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Development of Entertainment Based Learning Features in Programming Learning support System

Eiji Nunohiro, Masanori Ohshiro, and Takashi Yamaguchi

Tokyo University of Information Sciences, 4-1 Onaridai, Wakaba-ku, Chiba 265-8501, Japan
(Tel: 81-43-236-1292; Fax : 81-43-236-1292)
nunohiro@rsch.tuis.ac.jp

Abstract: In this research, we developed a self learning programming support system called CAPTAIN (Computer Aided Programming Training And Instruction) that stimulates students' interest and motivation of their study continuously. When students use CAPTAIN, they feel that they are just like playing their computer games. In order to identify advantage and disadvantage or to investigate how to improve CAPTAIN, we are now using CAPTAIN for the tutorials of a Java programming course. We developed an improved version of CAPTAIN, a learning programming support system which has the feature of entertainment. In this paper, we describe the overview of the proposed learning programming support system CAPTAIN3.4 which contains entertainment features, such as interactively showing animation and inciting the students to compete like their games. The proposed system has been applied to an actual university programming course and we evaluate the effect of this system by comparison between the students' progress with this system and that without using this system. We then discuss possible future works based on the evaluation.

Keywords: E-learning, Programming, Entertainment Based learning.

1 Introduction

It is said that the interests of students taking computer or information sciences courses in educational institution are expanding various directions. Their interests do not only include computer science but also Web design, game, multi-media and so on. In order to teach those students effectively in a same class, those students in the tutorial classes of programming are classified into small groups depending upon their initial skill, experience and ability and teach those tutorial groups separately. However the restriction of staff resource, it is often happened that the size of those tutorial groups is between 40 and 50 which is not ideal to give a high quality support to every one of the member of the students. In conclusion, slow learning students could not achieve their targets, whereas advanced students finish quicker, so get bored. In either case, the motivation of those students will be lost. It is therefore required a learning support system that stimulates every students' interest and the motivation of their studies.

For past research on learning programming systems, one of the methods, suggested, provides spaces in a source program then students fill program code in the spaces by instructions provided [1]. For the research on motivational learning methods, there is a method based on ARCS model [2] [3]. However, we could not find a teaching system, applied by ARCS model in the literature, which continuously stimulates students' interest and motivation.

In this research, we developed a self learning programming support system called CAPTAIN (Computer Aided Programming Training And Instruction) that stimulates students' interest and motivation of their study continuously. When students use CAPTAIN, they feel that they are just like playing their computer games. In order to identify advantage and disadvantage or to investigate how to improve CAPTAIN, we are now using CAPTAIN for the tutorials of a Java programming course.

In this paper, we describe the overview of the proposed learning programming support system CAPTAIN ver.3.4 (CAPTAIN3.4) which contains entertainment features, such as interactively showing animation and inciting the students to compete like their games.

The proposed CAPTAIN3.4 has been applied to an actual university programming course and we evaluate the effect of this system, especially the function of competitive learning function using nickname which is a new function of CAPTAIN3.4 by comparison between the students' progress with this system and that without using this system. We then discuss possible future works based on the evaluation.

2 Purpose of the programming learning support system

From past experience, the low motivation of learners who have difficulty in programming is strongly related to stumbling in the early stages of programming training. We considered that a game-based programming learning

environment that focuses on program structure recognition and training would stimulate and sustain the learning motivation as well as improve programming skill. From this, we proposed a programming training system with game based learning features to stimulate and sustain motivation for beginners and slow learners in programming. We aimed at developing a learning environment that can expect the following learning effects.

(a) To introduce programming training through a gaming experience in order to stimulate interest in programming.
(b) To improve understanding of programming structures and control flow through a gaming experience, instead of focusing on the language syntax or particular algorithms.

3 Feature of the programming learning support system

We have already reported [4]-[9] about CAPTAIN, a puzzle-based programming training system with motivational learning methods, in which learners create programs similarly to solving a puzzle game. In this research, we developed learning programming support system which contains entertainment features and implemented these functions in CAPTAIN3.4, based on the previous version of CAPTAIN. The main features of this system are shown in Table 1 and the content of each function is described below.

3.1 Competitive learning function using nickname

(Nickname function)

This function provides a competitive learning environment using nicknames which is new function of CAPTAIN3.4. This function aims to introduce the game nature between students, and improved a concentration skill such as raising the number of programming exercise which is solved in a definite period of time. The function assigns different nicknames to each learner individually in the beginning of an exercise at each time and displays ranking using nicknames to all learners and teachers. Each leaner can know own relative rank compared to other learners in the same group. Figure 1 shows a screenshot of the ranking display using nicknames.

