

## **A Peer-to-Peer and Instructor-to-Students Interactive Learning Process in Engineering Design Courses Enhanced by an e-Learning System**

**Masakatsu Matsuishi, Dr. of Engineering**

Matsuishi@neptune.kanazawa-it.ac.jp

**Kazuya Takemata, Dr. of Engineering**

Takemata@neptune.kanazawa-it.ac.jp

**Toshiyuki Yamamoto, Ph.D.**

caitosh@neptune.kanazawa-it.ac.jp

**Division of Engineering Design  
Kanazawa Institute of Technology  
ISHIKAWA 921-8501 Japan**

### 1. Introduction

Engineering Design Courses (henceforth, ED Courses), characterized by Project-Based Learning in Teams, are unique to Kanazawa Institute of Technology (henceforth, KIT). A total of 1,700 engineering students from all eight engineering departments must take Engineering Design Courses I through III before they graduate. In each Engineering Design Course, the students must conduct two hours of in-class instructed learning as well as four hours of outside-class learning activities in teams per week for ten weeks. KIT has also been a laptop engineering institution since 1994, offering students a 24/7 learning activity lounge and e-Learning system in order to support their out-of-class learning.

Fifty Engineering Design Courses are offered in each year. In order to maintain a high level of quality in the course management, a learning manual for students as well as a course management manual for instructors have been published as shown in Figure 1, and a web site to offer virtual learning space to students has been set up. All manuals as well as the corresponding

web site contents have been updated every year.<sup>1</sup>

In the year 2002, an e-Learning system was introduced to Engineering Design Courses. Collaboration functions in the e-Learning system enhanced the Problem-Based Learning in Engineering Design Courses.<sup>2</sup> Furthermore, in the year 2004, an on-line self-study module was developed. This on-line self-study module was used in the peer-to-peer and instructor-to-students interactive learning process, in which the students taught each other after using the on-line self-study module and the instructor supported this learning environment.

The purpose of this study is two-fold:

- (i) This study reports the major characteristics of the originally developed e-Learning system as well as its associated instructional strategy.
- (ii) The learning outcome after implementing the e-Learning system and its associated instructional strategy is analyzed. Furthermore, the validity of the instructional strategy is discussed.

In the conventional Engineering Design Course, a team consisting of four to seven members tackles a project theme. The team generated viable design solutions, from which the team selected the most optimal solution. The team then worked on design specifications to satisfy the needs and functions of the chosen solution. Next, the team developed a piece of software. In the final step, the team submitted the developed software as its final product of the project for the course. In this study, in addition to the above stated processes, the team used the originally developed e-Learning system and its associated instructional strategy from the beginning of the course until the stage for developing a piece of software.

It was proven that a newly developed e-Learning system has enhanced the knowledge and skills of the team in the process of working on their project theme, and that the newly developed instructional strategy generated more learning outcome than the conventional curriculum.

## 2. Introductory Engineering Design Education at KIT

Introductory ED Education consists of two ED courses; ED I and ED II. ED I is taught in the Fall term of the freshman year, and ED II in the Winter term of the sophomore year. The course objectives of ED I and ED II are distinct and properly coupled in order to achieve a seamless transition as shown in Figure 2. ED courses are characterized by Project-Based Learning in Teams. The goals of ED I and ED II are to have students gain actual engineering design experience through working on real-life projects, and to present their results in written as well as oral reports. It should be pointed out that this course offers students the first experience in

working in teams. The students are given open-ended problems. In the process, they are expected to learn teamwork skills such as communication skills and leadership. In each team, students choose an engineering topic related to their daily life, identify their project, characterize their design project, generate design concepts for the design project, evaluate the design concepts, select the most promising concept, and design in detail. Students are encouraged to develop a distinct and creative design solution.

The procedures covered in ED I and ED II are:

- To identify project/design opportunities
- To characterize design projects
- To generate design concepts
- To evaluate design concepts and to select the most optimal concept
- To design in detail
- To present results



Figure 1. Originally developed textbooks

### 3. Engineering Design Education for the Department of Computer and Information Science

To report the use of the e-Learning system in the Engineering Design Education, sophomore teams in the Department of Computer and Information Science were focused. The class management and learning activities in design teams were elaborated in this section. A class consisting of 28 students was divided into seven teams. Each team consisted of four students. Each team selected a unique project theme.

