Adaptive e-Learning Systems with Learning Portfolio for IT Education

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Abstract: This paper describes adaptive e-learning systems with learning portfolio for IT education. Our project is one of Modern Good Practice (MGP) which is supported by Ministry of Education, Culture, Sports, Science and Technology in Japan. We have developed the framework of adaptive e-learning systems which is called POLITE. POLITE has a curriculum-based learning environment based on SCORM2004 and exploratory-based learning environment with interactive Q&A and virtual systems development world. The goal of our project is to provide a framework to learn knowledge and skill for Application Specialist, a job category of ITSS in Japan. The learner can learn via three levels of instructional material (advanced, intermediate and beginner level). Furthermore, the learner can use interactive question and answer (Q&A), data modeling tool, and Java simulator. The students in the POLITE class achieved the same or better level of understanding than in the standard face-to-face class.

Introduction

Our project is one of Modern Good Practice (MGP) which is supported by Ministry of Education, Culture, Sports, Science and Technology in Japan. The purpose of MGP is to facilitate innovation of university education such as improving the quality of teaching and learning. The Ministry selects beneficial practice projects through judging the submitted projects from many universities, and they support the budget for each selected project. Our project is a three-year project which started in 2005, and we have already developed a framework of adaptive e-learning systems called "Portfolio Oriented e-Learning for IT Education" (POLITE). We have used POLITE systems in two courses: "Foundations of Information Systems 1" and "Programming Language 1"; through which we have evaluated POLITE systems.

IT society in Japan needs people who are able to find any existing problem for customers and to solve the problem with their IT skill. The Application Specialist is expected to have the requisite skill and knowledge to solve these problems. Our project focuses on Application Specialist education on the university level in Japan. The required skill and knowledge for the Application Specialist is described in the official Information Technology Skill Standard (ITSS), released by Ministry of Economy, Trade, and Industry (METI). It is categorized by specific IT field--such as IT Architect, Project Management, IT Specialist, Application Specialist, and so on. The learning goal of POLITE is linked to the Application Specialist as listed in ITSS.

Our project members have prior experience in developing application frameworks: AVALON [Fuji et al. 1994] for the individual learning environment, CAMELOT [Fuji et al. 1996a, b] for the collaborative learning environment, and REBECCA [Fuji et al. 1995, 1997] for repository systems. These ideas have been helpful for the systems development of POLITE in our project.

Learning Management Systems like WebCT [WebCT] are used in many universities, but the function of adaptive learning is very limited. The research on adaptive learning systems has been developed since intelligent tutoring system like ELM-ART [Brusilovsky et al. 1996]. Recently, web-based educational application has been developed such as AWBES [Nodenot et al. 2004] and Knowledge Tree [Brusilovsky 2004]. The Authoring tool for adaptive learning was also developed [Berlanga & Garcia 2005]. These approaches are focused on the structure of learning objects. Our approach is not only via the structure of learning object, but also using a learning portfolio. Although some learning portfolios are used in the filed of computer science [Estell 2001], [Higgs & Sabin 2005], these learning portfolios do not link to adaptive e-learning.

This paper is organized into three sections; Section 2 outlines a framework of adaptive e-learning systems with learning portfolio, while Section 3 introduces case study for IT education. Section 4 describes evaluation of POLITE systems.

A Framework of Adaptive e-Learning Systems with Learning Portfolio

Needs of adaptive e-learning systems

Japanese university learning environments have experienced big changes. The number of graduating high school students will be same as the entrance quota of universities. This means that the university will have more variety in student career interests/needs than ever. We, the universities, have to provide an adaptive learning environment for each student's level of understanding..

Therefore, it is vitally important to provide the systems development environment for Application Specialist education, facilitating learning of skill and knowledge through the systems development practice activities. Additionally, establishing a learning environment for practice of trial and error is necessary.

Monitoring learning results for each individual student is essential for identifying and isolating the gap between learning results and ITSS. The systems should understand the gap and, accordingly, plan learning strategy for each student.

