

Development of a Similar Question Generator to Support Peer Teaching

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ABSTRACT

We developed a similar question generator and introduced it in general chemistry classes, and found that the exercises using the similar questions activated peer teachings effectively in face-to-face general chemistry classes. Peer teaching is one of the useful teaching techniques based on the social constructivism and should be applied to the exercises. For a purpose of supporting the exercise, we developed the similar question generator which can produce a set of similar questions from an XML description file including definitions of variables, calculation formula of correct / incorrect answers and choices. For evaluation of the generator, we plugged it into our LMS and utilized the LMS in three general chemistry classes. From the analysis result of the recorded data, in comparison to the control group, the exercise with similar questions activated more peer teachings than the exercise with the same questions for all students. In term examinations, the score of questions related to the exercises using the similar questions increased than ones using the same questions with a significant difference. According to a questionnaire, the exercise with similar questions was viewed favorably by 82% of responded students especially middle- and low-grade students.

Keywords: *Question generation, Similar questions, Peer Teaching, Chemical Education, Learning Management System*

INTRODUCTION

Peer teaching is a complex process by which students learn from students that are more experienced and knowledgeable about the subject material. Students play not only as a learner, but also as a teacher in peer teaching, and it derives many benefits. Vasay (2010) studied the effect of peer teaching in college mathematics, and concluded that "Peer teaching greatly affects the intellectual and moral values of the students such as the ability to express their ideas, mastery of different concepts, time management, sense of responsibility, sharing, self-discipline, self-reliance, self-confidence, resourcefulness, cooperation, obedience, etc." Peer teaching was applied as a methodology in teaching chemistry too. Gosser & Roth (1998) found "statistically significant improvement by peer lead team learning in grades, retention, and

levels of student satisfaction.” Tien (2004) reported that “interacting with other students and explaining their reasoning to one another had a much greater effect on their understanding.” In our case, we did not incorporate peer teaching into our course intentionally, but we have found that exercises using the similar questions activated peer teachings effectively.

We have used homemade LMS (learning management system) in face-to-face general chemistry classes at Tokai University since 2001. In these classes, we introduced quiz-based exercises in order to enhance encoding and verification based on Gagne’s nine events in instruction (Gagne et al, 2005). The quiz-based exercises are used out of concern over lack of motivation in chemical education (Ochs, 1998). But these quiz-based practices were not enough effective for low-grade students because the same questions were distributed to all students and they copied answers of high-grade student. For solving this problem, first, we distributed different questions for each student. This strategy worked for preventing the copying, but it led low-grade students to giving up solving quizzes by themselves and to asking one of the highest-grade students intensively. After that, we prepared similar questions where variables, figures and choices were slightly different from each other, and manually distributed in a class. As a result, the one-way asking behavior was reduced, and peer teaching among low-grade students was activated.

Though the quiz-based exercises with similar questions are expected to be effective, but it is very hard to conduct the exercise because it requires many similar questions. Then we decided to develop a similar question generator to improve the efficiency of preparation of similar question, and plugged it into classroom practice to validate usefulness.

RESEARCH QUESTIONS

The purpose of this study was developing a similar question generator as a LMS module and evaluating how quiz-based exercises using it influence peer teaching. One of the important points to conduct the exercise effectively is to prepare a large number of similar questions. For this reason, we had to firstly develop the module and plugged it into our homemade LMS.

METHODOLOGY

Development of Similar Question Generation Module

Several quizzes were developed in chemical education (Kolodny & Bayly, 1983; Freasier et al., 2003). In these studies, questions were stored in the database beforehand and randomly displayed at runtime environment. This methodology is difficult to prepare a large number of questions because teacher, after all, had to prepare questions manually and had to consume much time and labor. The other hand, Takano & Hashimoto (2004) and Kanenishi (2003) reported methods for generating question. But these methods used knowledge base and it was too difficult for non-experts to describe the knowledge of the question. In our LMS, each question is defined by extensible markup language (XML) and is delivered to each client PC of student with the similar question generator coded by javascript. It means that our module generates similar questions dynamically on the client side. Screenshots of the generated questions are shown in Figure 1. The generator can produce many similar questions and we show two examples here. Students find differences of their questions and may also notice the differences are not so much. Figure 2 shows the corresponding XML code which can generate variations of similar questions.

The schematic diagram of the exercise with similar questions utilized our homemade LMS is shown in Figure 3. The LMS send the generation module and a question definition file to each client PC according to the content of personalized course definition file. The accesses of the students can be logged as the primary LMS function.

