Development and Assessment of CSCL System for Large Classrooms Using Collaborative Script

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Abstract— **In the area of Computer Supporter Collaborative Learning (CSCL) research, scripting collaborative learning is a relatively new but promising approach to promote learning. The term scripting is used to describe ways of prescribing relevant elements for collaborative interaction, such as group formation, roles, learning activities, sequence of learning activities. Many studies have shown that free collaboration without explicit scaffolding rarely produces effective interaction and that the script can be one of the most effective scaffoldings. Basing on reciprocal learning method, we have designed a script which allows students to create questions and answer them mutually. To implement this script for large classrooms, we have developed a CSCL system which has two important functions: automated group formation function that can form groups on the fly, based on students' personal traits, and chat function by which students can discuss each other within their groupe. For the evaluation, we have conducted an experiment with some 300 students in a large classroom to evaluate our system and analyze interactions in detail during each sequence of learning activities. Based on the assessment result, the learners felt encouraged to understand better about learning task. At the same time, it became clear that the quality of discussion on chat affects reciprocal question posing. As well, it was indicated that group size and knowledge level of leader or other members affect the process of reciprocal actions and activities at some degree.**

Keywords-Collaborative learning; CSCL;script.

I. INTRODUCTION

A. CSCL and its issues

According to the social constructionism presented by Vygotsky and the theory of legitimate peripheral participation presented by Lave and Wenger, the learning, which was understood as a cognitive process in an interior of an individual leaner, will be recognized as a social process, or social cognition that progresses while cooperating with others [1]. Far from denying the learning as an individual cognitive activity, the social cognition can promote knowledge construction at an individual level and metacognition for learning strategies, through problem-solving by discussing with others [2].

The environment for such collaborative learning is built on the computer network, and such computer technologies are used as a supporting tool to promote collaborative learning, which is called, Computer Supported Collaborative Learning (CSCL). Advantages of CSCL over the face-to-face learning are: learners who are geographically or timely distant from each other can learn, a large number of learners can learn and be managed, logs of the learning process in details can be saved for learners, managers and scholars to re-use them, learning software and contents can be used and many more.

On the other hand, many case studies on the collaborative learning point out that it is highly unlikely for leaners to carry out collaborative activities voluntarily while learning without an external scaffolding [3]. For this reason, in order to resolve such issues in learning, various methods have been developed to appropriately regulate and structure the learning process within a group for effective and productive work and discussions among learners.

In this study, one of such methods, "collaborative script" was implemented in the CSCL system and used in a large classroom in the university. First, the next section will provide the overview of the collaborative script.

B. Collaborative script and its issues

The concept of script was originally suggested by Schank and Abelson in the field of cognitive science, and it has a meaning of internalized knowledge about socially sharing steps and rules people should follow in a certain situation (e.g., eating at a restaurant) [4].

Once the concept was introduced in the field of collaborative study, the script became a series of external scaffolding methods that are provided to promote collaborative learning. The first study on collaborative script was proposed by O'Donell and Dansereau [5], which defines the script as a scenario for a small learning group, which prescribes in details, who is carrying out what kind of learning activities and when. Due to the complexity of the script before the learning activities themselves, learners needed to be trained to follow the script.

After the script was adopted in CSCL, instead of training learners to execute the script prior to learning, the system interface was used to indirectly lead them to the scripted learning process.

Many researches indicate that the script can be designed at 2 levels in the CSCL environment. First, there is a design approach at a macro level; it defines who will learn, what assignment subjects for a group and how to distribute tasks

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among learners. On the other hand, there is a micro level approach which consists in prescribing the details of each learning activity in order to revitalize social interactions among learners.

