ShareHandy: Peer Teaching Support System for Online Exercises of IoT Prototyping

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***Abstract*— Peer teaching is said to be one of the most useful means for students to learn deeply. However, in online exercises for assembling hardware, students cannot easily share their hardware assembly status among them, which hinders peer teaching among them. To solve this problem, we developed a hand-sharing system, ShareHandy, which allows students to share video images showing their work in progress hardware with their smartphones. This paper proposes the system, describing its design and rationales, and verifies the usefulness of the system through an experimental exercise of Internet of Things (IoT) prototyping. The results show that the proposed system can effectively promote peer teaching and improve the efficiency of the exercise.**

Keywords-online education; peer-teaching; IoT exercise.

I. INTRODUCTION

Peer-teaching is a learning method in which students teach each other and is attracting attention to increase the learning effectiveness of students [1]. Recently, the COVID-19 pandemic has increased the number of online classes and exercises. However, such online situation also limits the interactions among students to online, making it difficult to hold peer teaching [2]. One of the major reasons for this is that it is difficult for students to share their assembly status of hardware with the other students. For example, when students are learning electric circuits online, they lose important peer-teaching opportunities, such as sharing one student's work with the teacher and other students, pointing out and giving advice to each other interactively, and being able to review the points and advice after that.

To solve this problem, Dorneich et al. clarify the classification and criteria for online classes [3]. Kitagami et al. propose an exercise method of using a virtual camera to share camera images, documents etc. in one screen in a Web conference system, in which students watch the screen image transmitted by the teacher as they proceed with the exercises [4]. However, this method does not allow students to see other students' status while receiving teacher's transmission. Hamblen et al. proposed a method for peer teaching of hardware assembly in an asynchronous environment using a wiki [5]. However, this method does not allow students to interact with each other in real-time.

To solve the above problems, we propose a peer teaching support system ShareHandy, which provides the function for students to share their assembly status of the hardware with a camera, point and draw on the shared images, and save these images data. The proposed system allows students to facilitate real-time peer teaching within a group.

This paper first presents the requirements for a peer-teaching support system, the corresponding design, and its rationales, describes the prototype implementation, and evaluates its usefulness by applying it to a group exercise of Internet of Things (IoT) prototyping held online. The results show that the proposed system allows students to understand each other's situation quickly and accurately in group work exercises. Therefore, the proposed system has proven useful in supporting peer teaching.

In this paper, Section 2 presents the details of our proposal system, Section 3 and Section 4 describe the experimental evaluation, and their results and discussion, and Section 5 concludes this paper.

II. PROPOSED SYSTEM

To support peer-teaching in IoT prototyping exercises, it is necessary to have a support function for the teacher and the students to share the hardware assembly status. The basic function of the proposed system is to stream live videos of students' at-hands using their own smartphone camera for peer-teaching.

The following subsections describe the assumptions and scenarios of using the proposal system, the functions provided by the system, and how these functions can be utilized in the scenarios.

A. Usage Assumptions and Scenarios

We assume that the exercises to be supported are designed for each student to work in a group and assemble the same hardware individually. The group can use the support functions to discuss and teach each other within each group. The proposed support system works as an auxiliary system for the Web conferencing system, which handles document sharing and voice communication. This support system helps the group members share the video images of their work in progress.

The following scenarios are considered as the major use of the support functions.

 ISBN: 978-1-61208-926-3

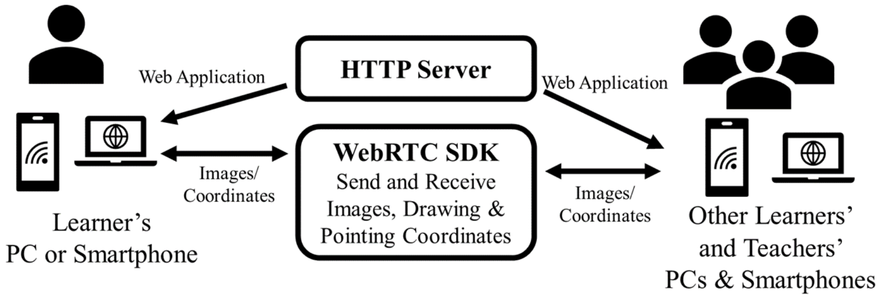

Figure 1. System Structure of ShareHandy

- Students who have successfully completed the assembly and those who have not work together to review their work each other's work to find out what the problems are.
- A student asks the teacher some question about how to proceed with the exercise, and a session is held to answer the question. Several students who are interested in the questions participate in the session, and the session proceeds on a question-and-answer basis.

