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# Programming Learning Support System 'CAPTAIN' with Motivational Study Model

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**Abstract:** ARCS model is known as a learning model aiming at stimulating and sustain the learner's motivation to learn. In this paper, the ARCS model is applied for a motivational learning model for programming language learning environment. Features to realize the motivational learning model are proposed, and implemented in the programming training system CAPTAIN currently under development. The proposed system is applied in an actual programming course. Finally, the effectiveness of the proposed features designed to realize the motivational learning model is discussed, and future works are pointed out.

**Keywords:** E-learning, Programming, Motivational study model, ARCS model

## Introduction

Recently, the field of study of students choosing to take courses in computer and information sciences has broadened, to include not only science fields but also the arts fields including Web design, game, and multi-media. In such learning environments where students with different backgrounds take the same course, one method is to divide the course into classes depending on the initial skill or experience of the students. Even in such cases, depending on the teaching staff resources, each classroom may have as many as 50 students. In larger classes, it becomes more difficult to care for each individual student, and slower students fall behind, while advanced students become dissatisfied with the slow speed of progress. In either case, the student's motivation to study deteriorates. This has lead to the increased interest in improving the motivational aspects of learning in computer related courses.

Research on motivational learning methods for programming education based on the ARCS model[1] has been reported[2]. But there have been no reports on implementation of a motivational learning model in an actual e-learning system, and evaluation of the motivational learning model for programming training. In this paper, features designed to realize the ARCS model are proposed, and implementation in a programming training system are explained. Finally, the effectiveness of the proposed features and future works are discussed.

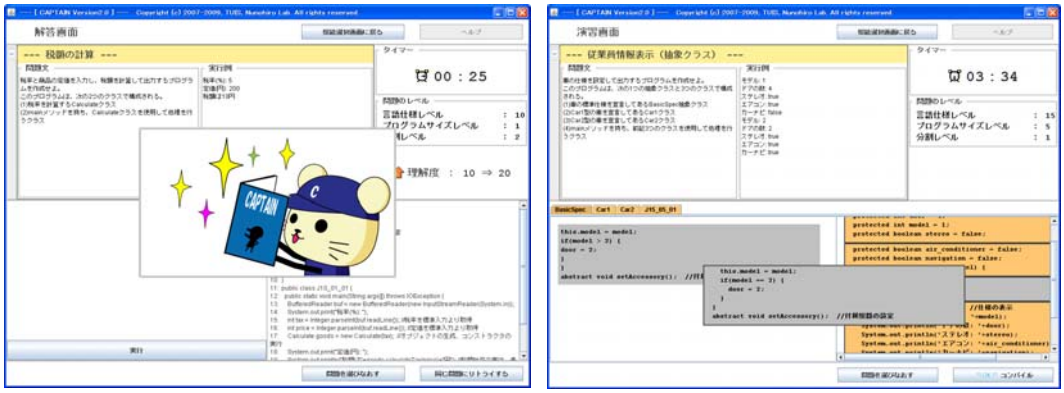
## 1. Programming study model

The authors have previously reported on CAPTAIN[3][4][5], a puzzle-based programming training system, in which learners create programs similarly to solving a puzzle game. In this paper, a learning model to stimulate and sustain motivation of the learner is considered, and implementation of the model in CAPTAIN is reported. ARCS model is selected as the motivational learning model. The programming training support components based on the ARCS model was categorized as below.

(1) Attention
Animation and illustrations are inserted in the learning process to stimulate and keep the attention of the learner.
(2) Relevance
The training problems match the contents of the lecture and training goals.
(3) Confidence
The learner and trainer can monitor the learner's progress and comprehension in real-time.
(4) Satisfaction
The training problems are provided step-by-step, and the learner can review the contents of the training.

## 2. Features of the programming training support system (CAPTAIN)

Using the previously developed CAPTAIN as the basic system, for this research, programming training components based on the ARCS model was implemented to develop CAPTAIN ver. 2 (CAPTAIN2). Screen shots of CAPTAIN2 are shown in Fig.1.