There have been many studies that indicate the effectiveness of various CSCL systems with the script, but there are some issues at the same time. First, there is an issue on controlling a compelling power of the script. In other words, it means how to deal with the risk of over-scripting which takes too much self-motivation out from learners [6]. Next, despite a lot of empirical case studies, yet there are very few suggestion on a script design model that can be commonly used, with some exceptions [7] [8]. About the first issue, we suggested previously a method to flexibly adjust compelling power of the script according to learners' traits and learning situation [9]. So, this study focuses on the second issue, adopting a design method as the approach in order to design the script based on the design principle and implement and assess it.

C. SWISH MODEL as Design Principle

The purpose of the collaborative script is to support the problem solving and knowledge construction by social interactions among learners. To do so, a mechanism to trigger effective interactions is an important element. A Swiss scholar, Dillenbourg, suggests SWISH model as such mechanism. This model is the design principle for collaborative script that gives tasks that would generate conflicts among learners; it is supposed to promote intense interactions (statements, explanations, discussion, etc..) to overcome these conflicts [10].

From this model, three script schemata are drawn as design guidelines : 1. jigsaw schema, 2. reciprocal schema, 3. conflict schema. This time, we adopt the reciprocal schema. The most well-known example is Palinscar and Brown's reciprocal teaching method [11]. In this schema, learners take turns assuming roles (summarizer, questioner, clarifier, predictor). So, Since the steps of the problem-solving process are distributed horizontally among learners, they must continuously collaborate to build a shared solution.

D. Structure of this paper

This paper is structured as follows. Section II presents the general outline and the purpose of this study, and Section III describes our CSCL system for large classrooms. The collaborative script design is discussed in Section IV. Then, we present our experiment and results from our evaluation in Sections V and VI. Section VII concludes the paper.

II. PURPOSE OF THE STUDY

In this study, the script based on the reciprocal schema, is designed and implemented in the system to assess its effects. The system is for an environment where several hundred students in higher educational institutions cannot interact with one another face-to-face. The collaborative learning is carried out by those students using the system online.

As for the assessment, assignments and chat log data are used to assess the quality of interactions during the collaborative process and its learning effects. By analyzing the correlativity between the two, we aim to have some guidelines for improving the script and design principle.

III. SYSTEM

As Fig. 1 shows, our system was developed for an environment, such as a large classroom with several hundred people at higher educational institutions where face-to-face group learning is difficult. A teacher and students gain access to the CSCL server through PCs that are connected to the network. Learners can form a group regardless of where their locations are, and a teacher can remotely keep track of learning state of each group.

A. System Overview

As Fig. 2 shows, the system consists of different functions, such as "automated group formation" and "questionnaire preparation" by which a teacher designs a collaborative learning, "assignment submission", "reciprocal reviews" and "chat within a group" that provide a collaborative environment to learners. "Learners' properties" in Fig. 2 are drawn from questionnaires and pre-tests that were administrated before. Based on the properties, the system automatically forms groups.

B. Flow of Collaborative Learning

The collaborative learning in this system are composed of 5 blocks, as Fig. 3 shows. The following is the learning flow.

1. "Prior Setting" allows a teacher to conduct questionnaires, prepare pre-tests and register to the system.
2. In "Pre-learning", each learner submits the questionnaire and pre-test which was registered in "Prior Setting" on the system.

