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A Model of Flipped Classroom Using an Adaptive Learning System

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Abstract: In this paper, we propose a model of flipped classroom using an adaptive learning system that provides a function of computer-based testing and Training measuring the degree of understanding through the item response theory. We have evaluated the learning effectiveness of this system through a case study of a C programming class.

Keywords: LMS, CBT, IRT

1. Introduction

It is important for learners to acquire knowledge in academic disciplines requiring advanced expertise, and it is necessary to confirm the degree of their knowledge in various situations of lectures. In a previous study, some of us developed a learning support system with a knowledge map in which domain knowledge was categorized and structured (Takano et al., 2014). Using this system, learners can view knowledge items on the map and solve quizzes related to the considered item. We evaluated the system effectiveness for the acquisition of basic knowledge through a case study. In the present study, we extend the system to an adaptive one that can provide learning quizzes corresponding to learners' understanding degree of knowledge determined on the basis of the item response theory (IRT). The system mainly provides two functions, namely, (i) an adaptive test function (ATE) and (ii) an adaptive training function (ATR). We propose a learning model of flipped classroom using the system, which has been evaluated through a case study in a C programming class.

2. Proposed Model

2.1 System

In our constructed system, knowledge items on the knowledge map are linked to learning quizzes corresponding to that knowledge. Note that the quiz format comprises a problem, an answer, and an explanation. Each learning quiz is classified into seven levels of categories determined by the IRT. In the first learning step, both ATR and ATE functions start to provide learning quizzes at level three and change quizzes adaptively, corresponding to the value of the learner's learning ability based on the IRT. The ATE function provides tests in which problems are automatically selected from quizzes. In the ATR function, the quizzes are adaptively provided on the basis of the learner's history of correct or incorrect answers through the knowledge map.

2.2 Learning Design

We assume that several learning objectives are applied to a class and several lessons in the class are needed to master one objective. For instance, we have fifteen lessons in the C programming class, and

three lessons are needed to master the ability for using functions in the C programming language. We define the period of the lessons for mastering the given learning objective as a "learning unit". In the present study, the learning objective is related to a knowledge item in the map and learning quizzes included in the item are structured in accordance with the understanding degree of the learning objective. As mentioned above, the learning quizzes are classified into seven levels depending on the IRT, and according to the levels, the objective of understanding knowledge concept is set to level 1~2, that of knowledge utilization is set to level 3~5, and that of application of knowledge is set to level 6~7.

2.3 Case Study

We introduced this model to a class on C programming. The scheme of its "learning units" is shown in Figure 1, and we suppose that each one of them consists of three lessons. The learning objectives of each lesson correspond to those of level 1~2, 3~5, 6~7, successively. Before each lesson, learners are recommended to do preparatory learning and for this step they can use the function of ATR. At the beginning of each lesson, learners are assigned to take tests for checking the degree of understanding for the preparatory learning. The first characteristic of our model lies in the system utilization. The tests are performed using the function of ATE and the data of learning degrees are automatically stored in the system and the teacher can gauge all learners' progress and control or manage the classroom easily. For instance, when the teacher plans to coordinate group work in the classroom, he or she can consider all members' learning ability in each group. Then it is expected that the learner with the highest score in the group encourage all other members in his or her group and advice them to actively participate in the group work. The second characteristic of our model lies in the capability of managing various learning situations through the iterated learning process by using the system. All learners start preparatory learning in the first step of the "learning unit" shown in Figure 1, using ATR out of classrooms. In the middle step, some learners also do the preparatory learning for the second class, but others may review the first class because of their lack of knowledge. In our learning model, this learning phase is allowed by the use of ATR. Learners are adaptively recommended to do their exercises and gain total knowledge in the "learning unit" through our implemented system.