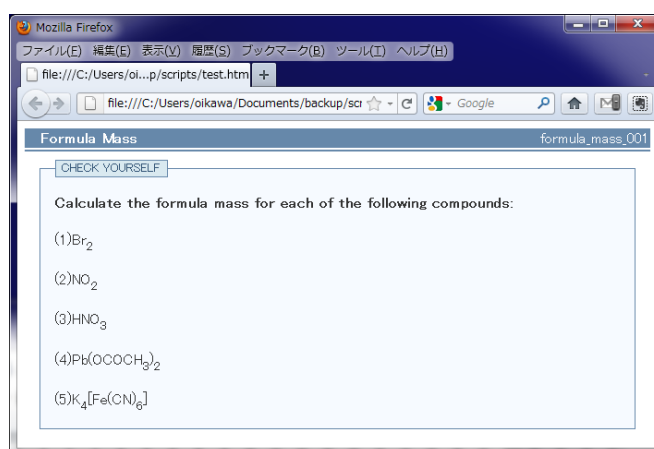
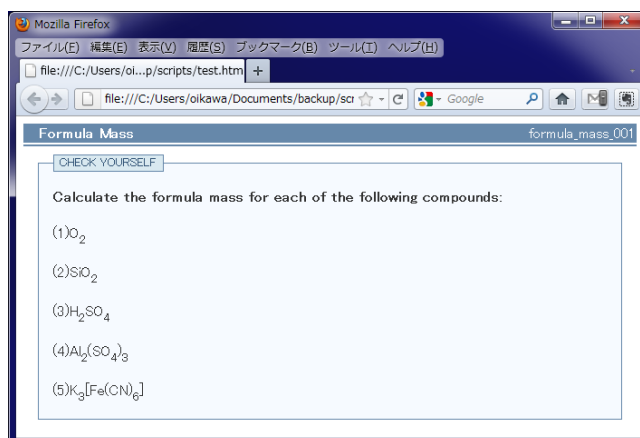


