Designing a Blended Undergraduate General Chemistry Course Using the ARCS Model

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Abstract: The ARCS model is one of the representative instructional-design theories. We applied this model to design a general chemistry course that was conducted as the blended learning. The course is offered to students of physics, mathematics and mathematical science. Firstly, we designed a framework of instruction and contents in accordance with the ARCS model containing preparation and review, and evaluated it by the questionnaire that was related to the four categories of the ARCS model. After that, we improved methodology and course contents by the results of the questionnaire, and applied them to our general chemistry course of Tokai University. We have had a continuous improvement in the learning materials with the results of the questionnaire taken in the last semester. We got 4.5 points of student evaluation witch was higher than that of the last year by 0.6 in five points scale. Seventy nine percent of respondents felt that the course had relevance to them. The attitude survey for the students who took a credit of the course shows that the interest for the chemistry tended to increase. But there was no significant difference among the amount of document and the average score of the written examination.

Keywords: *ARCS Model, Course Design, Chemical Education, Blended Learning*

INTRODUCTION

One of the educational goals of Tokai University is development of human resource with a problem solving abilities. To acquire knowledge and ability to take a broad view of things is indispensable to achieve this goal. But most of our students had had limited interest about knowledge outside their major. For improving this situation, we decided to open several new courses for science students to provide opportunity to learn other specialties of science on the occasion of the curriculum reform in 2011.

We developed a general chemistry course and it has been opened for students majoring in science except for chemistry major. Students taking the course are poor at chemistry, hence we thought that increasing motivation was important for these student's learning, so we decided to apply the ARCS model in designing our course.

The ARCS model (Keller, 1983) is one of the representative instructional-design theories that present a classification of motivational concepts into the four categories of attention (A), relevance (R), confidence (C), and satisfaction (S). This model has been considered a systematic and easy-to-apply model for designing motivational instruction (Shellnut, Knowlton & Savage 1999; Song & Keller 1999). The model was applied chemical education, but in this study, the ARCS model was only applied to design activities in a classroom (Sung & Hsiao 2005).

The average amount of time a university student studying out of classes is only 39.2 minutes per day in Japan recently (National Federation of University Co-operative Association [NFUCA] 2013a, 2013b). As a viewpoint of quality assurance of student learning outcomes, this situation has to be improved. We therefore tried to design the course including preparation and review.

PURPOSE OF THIS STUDY

The purpose of this study is threefold: first to develop a general chemistry course designed with the ARCS model, second to apply it to the practical lecture and third to evaluate how learning in the course influences student's attitude toward chemistry.

METHOD

Designing framework of the course

The Topic Titles in Syllabus

According to journal author academy of Springer (n.d.), the title of manuscript is usually the first introduction readers have to published work, therefore, an author must select a title that grabs attention, accurately describes the contents of the manuscript, and makes people want to read further. We thought that this point of view was common to a lecture title. A syllabus is the first introduction to learners. Therefor, selecting a title of lecture is important for grabbing attention of students. In the ARCS model, *attention* is an important aspect for attracting learners. However, many of topic titles in the syllabus were traditional and never grab student's attention. While designing our course, firstly we started to improve each topic title.

The comparison of our topic titles and common ones were shown in Table 1. We adopted titles impressive or appealing to learner's interest.

Table 1: Comparison of topic titles between a common course and our course of introductory chemistry.

A Common Course	Our Course
Matter and Atom	Magnify! Magnify!
Gas Law	How elastic!
Liquid and Solution	If it is cooked in a pressure cooker...
Equilibrium	Going back and forth
Stoichiometry	What is measurement?
Chemical Formula	The language is important.
Amount of Substance	A world on a spoon.
Energy	Where does the heat come from?
Acid and Base	Cut off the cause of the fish's smell!
Redox Reaction	Rusting
Organic Chemistry	What is organic?
Environmental Chemistry	Let's talk about environment.

Preparation

As we mentioned introduction section, we tried to design a lecture including preparation and review. We designed the functions of the preparation as grabbing attention, narrowing directionality of student's interest and checking one's prior knowledge. We thought that a problem (quiz, thinking about a video content, etc.) provided in the preparation is good chance for us to let students attend to a lecture.