3.2 Puzzle style program exercise function

This function implements puzzle-based interface in order to introduce programming training through a gaming experience. Programming training from the viewpoint of program structure comprehension and program flow comprehension can be compared to solving a 2-dimensional puzzle by logically laying out the puzzle pieces. From this standpoint, this function breaks up a program into puzzle pieces, and the user must reconstruct the program by selecting the correct program puzzle pieces in the correct order. Figure 2 shows a screenshot of the puzzle interface during programming exercise.

Table 1 main function of CAPTAIN3.4

No	main function	contents
1	Nickname function	This function monitors the statuses of all students' progresses and evaluates their degrees of achievement and ranks them using nickname in real time and continuously.
2	Puzzle style program exercise function	This function automatically creates puzzle pieces from the problem source code according to the progress and comprehension level of the learner, and offers the puzzle based interface for program exercise.
3	Animation display function	This function provides user interface in order to give effective breaks and to keep the motivation in program exercise.
4	Learning history display function	This function displays individual learning history with the progress report and the accuracy rate to give the sense of accomplishment.
5	Learning progress monitoring function	This function provides real-time progress monitor to display every learner's progress status.

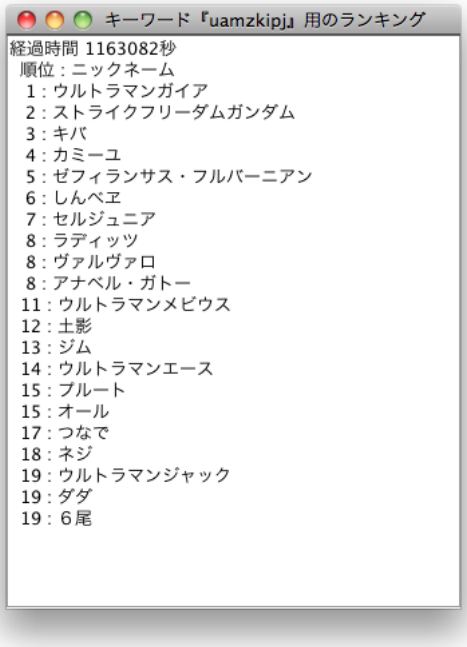

Figure 1 Example of ranking list using nicknames.

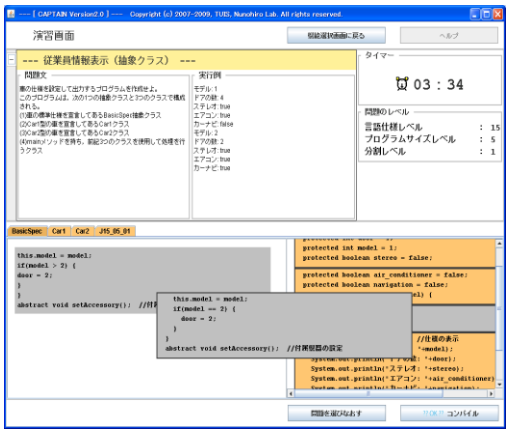

Figure 2 Programming training screenshot

3.3 Animation display function

This function aims to give effective breaks and to keep the motivation by using the visual stimulus such as display of the animation depending on the learner's exercise result and progress report in the programming training. Figure 3 is an example screenshot of an animation for a correct answer.

Figure 3 Animation for correct answer

3.4 Learning history display function

This function aims to give sense of accomplishment can be given to the learner by displaying the study history and the acquired training contents. The learner can confirm the exercise which were answered correctly and correct answer rate on the progress monitoring screen. Figure 4 shows an example screenshot of a learner's progress monitoring screen.

Figure 4 Progress monitoring screenshot

3.5 Learning progress monitoring function

This function aims to improve the satisfaction of learners by providing progress situation of learners to teachers in real time, and allowing teachers to quickly support the learners who fall behind or repeatedly error on particular problems. Figure 5 shows the instructor's monitoring screen displayed as a Web application. The monitoring program retrieves updated progress status of all learners from the database on a short time interval, and displays the progress visually on a Web browser. On the monitoring screen, the seating layout of the learners using CAPTAIN3.4 is shown and user ID and the degree of achievement are expressed as numerical value and color in each seat.