As the first step, each team conducted market research and a needs assessment. Then, the results of the analysis were realized in project characterization. Based on the project characterization, possible solutions or concepts were generated, from which the most optimal concept was chosen. Based on the chosen concept, the final product software was developed. Finally, at the end of the term, each team demonstrated its final product and presented its report.

Students in the Department of Computer and Information Science are required to master the following seven learning objectives.

- (1) Ability to choose a project theme
- (2) Ability to market research and to assess needs of clients
- (3) Ability to determine an optimal design specification from clients' needs
- (4) Ability to generate solutions, to evaluate them, and to choose the most optimal solution
- (5) Ability to develop a software program
- (6) Ability to work in a team
- (7) Ability to communicate effectively

All seven abilities except (5) are required to be achieved by all engineering students. The ability stated in (5) is only required by the students in the Department of Computer and Information Science.

In Engineering Design II for the students in the Department of Computer and Information Science, besides the learning manual for students, the course management manual for the instructor, and a web site for Engineering Design Courses, an additional programming textbook was developed and began to be in use in 2002. This programming textbook made it possible for the students in the Department of Computer and Information Science to acquire enough programming skills to program software as their final products.<sup>3</sup>

As a sample of a project theme, this paper reports a team which worked on a project theme: "Design an Attractive Virtual Zoo." A motivation for this project theme was to create a zoo virtually so that people can visit there without fighting the congested traffic during a holiday season. Another motivation was to seek for possibility to creating a zoo system on the Internet.

In order to create an attractive Virtual Zoo for adults and children, the team assessed needs and market researched on available Virtual Zoos on the Internet. After analyzing the results, the team characterized their design project. Based on their design project, the team generated design concepts. In order to generate design concepts, the team drew a Fish Bone Diagram to enumerate aspects for a Virtual Zoo as shown in Figure 3. Based on the Fish Bone Diagram, the team decided to develop a Virtual Zoo software program with the following five characteristics:

- (1) A file size of the top page is reduced.
- (2) In order to deliver movies smoothly, streamed movies are employed.
- (3) In order to deliver sound smoothly, streamed sounds are employed.
- (4) Stricter security is employed.
- (5) In order to optimize search engines, META tags are employed.

As the outcome of the term, each team must submit a design report, a software program, presentation slides, and a poster for the term-final poster session. Presentation slides are shown in Figure 4 and the poster is given in Figure 5.

