A Practice of Collaborative Project-Based Learning for Mutual Edification between Programming Skill and Artistic Craftsmanship

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Abstract - **It is well known that using computer games as educational materials for computer programming and software engineering education effectively motivate students. For this purpose in Konan University, we have practiced project-based learning to develop game programs. From instructional practice in Konan University to date, we concluded that we need more specialized game contents in order to better motivate the students. On the other hand, in character design training in Osaka University of Arts, it has been expected that showing students a goal where their characters are animated in game system effectively motivates the students. However, to develop game system, high level programming skill is needed. To address these problems, we propose a collaborative project-based learning approach which can be practiced in cooperation with a faculty of computer science and a faculty of arts. In the learning process, program codes are developed by the computer science students and game contents are created by the arts students. The process also includes online meetings to coordinate their work. Through the project, students would not only improve their expertise but learn unprofessional knowledge, experience collaborative work and improve communication skill. In the last year, we have practiced the collaborative project-based learning to develop a 3D fighting game in cooperation with Konan University and Osaka University of Arts. In this paper, we will report the practice and evaluate its educational effectiveness by student questionnaires about the learning and examinations about software engineering.**

Index Terms – PBL, Software engineering education, Character design, Collaborative learning.

INTRODUCTION

Recently in computer programming and software engineering education, there has been an increasing interest in using computer games as educational materials. A computer game effectively motivates the students and it can introduce to them integrated techniques from a wide range of subjects including computer science, mathematics and physics. There have been offered a lot of project-based learning (PBL) to use computer game projects [1]-[4].

Computer game-based projects are surely effective for computer programming and software engineering education. However, for students who play commercial computer games on a daily basis, sufficient educational benefits may not be attained. Since commercial level game production requires not only techniques from computer science but also artistic craftsmanship, the game which they have developed in the PBL course will be far lower in quality than commercial computer games especially in the area of game contents such as game characters and background scenes. Therefore, the students may become unmotivated or discouraged by the quality differences. Since the creation of game contents is not usually an area of study in a faculty of computer science, a reasonable method to obtain high quality game contents which can be adapted to their game program is needed.

On the other hand, in the character design training course in a faculty of arts, it has been expected that to create characters as part of a computer game project motivates the students effectively. However, development of a game program which animates created characters needs high level programming skills. To provide such a PBL course in an arts curriculum is generally difficult to achieve.

Therefore in this paper, we propose a PBL method (CPBL: Collaborative Project-Based Learning) which can be practiced in cooperation with a faculty of computer science and a faculty of arts. In the last year, we have practiced a CPBL to develop a 3D fighting game from a collaboration of a PBL course which has been offered in the faculty of Intelligence and Information in Konan University and character design training courses which have been offered in the faculty of Arts in Osaka University of Arts. In the practice of CPBL, 13 senior students of Konan University and 75 sophomore students of Osaka University of Arts have

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participated. The specification of the 3D fighting game is initially developed by the student of Konan University and reviewed by the student of Osaka University of Arts. The game system is designed and implemented by the student of Konan University using Java and Java3D [5]. All game characters and their 3D data are designed and modeled by the student of Osaka University of Arts using Metasequoia [6]. In this paper, we propose CPBL, and report and evaluate the practice.

OVERVIEW OF CPBL

Many educational benefits are expected by inter-faculty collaborations in a PBL. We designed CPBL so that the following educational benefits can be obtained.

- For the students of a faculty of computer science, high quality game contents suitable for their game system can be obtained, and for the students of a faculty of arts, animated motions of their creations in a game can be obtained. As a result, it is expected that the total quality of their products is improved and their work becomes highly-motivating to each other.
- The students on one side of the collaboration can be regarded as customers of the products from the other side of the collaboration. In this situation, we can introduce a kind of external evaluation into the project and can improve the quality of the products. Moreover, a realistic tension can be incorporated into the project and a practical industry-like environment can be simulated in the project.
- In an actual game development project, constraints on the system architecture may affect the creation of the game contents, and on the contrary, a design of the game contents may affect the program design. Similar situations can occur in the CPBL and such situations may enhance the practical workability of student learning.
- The students can learn a concrete process of the production of the other field's work.
- Practical communication skills can be acquired by communicating with the students of the other field.

