Web-based Learning in Remedial Course of Science and Technology

Hiroto Yamakawa
Chtose Institute of Science and Technology
758-65 Bibi, Chitose, Hokkaido
066-8655 JAPAN
+81-123-40-2308
yamakawa@kklab.spub.chitose.ac.jp

Fumiko Watanabe
Chtose Institute of Science and Technology
758-65 Bibi, Chitose, Hokkaido
066-8655 JAPAN
+81-123-40-2308
fumiko@kklab.spub.chitose.ac.jp

Hiroshi Komatsugawa
Chtose Institute of Science and Technology
758-65 Bibi, Chitose, Hokkaido
066-8655 JAPAN
+81-123-27-6094
hiroshi@kklab.spub.chitose.ac.jp

ABSTRACT

We have been experimentally developing a web-based learning (e-learning) system for remedial courses of science and technology in higher education over last four years. We have improved several functions of the LMS and created more than 3000 contents, for practical use in educational institutions. In 2005, 12000 Japanese users including the learners in 80 secondary education institutions use our e-learning system. In the present paper, first, we report the outline of our project including the construction of system and the result of a case study in the remedial education. Second, we report a challenge to extend to an agent-based personal assistant application, aiming to effectively use educational resources in our e-learning system.

Categories and Subject Descriptors

K.3.1 [**Computer Uses in Education**]

General Terms

Design

Keywords

e-Learning, remedial education, agent

1. INTRODUCTION

Recently, the decline of basic learning abilities of students as regards science and technology has become a serious problem in Japan. A representative of this is a college student who cannot solve a fraction calculation. The Japanese government has begun supporting the efforts of elementary and secondary education institutions to promote basics of educational skills. Higher education institutions have also improved the elementary curriculum of science and have begun to introduce remedial education for mathematics and physics. To help the students acquire basic learning skills, higher education institutions may consider establishing additional curriculum employing small-class/group teaching techniques.

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On the basis of this social background, we have studied the use of web-based education as a means to enhance the teaching and learning effectiveness of fundamental course of mathematics and physics. We have been experimentally developing an e-learning system for mathematics since 1999 for recovering basic learning skills of students such as problem solving skills. [1] To provide practical solutions for students in educational institutions, we have developed our project in collaboration with teachers of junior high schools and high schools.[2] In 2005, 12000 users including the learners in 80 secondary education institutions use our e-learning system. More than 20 higher education institutions also use our system.

In this paper, we describe the e-learning system that is designed to support the self-learning process in remedial education for science and technology. In particular, we explain the construction of the system and the contents making to provide the practical use in educational institutions. In addition, we indicate the result of a case study and describe the effective learning style using e-learning. In the last part of this paper, we report a challenge to extend our e-learning system to an agent-based personal assistant application, aiming to effectively use large amount of educational resources in our e-learning system.

2. SYSTEM

2.1 Overview of the System

The implemented system is a WBT system that uses the function of problem solving, which consists of LMS and contents. Learners can study elementary courses of mathematics and physics, using the educational resources stored in this system.

Our study aims to realize the practical use of this system in educational institutions. The system developed in our study is characterized by:

- Educational resources consisting of multimedia materials, exercises and tests that are created in collaboration with teachers from secondary education institutions.
- Systematic maintenance of educational resources through the knowledge database to support knowledge acquisition of learners in remedial courses.

- Application of the knowledge database to the e-learning system through an instruction policy that aims at learning corrected and repeated problem solving in remedial education.

For the implementation on the server side, we use the Java Servlet Server and Tomcat which is a reference implementation of the Java Servlet. The Servlet server on the Linux OS manages the user session, answer check, and analysis of the users' learning history. PostgreSQL is used as the database server in which user data required for LMS are stored.

2.2 Contents

In mathematical education, expansion of logic is important and it is difficult to visualize its process. However, teachers in educational institutions, in their lectures, usually instruct on the logical steps, using images drawn on blackboards. In our study, this educational method is adopted in contents making. To promote the learners' interest and to encourage understanding, we design multimedia materials based on the blackboard image drawn by teachers during the actual lectures. Each material includes moving figures, expressions and characters. Users can read stories in the material at their own pace by clicking the control button and confirming expressions or figures step by step. The sequence of elements is based on the scenario designated by the actual teachers (experts) participating in our project. We prepared 1000 materials for mathematics and physics (science), which cover academic content from junior high school to the fundamental courses of universities. The series of multimedia materials adopted in our e-learning system is created in the SWF (Shock Wave Flash) format and viewed using a Flash plug in.