In the real world, the Application Specialist is educated in a system similar to the old apprentice system. That is the reason why a trial and error learning environment is necessary. The main skills of the Application Specialist are as follows.

- requirement analysis
- modeling (data modeling, process modeling, object modeling)
- programming
- communication skills

Overview of POLITE systems

POLITE has three functions: planning pedagogy, learning, and evaluation. The Learning function is composed of the curriculum-based learning environment and exploratory learning environment. Figure 1 shows the POLITE systems conceptual model. The characteristics of POLITE are the following:

- Learning portfolio. The Learning goal is based on the Application Specialist description of ITSS. Each student's knowledge and skill are recorded in the learning portfolio.
- SCORM2004 [SCORM 2004]. Instructional material is designed based on SCORM2004. POLITE provides adaptive instructional material consisting of three different levels (advanced, intermediate, beginner).
- Virtual systems development world. Data modeling with ER diagrams and Java programming are supported in this exploratory learning environment.
- Reuse. Instructional material and pedagogy are stored in the repository. This enables and facilitates faculty/staff to be able to improve and reuse their instructional material and pedagogy.
- Cooperation with IT enterprise. IT enterprise provides some instructional material at the advanced level, which provides very practical information for the university student.
- Cooperation with students. Instructional materials at the beginner level are developed by students from the student's point of view.

Gap Analysis

Planning pedagogy includes gap analysis between the learning goal and the individual learning portfolio. Gap analysis of IT skill identifies the gap of between ITSS requirements and each learner's learning portfolio. ITSS lists the Skill item and Skill level. The Skill item is based on the life cycle of systems development such as planning, systems analysis, systems design, and construction. The Skill level has four different levels. Level 0 means learner does not have the skill. Level 1 means learner has general knowledge of the skill. Level 2 means learner can do it with help. Level 3 means the learner can do it by

himself/herself. Level 4 means the learner can teach the skill to another learner. Gap analysis of each course details the gap of each learner in each course. For example, the gap analysis of IT skill shows 'requirements analysis', while the gap analysis of each course shows learning 'chapter 6 of Foundations of Information Systems.'

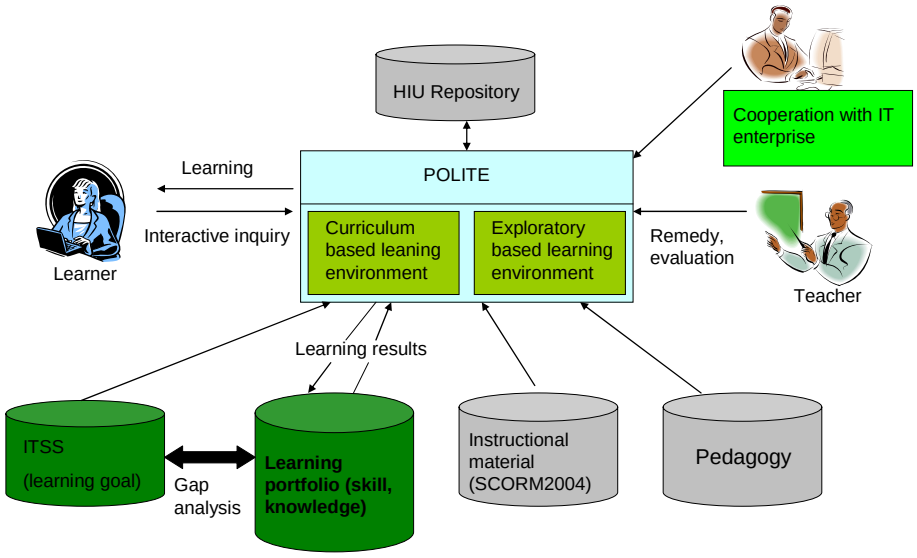

Figure 1: POLITE Systems Conceptual Model

Curriculum-based learning environment

The purpose of curriculum-based learning environment is to acquire knowledge for Application Specialist. POLITE systems provide adaptive instructional material such as the beginner level, intermediate level, and advanced level. The system can assess and evaluate each learner's level by giving a quiz in each section. Figure 2 shows the adaptive learning process with POLITE. Instructional material in curriculum-based environment is based on SCORM2004. The pedagogy is defined in manifest file with XML.