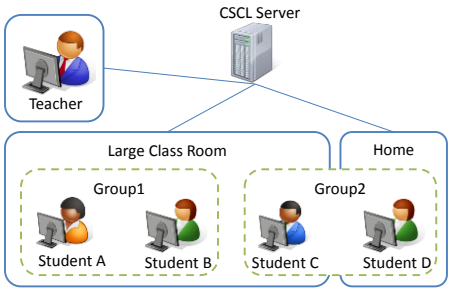


Figure 1. System overview

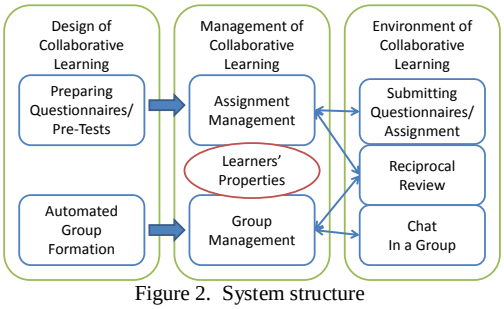


Figure 2. System structure

3. In ”Group Formation”, the system automatically forms groups based on the parameters the teacher has set and results of statements/answers by the learners. Small adjustments to the group formation can be made manually by the teacher.
4. In ”Collaborative Learning”, reciprocal reviews within a group and among groups as well as chat system within a group can be done in the system. The learners carry out these collaborative works according to the collaborative script.
5. In “Post Assessment”, the teacher reviews and grades submitted assignments.

C. Automated Group Formation Function

In this study, group formations are made possible in various ways that a teacher intends to do, by combining multiple elements of user characteristics that are obtained beforehand.

For example, a teacher can freely decide how many people to be in a group. He can also form flexibly groups with members of which properties are similar, or different.

D. Collaborative Script Function

In collaborative script, tasks are assigned according to roles, such as “Preparer”, “Answerer” and “Grader”. In the system, the group management function assigns tasks to each learner while the assignment management distributes allocated tasks. Also, roles which each learner is supposed to play and tasks are given automatically so that learners can work on their tasks at an appropriate speed without having to think about the collaborative script.

IV. COLLABORATIVE SCRIPT DESIGN

Supposing the experimental environment shown in Table1, the details of the collaborative script to be executed in the proposed system were designed.

A. Question-Posing Script

A script was made for the learning process in the task model called “reciprocal question-posing”. The following is a flow of ”reciprocal question-posing collaborative script”, which was designed in this experiment.

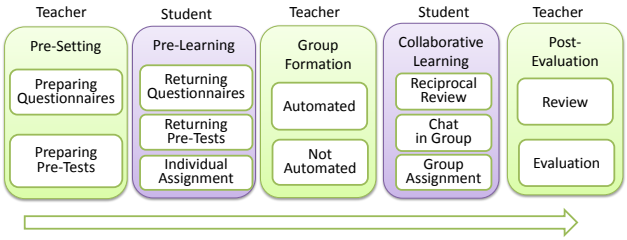


Figure 3. Flow of collaborative learning suggested by the system

TABLE 1. PRECONDITIONS OF COLLABORATIVE SCRIPT

Number of Students	Aboue 300 People
Member of Groups	3 People
Learning Time	90min × 2
Design Guideline	Reciprocal Teaching

Phase-1 : Preparing individual questions
A theme of question posing is given to learners. All the students prepare a question based on the given theme and submit it, including the answer and explanation about the question.

Phase-2 : Reviews within group
Regarding the question prepared at Phase-1, 3 members within a group are assigned as a question preparer, answerer and grader and review reciprocally within the group through the following activities (Fig. 4).
a. An answerer prepares answers to the questions prepared by a question preparer and submits the answer and evaluation of the question.
b. A grader grades the answer submitted by the answerer in a. and submits the graded result and evaluation of the question.
c. Based on the evaluation submitted in a. and b. a question preparer evaluates himself/herself,
d. The above process from a to c is repeated until all the learners rotate to take a different role within the group and become a question preparer

Phase-3: Question preparation within a group
Through a discussion in a group chat, a question must be prepared for submission. The answer and explanation are prepared along with the question.

Phase-4 : Submission and publish of final questions
Students submit a question/answer/explanation to their teacher. The teacher then publishes the questions as a assignment among groups.

Phase-5 : Solving questions reciprocally among groups
Students solve group questions that are published.