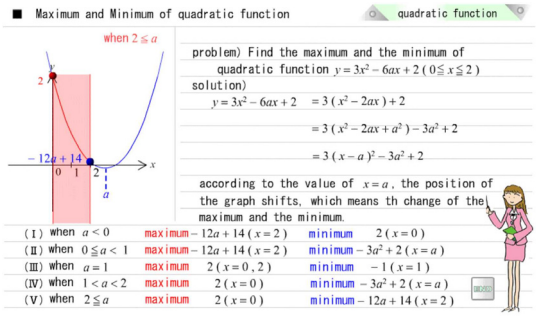

Figure 1: Sample image of multimedia materials.

Figure. 1 represents the mathematics material and indicates a problem and solution for calculating the maximum and minimum of a quadratic function with a variable. When a user clicks the control button on the material, explanations that use characters and mathematical expressions appear. Mathematical expressions, in particular, gradually appear, in the actual order that a teacher writes them in on a blackboard.

Exercises are also created using the Flash format. Each exercise consists of three frames; problem description, hint information, and answer box. The problem description frame allows users to create a problem using characters, mathematical expressions, and graphics. The hint information frame allows users to create hints at three levels, which appear step by step, according to the users' requests. A sample image of the exercise is shown in Figure. 2. The numbers 1, 2, and 3 in the figure correspond with the hints that appear step by step.

In our project, we prepared 1000 exercises for the fundamental courses and 1000 exercises for the standard courses of mathematics and physics (science), which cover academic contents from junior high school to the fundamental courses of universities. Furthermore, we prepared tests for learners to correct their own exercises in the section. There are 10 problems per section in each test. The test format is the same as that of the exercises, except for the hint information frame.

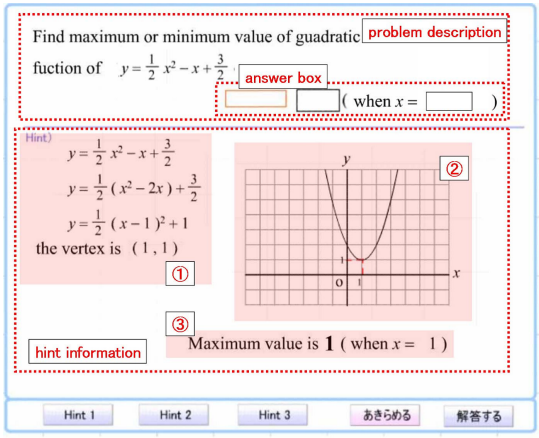

Figure 2: Image of exercises.

2.3 Knowledge Database

In remedial education, acquiring basic knowledge through training is one of the most important factors. In the present study, using original IDs, we reviewed and classified mathematics knowledge related to our materials and exercises. We categorized knowledge in order to support the learners educated through remedial study and defined 160 categories of knowledge. We rearranged the knowledge in the knowledge database whose data frame consisted of the name of the knowledge, its identification (knowledge ID), and its contexts.

Our final goal is to develop an effective e-learning system to support the knowledge acquisition of learners, using this knowledge database. Using the relation between the knowledge database and the exercises, we can provide appropriate materials for learners who attempt to solve a problem but do not understand its meaning. Learners can also identify their lack of knowledge through the knowledge names obtained on the basis of an analysis of the users' learning history.

2.4 LMS

It becomes particular important for the educational institutions to understand the learners' learning process in a time series. Therefore, our system provides three statuses of right, wrong, and hint information in time series, such as one day, one week, and one month. The user interface of the time series through graphics is shown in Figure. 3. Teachers can select a date from the calendar and view a learner's status through the graphics and table. This function is mainly used when teachers perform individual instruction as support for the learners' homework.