B. Designed functions and their usage scenarios

1) Setting up rooms for group sharing

The system is designed to set up multiple rooms simultaneously so that some group members can easily have a space to discuss some topic and other members interested in it can participate freely.

2) Real-time video streaming

Using cameras of smartphones or Web cameras attached to laptops, images of multiple students' work-in-progress artifacts are streamed in real-time. The system can display multiple images at the same time so that the students can see each other's at-hand work at the same time. This allows the person teaching the session to communicate the correct sequence of steps in a work, the changes on the artifact for each work step, and the person being taught to communicate how his/her work has been progressing so far and what the problems are. In addition, the system can convey information enabling a three-dimensional recognition of the artifact through video, which cannot be conveyed by documents or still images.

3) Pausing video and broadcasting still images

The video being streamed can be paused and streamed as a still image. This allows the person teaching to take enough time to give a detailed explanation of the work steps of focus and their key points, and allows the person being taught to be able to stop at his/her problematic work points to ask questions to investigate what is wrong.

4) Pointing by participants

Each participant has a cursor with an individual identifier and can point to a certain position on the video image. This allows the person teaching to clarify the points of focus, explain the situation, and give instructions accurately. It also allows the person being taught to clarify the points to ask.

5) Drawing by participants

Participants can use their fingers, pens, mouse, etc. to write texts and draw figures on the streaming videos (including still images). This allows the person teaching to label related locations (e.g., name and number in the image locations) and to indicate directions drawing arrows. In addition, the person being taught can leave notes to be shared.

6) Saving video captures and drawings as still images

A still image of an arbitrary video scene with drawing data overlaid on it can be stored on the participant's device. This allows the person being taught to reflect on the session through self-study afterwards.

C. Implementation of the Proposed System

The proposed system is implemented as ShareHandy, which enables easy sharing of the sight at hand. The structure of ShareHandy is shown in Figure 1.

The system is designed to work on any devices such as PCs and smartphones. Therefore, this system is built as a Web application, which runs on a Web browser and has the advantage of being able to support multiple operating systems with a single code. Another advantage is that users only require access to a web page for using the application and there is no need to install additional applications on each device.

As shown in Figure 1, we use WebRTC (Web Real-Time Communication), which enables real-time communication of video, audio, and general data via a Web browser [6]. WebRTC communication allows the users to send and receive images, coordinates of drawing and pointing, and other control signals in real-time.

Figure 2 shows an example of using ShareHandy. Two people participate in a session, sharing videos showing their artifacts. In the left screen, the pointers of the participants (shown with a "P" mark) and the drawing data are displayed.

III. EXPERIMENTAL EVALUATION

A. Purpose of the Experiment

We formulate two hypotheses concerning the effects that can be achieved by using this system in online exercises.

 ISBN: 978-1-61208-926-3

Figure 2. User Interface of ShareHandy and Demonstration

[Hypothesis 1] This system makes it possible for the person teaching to quickly and accurately covey a set of instructions on the artifact at hand to the person being taught.

[Hypothesis 2] This system enables group work to be carried out smoothly, and as a result peer teaching can be promoted.

We conducted experiments to test these hypotheses.

B. *Method of the experiments*

1) *Exercises to which the method is applied*

Two exercises on IoT prototyping:

- Individual exercises following a sample procedure, where every student belongs to some group, whose members can communicate within it.
- Project-based learning style exercises, in which each group develops a prototype to solve their problem.

2) *Subjects*

10 undergraduate students and 4 graduate school students. All subjects were students at Shibaura Institute of Technology, and majored computer science and engineering.

3) *Experimental procedure*

The subjects formed small groups of three to four people, and the groups were asked to use ShareHandy freely during the exercises. We did not instruct where and how to use it in particular.

4) *Evaluation method*

We asked the subjects to answer a questionnaire after finishing the exercises. We analyzed their answers to evaluate the results of the experiments. The questions in the questionnaire are shown in Table 1. In addition to this, we directly interviewed the subjects after the exercises.

C. *Result of the Experiment*

We receive 14 answers from all the subjects. The results of the questionnaire are shown in Table 2.

- Concerning the answers to Q3-1, 86% of the subjects answered positively to the question “Was it easy to see the other person's hand?” In addition, all the subjects felt positive about Q3-2 “The other person quickly understood my situation” and Q3-4 “It was easy to communicate by pointing with my hand.” Furthermore, 86% of the subjects answered positively to Q3-5 “I was able to proceed with the work efficiently.” From these results, we can confirm that our hypothesis 1 is true, that the system achieves the targeted effect and allows the subjects to covey instructions on artifacts at hand quickly and accurately.
- To Q3-5 of " It lowered the barrier for teaching each other", all the subjects answered affirmatively.