For this purpose, we think that the learning environment and process of CPBL must satisfy the following requirements.

R1. Online meeting system should be prepared between the faculties, and online meetings can be frequently scheduled in the course.
R2. The genre of the game should be initially decided for the efficiency of whole tasks.
R3. Basic tools and programming languages which are needed by students to produce their own products should be properly lectured and trained before or at an early session of the course.
R4. The architecture of the game system should be defined before starting the character modeling process because the specification of the model data may depend on the architecture.
R5. The specification of the game should be initially developed by the students of the faculty of computer science because they know the architecture of the game system well. Afterwards, the specification should be reviewed by the students of the faculty of arts to reflect their requirements in the specification.
R6. Any problem which may affect a task on the other side of the collaboration should be properly reported to each other through online meetings.
R7. Final products should be evaluated by each other.

A PRACTICE OF CPBL

We have practiced CPBL to develop a 3D fighting game like Super Smash Brothers [7] from April to November of the last year. In the practice, 13 senior students of the PBL course in Konan University and 75 sophomore students of two character design training courses in Osaka University of Arts have participated. PBL course in Konan University meets 2 times a week (180 minutes each) in two semesters. The students of the PBL course had already been trained in Java programming using Eclipse [8], and lectured UML and other basic software engineering topics. Each of two design training courses in Osaka University of Arts meets 2 times a week (90 minutes each) and one course of them meets in the first semester and the other meets in the second semester. A student in Osaka University of Arts can attend only one of these courses.

In the practice, we held online meetings six times. We used Skype for online meetings. Character data and game programs are sent via e-mails. The structure of the system used in the online meetings is shown in Figure 1. The time-line of the practiced CPBL is summarized in Table I. As shown in the table, the whole process of the CPBL is divided into eight sessions by online meetings and summer break. At the first session, the students of Konan University are lectured and trained in Java3D, and those of Osaka University of Arts are lectured and trained in Photoshop and Metasequoia, which is a 3D modeler. In the first online meeting, rough designs of game characters created by the students of Osaka University of Arts were reviewed. Furthermore, basic behaviors of game characters were defined in the meeting because the architecture of the game

