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The Case Study of a Flipped Classroom Using an Adaptive Learning System

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Abstract: In this study, we verify the model, which has been proposed in our previous study, in a flipped classroom using an adaptive learning system that provides a function for computer-based testing and training. This model measures the degree of learner's understanding through the item response theory. We perform three case studies, including a "C programming", a "Java programming", and an "Algorithm and Programming" classes. Further, we evaluate the learning effectiveness of our model through these case studies.

Keywords: LMS, CBT, IRT

1. Introduction

It is important for learners to acquire knowledge in academic disciplines that require advanced expertise, and it is necessary to confirm the degree of their knowledge in various situations of lectures. In a previous study (Ueno et al., 2017), we proposed a learning model for a flipped classroom using an adaptive learning system that provided 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: (i) an adaptive test function (ATE) and (ii) an adaptive training function (ATR). Further, the model was evaluated through the case study of a C programming class. In the present study, we evaluated the learning effectiveness of the model through three case studies: a "C Programming", a "Java Programming", and an "Algorithm and Programming" classes.

2. Model

2.1 System

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

2.2 Learning Design

We assumed that several learning objectives were applied to a class and several lessons in the class were needed to master one objective. For instance, we had 15 lessons in the C programming class, and three lessons were needed to master the ability for using functions in the C programming

language. We defined the period of the lessons for mastering the given learning objective as a "learning unit".

2.3 Case Study

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 corresponds to those of levels 1–2, 3–5, and 6–7, successively. Before each lesson, learners were recommended to do preparatory learning and for this step they could use the function of ATR. At the beginning of each lesson, learners were assigned to take tests for checking the degree of understanding for the preparatory learning. Our model's major characteristic lies in the capability of managing various learning situations through the iterated learning process by using the system. All learners began their 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 was allowed by the use of ATR. Learners were adaptively recommended to do their exercises and gain total knowledge in the "learning unit" through our implemented system.

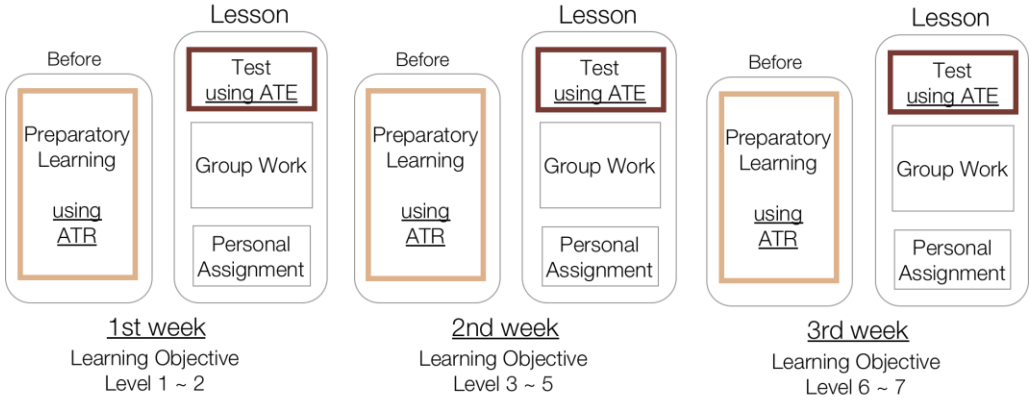

Figure 1. A Model for a Flipped Classroom in C programming class.

3. Evaluation

We performed three case studies: a C programming class, a Java programming class, and an "Algorithm and Programming" class. In the C programming class, the 15 lessons were classified into 5 "learning units". The objectives of each "learning unit" were "Variables, If and, Loops" in the first two lessons; "Arrays" in the 3rd and 4th lessons; "Functions" in the 5th, 6th, and 7th lessons; the midterm examination in the 8th lesson; "Pointers" in the 9th, 10th, 11th, and 12th lessons; and "Structures" in the 13th, 14th, and 15th lessons. In the Java programming class, the 13 lessons were classified into four "learning units". The objectives of each "learning unit" were "Basic Grammar" in the first 3 lessons; "Class" in the 4th, 5th, and 6th lessons; "Class Design" in the 7th, 8th, and 9th lessons; the midterm examination in the 10th lesson; and "Library and Exception" in the 11th, 12th, and 13th lessons. In the "Algorithm and Programming" class, the 15 lessons were classified into 5 "learning units". The objectives of each "learning unit" were "Flowchart" in the first 3 lessons; "Stack and Queue" in the 4th, 5th, and 6th lessons; "Lists" in the 7th, 8th, and 9th lessons; "Recursion" in the 10th, 11th, and 12th lessons; and "Sorts" in the 13th, 14th, and 15th lessons. The results of the ATE function in the lessons are shown in Figure 2, which shows that the understanding degree of each learning objective was improved at the end of each "learning unit". This result indicates the effectiveness of our learning model using this system.

