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Development of An Algorithm for Groupware Modeling for A Collaborative Learning

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Abstract: This paper reports an algorithm for forming groups of students with regard to a computer system for collaborative learning designed to give a cue for debate utilizing mobile terminals. With this system, questionnaires which should be used as the seeds for debates are prepared in advance on the Web and all students attending the class answer to the questionnaires on the Web through their mobile terminals. Following this, the computer assigns students to appropriate groups based on the results of answers, and transmits each of answers and information of the group member to terminals of the students. Based on the information, students form groups and each group starts debate. In this study, system composition is dealt with first and algorithm for forming groups using answers by the students is discussed.
Keywords: Group forming, algorithm, collaborative learning, mobile terminal, debate system, groupware

1 Introduction

This study relates to university class in Japan. In many cases, lectures are given in one-sided manner, and it is pointed out that some schemes are necessary to encourage students to express their opinions or to induce discussions by students themselves[5][8]. Considering the recent trend that almost all students carry their own mobile terminals[6][7], this study relates to a learning system that utilizes mobile terminals as an ancillary tools for debate. Students are divided into groups making use of the information of answers by the students against questionnaires presented beforehand. On this occasion, information necessary for grouping and results of grouping are transmitted together with contents of each of answers to mobile terminals of the students. Students are then requested to form groups based on these information and to initiate debates in each group. In other words, this system is one sort of blended learning in which face-to-face debate is carried out utilizing electronic educational information communication. In this study, algorithm for grouping based on information of answers by the students is dealt with. With collaborative learning as mentioned, two points can be expected as mentioned below.

1. Groups are being formed considering education effects. Therefore, every student can know why he/she is assigned to the current group.

2. Students are instructed to start debate using the information on their answers as the seeds. Therefore, they can easily grasp a cue for debates.

According to the conventional method of grouping of students, groups are formed simply mechanically in the order of student ID numbers or those seating nearby are assigned to the same group. Meanwhile, in this study, it is attempted to form groups appropriately based on answers against some sort of assignments including tests. Teaching by groups which were formed based on answers of the students was attempted by the prior study[2][3]. At the time of this study, since possession of a mobile terminal by every student was not practical, test results were collected and marked by the teacher, groups were formed based on the results. Test papers were returned to the students, groups were formed, and students in each of the groups are requested to discuss primarily incorrect answers. For this reason, it took enormous time from answering to the questionnaires by the students to group discussion. This time, fully making use of information technology available today, we configured a new collaborative learning

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system. Thanks to assistance by mobile terminals, it is expected that from answering by the students till execution of discussions can be made promptly and smoothly. This system is currently under development. In Section 2, outline of system composition will be described, and an algorithm for forming groups will be introduced in Section 3 onward. Although the algorithm is one portion of the system, it is significant to make that in order to put the system into practical use, which may promote the practical e-learning in universities[1].

2 System Flow

Total four files are prepared and used in this system, student file, questionnaire file, aggregation file and groupware file. These files are used in this order.

1. Student file
   Basic information such as mail address, age, gender or the like of students are summarized in this file.

2. Questionnaire file
   Questionnaire or the like concerning discussion theme are summarized in this file. This file can be consisted of any of three types, multiple-choice method that allows only one selection, multiple-choice method that allows a plurality of selections, and free composition. (Multiple-choice method alone is subjected to processing of item 4. onward.)

3. Aggregation file
   Answers by the students for questionnaires in 2. are aggregated in this file.

4. Groupware file
   The computer forms student groups appropriately based on results of answers by the students in 3. This file also includes information on, in addition to answers by the students, which students form one group.

Execution procedures for preparing and utilizing above-mentioned files are shown in Fig.1.

(1) A student accesses the predetermined URL, enters basic information such as gender, ID number or the like and transmits it. His/her file (EXCEL) is then completed while the teacher may execute input and deletion of the information by operating EXCEL directly. Basic information of a certain class is stored here and this file can be utilized at every round-table discussion held by the class.

(2) With regard to a discussion planned by a certain teaching, a group of questionnaires which may benefit grouping is prepared and is registered to the system as a questionnaire file.

(3) Several groups of questionnaires are being registered in the questionnaire file. The teacher picks up specific groups of questionnaires and transmits URL for browsing questionnaire items to mail addresses of all students.

(4) Students answer the questionnaires and transmit them to create an aggregation file.

(5) Based on the information in the aggregation file, students are assigned appropriately to a certain group.

(6) Information on grouping is transmitted to mobile terminals of the students.

Upon completion of above-mentioned procedures, the students are grouped in the class and start discussions using results of answers as the cue.