Figure 1. Examples of the generated similar questions

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<?xml version="1.0" encoding="UTF-8"?>
<question check="off">
<caption>Formula Mass</caption>
<ask><b>Calculate the formula mass for each of the following compounds:</b></ask>
<blocks>
  <block><ask>(1)H<SUB>2</SUB></ask></block><block><ask>(1)O<SUB>2</SUB></ask></block>
  <block><ask>(1)N<SUB>2</SUB></ask></block><block><ask>(1)Cl<SUB>2</SUB></ask></block>
  <block><ask>(1)Br<SUB>2</SUB></ask></block>
</blocks>
<blocks>
  <block><ask>(2)SO<SUB>2</SUB></ask></block><block><ask>(2)SiO<SUB>2</SUB></ask></block>
  >
  <block><ask>(2)CO<SUB>2</SUB></ask></block><block><ask>(2)NO<SUB>2</SUB></ask></block>
  >
</blocks>

```

Figure 2. The corresponding XML code for Figure 1.

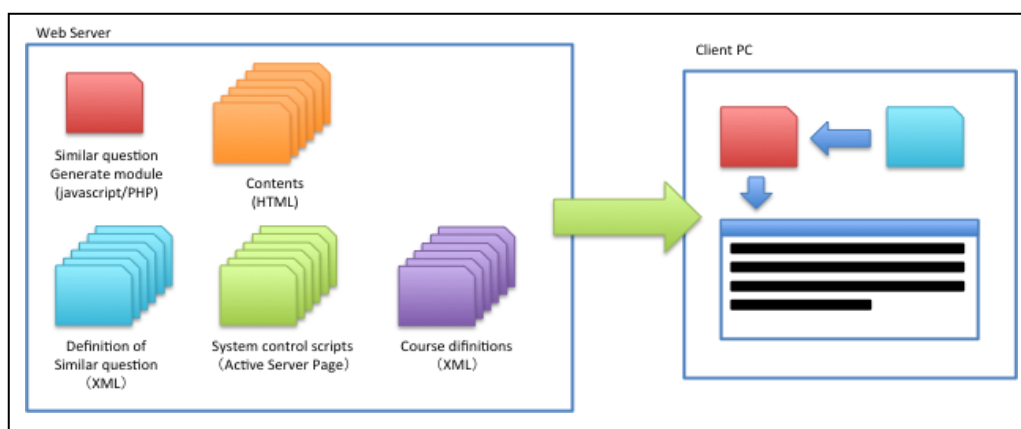


Figure 3. Schematic diagram of exercise with similar questions

Classroom Practice

For the purpose of evaluating the exercise with similar questions, we applied the developed system to three general chemistry classes. The classes are remedial courses designed for a student who hardly studied chemistry in high-school days. Each semester, there are 40 or less students in a class. The class meets for 90 minutes twice a week in a PC-room they sit in front of each PC. In each class, firstly, the course teacher explained the topics briefly, and then students read texts and exercised on the LMS, where they got own similar questions generated by the developed module. Students were permitted not only to talk each other, but also to walk about the classroom. They could discuss about their questions each other, and we expected that the peer teaching would be activated. Finally, students submitted the answer paper sheet to the teacher. The condition of the classes is shown in Table 1.

Table 1. Condition of general chemistry classes for students of engineering for evaluation

	Number of student	Majors of students	Grade of students	
Group-A	29	One major	Sophomore	The exercises with similar questions were utilized in six of thirty chapters in the class (2011, Spring semester).
Group-B	24	Three majors mixed	Sophomore, Junior, Senior	The exercises with similar questions were utilized in six of thirty chapters in the class (2011, Spring semester).
Group-C	14	Three majors mixed	Senior	The exercises with similar question were utilized in six of thirty chapters in the class (2012, Spring semester).
Group-D	39	One major	Sophomore	This was a control group. The exercise with similar questions did not use. (2010, Spring semester)

Writing down or Recording student activity

From the result of classroom practice, we expected that the exercise with similar questions let the peer teaching activate more and it may affect student activities. We wrote down the activity or recorded it with digital video. The recorded data was converted into relationship diagram we named in which the symbol pictures of student were linked together by arrows from teacher role student to learner role student.

Questionnaire survey

At the end of the semester, we carried out questionnaire for attitude survey about peer teaching as shown in Table 2. This survey was conducted to Groups utilized the exercise with similar questions.

Table 2. Statement and type of questions in the questionnaire

Statement	Type
Did you join the peer teaching?	Dichotomous: Yes/No
What was your main role in the peer teaching?	Bipolar: Teacher-----Learner
Was the peer teaching helpful or not in your learning?	Bipolar: Helpful-----Unhelpful
Did your partner's understanding (assisted by your teaching) increase or decrease your satisfaction?	Bipolar: Increase-----Decrease
Did you join peer teaching? If not, why not?	Closed and Open format
Did you teach other students? If yes, how did you feel when the partner solved the question with your assist?	Closed and Open format
Did you teach other student? If yes, what were your feelings in the situation to teach?	Closed and Open format
Did you learn from other student? If yes, what were your feelings in the situation to ask?	Closed and Open format

Analysis of percentage of correct answer

Tessier (2007) reported that students performed better on exam questions based on material that they taught to peers or learned from peers than on material that they learned from a traditional lecture approach in introductory biology class. This study showed that the usefulness of a certain method for peer teaching could be evaluated by analyzing the result of the examination. We classified each exam's questions into two categories: questions based on the exercise with similar questions and ones based on the exercise with the same questions, and compared the rate of correct answers with each other.

RESULTS

A pre-test was conducted in first meeting of each class for evaluation of group's achieved level. The test was composed of 30 basic questions that students would normally learn in a high school in Japan. Result of t-test for the pre-test showed no significant differences between each groups.

Student activity

A typical relationship diagram is shown in Figure 4, where arrows means the directions of question-asking behaviors. In case of the exercise with the same questions (a), the role of peer teaching was almost fixed as: high-grade students were as teachers and low-grade students were as learners. The asking targets were concentrated to the specific students, and not logic of solving question but only answer of the student was propagated to the group members. Critical checking of students' answer papers showed that mistake of high-grade students was spread to the class.

In contrast, in case of the exercise with similar questions as shown in Figure 4 (b), the simple asking behaviors almost dispersed. One of the notable points of this case is that the number of both arrows increased in comparison with the case of (a). This means that many students played the role of teacher and peer teaching was activated qualitatively. The act of teaching others enhances student's own learning (Bargh & Schu, 1980; Whitman, 1988). Therefore, peer teaching, including the exercise with similar questions, is regarded as one of the useful methodology to learning.