Exploratory-based learning environment

It is very important for each learner to keep concentration focused on learning with the computer. Exploratory-based learning environment is designed to facilitate motivation for e-learning.

Virtual systems development world

POLITE provides the tool for data modeling and programming. Each learner can describe entity-relationship diagram with the tool, and also he/she can create a Java program with the Java simulator. As each learner can learn through trial and error, it is a very effective environment for learning Application Specialist.

e-coach

The role of e-coach is to motivate learners through e-learning and to navigate the learning process. Since POLITE has a data log of each learner's activity, the system gives feedback to each learner. Furthermore, learners can ask questions interactively of the e-coach. Detailed questions and answers--that a teacher knows are frequently asked--are stored in the database. The Searching function of different levels of instructional material is also supported. A Mentoring function is under construction.

e-note

Each learner can take his/her notes during e-learning, and also he/she can submit a report to the teacher. The teacher can review each learner's report and evaluate.

Evaluation of skill and knowledge

After learning each chapter, each learner has a post test. The systems compare the results between pre test and post test and show the outcome of learning. And also, each learner can find skill and knowledge to learn for Application Specialist by looking through the learning portfolio.

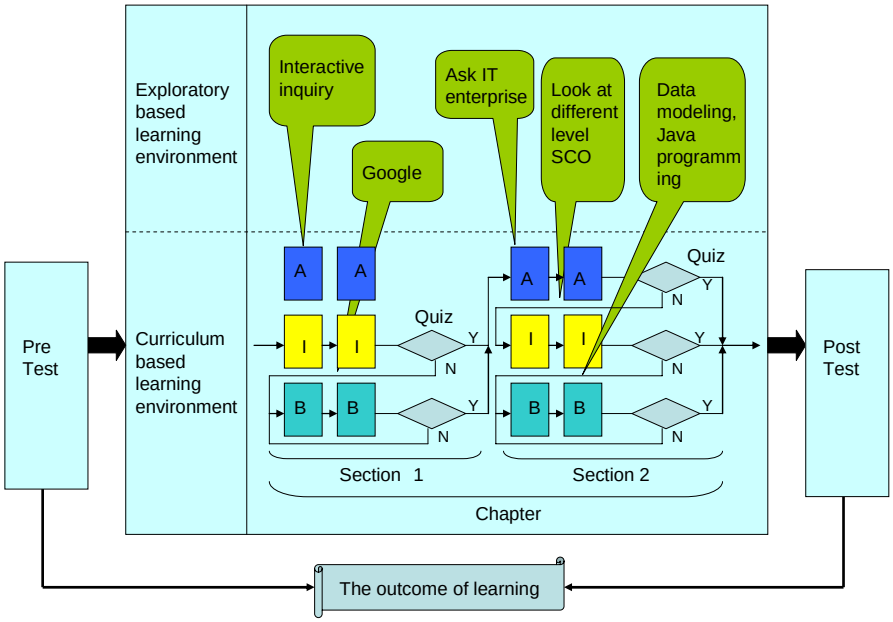

Figure 2: Adaptive learning process

Case Study for IT Education

We started to use POLITE systems in two different types of courses. One of them is a standard lecture course, "Foundations of Information Systems 1." The other course is an exercise type course, "Programming Language 1" Both courses are basic learning subject areas for an Application Specialist.

Case 1: Foundations of Information Systems 1

This course is an elective course for 2nd year students and carries two credits. The class meets 13 times to 14 times in the term, and each class is 90 minutes. Knowledge of the relationship between IT and competitive advantage [Fuji 2005] is essential in this course. The number of students in this class is over 100. The case study was done in chapter 6 and chapter 8. The class was divided two groups according to odd or even student number. One group took the conventional face-to-face class, and the other group took the e-learning POLITE class. In order to compare the outcome between the conventional class group of students and the POLITE class group of students, we gave the pre test and post test to both groups.