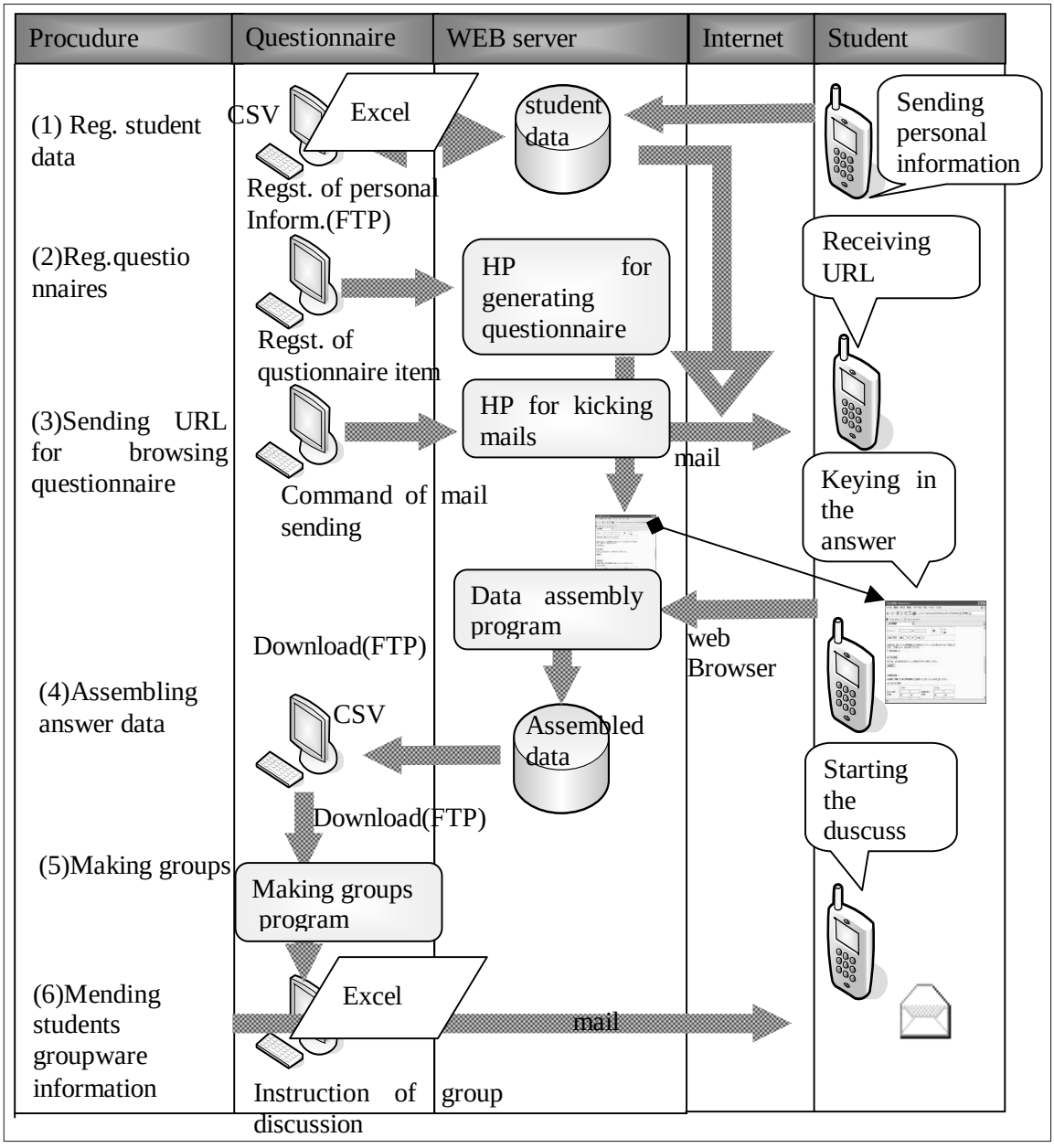

Figure 1: System flow

3 Construction of students groups

Suppose that there are four students A, B, C and D, and three questions a, b and c are given. Results of evaluation of answers to these questions are shown by O and X as shown in Table 1. One group consists of two students and discussion is made within the group primarily for questions which resulted in incorrect answers. In this case, two types of grouping shown in the table are compared. With grouping p, students A and B and students C and D constitute one group, respectively. However, in both groups, each of group members presented the same correct/incorrect pattern. Namely, in group 1, both members gave incorrect answer for question b and a possibility that they can teach each other for problem solving is low. The same also applies to group 2. Contrary, with grouping q, students A and C and students B and D constitute one group, respectively, and the said problem does not occur in this case.

From above-mentioned cases, it may be said that grouping q is superior to grouping p. When we focus on problem solving of correct answers and incorrect answers of the test, possibility of problem solving is considered to be higher for such a case where there are different patterns of answers rather than a case where there is only one pattern in the same group.