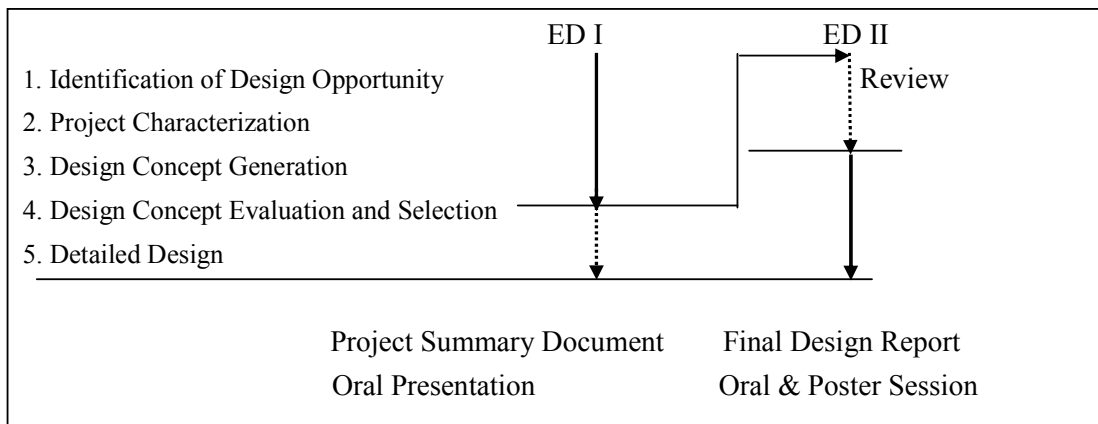


Figure 2. Flow of ED I and ED II

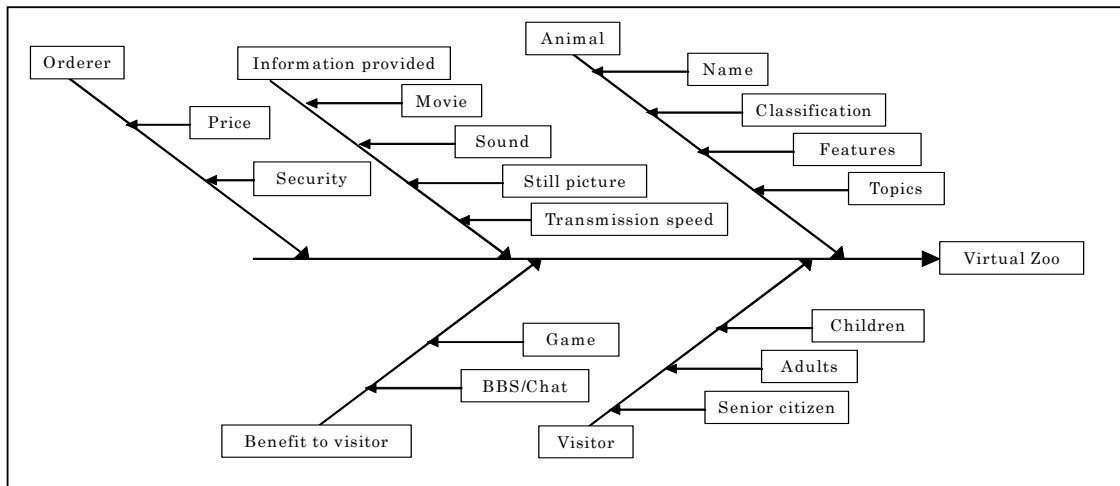


Figure 3. Fish Bone Diagram of an Attractive Virtual Zoo

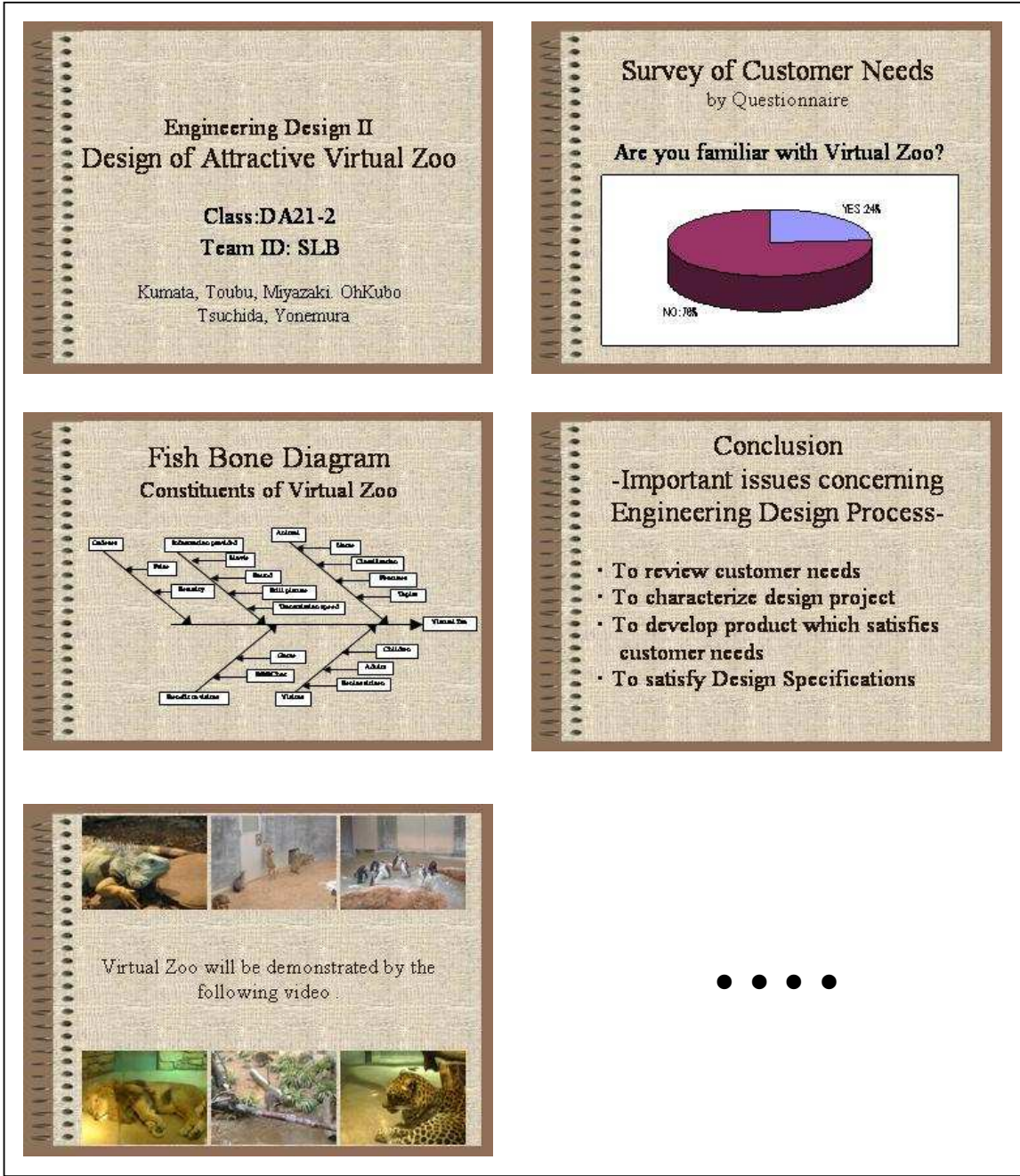


Figure 4. Final Presentation Slides of the Design of an Attractive Virtual Zoo



Figure 5. Poster of an Attractive Virtual Zoo

#### 4. A Peer-to-Peer and Instructor-to-Students Interactive Learning Process

##### 4.1 On-Line Self-Study Module

Although a textbook for software development was specially prepared for the students in the Department of Computer and Information Science, most students' ability to develop software did not improve. As a result, team members who would not participate in programming activities

caused negative impact on team work activities. In order to improve students' ability to program and develop software, the On-Line Self-Study Module was developed. The On-Line Self-Study Module consisted of weekly based instructional materials. The On-Line Self-Study Module had many ideas and devices to encourage self-learning. For example, when a student encountered an unclear part, its explanation was given by clicking on the help icon. In this way, help icons hyper linked with explanations were omnipresent throughout the learning material.