In addition, 92% of the students answered affirmatively when asked if they would like to use this system again, suggesting that using this system is useful.

From the interviews with the students after the experiment, we obtain the following points of their impressions and dissatisfaction.

Positive comments include:

- Because handling the objects can be easily seen, it is easy to understand how they are built Because objects at hands can be easily seen, how they are built can be understood well (from many subjects).
- Because group members can share the view of the objects at hand, it is easy to explain them. It can also be used to check if the right sensor has been selected.

The latter comment suggests that we can apply this system to much broader things than we originally expected.

Negative comments include:

- The screen of the smartphone is too small to see the screens of other participants.
- Because the camera does not focus well, it is difficult to see small characters.

These negative comments suggest a need for improvement on both the system itself and the way to use it.

IV. DISCUSSION

We found that the proposed system effectively achieves the effects that we targeted in the design of the system from the answers of Q3-1 to Q3-4. Therefore, the system allows all

TABLE I. QUESTIONS ON THE QUESTIONNAIRE ADMINISTERED AT THE END OF THE EXPERIMENT

No.	Questions and Options
Q1	What is your position?
Q2	In what situations did you use the system? · Teaching each other in the group · Creating something with the group member · Teaching each other with one-on-one
Q3	Please answer the following questions in four choices: Agree, Almost Agree, Almost Disagree, or Disagree
Q3-1	It was easy to see the other person's hand.
Q3-2	Groupmates understood my situation right away.
Q3-3	I was able to work efficiently.
Q3-4	It was easy to communicate by pointing at the hand.
Q3-5	It lowered the barrier for teaching each other.
Q3-6	I would use this system again.
Q4	Any other comment (Free text)

 ISBN: 978-1-61208-926-3

TABLE II. RESULT OF THE QUESTIONNAIRE

No.	Question	Answer			
Q1	What is your position?	**Undergraduate Student**		**Graduate Student**	
		10		4	
Q2	In what situations did you use the system?	**Teaching each other in the group**	**Creating something with the group member**	**Teaching each other one-on-one**	
		7	7	0	
Q3	Please answer the following questions	**Agree**	**Almost Agree**	**Almost Disagree**	**Disagree**
Q3-1	It was easy to see the other person's hand.	9	3	2	0
Q3-2	Groupmates understood my situation right away.	7	7	0	0
Q3-3	I was able to work efficiently.	10	2	2	0
Q3-4	It was easy to communicate by pointing at the hand.	8	6	0	0
Q3-5	It lowered the barrier for teaching each other.	7	7	0	0
Q3-6	I would use this system again.	5	8	1	0

the participants (including teachers and students) to share the status of multiple participants' hardware in real-time (Hypothesis 1). Moreover, directly from the answers to Q3-5, we found that the system promotes peer teaching.

From the results of the questionnaire, the level of satisfaction in using this system is high. This is because there is no other way for students to see the others' hands in real-time. The real-time nature of the system and its pointing function may have increased the user's satisfaction.

However, the system has not been used very often during the exercises, with the usage frequency being lower than we expected. Some students commented that:

- The system is easy to use, but we did not have so many opportunities to use it.
- We did not have so many problems relating to hardware in IoT prototyping.

The IoT prototyping used in the experiments does not have so many complicated tasks relating to hardware which need someone's help. In addition, we guess that online exercises may create a sense of emotional distance between students. This may be the reason why many students hesitated to ask the other group members a question or preferred to research the answer on their own instead.

To overcome such limitations for the validity of the experimental evaluation, we need further experiments that include giving the subjects a method to decrease the hesitation in communicating online or giving them a problem on IoT prototyping with a high level of hardware difficulty.

V. CONCLUSION

We developed a web application, ShareHandy, which can be used in the context of hardware assembly to share video images showing hardware assembly status with the other students. Our experiment to confirm its usefulness in improving comprehension and peer teaching gave positive results from students who used the system. The results of the questionnaires and interviews suggest that the system is effective enough to support group work and peer teaching.

Through this study, we found some issues such as the search for an effective way to use the system for online exercises, the improvement of the accuracy of the system, and the evaluation method of the system.

In future work, we will improve the reliability and usability of the proposed system, find an effective way to use it in online exercises, and solve the problem of video quality. In addition, we will apply and evaluate the system on a larger number of subjects and explore better evaluation methods through quantitative data measurement.

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