(a) Animation for correct answer (b) Programming training screenshot

Fig.1 CAPTAIN2 screenshots

In CAPTAIN2, the major components designed around the ARCS model are the following features for Attention and Relevance

(1) Attention: User interface for programming training similar to a gaming experience
(2) Relevance: Automatic programming problem creation matching the learner's progress

### *2.1 User interface*

A Display feature to visually show the learner's progress and the learner's relative level compared to other learners in the same group was implemented, in order to stimulate the learner's attention and motivation. Furthermore, animation features to visually stimulate the learner during the training were implemented (Fig.1 (a)).

### *2.2 Automatically generation of programming problems*

CAPTAIN already has functionality to automatically create puzzle pieces from the problem source code according to the progress and comprehension level of the learner, by selecting appropriate piece sizes and piece division, as well as the actual problem solving function in which the learner tries to reorder the program pieces in the correct order. In CAPTAIN2, a new navigation feature to guide the learner according to a training schedule, as well as

functions to automatically insert incorrect and unnecessary puzzle pieces (Fig.1 (b)) were added.

## 3. Application and evaluation of CAPTAIN2 system

### *3.1 Application*

CAPTAIN2 was applied in a Java programming course for 2nd year students in the Department of Information Systems, Tokyo University of Information Sciences. In this course, the students were divided into 3 classes, advanced, intermediate, and introductory, according to the results of a preliminary test. CAPTAIN2 was applied in the introductory class. The applied programming course is a full year course. The general flow of each lecture is shown in Fig. 2. The contents of the lecture and teaching material such as slides and programming problems used are the same for all 3 classes, and the programming education experience of the teachers are also similar.

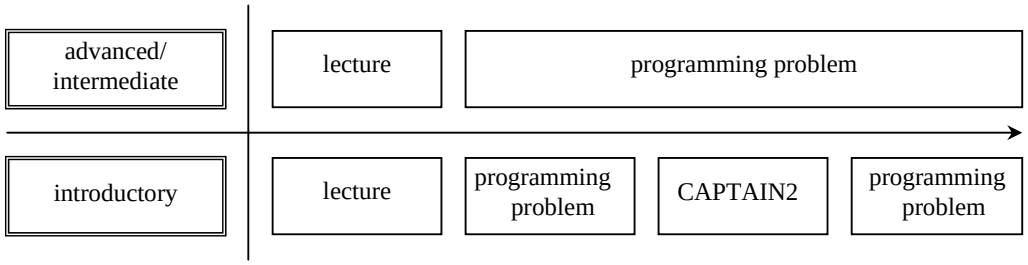



Fig.2 Flow of each lecture

### *3.2 Evaluation*

In order to evaluate the effect on motivation and ease of use of CAPTAIN2, a questionnaire was taken from the 130 students in the introductory level. The same progress evaluation test was taken by 25 students in the advanced level, 25 students in the intermediate level, and 130 students in the introductory level classes, in order to evaluate the learning effect.

(1) Questionnaire

An anonymous questionnaire was taken from 130 students in the introductory level classes. The questions were chosen to evaluate each component of the ARCS model, and student selected from 1 to 5 for each question where 5 was the highest positive reply.

a. Attention
   Do you want to continue using CAPTAIN2?
b. Relevance
   Did you find the contents of CAPTAIN2 to be relevant to the associated lecture?
c. Confidence
   Did you feel that you improved your programming skills by using CAPTAIN2?
d. Satisfaction
   Did you feel CAPTAIN2 helped you do better in the test?

The results of the questionnaire are shown in Fig.3-6. For the question regarding 'Attention', the same question was taken 3 separate occasions in order to evaluate temporal change. It can be seen from Fig.3 that there is a large number of students who want to continue using CAPTAIN2 from the beginning, and that this ratio continues to increase as the students use training system. It can be deduced that the students' motivation and interest in programming training increased by using CAPTAIN2. From Fig.4 it can be seen that the training schedule of the system succeeded in matching the pace of the lecture. However, from Fig.5 and Fig.6

a strong relationship between test results and system use could not be seen. This may have been because the problem style of CAPTAIN2 did not match the test problem style.