Increasing the students' motivation to continue a participation in a lecture is an important issue of our course design. The low motivation student was apt to absence from a lecture and the lack of motivation is also one of the factors of dropping out from school (Woodley & Parlett 1983).

The course was offered to students of physics, mathematics and mathematical science. This group composition was going to make it difficult for us to relate our lecture to their interest because the directionality of the interest differed depending on their major. We thought that thinking about the same problem and sharing their answer can narrow the directionality of the interest. Therefore we decided to offer the problem for preparations to the student on the LMS (Learning Management System), and to let them write in their answer at bulletin board system before a lecture. This approach also included the encouraging of the voluntary learning of the student out of the lecture.

As Keller (2010) described that people tend to be most interested in content that has some connections to their prior experiences and interests, we kept it in mind so that we made the contents of the problem familiar with their daily life.

Relationship between the strategy that we designed as student activity and the category of the ARCS model was shown in Table 2.

Lecture

A lecture of the course was conducted in computer room. Each lecture time was 90 minutes, and there was once per week and were 15 weeks for one semester. All text and materials were provided on the LMS that is accessible from the Internet, therefor students were able to use them out of the lecture.

In the introduction phase of the lecture, the professor added explanatory notes to some answers or opinions for the problem of the preparation by projecting them on the front screen in the classroom. Then the students rethought the problem through discussion and wrote their answer or opinion to the bulletin board again. This method was used everywhere of the lecture, because it was necessary for the student to participate in the lecture positively.

In the evolving phase, the professor explained knowledge and skills for solving a chemical problem by using digital materials such as digital slide, video, simulator and digital text. The variation of instruction method is useful for grabbing attention continuously. In the ARCS model, this factor is categorized into *variability*. Of course our class carried out a real experiment because true experience is important in chemical education. Quizzes were also used in the lecture. The results of the quizzes were projected on the screen in real time. A proper graded quiz will give student an opportunity to get *success opportunities* and *natural consequences*.

In the conclusion phase, students rethought and answered the question given in the introduction phase. We thought that the student could easily recognize own change by the comparison of answers for the same question. For encouraging learning, the professor gave positive comments to the final answers. In some lecture, students really conducted experiment and evaluated its result. Keller (2010) described one of the most rewarding results of performance-oriented instruction is to use newly acquired skills or knowledge. The experiment of the student is related *natural consequences* in the ARCS model.

Review

It is important for the learning process that students reflect what they learned. As we mentioned in the introduction section, the average amount of time a university student studying out of classes is only 39.2 minutes per day. It is too short to reflect own learning. In our course, student had to summarize what they learned in a lecture and had to send it as a report. Furthermore, students had to send a report their unclarified issue or what they were interested in newly. The professor evaluated these reports uploaded on the LMS and gave the feedback on the report.

Participants

The student configurations were shown in Table 3. Freshman, sophomore and junior attended the course together. Most students were poor at chemistry.

Table 2: A framework of the general chemistry course and relation to categories of the ARCS model.

Phases		Students Activity	Related categories of the ARCS model
Preparation		Writing one's opinion or question at the electric bulletin board.	A1: Perceptual arousal A2: Inquiry arousal R1: Familiarity
		Checking the prior knowledge.	R1: Familiarity R2: Goal orientation
Lecture	Introduction	Checking other opinions or questions on the electric bulletin board with colleagues.	R1: Familiarity R2: Goal orientation
		Recognition of purpose of the lecture.	R2: Goal orientation
	Evolving	Writing answer or opinion at the electric bulletin board.	C1: Learning requirements
		Watching demonstration or experiment	R2: Goal orientation R3: Motive Matching
		Answer quizzes	R3: Motive Matching C2: Success opportunities
	Conclusion	Rethinking and writing new answers at electric bulletin board.	S1: Natural Consequences
		Get positive comments form professor and colleagues.	S2: Positive Consequences
		Estimation of the result of experiment that related the lecture or the problem.	A1: Perceptual arousal A2: Inquiry arousal S1: Natural Consequence
Review		Send a report about the reflection of the lecture.	S1: Natural Consequence S2: Positive Consequence
		Send a report one's unclarified issue and study result of it.	R2: Goal orientation R3: Motive Matching C3: Personal Control

Table 3: Number of students that attended the general chemistry course and of valid responses of the questionnaire provided by Tokai University.