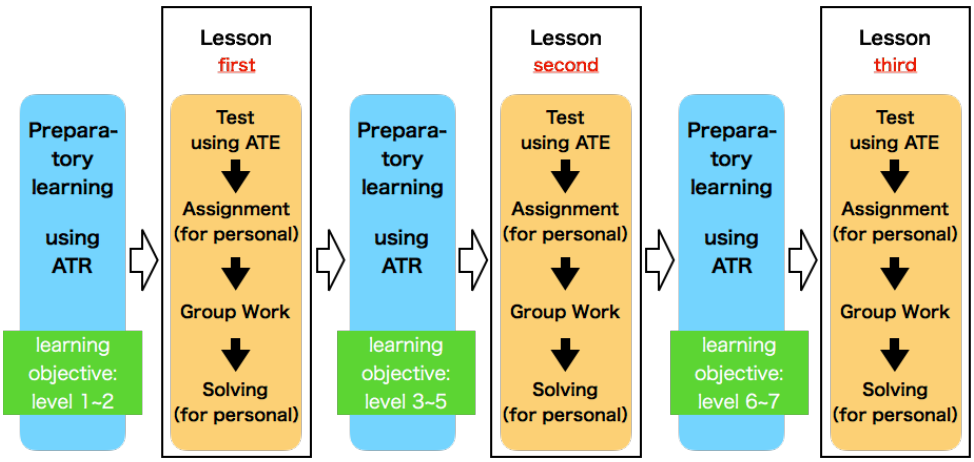

Figure 1. A Model for a Flipped Classroom in C Programming Class.

3. Evaluation

3.1 Evaluation of ATE Results and Midterm Examination

We performed a case study of a C programming class in which 7 lessons were held and classified into three "learning units". The objectives of each "learning unit" were "Variables, If and Loops" in the first 2 lessons, "Variables, If, Loops and Arrays" in the third and fourth lesson, and "Functions" in the last 3 lessons. Results of ATE in each lesson are shown in Figure 2, which shows that the understanding degree of each learning objective is improved at the end of each "learning unit". This result indicates the effectiveness of our learning model using this system.

We performed the same midterm examination as last year, which was not adapted to our model; the number of students was 75 in 2017 and 74 in 2016. We found that the number of students with a score lower than 70 decreased from 15 to 4 and the number of students with a score higher than 80 increased from 45 to 60. Our result indicates that the learning model using CBT contributes to the improvement of the learners' degrees of knowledge.

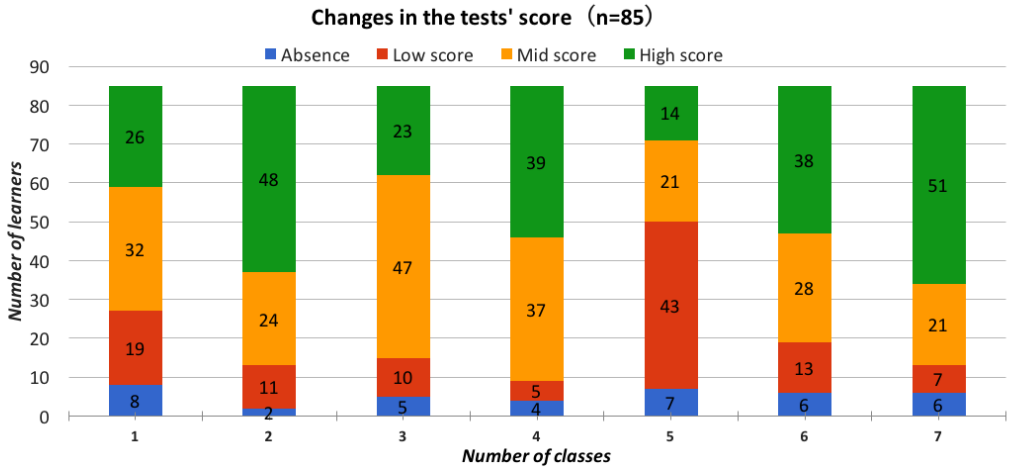

Figure 2. Changes in the tests' score.

3.2 Evaluation through Questionnaires

Three questionnaire surveys were conducted with the students. In the first questionnaire with 62 students, they were asked to answer the question: "Do you think you have trained your own ability (think for yourself and try to solve the problem) in the class?" Approximately 84% of the students answered "Yes". In the second questionnaire with 62 students, they were asked to answer the question: "Do you think it is good to be able to confirm your level through the test in each lesson?" Approximately 84% of the students answered "Yes". In the third questionnaire with 72 students, they were asked to answer the question: "Do you think it is useful for you to confirm your own level through the tests and learn using the knowledge map on improving your programming skill?" Approximately 88% of the students gave a positive response. The result also supports the notion that our model gives a positive contribution to the improvement of the degrees of knowledge.

4. Conclusion

In the present study, we have extended our legacy system to an adaptive learning one and using it we propose a learning model of flipped classroom which has been evaluated through a case study in a C programming class. The results obtained from this case study indicate that the learning model using CBT give a positive contribution to the improvement of the learners' degrees of knowledge.

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References

Takano Y., Miura K., Tsuji K., Kaneko D., Yamakawa H. & Komatsugawa H. (2014). *Development of a Learning Support System for Visualization and Acquisition of Knowledge through Collaborative Problem Posing*. Work-in-Progress Poster, The 19th International Conference on Computers in Education. Asia-Pacific Society for Computers in Education 22-24.