The On-Line Self-Study Module were composed of (i) XML documents and processing, (ii) learning objectives, (iii) HTML, explanations of JavaScript and exercises, (iv) basics of XML, explanations of data binding, and exercises, (v) explanations of Document Object Model and exercises, (vi) explanations of eXtensible Stylesheet (XSL) and exercises.

The On-Line Self-Study Module was delivered via an e-Learning system, WebCT Campus Edition. Figure 6 shows a screen snapshot of The On-Line Self-Study Module. Students must log in their own WebCT accounts at least once a week and access the On-Line Self-Study Module to learn its contents.

Furthermore, with the instructor's facilitation, the students must teach each other concepts of programming in the On-Line Self-Study Module in the classroom as well as over the communication functions of the e-Learning system. In this way, higher learning outcome was achieved. Let us call this learning method "a peer-to-peer and instructor-to-students interactive learning process," which is elaborated in the following section.

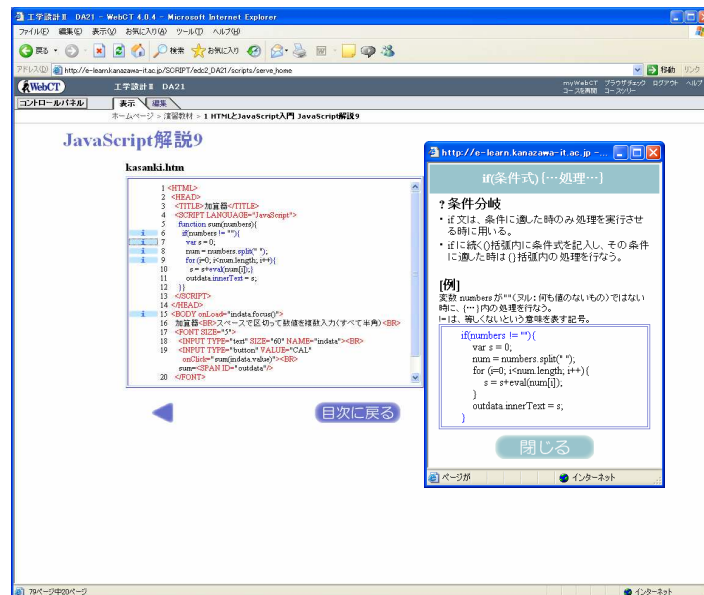


Figure 6. An Example of On-Line Self-Study Module



#### 4.2 A Peer-to-Peer and Instructor-to-Students Interactive Learning Process

A peer-to-peer and instructor-to-students interactive learning process applied to the On-Line Self-Study Module is demonstrated in Figure 7 and diagramed in Figure 8.