Year		2011		2012	
Semester		Spring	Fall	Spring	Fall
Major of student	Mathematics	2	4	15	5
	Mathematical Science	29	5	5	6
	Physics	2	3	16	12
The number of valid responses		30	7	28	21

Questionnaires and Evaluation

We used three questionnaires for evaluation and improvement of the course. The first questionnaire included questions related to the ARCS model. It was carried out on the LMS at the end of each lecture. The second one was the unified questionnaire provided by our university (Tokai University) for improvement of the lectures that was anonymously carried out in the last lecture time for all courses and the results are opened to all students and staffs. Two months after the course of 2012 was finished, the third questionnaire was carried out for all students who earned credit of the course in 2011 and 2012 by sending e-mail that directs them to the questionnaire site. The third one will be shown in detail later.

RESULT AND DISCUSSION

Surveys

The course topics as shown in Table 1 were decided on the agreement of the professors belonging to the department of the target students. After that, we started to develop our lectures based on the framework that was shown in Table 2. We decided the constitution of the lecture while being conscious of four motivation factors of the ARCS model as much as possible. We conducted simple questionnaire and the interview at the end of each lecture, and the result of them was reflected to improving educational materials and methodology. This improvement approach was continuously used in each semester. For evaluating of the improvement, we used the result of the second questionnaire that was mentioned in former section. If a comprehensive evaluation is an index to express the total satisfaction of the students, we thought that the evaluation score would rise with improvement.

The Average value of comprehensive evaluation in each semester was shown in Figure 1. A student answered this evaluation with a 1-to-5 scale. Generally, the scores are tending to go up at smaller classes and only seven students participated in the course of the fall semester of 2011. This is the main reason of which the value of the semester was particularly higher. The mean value of 3.9 of the spring semester in 2011 increased every semester, and it became 4.5 of the fall semester in 2012. This increase showed that our course was improved as expected. The evaluation value was higher in comparison with other general chemistry courses. In case of 2012, the mean value of others (n=17) was 3.8. The result of fall semester's survey in 2012, 79% students felt that the course had relevance to them.