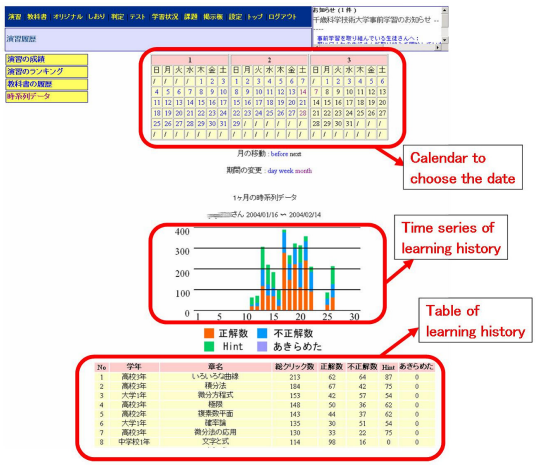

Figure 3: Time series of learners' history.

Table 1: Sample messages provided through the assignment system.

You should practice solving problems repeatedly.
You may solve questions correctly.
You should solve problems correctly without getting hints and making mistakes.
You make a lot of mistakes.
You refer to too many hints.
You should refer to textbooks positively.
You can solve problems. Referring to textbooks is good approach.
You can achieve the assignment. It's perfect.

The main targets for our system are learners doing homework and exercises related to subjects or lectures. To support these learning processes, we implemented the assignment function that teachers could designate previously for their lectures' homework or exercise. Through the interface of LMS, teachers can select not only names of students participating in the class but also types of exercises required in the assignment. Furthermore, in our study, we prepared typical instructional messages for learners in the database, that were provided automatically when the duration of assignment expired. These messages are determined in advance on basis of teachers' instructional policy, and the choice of messages is determined by if-then rules based on learners' click information for the assignment. The sample messages provided from the assignment function are shown in Tab. 1.

3. CASE STUDY

We investigated effectiveness of e-learning through its utilization in the actual lectures of a university. In the present paper, we present the results of a case study performed in a remedial course of mathematics at Chitose Instiute of Science and Technology (CIST). There were 120 learners and investigated terms were spring and autumn of 2002. On the basis of these results, learners at lower results could participate in the remedial course.

We divided this remedial class into two classes referred to as classes A and B. In class A, the same style as the exercise class was employed; a teacher chooses the subjects related to the mathematics lecture and provides several exercises to the learners. The homework is handed to learners on paper at the end of every remedial class and the results are returned two weeks later. In class B, the e-learning system is applied to the remedial class and learners can spontaneously study the subjects through the e-learning system. Homework is also assigned through the e-learning system, and the results are checked through the LMS by the learners.

Table 2: Comparison of both classes; without using e-learning (class A) and with e-learning (class B).

self-check	1st test	2st	3st	4st	5st
Month	4	5	6	7	8
Average (classA)	0.0	0.0	0.0	0.0	0.0
Average (classB)	-6.5	7.1	15.0	10.7	1.8

We investigated the results of tests administered four times in the spring term. The comparison between classes A and B is presented in Table 2. Note that the results of class A are set to 0 in comparison with that of class B. Each set of data is an average of the learners' numbers. The "self-check" data in the table presents the results of the self-check test, which indicates that learners of class A have more skills than those of class B, before the beginning of the remedial course. The other four set of data indicate the results of examinations held after the start of the lecture and exercise in the spring term, which indicates that the results of class B always acquires more skills than those of class A.

To consider the skill of the teachers in the lecture and exercise class, we exchanged the teachers of the two remedial classes in the autumn term. The e-learning system was then applied to class A. Consequently, the averaged score of class A was always higher than that of class B. A series of results indicates that the utilization of the e-learning system in the remedial class is effective for an increase in basic learning ability.

The reason for this effectiveness is simple. The characteristics of using the e-learning system are;

- The learner's choice of subjects soon after the face-to-face lecture.
- Homework that is accompanied by answer check in real time.
- Development of individual instruction according to the information of LMS based on the time series of the learners' learning history.

4. EXTENSION

A series of our e-learning project has a feature of blended learning through web-based education. Actually, to recover basic skills or knowledge acquisitions of learners in the remedial class, we adopt not only the e-learning system but also teaching assistants to support the class.

Then, we started a new challenge to extend our e-learning system to a personal assistant application that imitated roles of teaching assistants in the blended learning and planned to instruct, using these educational resources.