V. EXPERIMENT OVERVIEW

To assess this system, an experiment was carried out during a class at Tokyo University of Technology. The overview is as follows:

・Targets: Students at Tokyo University of Technology Freshman to Senior 298 students, 112 groups

・Dates for the experiment: January 10 (Tue) and January 18 (Wed), 2011

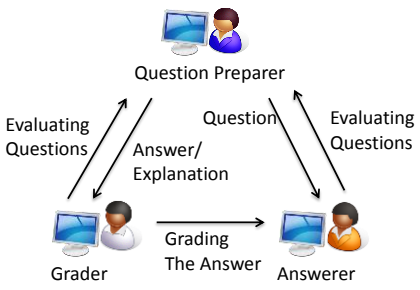


Figure 4. Group review

・Lecture: Basics of the logic

・Learning assignment: students prepare a question; the question has statements in Japanese that represent an deductive inference that contain several premises and a conclusion. The answer must have a well–formed formula that represents correctly the inference, and a truth table that verifies the validity/invalidity of the inference. For this assignment, several exercises had been done during previous lectures. Also, similar question were distributed and completed as a pre-test one week before the experiment. The pre-test was graded by the teacher in charge.

The experiment was carried out during 2 days in a 90 minute class. On day 1, 60 minutes were spent for answering/evaluating reciprocally within each group. On day 2, another 60 minutes were spent for posing questions reciprocally within each group. The flows for learning are shown in Fig. 5.

The group review phase for day 1 is for answering/evaluating questions, grading/evaluating questions and self-evaluation. Fig. 6 shows evaluations of a question by a grader's point of view.

The group review phase for Day 2 is for preparing group question. Using a group chat function, learners discuss how to pose the final question.

In this experiment, a number of group members was set to 3, but there were some groups of less than 3 group members due to no attendance of some members. Specially, since groups could not be changed on Day 1 and Day 2, there were many groups of less than 3 group members due to no attendance of group members on Day 2. For this reason, the evaluation of this experiment was done on only 93 groups with group members of 2 or 3 on Day 2. Table 2 shows changes in a number of group members.

Also, on Day 1 carry out a group review, group members of less than 2 members could not carry out a group review. In this case, the groups of 2 members continued the learning using a different script that allows the 2 members solved questions and graded reciprocally. For a group of 1 member, the 1 member had additional members who came in late.

VI. ASSESSMENT

A. Automated Group Formation

In this experiment, groups were formed in a way that the academic level for each group is similar. Each group consists equal numbers of learners who ranked top, middle and low in the pre-tests about the content of the lecture. The results of the pre-tests were total points (perfect score is 400 points) of 4 pre-tests that had been implemented according to the progress of the lecture. All the grading was done by the same teacher. Fig. 7 shows the distribution of individual score and average score within group. Because the average scores gather in the median, the automated group formation functions normally.

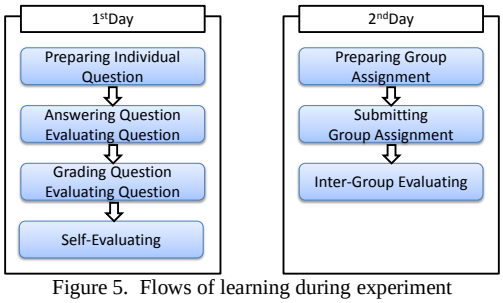
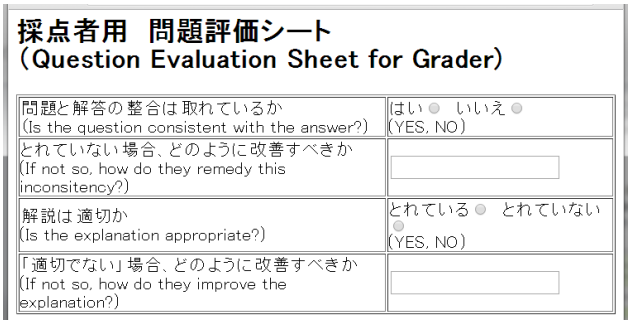


Figure 5. Flows of learning during experiment


採点者用　問題評価シート
(Question Evaluation Sheet for Grader)

問題と解答の整合は取れているか (Is the question consistent with the answer?)	はい ○ いいえ ○ (YES, NO)
とれていない場合、どのように改善すべきか (If not so, how do they remedy this inconsistency?)	
解説は適切か (Is the explanation appropriate?)	とれている ○ とれていない ○ (YES, NO)
「適切でない」場合、どのように改善すべきか (If not so, how do they improve the explanation?)	