Figure 5 Progress monitoring Web application

4 Application and evaluation of Captain system

4.1 Application

CAPTAIN3.4 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, introductory) according to the results of a preliminary test. CAPTAIN3.4 was applied in the introductory class. The applied programming course is a half year course consisting of 90 minutes lecture and 90 minutes lab per week. The students recognize grammar at the lecture and recognize the program structure and the flow of processing by solving programming exercise. Here, the experience about programming education of the teachers is also similar.

4.2 Evaluation

We executed the same progress evaluation test (2 mid-term exams and 1 final exam) for 3 classes (advanced, intermediate, introductory) in order to evaluate the learning

effect by using CAPTAIN3.4. Moreover, the introductory class was divided into the class using the nickname feature and the class which is not used in order to evaluate the efficient of nickname feature which is main function supported in CAPTAIN3.4, and an anonymous questionnaire was taken in the classes. The evaluation period is from April in 2012 to July in 2012 and the evaluation was applied to student data (21 students in the advanced, 31 students in the intermediate and 39 students in the introductory classes) who had attended all mid-term and final exams. The flow of programming course and evaluation is shown in Figure 6. The number in ( ) is the number of lectures between evaluation.

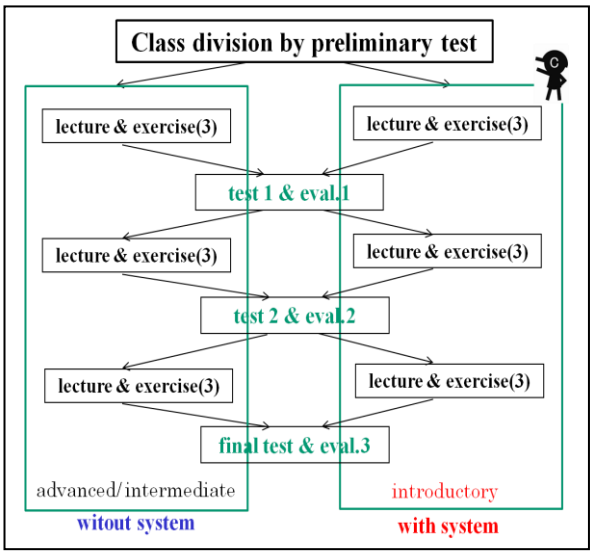

Figure 6 Flow of programming course and evaluation

4.2.1 Comprehension evaluation test

The Comprehension evaluation test were classified into the following five skill groups, and the maximum total points for each test were 35 points.

(a) Basic knowledge for Java programming
(b) Program creation (fill in the blanks without answer group)
(c) Program analysis (execution results analysis without answer group)
(d) Program creation (fill in the blanks with answer group)
(e) Program reconstruction (program reconstruction using program pieces with answer group)

Figure 7 shows the transition of average score for the mid-term and the final exam of the advanced/intermediate (CAPTAIN3.4 not used) and introductory (CAPTAIN3.4 used) classes. Figure 7 shows that there was not enough improvement in programming skill immediately since the difference of average score for the tests between the advanced, intermediate and introductory classes was almost no change.

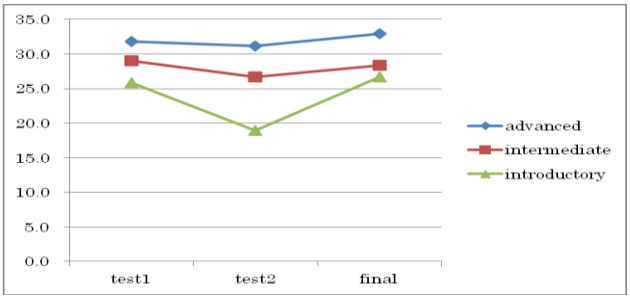

Figure 7 Transition of average

4.2.2 Questionnaire

An anonymous questionnaire was taken in the introductory level classes. The questions were chosen to evaluate CAPTAIN system, and student selected from 1 to 5 for each question where 5 was the highest positive reply. The questionnaire results of the class which uses the nickname function and the class which did not use the nickname function are shown in Table 4.

The results of questionnaire show that the evaluation result of the class using a nickname function is higher than the class which did not use a nickname function in all questionnaire item. It seems that the student showed interested in programming by using nickname function.