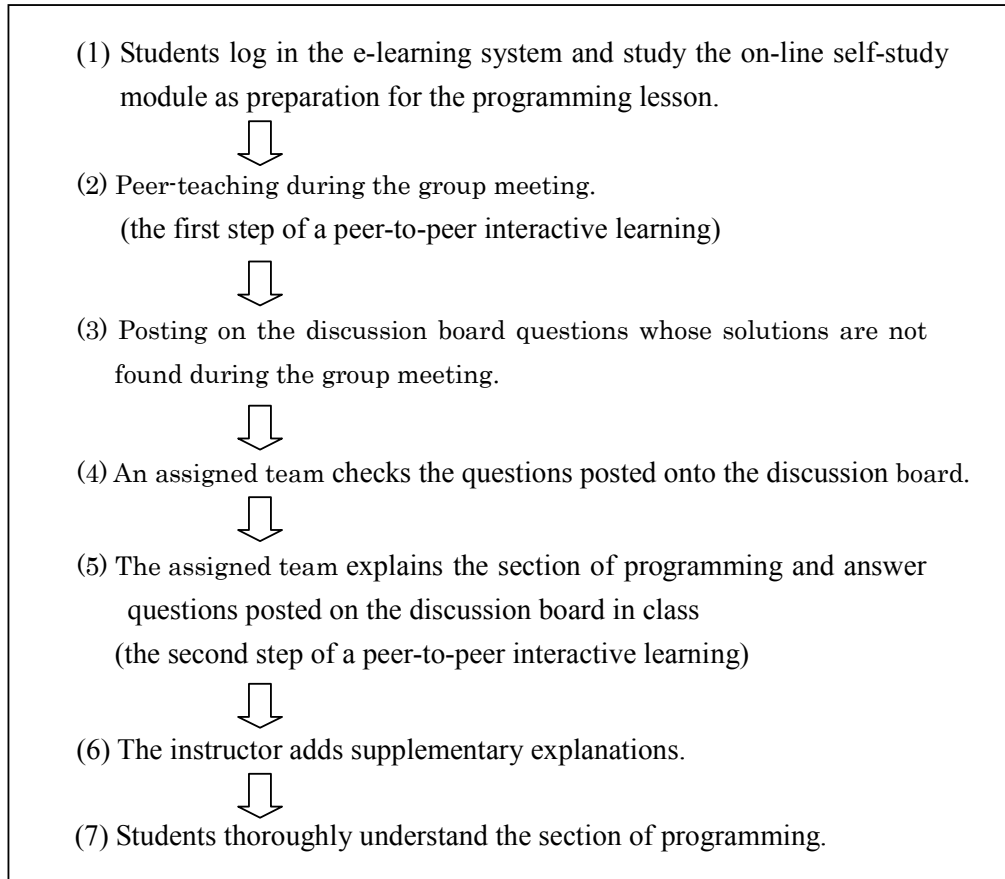
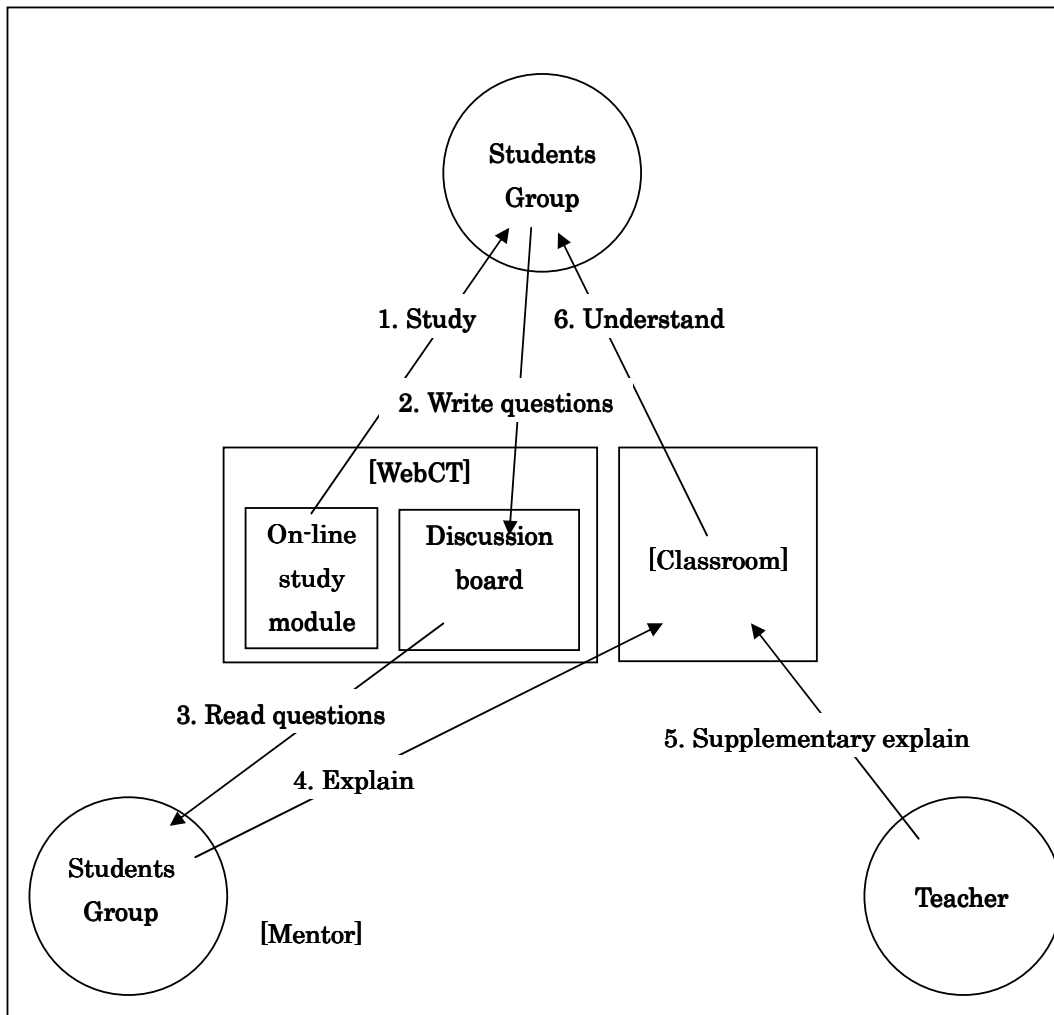