Table 1: Example of results of evaluation of answers and grouping

Student	Result of evaluation of question a	Result of evaluation of question b	Result of evaluation of question c	Grouping p (Group ID)	Grouping q (Group ID)
A	◯	×	◯	1	1
B	◯	×	◯	1	2
C	×	◯	×	2	1
D	×	◯	×	2	2

Suppose that the number of members in each of groups is the same. Then excellence of grouping ug in a certain group g ($g \in G$) is defined. Question j and question set are expressed by m_j and M ($m \in M$), respectively, and student i in one group g and the student sets is expressed by s_i and S_g ($s_i \in g$), respectively. Further, result e of evaluation of answer for question m_i and for student s_k are expressed by $e(m_i, s_k)$.

- Answer is correct → $e(m_i, s_k) = 1$
- Answer is incorrect → $e(m_i, s_k) = 0$

$$u_g = \frac{\sum_{s_k \in g} \sum_{m_i \in M} (1 - e(m_i, s_k)) \bigcup_{s_j \in g} e(m_i, s_j)}{|M \parallel S_g|} \tag{1}$$

where, $|M|$ denotes the number of elements of sets M. Grouping u of entire class is expressed by Equation (2)

$$u = \frac{\sum_{g \in G} u_g}{|G|} \tag{2}$$

Although two u_g's obtained by equation (1) are comparable to each other only for the case that both groups consist of the same number of the students, the proposed idea in this paper will be able to be

extended to the different number of groups in a classroom by equation (3) where both equations (1) and (2) are combined:

$$u_g = \frac{\sum_{g \in G} \sum_{s_k \in g} \sum_{m_i \in M} (1 - e(m_i, s_k)) \bigcup_{s_j \in g} e(m_i, s_j)}{|M \parallel S_g|} \tag{3}$$

where N means the number of the students in a classroom. Actually there could be that several groups are different in the number of group members because the total number of the classroom cannot be well divided into an integer by appropriate integers.

Whether the number of the students in a group is equal or not, it is necessary to calculate equation (2) or (3) for all the combination of student group in order to obtained the maximum solution. Although it is possible to do that theoretically, it is difficult to obtain the strict solution because of the enormous number of calculations. In reality, if the number of group members is supposed to be 4, the computer can execute computations of a class consisting of 50 peoples at the most. Then more simplified method should be used. In other words, with the relevant algorithm, suppose that students of one class are re-expressed as $s_1, \ldots, s_N$, the following replacement is made which results in calculations of N (N-1) times in total, and a group in which u becomes the maximum is judged to be the optimum grouping.

$$\begin{array}{l} s_1 \text{ and } s_2, s_1 \text{ and } s_3, \cdots, s_1 \text{ and } s_N \\ s_2 \text{ and } s_3, s_2 \text{ and } s_4, \cdots, s_2 \text{ and } s_N \\ \cdots\cdots \\ \cdots\cdots\cdots\cdots s_{N-1} \text{ and } s_N \end{array} \tag{4}$$

It is already known that when one class consists of 20 and several members and one group consists of four members, excellence of grouping by the simplified algorithm as used in the current proposal is, compared with a case where the same is obtained for all combinations without simplification, approximately $60 \sim 100\%$ optimization rate depending upon the answer pattern[4].

4 Discussion in a classroom

Two kinds of discussion were administrated concerning the proposed method.

The first kind is the one for discussing test answers, where the evaluation either of correct or wrong was determined. Digital mathematics served as the subject. Several test problems were given to the students. All the test problems had multiple choice type of answers thus the students selected an answer among them. Because the evaluation was already done, the instructor, after group making, told them to start by telling the evaluated result then discuss the answer which was evaluated wrong.

The second kind is the one for discussing opinions, where the evaluation either of correct or wrong cannot be determined. Training program for job hunting served as the subject. The example of a question done by an interview and the answer by the interviewee was presented followed by several opinions for the answer then the students selected an opinion which they thought the closest to their impression. The instructor, after group making, told them to start by telling their own choice, discuss a better answer then make the report as group co-working.

Through several administrations, the method was thought to give the students learning motivation because, every time when the proposed discussions were done, group member changed for clear reason leading to their refreshment. In addition to that, we thought that, if the more detail direction in what point the discussion ought to be done was given to the students, they may think it easier to start.

5 Consideration

According to the algorithm for forming groups used in the current proposal, grouping is made so that results of evaluation of answers of the test by students may become different as much as possible. For the sake of establishment of more generalized algorithm, overall investigations are necessary which includes what sort of group discussions are actually available, what sort of information are effective for forming groups, what judgment criteria should be used to determine good or bad of grouping based on the said information. Although in the present study, results of evaluation of answers are digitized to either 0 or 1, the authors intend to investigate another algorithm capable of coping with more diversified evaluation results. At the same time, utility of this group discussion system and points to be improved will be checked from both software and hardware aspects through practicing.

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