To implement a series of adaptive personal assistant system, we utilized multi agent platform of JADE(Java Agent Development Framework).[3] Basic concept of the agent platform is as follows. The agent platform can be accessed from the server-side application. Under the initialized platform,

each agent is activated and every request among agents is launched through multithreading. The agent works with serialized objects that are encapsulated as content of the ACL messages. Recently, implementation of adaptive Web application using multi agent framework with JADE becomes widely reported in researchers. As for adaptive e-Learning, several types of architectures are modelled and constructed.[4] In addition, practical development of the system assuming course management is also reported. [5]

In the present case, we defined four types of agents referred to as Adapter agent, User agent, Inference agent, and Subject agent. The User agent and Inference agent correspond with modules of a personal assistant agent. This personal assistant agent is designed to invoke to each learner and to be active only when the learner is in on-line status. The Subject agent is a single agent to share information among all personal assistant agents. The Adapter agent is a wrapper agent to listen to all messages as event from server-side. It is instantiated inside application-context on server-side and runs as session bean but it is started on the JADE platform by the server-side component. The agent architecture in our study is shown in Figure. 4.

From the autumn in 2004, we started to employ the agent-based system in the exercise time of remedial course using the assignment functions mentioned in sec.2.4. To operate the system in the practical use, we adopted distributed environment using network agent framework where the User agent and the Inference agent were separately coordinated in the physical environment. The averaged on-line users in the remedial class were 160. The message type and the instructional policy were designated to match the exercise course using assignment function. The Subject agent was also designated to manage the subject related to the context of the assignment. In this educational situation, a learner could usually obtain his/her personal learning degree for problem solving, but could sometimes get information of his/her degree among other learners in the class. For instance, when the learning degree of the learner was not good, agents recommended him/her to solve problems using hint information and related materials. However, if the Inference agent judged that total learning situation in the class was not good and his/her learner was in worse situation, agents recommended the learner to change the learning course. We show the user interface displayed by agents in Figure. 5.

5. SUMMARY

In the present paper, we reported the implementation of our e-learning system and effectiveness through the case study. Furthermore, we reported a challenge for extension to the personal assistant system through instructional messages, using multi agent framework. In consequence, we confirmed that agents collaborated and provided the adaptive messages to our legacy e-learning system, corresponding with the learning degree of on-line learners. In the future work, our educational resources should extensively apply to the adaptive system further more and consider the practical use of adaptive e-Learning system through a case study.

6. ACKNOWLEDGMENTS

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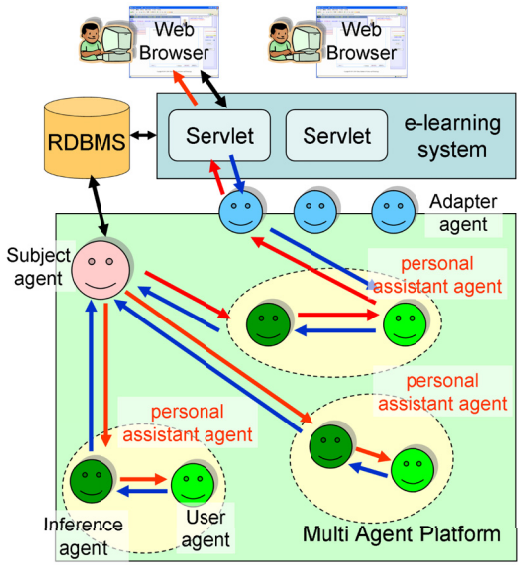

Figure 4: Agent architecture.

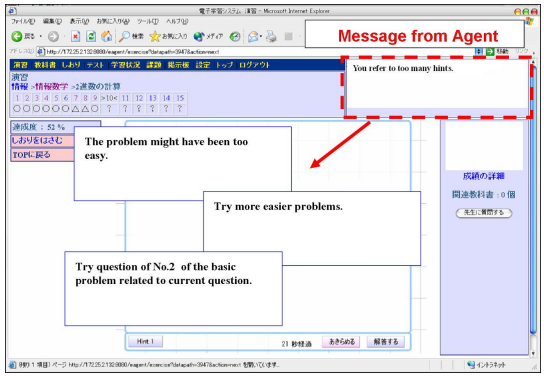

Figure 5: Examples of messages from agents.

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