Figure 6. Evaluations of a question by a grader's point of view

B. Question-Posing Script Evaluated by Learners

At the end of the experiment, we distributed a questionnaire to the students. Fig. 8 shows the responses to the question "Did you have a deeper understanding through posing questions?" Since many responded, "Deepened" and few answered, "Not deepened" and "Not at all deepened", the learners find the script effective.

Fig 9. shows the responses to the question, "what was the most useful reference while question-posing?". Responses as "Chat within Group", "Evaluation on questions by answerers" and "Evaluation on questions by a grader", of which teamwork take a large part, were highly evaluated.

C. Interaction within Groups

Contents of the chat were divided up into the following 5 categories: "Detailed discussion on important points", "Discussion on important points", "Discussion that often went off on a tangent", "Discussion that were mostly chit-chatting" and "Pointless discussion". The categories are shown in Table 3. We fixed these categories after the attentive reading of the contents of the chat. The evaluation was executed by 1 person according to the evaluation standard while the another checked the result.

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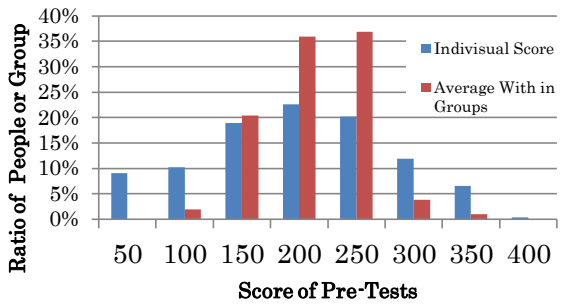

Figure 7. Distribution of individual score and average score within groups

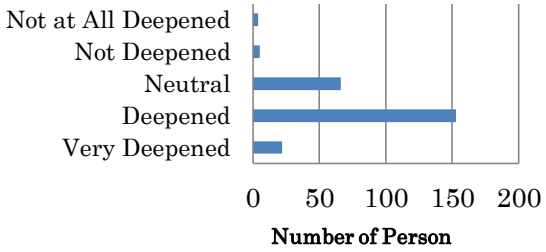

Figure 8. Responses to the question "Did you have a deeper understanding through posing questions?"

TABLE 2. CHANGES IN A NUMBER OF GROUP MEMBERS

Number of Members	Number of Groups	
	1st Day	2nd Day
3	77	40
2	32	53
1	3	15

TABLE 3. QUALITY OF DISCUSSION

Detailed Discussion on Importnant Points	Participants discuss carefully and meticulously to decide how to carry on.
Discussion on Important Points	Decision are taken by short discussions. Assignments are completed rapdely with modifications.
Often Went Off on a Tangent	Participants discuss on important points. But they chitchat often.
Mostly Chit-Chatting	Participants chitchat more often.
Pointless Discussion	Participants always chitchat and don't try to complete the assignments

Table 4 to 6 are extracted from the chat logs. Table 4 shows a part of discussions that was evaluated as "Detailed discussion on important points". It shows that 3 people consulted with one another on how to carry on.

Table 5 shows a part of discussions that was evaluated as "Discussion on important points". It shows that only some casual conversations were the basis for making a decision to carry on. Even after the conversations, there were many communications to inform what had been decided and agreements on what had been decided. "Going off on a tangent" contained chit-chatting in the above conversations while "More chit-chatting" had more chit-chatting than discussions.

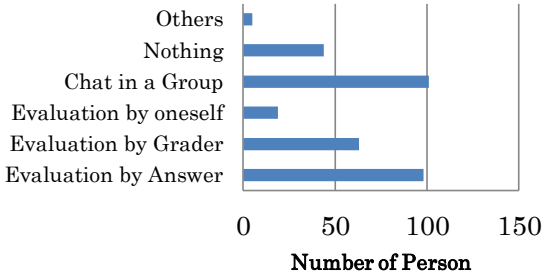

Figure 9. Responses to the question "What was the most useful reference while question-posing?"

