questionnaire contained five questions concerning peer relationship formation between the robot and students, five questions regarding whether the robot helped in the lessons as a peer tutor, five questions regarding the mutual interaction between the robot and students, and three questions asking the respondents to compare the robot to regular peer tutors. The answers were given on a 5-point Likert scale 1 indicated low and 5 high.

Table 4 Questionnaire questions

Criterion	**Question No.**	**Question(s)**
General background	1-4	Sex, age, education level, teaching experience
Formation of peer relationship between the robot and students	A1	Were the students interested in the robot during class?
	A2	Did the students want to show their poem drawings to the robot?
	A3	Did the students express friendliness towards the robot, such as by initiating conversations?
	A4	When the robot sung a song, were the students interested?
	A5	Upon completion of the lesson, did the students express friendliness towards the robot as they were parting? (e.g., saying farewell, sorry to say bye, etc.)
Robot helping in class as a peer tutor	B1	Did the students pay attention when the robot read the poem?
	B2	When the robot spotted an interesting part in the poem (gam, gam, gam – bam, bam, bam), did the children empathize?
	B3	When the students read and wrote down the poem, was the robot's help necessary?
	B4	When the students read and wrote down the poem, did they do the dictation task well with the robot's assistance?
	B5	When the students read and wrote down the poem, was the robot considerate of the students?
Interaction between robot and students	C1	Did the students empathize with what the robot said (e.g., show response or seem impressed)?
	C2	Were the questions and answers between the teacher and robot helpful to the students?
	C3	Did the students successfully concentrate on the robot's explanation?
	C4	When the students did not understand what the robot said, did they ask it questions?
	C5	Did the students seek help from the robot?

Comparison between the robot and regular peer tutor	D1	Compared to the regular peer tutors, was the robot peer tutor more considerate of the students?
	D2	Compared to the regular peer tutors, was the robot peer tutor kinder?
	D3	Compared to the regular peer tutors, was the robot peer tutor more effective?

This study calculated reliability by using Cronbach's α, which is the internal consistency calculation coefficient, in order to assess the consistency among the questions in the questionnaire (Oh, 2003). The survey results revealed high internal consistency, as shown in Table 5, a Cronbach's α of .899 for one variable, .724 for two variables, and .711 for three variables. The survey results showed an average of four points on all questions related to peer relationship formation between the robot and students. The question about whether the robot assisted in the peer tutor lesson also showed an average of four points. In terms of the interaction between the robot and students, there were only answers that fell between "average" and "yes," with an average of 3.5 points on the question about whether the students requested help from the robot. Lastly, the answers to the questions about the comparison between the robot and regular peer tutors recorded at least an average of 4.3 points, showing that the robot was more considerate of the students, kinder, and more effective.

Table 5 . Results of the analysis

Criterion	Question No.	Average	Standard Deviation	Cronbach's α
Formation of peer relationships between the robot and students	A1	5	0	.899
	A2	4.2	0.75	
	A3	4.8	0.40	
	A4	4.6	0.89	
	A5	4	1.09	
Robot helping in class as a peer tutor	B1	4.2	0.98	.724
	B2	4.2	0.40	
	B3	4.2	0.98	
	B4	4	0.63	
	B5	4.5	0.83	
Interaction between the robot and students	C1	4.5	0.55	.711
	C2	5	0	
	C3	4.7	0.52	
	C4	4.5	0.55	
	C5	3.5	1.22	
Comparison of the robot and regular peer tutors	D1	4.3	0.81	.404
	D2	4.7	0.10	
	D3	4.5	0.55	

IV. CONCLUSION

This thesis demonstrated the possibility of establishing a disabled students peer tutor support system using the telepresence robot technology that is currently being developed and applying the system on-site. The possibility of using the peer tutor support system was verified using the telepresence robot technology in an open class for 10 students at an elementary school in Gyeonggi Province and by surveying six teachers who observed the open class. The survey asked the teachers to assess the formation of peer relationships between the robot and students, whether the robot helped the class as a peer tutor, and the interactions between the robot and students, as well as to compare the robot and regular peer tutors.

The question about whether the students requested help from the robot received only answers that fell between "average" and "yes," with an average of 3.5 points, while all other questions showed positive results of at least four points. In particular, in response to the questions, "Did the students show interest in the robot during class?" and " Did the questions and answers between the teacher and students help the students?" all of the teachers responded "Very much so (5 points)," demonstrating that the peer tutor support using the telepresence robot helped the students in the lessons. Also, in the responses to the questions regarding the comparison between regular tutors and the robot peer tutor, which could be said to be the objective of this study, the teachers reported that the robot peer teacher was more considerate of the students than the regular peer tutors, and was kinder and more effective.

These results could be said to demonstrate that the problem that peer tutor effects cannot be generalized in the field of education (which were sufficiently proven to be effective but limited by playing around between the peer tutor and peer tutee, difficulties in preparing to teach, damage to pride, etc.), could be resolved through remote support by experts using a telepresence robot. Also, by resolving such problems, this study showed the possibility of resolving the problems that arise in the unified education classrooms of disabled students.

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