Figure 7. a Peer-to-Peer and Instructor-to-Students Interactive Learning Process



**Figure 8.** Diagram of a Peer-to-Peer and Instructor-to-Students Interactive Learning Process

Students logged in the e-Learning system and access the On-Line Self-Study Module to preview programming. The students going through this learning process went back to the group meeting, peer-taught the rest of the members the learned content, and discussed what they learned. This stage was the first step of peer-to-peer interactive learning.

There were often some issues which the group meeting could not find solutions. Such issues were posted on the discussion board in the e-Learning system. Furthermore, suggestions for revisions for explanations due to unclear descriptions were also posted on the discussion board.

The seven teams took turns to play the role of a mentor to explain a section of programming in class. An assigned team checked the content of the discussion board prior to the classroom

instruction. In class, the team explained its assigned section of programming and followed up on the questions posted on the discussion board. This stage was the second step of peer-to-peer interactive learning. At this time, the suggestions for revisions for explanations due to unclear descriptions posted on the discussion board were evaluated and the final suggestions were announced in class.

The instructor's clew and suggestions facilitated the assigned team to clearly and perfectly understand the assigned section of programming so that questions raised on the discussion board be fully answered in class.

Table 1 shows samples of posted question on the discussion board. Corresponding answers prepared by the assigned team are given in the form of PowerPoint slides in Figure 9.

Table 1. Examples of Questions posted on Discussion Board

<p>1. <u>Question posted by Student A</u>          What does the button "Copy" mean, which appears after executing DATABIND3?          Why does an error message "An error has occurred" appear after executing DTABIND3?</p>
<p>2. <u>Question posted by Student B</u>          The Explanation 4 of eXtensible Stylesheet (XSL) is not adequate. Therefore we can not understand how the program works. Please give us a clear and detailed explanation.</p>

The above stated learning activities continued from the first week to the fifth week. From the sixth week until the ninth week, all teams conducted the programming development for the most optimal concept or solution.

It should be pointed out that the learning method called "a peer-to-peer and instructor-to-students interactive learning process" making use of the On-Line Self-Study Module offered students a great opportunity to preview the learning content before attending the class. Furthermore, it was worth pointing out that the students' motivation for learning increased due to peer-teaching in and outside class.