Table 4 Results of the questionnaire

questionnaire item	class	Results(%)				
		5	4	3	2	1
(a) Did you feel the game like programming training?	with nickname	27.5	50.0	5.0	7.5	10.0
	without nickname	22.2	27.8	11.1	11.1	27.8
(b) Did you feel the sense of accomplishment by the display of your study history?	with nickname	15.0	50.0	17.5	10.0	7.5
	without nickname	16.7	33.3	5.6	16.7	27.8
(c) Did you feel that greediness for learning improved by the display of your ranking?	with nickname	17.5	35.0	25.0	12.5	10.0
	without nickname	22.2	27.8	11.1	0.0	38.9

The questionnaire also accepted free comments, in order to collect other opinions that were not covered in the fixed questions. From among the free comments, there were many positive comments as follows.

Q1: Did you feel the game like programming training?
A1: Although I was poor at programming, I was able to enjoy like the game.

Q2: Did you feel the sense of accomplishment by the display of your study history?
A2: Since this function displayed the mistaken part intelligibly, it was able to do the given exercise comfortably.

Q3: Did you feel that greediness for learning improved by the display of your ranking?
A3: I was able to keep the motivation in order to get 1st rank.

5 Conclusion and future works

In this paper, we developed game based learning features in a programming learning support system, to offer a learning environment that stimulates and sustains the motivation of the learner during programming training. The proposed system was applied to an actual college programming course to verify the effectiveness of the proposed system.

From the result of questionnaire, we concluded that the developed CAPTAIN system was effective in the viewpoint that the student showed interested in programming. However, from the result of the transition of average score of the mid-term and the final exam for the advanced/intermediate (CAPTAIN3.4 not used) and introductory (CAPTAIN3.4 used) classes, it could not be established that the proposed method had a positive effect in improvement of the programming skill, and improvement of the learning features and revision on method for applying the proposed system is necessary. There was also another education effect considered that some students who were using CAPTAIN got interested in development of an education system. For future works, we plan to improve learning functions which support improvement in the capability to constitute the flow of processing or programming creation capability with entertainment features.

Acknowledgments

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References

[1] Sugumura Akira, Mine Tsunenori, Shoudai Takayoshi "Automatic Exercise Generating System That Dynamically Evaluates both Students' and Questions' Levels(Learning Support)", IPSJ Journal, Vol.46,No.7, pp.1810-1818 (2005)

[2] Principles of Instructional Design (2005), Robert M. Gagne, Walter W. Wager, Katharine C. Golas, John M. Keller, Wadsworth Pub Co.

[3] Wenyong WANG, Mitsuru IKEDA, Fengrong LI (2007), Proposal and Evaluation of the "Motivation-Oriented" Teaching Method in Programming Education, Japan Society for Educational Technology, Vol.31, No.3, pp.349-357 (in Japanese)

[4] E.Nunohiro, K.J.Mackin, M.Ohshiro, K.Matsushita, K.Yamasaki (2007), Implementation of a GA driven programming training support system, The 12th International symposium artificial life and robotics, pp.517-522

[5] E.Nunohiro, K.Matsushita, K.J.Mackin, M.Ohshiro, K.Yamasaki (2008), Design and development of a puzzle based programming learning support system with genetic algorithm, Transactions of Japanese society for information and system in education, vol.25, No.2, pp.207-213 (in Japanese)

[6] Yuji Yoneyama, Kotaro Matsushita, Kenneth J. Mackin, Masanori Ohshiro, Kazuko Yamasaki, Eiji Nunohiro (2008), Puzzle Based Programming Learning Support System with Learning History Management, The 16th International Conference on Computers in Education (ICCE2008), pp. 623-627

[7] Yuuko Yamakawa, Masanori Ohshiro, Kotaro Matsushita, Kenneth J.Mackin, Eiji Nunohiro: "Programming Learning Support System 'CAPTAIN' with Motivational Study Model", The 18th International Conference on Computers in Education (ICCE2010), pp.171-175

[8] Eiji Nunohiro, Kotaro Matsushita, Kenneth J.Mackin, Masanori Ohshiro:"Development of Game Based Learning features in Programming Learning Support System", The Seventeenth International Symposium on Artificial Life and Robotics (AROB 17th '12), February, 2012, ISBN 978-4-9902880-6-8, Proceeding,230-233

[9] Masanori Ohshiro, Kotaro Matsushita, Kenneth J. Mackin, Eiji Nunohiro:"Programming Learning Support System with Competitive Gaming Using Monitoring and Nicknames", The Seventeenth International Symposium on Artificial Life and Robotics (AROB 17th '12), February, 2012, ISBN 978-4-9902880-6-8, Proceeding,238-241