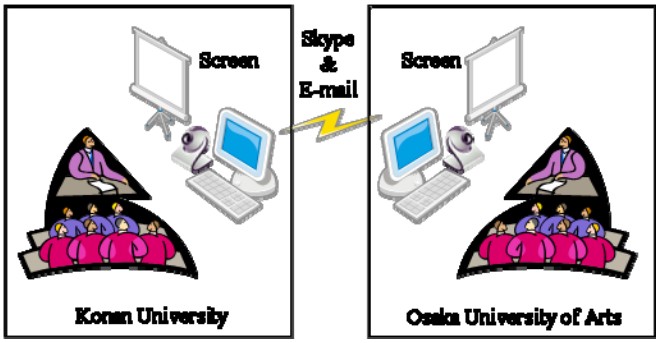

FIGURE 1
SYSTEM STRUCTURE FOR ONLINE MEETING

TABLE I
TIME-LINE OF THE PRACTICED CPBL

Date	Tasks in Konan University	Tasks in Osaka University of Arts
4/15 ~	● Lecture and Practical Training of Java3D	● Lecture and Practical Training of Photoshop ● Rough design of game characters in 2D images ● Lecture and Practical Training of Metasequoia
5/16	Online meeting ● Review of the rough designs of game characters ● Defining basic behaviors of the game characters	
	● Architecture design	● 3D modeling of game characters and stages
5/30	Online meeting ● Explanation of the specification for 3D data creation	
	● Design and Implementation of the 3D game framework	● 3D modeling of game characters and stages
6/13	Online meeting ● Requirement elicitation for specification development	
~7/22	● Design and Implementation of the 3D game framework	● Revision of 3D models
Summer break		
9/19~	● Specification development	● Lecture and Practical Training of Photoshop ● Rough design of game characters in 2D images ● Lecture and Practical Training of Metasequoia
10/17	Online meeting ● Review of the first half of the game specification	
	● Design and Implementation of the game ● Revision of the specification	● 3D modeling of game characters and stages
11/14	Online meeting ● Review of the last half of the game specification	
	● Design and Implementation of the game ● Revision of the specification	● 3D modeling of game characters and stages
11/28	Online meeting ● Demonstration of the game	
	● Testing	● Revision of 3D models

system should be designed so that those behaviors can be implemented. In the second online meeting, instructions for 3D data creation, which are required by the design of the architecture, were explained to the students of Osaka University of Arts. Based on the instructions, the students modeled 3D data of their characters at the third session. In Konan University, a kind of spiral model was used to develop the game system. At the first iteration of the development process, an application framework for 3D games, named Radish framework, and a prototype of the game system were developed. Radish framework has layer architecture and consists of five subsystems, 3DModel, Animation, Physics, RWT and GameMain (shown in Figure 2). The framework is designed so that it can be flexibly reused for various kinds of 3D games. In the figure, each

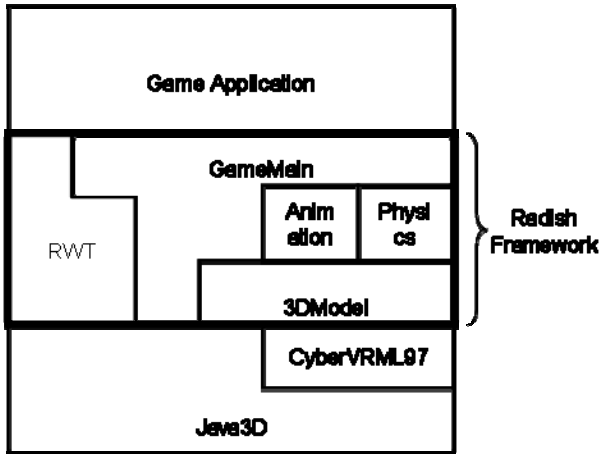

FIGURE 2
ARCHITECTURE OF THE GAME SYSTEM

subsystem is depicted as a closed region and uses its lower neighbor subsystems. The lowest subsystem, 3DModel abstracts a static structure of 3D data. It is designed to be reused by a wide range of 3D games. Animation handles predefined motions of 3D data and Physics handles physical dynamics. According to the genre of the 3D game, these two subsystems can be reused independently. RWT provides a Java3D based GUI toolkit and GameMain controls and integrates the other subsystems. At the second iteration of the process, the remainder of the game system was developed using the prototype and the framework. The first iteration was completed by the end of the 4th session. In the 5th session, the specification of the game system was developed by the students of Konan University so that it can be effectively implemented by the framework and it was reviewed by the students of Osaka University of Arts at the 4th and 5th online meetings.

The total source lines of code were 4779 and the source lines of code of the application framework were 2307 (excluding whitespace). All source codes are written in Java and every version of them was controlled by CVS. About 1100 man-hours were spent on the implementation.

EVALUATION AND DISCUSSION

From the practice of CPBL reported in the previous section, we can see that CPBL is feasible. The six online meetings worked effectively both for the construction of the game system in Konan University and for the modeling of 3D characters in Osaka University of Arts. The requirements presented in section "Overview of CPBL" were satisfied by the practice. For example R1 was satisfied by the first session, and R5 was satisfied by the 5th session and 4th and 5th online meetings.