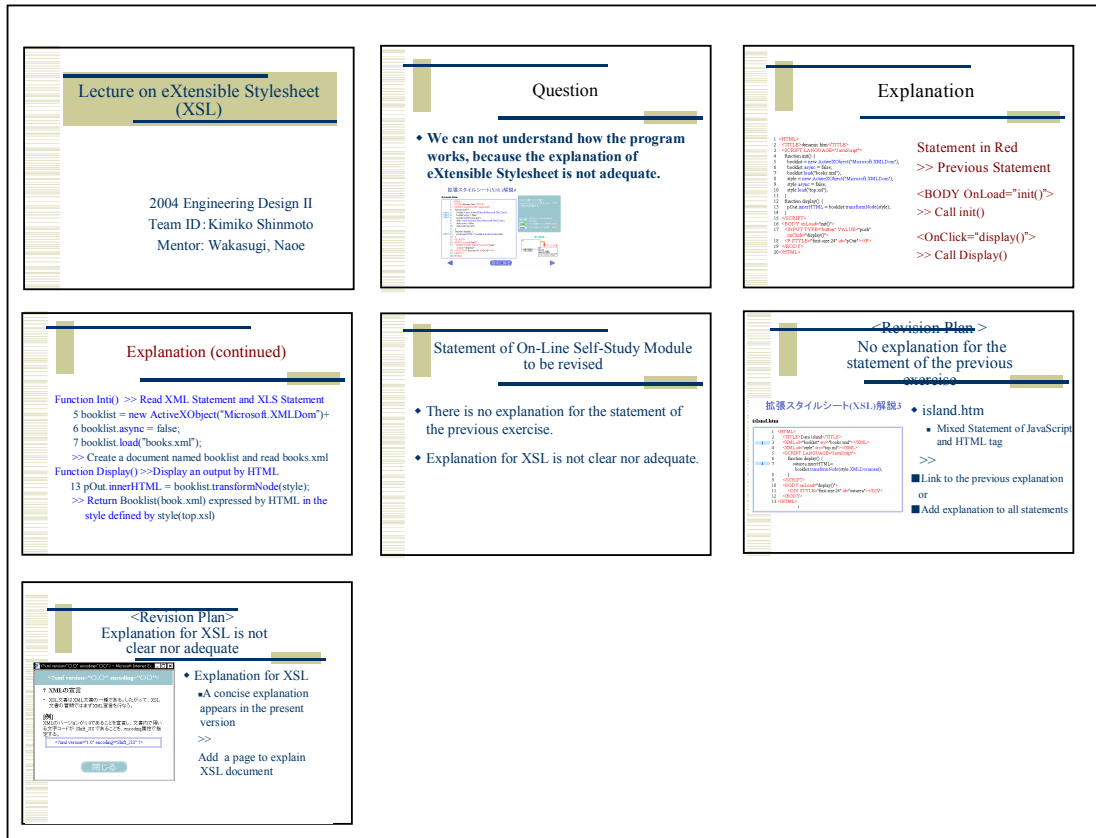


Figure 9. Example of Slides to answer Questions posted on Discussion Board

## 5. Learning Effect by the e-Learning System

### 5.1 Improved Software Development Skills

In order to investigate the improved programming ability by the peer-to-peer and instructor-to-students interactive learning process, the students self-assessed their programming skills on the first week and on the fifth week. Items in the self-assessment tool are shown in Table 2. Figure 10 demonstrates how much students' programming ability grew compared with the ability at the beginning of the course. The students' programming ability improved approximately 1.4 times compared with the results on the first week.

Table 2. Questionnaire for Programming Capabilities

1. Can you understand the meaning of technical terms?
2. Can you explain the role of each programming language?
3. Can you share the responsibility of programming with other team members?
4. Can you design good user interface?
5. Can you materialize your idea in your computer program?
6. Can you read programs developed by others?
7. Can you point out defects in programs developed by others?
8. Can you improve programs developed by others?
9. Can you explain your programs to others?
10. Can you allot work to team members to maximize an output by taking account of their programming abilities?