Instructional Material

We have developed three different levels of instructional material based on SCORM2004. The intermediate level is reorganized from the contents of the standard face-to-face class by instructional design. The reorganized instructional material became easier to understand for students. Figure 3 shows the intermediate level of instructional material. The beginner level was redone by some students who had already taken this class. They watched a video of the intermediate level contents, and they reformulated the contents from the student point of view. IT enterprise people supported the reconstruction of more practical instructional material for the advanced level.

Learning environment

The POLITE class was done in a PC classroom where there are 80 PCs. Students also were learning/studying at home after the class. Thus, each student was able to learn at his/her own pace and at his/her own adaptable level.

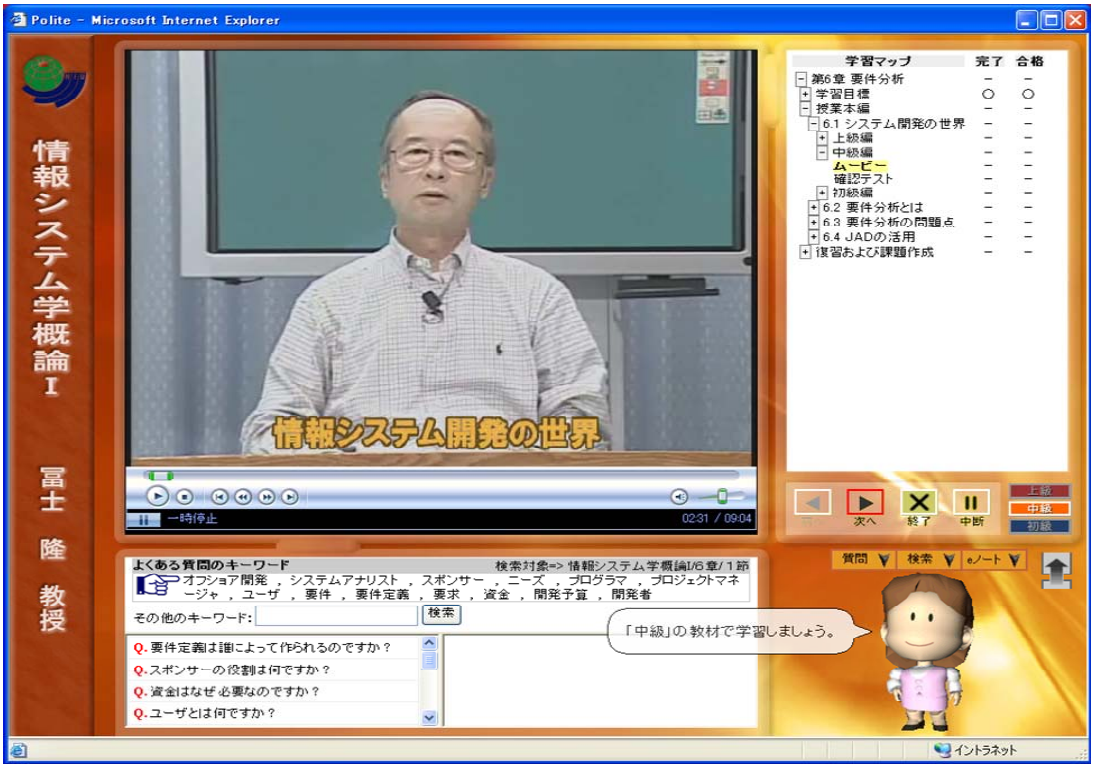

Figure 3: Screen sample of intermediate level

Outcome of POLITE class

The effectiveness of the POLITE class was better than that of the standard face-to-face class; the detail is recorded in section 4. Some (POLITE) students said they were able to concentrate better on learning rather than in the standard face-to-face class, because the POLITE class with headphones created peace and quiet and space without other students' private chattering. And also interactive questions and answers with the e-coach were very helpful aids in better understanding at the intermediate level.