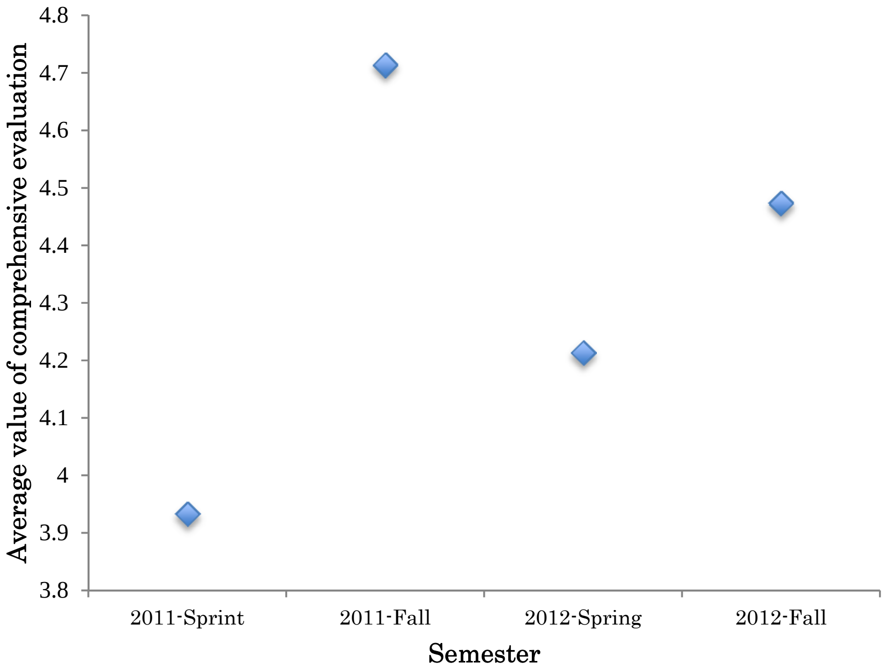

Figure 1: Average value of comprehensive evaluation in each semester

The result of the third questionnaire or the attitude survey for the course was shown in Table 4 and Table 5. In these surveys, we contacted the student who has earned the course credit by e-mail and there were twelve responders. The answer number of each question that related the preparation and the review was shown in Table 4. These results show that the student has affirmed the preparation and the review. For the preparation, 42% (n=5) of the responders agreed that the preparation attracted their interest more in the lecture or it increased their expectations of the lecture. For the review, 50% (n=6) of the responders agreed that the review (reflection report) is helpful for their learning, and 58% (n=7) of them felt that the review was helpful to get their confidences. *Success opportunity* and *personal control* are key factor to build learner's confidence (Keller 1983). By making a problem by themselves, students recognize that their learning is controlled by themselves. Even if the problem is self-made, the solving experience will lead to *success opportunity*. We thought that these were the reasons why the confidence of the student is built by the review.

The Result of attitude survey was shown in Table 5. Questions in the survey were multiple-choice type. After learning in the course, 58% of the responders came to be interested in chemistry related news, and 50% of them came to feel familiar with chemical knowledge. All students chose one of at least choices, and it was suggested that the course influenced the change of student’s attitude to the chemistry.

The review

Some of the students did not send the review reports and failed the course. These students got low scores of the examination, and the amount of words on their answer sheet was shorter than that of the credit-earned students. We found that there is a weak relation between the amount of words in the review reports and that in the examination. In the case of spring semester in 2012, the coefficient of correlation between the score of mid-term examination and the mean word count in the review reports is 0.27. Therefore we decided to select student by focusing on the word count of the review report and return feedback as soon as possible. As a result, amount of words in the examination increased in fall semester of 2012.

Table 4: Questionnaire result about the preparation and the review

Statement	Number of answer				
	Agree				Disagree
	5	**4**	**3**	**2**	**1**
Did the preparations attract your interest more in the lecture or increase your expectation of the lecture?	5	7	0	0	0
Did the review (reflection report) help your learning?	6	5	1	0	0
Did the review increase your satisfaction for learning?	3	7	1	1	0
Did the review help to build your confidence?	7	5	0	0	0

Table 5: Questionnaire result about the change of the attitude toward chemistry after this course study

Statement	Ratio (n)
I came to be interested in chemistry-related books.	33% (4)
I came to be interested in chemistry-related news.	58% (7)
I came to want to learn other chemistry course.	17% (2)
I came to think that chemistry is interesting.	42% (5)
I came to feel familiar with chemical knowledge.	50% (6)

CONCLUSION

We designed our new general chemistry course for undergraduate students using the ARCS model and opened the practical course since the spring semester in 2011. The course design included not only lectures but also preparations and reviews. For the evaluation of the course, we used results of three questionnaire surveys. The comprehensive evaluation score of the course tended to increase by our continuous improvement.

The preparation for the lecture attracted student’s interest and increased their expectation of the lecture. We found that the activity of making the preview report is helpful for student's learning and also is helpful to build their confidence. The course tended to affect the student’s attitude toward chemistry. Fifty-eight percent of the responders came to be interested in the chemistry-related news and 50% of the responders came to feel a familiarity with chemical knowledge. We found that there is a weak relationship between the word count of the review report and the achievement of each student.

In this study, the initial motivation of the students has not been evaluated. Hence, for a more thorough study, the initial motivation will need to be evaluated in some way such as survey with Students’ Motivation toward Science Learning questionnaire (SMTSL) (Tuan, Chin & Shieh 2005).

We used the results of the second questionnaire provided by Tokai University for improving lectures. The result is available for the comparison with other similar courses, but it is not able to identify individual person's answer because the questionnaire was conducted as anonymous one.

The word count of the review has weak correlation to student's achievement. This result suggests that checking the word count may predict student's achievement, and can be applied to detecting low-performing students automatically at an early stage to prevent them from dropping out.

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