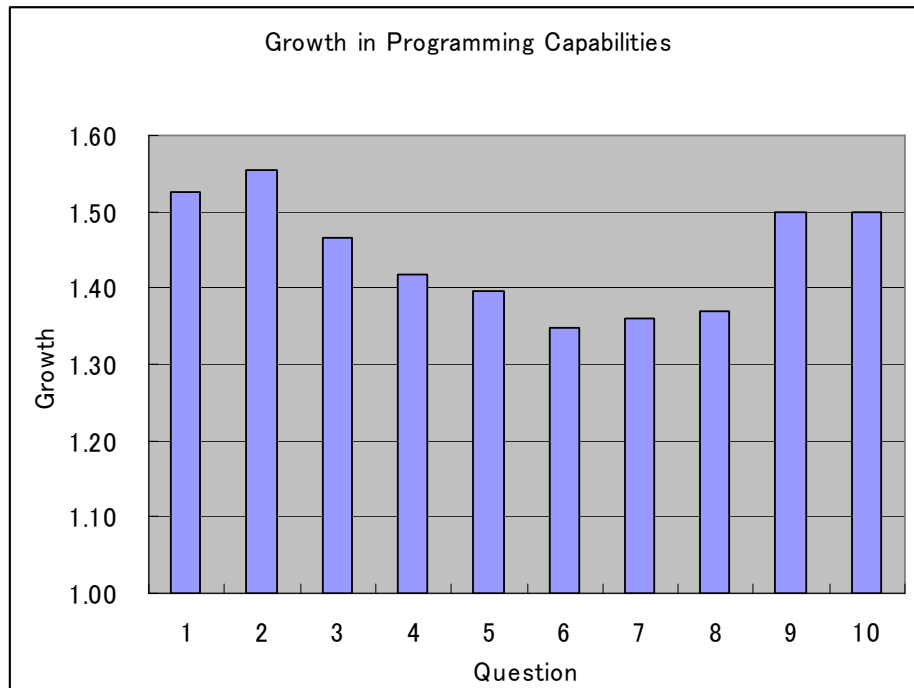


Figure 10. Growth in Programming Capabilities

## 5.2 Sharing the Responsibility of Programming among Team Members

In the last year's Engineering Design II, approximately one-third of the students were involved in the process of programming. The main reason for not all members were in charge of programming was that there were many team members who had poor programming skills. Those students who did not get involved in programming did other tasks such as collecting data for database, working on a design report, and so on.

On the other hand, in this year's Engineering Design II, all team members were involved in any one of the following programming tasks:

- (1) Man-machine Interface
- (2) Database
- (3) Movie Software
- (4) Voice Software
- (5) Various Sub-Programs

This new phenomenon was due to the effective result of the newly developed On-Line Self-Study Module in the e-Learning system incorporating the instructional strategy called "the peer-to-peer and instructor-to-students interactive learning process."

## 6. Concluding Remarks

In Engineering Design Courses, each design team selected its own project theme. And then, the team conducted a needs assessment analysis and market research. Based on the results of the needs assessment and the market research, a design project was characterized. Then, design concepts or solutions to meet the design specification were generated, evaluated, and the most optimal concept or solution was selected. Finally the most optimal solution was employed for designing the final product software.

In order for all members in the team to contribute to the process of programming, an On-Line Self-Study Module was developed in 2004 so that students could learn programming by teaching each other before they were at the stage of programming. With the constant support by the instructor as well as peer-to-peer learning in and outside the class contact hours, the students showed more learning outcome than the traditional instruction. This learning process was called "the peer-to-peer and instructor-to-students interactive learning process."

The following results revealed after employing the On-Line Self-Study Module enhanced with "the peer-to-peer and instructor-to-students interactive learning process" to the sophomore

students in the Department of Computer and Information Science.

- (1) In a newly developed e-Learning system incorporating the On-Line Self-Study Module enhanced with the peer-to-peer and instructor-to-students interactive learning process, the students' programming skills improved +1.4 times.
- (2) The newly developed e-Learning system made all team members contribute in the process of programming.
- (3) The newly developed instructional strategy generated more learning outcome than the conventional curriculum.

## 7. Future

A newly developed e-Learning system incorporating the On-Line Self-Study Module enhanced with the instructional strategy called the peer-to-peer and instructor-to-students interactive learning process will be continuously offered. Because this case study was a snapshot research, a longitudinal research must be conducted to prove increased learning outcome in the new instructional method.

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## Biographical Information

### DR. MASAKATSU MATSUIISHI

Education: 1969, Doctor of Engineering, Naval Architecture, Osaka University.

Professional Experience: 1999-Present, Professor, Kanazawa Institute of Technology. 1966-1999, Hitachi Zosen Corporation.

### DR. KAZUYA TAKEMATA

Education: 1998, Doctor of Engineering, Information and Computer Engineering, Kanazawa Institute of Technology.

Professional Experience: 2001-Present, Assistant Professor, Kanazawa Institute of Technology. 1987-2001, Assistant Professor, Kanazawa Technical College.

### DR. TOSHIYUKI YAMAMOTO

Education: 2002, Ph.D. in Media Technology, School of Education, Indiana State University.

Professional Experience: 1992-1998, Assistant Professor, Rose-Hulman Institute of Technology. 2002-Present, Professor, Kanazawa Institute of Technology.