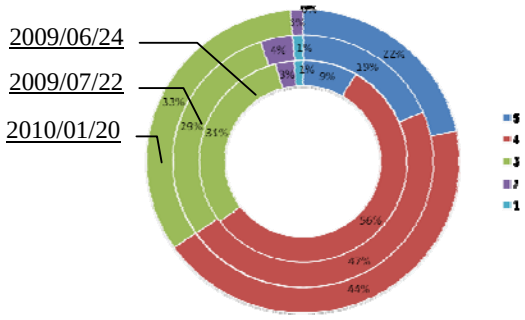



Fig.3 Attention:Continual use

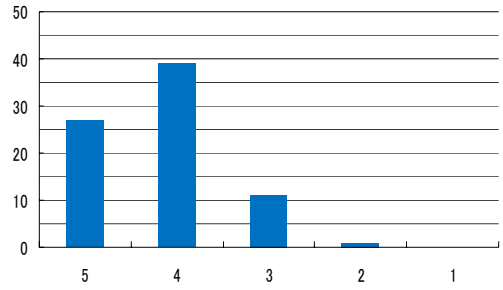



Fig.4 Relevance:Relevance to lecture

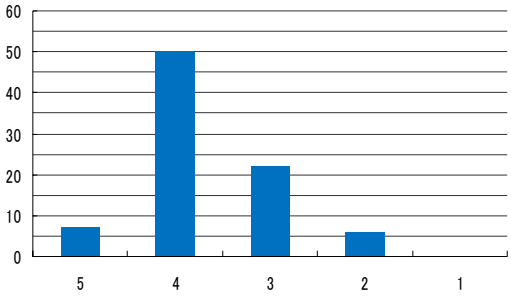



Fig.5 Confidence:Improvement in programming

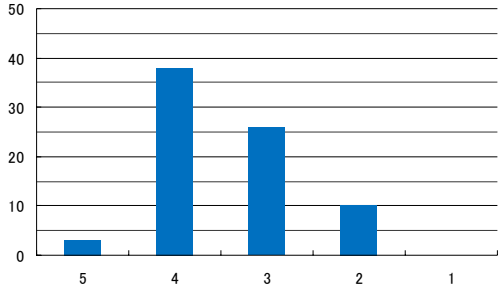



Fig.6 Satisfaction:Improvement in test

(2) Comprehension evaluation test

In order to evaluate the effectiveness of learning with CAPTAIN2, a comprehension evaluation test was carried out. Basic problems to test the understanding of each lecture were chosen. Table 1 shows the comparison of test results, and statistical t-test results between the advanced class and introductory class. Table 2 shows the same comparison between the intermediate and introductory class. The results showed no statistical evidence that the introductory class using CAPTAIN2 was able to narrow the skill difference between the more advanced 2 classes.

Table 1. Comparison of advanced and introductory classes

| Class | | 6/3 | 7/22 |
|---|---|---|---|
| advanced class (CAPTAIN2 not used) | Avg.[pts] | 31.7 | 31.3 |
| | Std. Dev. | 2.57 | 3.35 |
| introductory class (CAPTAIN2 used) | Avg.[pts] | 18.6 | 13.1 |
| | Std. Dev. | 6.18 | 7.11 |
| *t*-test between classes | *t* value | 13.27 | 15.24 |
| | significance | $p < 0.05$ | YES |

Table 2. Comparison of intermediate and introductory classes

| Class | | 6/3 | 7/22 |
|---|---|---|---|
| intermediate class (CAPTAIN2 not used) | Avg.[pts] | 25.7 | 22.0 |
| | Std. Dev. | 4.34 | 5.21 |
| introductory class (CAPTAIN2 used) | Avg.[pts] | 18.6 | 13.1 |
| | Std. Dev. | 6.18 | 7.11 |
| *t*-test between classes | *t* value | 5.84 | 5.55 |
| | significance | $p < 0.05$ | YES |

## 4. Conclusion and future works

From the results of the questionnaire and large number of positive comments, it could be concluded that there was partial success in motivational learning by the proposed system. However, the results could not be confirmed as statistical results of test score increase for the comprehension evaluation tests. It is assumed that in the proposed model, Attention and Relevance components of the ARCS model has been successfully implemented, but the added features did not contribute to the learner's confidence or test results. In order to improve these points, it is necessary to strengthen functions related to Confidence and Satisfaction in the ARCS model, including added support for learners and comprehension confirmation features.

For future works, we plan to develop features to monitor the progress and problems of the learners in real-time, and to provide necessary learning support according to the progress level of the learner.

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