TABLE 4. EXAMPLES OF "DETAILED DISCUSSION ON IMPORTANT POINTS"

Talker	Contents
D	Where do you want to change?
E	That's right … I guess, first of all, we definitely need to change the question, and then, what about the well-formed formula?
D	How is it that changes only the third line of the question?
D	Regarding the well-formed formula, it's the final part after ⊃.
E	That's good idea.
F	I agree. How do we want to change that?

TABLE 5. EXAPMPLE OF "DISCUSIION ON IMPORTANT POINTS"

Talker	Contents
G	Whose problem will we use?
H	How about I's Question? I don't have any particular reason for it though.
I	I think it's OK if it's corrected.
H	Then, let's make corrections on I's question and use itI.
G	All right, let's work it out.

TABLE 6. EXAMPLE OF "POINTLESS"

Talker	Contents
X	It's difficult to make a new question, isn't it?
Y	Why don't we pick the best question among three of us and submit it?
X	I think that's great!
Y	OK, let's do so.

Table 6 shows a part of discussions that was evaluated as "Pointless". It shows that the conversations were going into a direction of avoiding deep discussions.

Fig. 10 shows the quality of discussions by each group, of which chat logs were evaluated. In both groups of 2 or 3 people, more than 70% of all the groups fell into either one of the 2 categories, "Detailed discussion on important points" and "Detailed discussion", meaning that many groups had good interactions.

Fig. 11 shows the number of statements made per person within each group. In the groups of 2 people, an average number of statements made per person is 26.2 while in the groups of 3 people, the average was 22.3. These results suggest that in both groups, relatively active discussions were held, and the interactions were sufficiently activated. Also, a number of statements was higher in the groups of 2 people rather than in the groups of 3.

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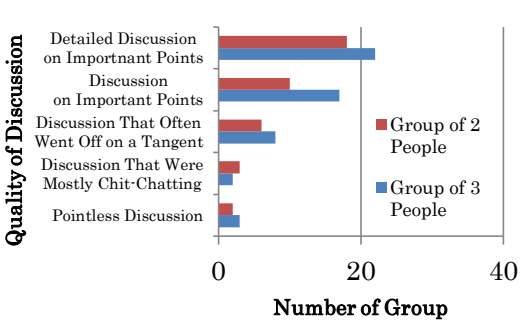

Figure 10. Quality of discussions and number of group

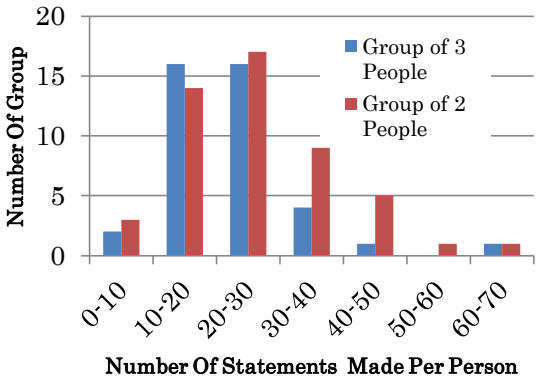

Figure 11. Number of statements made per person person within a group

Fig. 12 shows the comparison between the average scores of the pre-tests within each group and the qualities of the discussions. When the average scores were divided into the 3 different levels, "100 to 150", "150 to 200" and "200-250", most of those groups that falls into the highest level, "200-250", also falls into "Detailed discussion on important points".

D. Leader Function on Chat

From the chat logs, learners who took a leader role in the chat were identified, and the relationship between the learners' rank for the pre-tests within their group and the qualities of their discussions was evaluated.