Questionnaire survey

We conducted questionnaire survey to Group-A and Group-B (Table 1). The response rate was 74% (39 of 53 students answered) and, as a result, 32 of 39 responders (82%) answered that they joined peer teaching. The result also showed that students who did not join peer teaching felt difficulty to ask to other students whom major or grade differ from. And analysis of the relationship diagram showed that peer teaching occurred locally in Group-B while peer teaching widely spread in Group-A, where Group-A consisted of the same major and grade, and Group-B consisted of mixed majors and grades as shown in Table 1. These results suggest that students' sense of familiarity to other students affect occurrence of peer teaching. This idea is supported by the fact that fewer peer teaching appeared also in Group-C in which student relationships were weak. On the other hand, the result of questionnaire survey showed that the student who did not join peer teaching wished to learn with other students. Pairing of students is

important factor to support learner in e-learning environment (Monobe et al. 2008), it will be necessary to study pairing methods for more activations of the peer teaching.

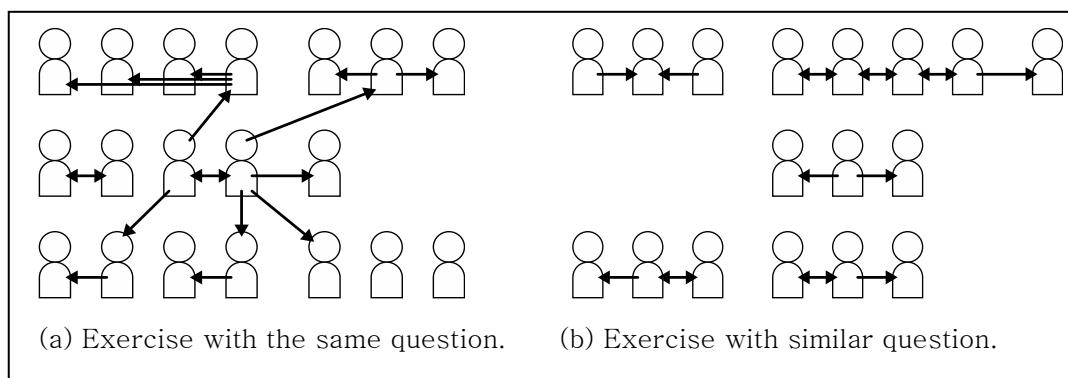


Figure 4. Typical relationship diagrams (patterns of students' activities)

Influence of main role of students to help in learning and their satisfaction was shown in Table 3 and Table 4. This result shows that the peer teaching is helpful to students learning and increase their satisfaction especially middle-grade student. Satisfaction generating is an important strategy in ARCS model approach (Keller, 2010). We think that our methodology utilizing similar questions can be applied to the motivation.

Table 3. Results of questionnaire on influence of the main role to the helpfulness in learning.

Question		"Was the peer teaching helpful or not in your learning?"				
		Helpful			Unhelpful	
Student main role		5	4	3	2	1
Teacher	5	0	1	0	0	0
	4	4	3	0	0	0
	3	6	4	2	0	0
	2	1	1	4	0	0
Learner	1	0	0	0	0	0

Table 4. Results of questionnaire on influence of the main role to the satisfaction.

Question		"Did your partner's understanding (assisted by your teaching) increase or decrease your satisfaction?"				
		Increased			Decreased	
Student main role		5	4	3	2	1
Teacher	5	0	0	1	0	0
	4	2	3	2	0	0
	3	4	6	2	0	0
	2	1	1	4	0	0
Learner	1	0	0	0	0	0

Exam score

Preceding studies showed that the peer teaching affected achievement or grade of student by analyzing test scores (Tessier, 2007; Giuliadori et al, 2008). If the exercise with similar questions activate peer teaching, it also affect to the test scores. Then we compared the percentage of correct answers of each questions in 2011 exam with those of 2010 exam as shown in Table 5. Total number of questions was 60 and the same questions were used in both exam. Students of Group-A and Group-B took the 2011 exam and students of Group-D took the 2010 exam. As a result of chi-square test, there was a significant difference ($p < 0.05$) between question types and the changing percentage of correct answers. It means that the exam score analysis also supported that peer teaching effect in our exercise using similar questions.

But there was not a significant difference between question types and the changing percentages of correct answer in 2012 exam Group-C took. We are still investigating what caused such a difference.

Table 5. The number of questions in 2011 exam whom percentage of the correct answers increased or decreased from 2010 exam.

Question type	Increased	Decreased
Exam questions related to the exercise with the same questions.	21	31
Exam questions related to the exercise with similar questions.	13	5

CONCLUSION

We developed a similar question generator and introduced it in general chemistry classes, and found that the exercises using the similar questions activated peer teachings effectively in face-to-face general chemistry classes.

We developed the similar question generator which can produce a set of similar questions from an XML description file and it can be plugged into the LMS for providing the exercise using similar questions.

For evaluation of the generator, we utilized it in three general chemistry classes. We wrote down the activity or recorded it with digital video. The recorded data was converted into the relationship diagram which describing students' teaching and learning activities. In case of the exercise with the same questions, the role of peer teaching was almost fixed as: high-grade students were as teachers and low-grade students were as learners. In contrast, in case of the exercise with similar questions, many students played as teacher and peer teaching was activated qualitatively.

From the questionnaire survey, 82% of responders answered that they joined peer teaching, and the peer teaching was helpful and increased their satisfaction especially for middle-grade student. Both analysis of the questionnaire and the relationship diagram indicate that students' sense of familiarity to other students affect occurrence of peer teaching, and it suggested the important of the pairing methods.

We compared the percentage of correct answers of each questions in 2011 exam with those of 2010 exam. As a result of chi-square test, there was a significant difference ($p < 0.05$) between the question types and the changing percentage of correct answers. But there was no significant difference for 2012 data, and we are still investigating it.

In future works, we will continue our study for developing the similar question generator with classroom practices. We are developing Moodle version of this module and it will be open in near future.

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