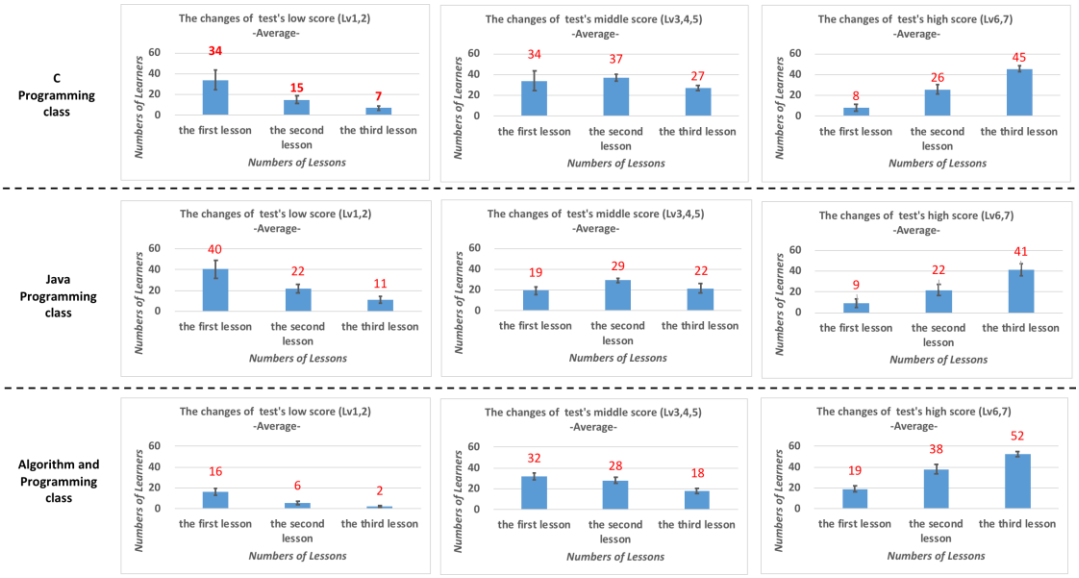

Figure 2. The test score variations.

We performed midterm and final examinations for the C programming and Java programming classes that were identical to that performed two years ago, which had not been adapted to our model. In the C programming class, we found that the average score of the midterm examination increased from 80.3 (n = 74) to 84.6 (n = 76) and that the average score of the final examination increased from 72.6 (n = 67) to 80.1 (n = 77). In addition, we found that there was a middle correlation (r = .633) between the midterm examination and the ATE results and that a middle correlation (r = .722) was observed between the final examination and the ATE results. In the Java programming class, we found that the average score of the midterm examination increased from 66.6 (n = 68) to 76.4 (n = 74) and that the average score of the final examination increased from 80.2 (n = 66) to 86.7 (n = 73). We also found a middle correlation (r = .533) between the midterm examination and the ATE results and a low correlation (r = .385) between the final examination and the ATE results. Our results indicate that the learning model using CBT contributed to the improvement of the learners' degrees of knowledge. Our results also show that the proposed model is suited to introduce not only programming classes but also those for logical thinking such as "Algorithm and Programming".

4. Conclusion

We evaluated the learning model for a flipped classroom using case studies in a C programming class, a Java programming class, and an "Algorithm and Programming" class. The results obtained from these case studies indicated that a learning model using CBT positively contributed to the improvement in the learners' degrees of knowledge.

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