Fig. 13 shows a result of the groups of 2 people while Fig. 14 shows a result of the groups of 3 people. Based on the results, in the groups of 2 people, when those who played a leader role have less academic ability than those who did not, their discussion tends to be well. In the group of 3 people, on the other hand, when those who had the best grade within their group played a leader role, their discussion tends to be well.

E. Evaluation of Group Assignments

In this experiment, since the assignments that are submitted individually and by groups are the same, these 3 patterns can be possible as re-submitted assignments: "Re-submitted after improving individual assignment", "Resubmitted the same individual assignments as is" and "Submitted completely new". Those assignments that were made completely new include the ones that combined several different assignments. Fig. 15 shows a distribution of the ways each group made their assignment. In both groups of 2 and 3 people, the results indicates most groups "Re-submitted after improving individual assignment".

"Re-submitted the same individual assignment as is" does not serve the meaning of collaborative learning, and it also means the collaborative script did not work well. Fig. 16 shows the quality of discussion being held by groups who "Re-submitted the same individual assignment as is". Many of these groups had a discussion that was "Mostly chit-chatting" and "Pointless", so some type of scaffolding is necessary for them.

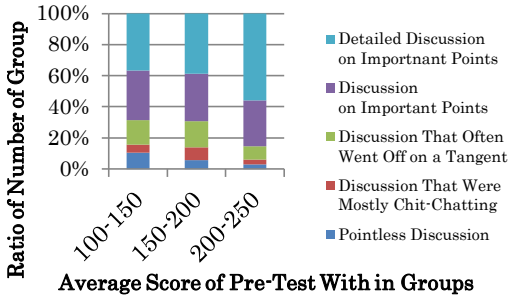

Figure 12. Pre-tests and quality of discussions

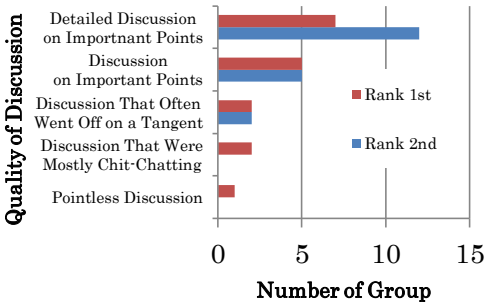

Figure 13. Leaders' rank in the group of 2 people

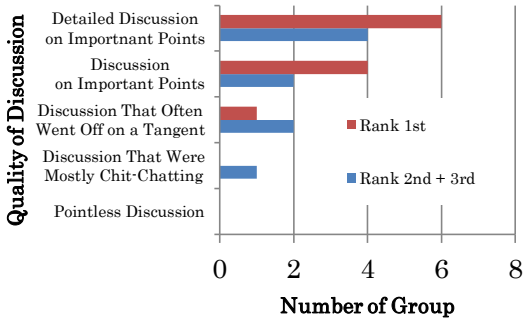

Figure 14. Leaders' rank in the groups of 3 people

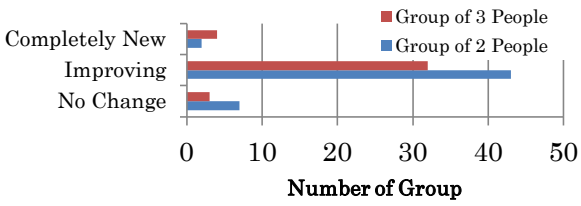

Figure 15. How they submitted group project

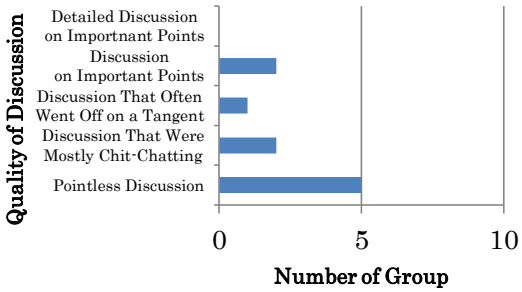

Figure 16. Quality of discussion held by groups without making changes

TABLE 7. EVALUATION STANDARD FOR PROJECT

Good	Complicated Question than the exercise shown in advance and an answer is right.
Average	Similar to the exercise shown in advance or equivalent in complexity, and a Answer is right
Bad	Similar to the exercise shown in advance or below equivalent in complexity, and an Answer is mistake