Case 2: Programming Language 1

This course is aimed at learning a structured programming style by using Java for 1st year students of the Department of Information Science. The main topics are variable, expression, console input/output, judgment and branching, loop. Two continuous lectures are held per week. In the first half of the 90-minute lecture, the students learn knowledge, syntax or algorithm concerning each topic from teacher. The programming problem relating to the class content that the student had learnt in the first half of the lecture is solved during the 90 minutes of the latter half.

The Overview of e-Learning contents

We developed an e-Learning course for Programming Language 1. In each e-Learning lesson, the students first take the pre-test which confirms whether or not they have already acquired subject content of the lesson. If a student passes the pre-test, he proceeds to study the advanced lesson concerning the topic. The e-Learning lesson is composed of two parts. One is a lecture component. In a lecture component the students learn the syntax and how to use the syntax to solve the problems by seeing a video. The other part is devoted to programming practice. In the programming practice part of the lesson, students solve the programming exercise and write the program by using the editor on the web browser. The system compiles the student's program and executes the program by using proper input values for evaluating the student's program. The system also conducts a diagnosis of the student's program.

Case Study in regular course

We conduct three lessons (sixth, seventh and eighth lesson) by using the e-Learning system in the regular course. In the sixth and seventh lessons, the students learn the "if-else" statement, and in the eighth lesson, the students learn the "while" statement. The lecture was divided two groups. One of the groups (23 students) was learning the sixth and seventh lesson material via the e-Learning system and was learning the eighth lesson subject material in the standard face-to-face lecture. Another group (24 students) was learning the sixth and seventh lesson material in the standard face-to-face lecture class and was learning the eighth lesson subject material via e-Learning. According to our questionnaire results, the opinion of the e-Learning lecture greatly split into sections. One individual said that it was better because he could learn by repetition when he did not completely understand the subject matter, and another individual said that he appreciated the fact that he could learn at his own pace. On the other hand, another individual commented that the fact he could not ask a teacher in person a direction question (when he did not understand something) was detrimental to learning. Another student was unhappy because the execution of the Java simulator was different from the practice in actual lecture, too. After three lessons, students take the test to evaluate their comprehension of the three lessons. The results of the standard face-to-face lecture are slightly better than results of the e-Learning lecture. The details are referred to in section "Evaluation of Case 2."

The Issue of case study of Programming Language 1

The opinion that the students could not ask a teacher a question directly is very important. For supporting student comprehension, the system must point out student mistakes more accurately. It is necessary to consider any student questions when the problem is solved, and to enhance FAQ. On the other hand, the enhancement of the Java simulator is important. It is necessary to be able to input a free value with the Java simulator, and to simulate the situation in an actual lecture.

Evaluation of Adaptive e-Learning with POLITE

In the first semester of last year, we performed some experiments using our e-Learning system. Two regular courses were selected for these experiments. One was "Foundations of Information Systems 1", the other was "Programming Language 1". We randomly divided each classroom into two groups of students. The one group learned a chapter with our e-Learning system, while the other group learned the same chapter by face-to-face style separately. Then, the students were tested on their understanding of the chapter. We examined the effectiveness of our e-Learning system by comparing the test scores. In addition, valuable student feedback was gathered through questionnaires.

Evaluation of Case 1

The first experiment was done in the lesson of the 6th chapter. Forty-nine students learned via the e-Learning system and 48 students learned by the standard face-to-face style. In a second experiment carried out on the lesson of chapter eight, 41 students learned via the e-Learning system and 46 students learned by face-to-face style. There is no student who learned both chapter divisions with the e-Learning system.