TABLE 8. QUALITY OF DISCUSSION AND EVALUATION OF PROJECT BEING SUBMITTED

	Evaluation		
	Good	Ave	Bad
Detailed Discussion on Importnant Points	13	18	9
Discussion on Important Points	3	18	6
Often Went Off on a Tangent	2	5	7
Mostly Chit-Chatting		3	2
Pointless Discussion		2	4

TABLE 9. HOW DISCUSSIONS WERE MOVED FORWARD AND PROJECT EVALUATION RESULTS

	Evaluation		
	Good	Average	Bad
Completely New	2	3	1
Improving	16	38	22
No Change		5	5

Table 7 shows a standard for the group assignment, “Good”, “Average” and “Bad”, which are used for grading. Table 8 shows a comparison between the evaluation result and the qualities of the discussions. The evaluation was done by 1 teaching staff who carried out the experiment. There were 2 different evaluators for this evaluator and the one who evaluated the qualities of the discussions. The result shows that the better the discussion quality is, the higher the assignment evaluation is.

Also, Table 9 shows a comparison between evaluation results and how discussions were carried on. “Made new” had a higher ratio of “Good” whereas “No changes” did not have any “Good”. As Fig. 16 suggests, “No changes” tends to result in “More chit-chatting” or “Pointless”. These points indicate that increasing a quality of discussion can lead to “Improvement” and “Make from scratch” with assignments highly scored.

VII. SUMMARY AND FUTURE ISSUES

A. *Summary*

Supposing a situation where a face-to-face learning is impossible, we developed a CSCL system which can form many small groups for the online collaborative learning, and then the question-posing collaborative script based on the reciprocal teaching method was implemented in the system.

Then, in the environment with 300 people, the automated group formation and the collaborative script were proved executable and effective.

(1) The learners felt that the mutual work using the collaborative script was effective. In fact, discussions through the chat were activated while keeping their quality high.

(2) Many groups improved their submitted individual assignment through discussions online. Those groups that held high quality discussions scored high on their group assignment.

(3) It is suggested that the activation of discussions depends on an academic ability of the learners who play a leader role within their group. However, depending on a group structure, higher (academic ability) does not necessarily mean good.

First, according to (1) and (2), the results showed that the design of the collaborative learning in this study was mostly appropriate.

Also, according to (3), it is important to identify the most suitable learners to play a leader role and assign them in each group. However, the characteristics of learners who should play a leader role cannot be selected based on their academic ability, such as scores of pre-tests. To resolve such issue, in the future, it is important to develop a method to identify learners with an ability to take a leader role from a pre-survey and activity logs.

On the other hand, when the collaborative script is executed in a class, it is important to plan for exceptional cases, such as students’ no attendance. Collaborative script does not allow a progress of tasks to be flexible, so the script often gets non-executable when the learning environment is off from an original plan. In this experiment, there are learners who attended on the 1st day and missed the 2nd day, or learners who missed the 1st day and

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attended on the 2nd day, so there were many groups that could not make progress their learning as planned. Also, there were some time limitations, such as a deadline for submitting assignments, so there were groups that had to submit without having sufficient discussions. Based on the above, executing a collaborative script needs some degree of flexibility depending on a learning environment and conditions of learners.

B. Future issues

In this study, the uniformed collaborative script was executed, but it is necessary to develop and practice collaborative script that is adaptable in groups in a way that the script changes flexibly depending on a group's characteristics and progress.

Also, for the automated group formation, it is necessary to be capable of forming various groups based on learners' detailed characteristics being specified and to clarify characteristics of groups depending on learners included in the groups.

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