Table 1. The average scores on the pre-tests and post-tests.

	e-Learning	face-to-face
Chapter 6	n = 49 pre-test = 29.8 post-test = 44.4 difference = +14.6	n = 48 pre-test = 32.3 post-test = 40.1 difference = +7.8
Chapter 8	n = 41 pre-test = 8.1 post-test = 26.2 difference = +18.1	n = 46 pre-test = 6.9 post-test = 15.5 difference = +8.6

The students took a pre-test and a post-test for each lesson. Both the pre-tests and the post-tests had a possible high score of 50 points (full marks). Table 1 shows the average scores on the pre-tests and post-tests, including difference between them. The average scores when contrasted between the post-tests and the pre-tests are much better with e-Learning, than with the standard face-to-face style.

Evaluation of Case 2

This course consists of 15 chapters with each lesson is divided into the first part of 90 minutes lecture and a second part of 90 minutes practice using PC. The first experiment was done with subject material of the 6th and the 7th chapters. The students learn the "if-statement" in these chapters; 23 students learned via the e-Learning system and 24 students learned via the standard face-to-face style. The second experiment was carried out using subject material of the 8th chapter. The students learn the "while-statement" in this chapter; 24 students learned via the e-Learning system and 23 students learned via the standard face-to-face style.
In the instance, students took post-tests only. The post-test on chapters 6 and 7 had a high score of 20 points (full marks). Another post-test was 10 points full marks. Table 2 shows the average scores on the post-tests. There was little difference in average scores relative to the two different kinds of learning styles.

Table 2. The average scores on the post-tests

	e-Learning	face-to-face
Chapter 6 and 7	n = 23 post-test = 14.0	n = 24 post-test = 13.0
Chapter 8	n = 24 post-test = 4.75	n = 23 post-test = 6.1

Feedback from the Students

Valuable student feedback was gathered through questionnaires. Typical comments about the e-Learning system by students who used it are as follows.

(Satisfactory points)
- I was able to concentrate my attention on the lesson with e-Learning system more than with the face-to-face style.
- I was able to learn at my own pace and at my own intellectual level.
- It was easy to understand learning contents because of useful, comprehensible and detailed "Frequently Asked Questions."
- As it was possible to repeat material and learn again and again, it was easy to understand the content

(Unsatisfactory points)
- To review the lesson, it was necessary to study starting at the first session again.
- It was hard to use an e-note for me.
- It was impossible to use practically speaking in the narrow communication band width of the environment available to me
- I found that there was too much material in each lesson for me to absorb.
- It was impossible to grasp the sequence of learning because of the lack of any tutorials to help.

Considerations

According to questionnaire results, the characteristics of the two courses were directly related to the resulting test scores. In general, the more the number of students in a classroom increases, the more noisy and distracting the classroom environment becomes. In the experiment of the "Foundations of Information Systems 1", about 50 students took the lesson with e-Learning and the others took it by face-to-face style, respectively. Therefore, it seems that the students who attended the e-Learning class were able to concentrate on the lesson more than in the standard face-to-face class style. As a result, the average difference of the scores between post-test and pre-test with e-Learning is much better than by face-to-face style. In other words, the individual learning with our e-Learning system is significantly more effective for students than with the standard face-to-face style. On the other hand, the total number of the students who took part in the face-to-face lesson is only about 50 in the case/experiment of the "Programming Language 1". In this case, each student was able to be guided by the teacher individually even without the e-Learning system. Moreover, "Programming Language 1" especially is a course that students have to learn one step at a time. It seems that the desired lesson effect is hard to

achieve and evaluate with our e-Learning system in a course like “Programming Language 1”.

Conclusions

In this paper, we have developed a framework of adaptive e-learning systems with learning portfolio for IT education. And, we have used the framework of our regular classes such as ‘Foundations of information systems 1’ and ‘Programming language 1. Through case study of the two different courses, we got feedback/outcome that our developed framework is more effective than the standard face-to-face class. In this hybrid learning environment, curriculum-based learning environment and exploratory-based environment, are very useful for e-learning.

As this project will be continuing through fiscal 2007, we are improving on systems such as mentoring, and developing other courses on “ERP Systems,” “Software Engineering,” and “Foundations of Information Systems 2.” Systems development environment for learning object based on the repository [Fuji & Tanigawa 2002] is also proceeding.

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