To evaluate the educational effectiveness of CPBL, we examined the students of Konan University on their knowledge and understanding of software engineering twice before CPBL and after CPBL. The examinations are not identical but of the same level of difficulty. The scores of the

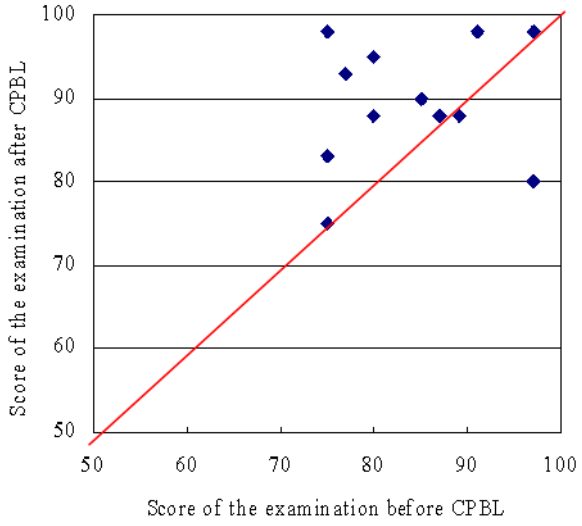

FIGURE 3
RESULTS OF EXAMINATIONS OF SOFTWARE ENGINEERING COURSE BEFORE CPBL AND AFTER CPBL

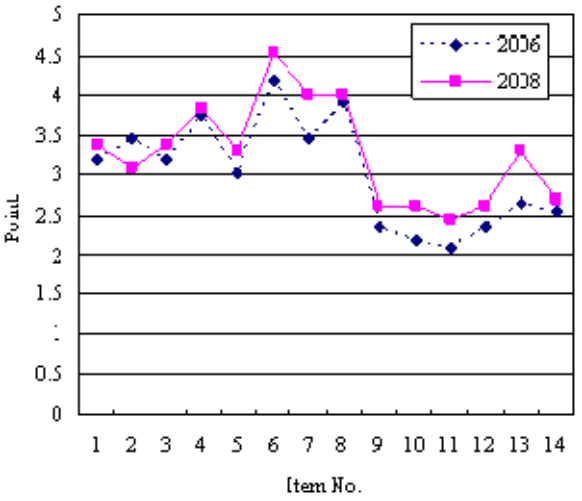

FIGURE 4
RESULTS OF QUESTIONNAIRES ABOUT PBL IN 2006 AND CPBL IN 2008

examinations for each student are shown in Figure 3. In the figure, the horizontal axis represents the score of the examination given before CPBL, and the vertical axis represents that of the examination given after CPBL. As we can see from the figure, the scores of 10 students out of 13 students increased. The average score increased from 84.2 point to 89.4 point. The p-value given by t-test is 0.042 and a null hypothesis that the two sets of scores do not differ is rejected with 5% level of statistical significance.

Furthermore, after completing the project, we had a questionnaire on the project for the students of Konan University. The questionnaire consists of 14 five-point Likert scaled items and the same questionnaire was conducted for 12 students who had participated in the traditional PBL course in 2006. In the PBL course, an AJAX based online typing game was developed and its game contents were created by themselves. The results of two questionnaires are compared in Figure 4. As we can see the figure, the point averages of almost all items have increased. Especially, the point average of 13th item has increased by 0.67 point and that of 8th by 0.55 point. The questions of 13th item and 8th item are "Have your understanding of object oriented development been developed?" and "Have your recognition of the importance of management in software development increased?", respectively. Only the point average of 2nd item "Did you get a sense of accomplishment after completing the project?" has decreased. We think it is due to that some tasks which were initially scheduled to complete remained undone. In both questionnaires, the point average of 6th item "Have your recognition of the importance of communications in software development increased?" is highest. From these facts, we can consider that CPBL is effective in enriching students' understanding of software engineering and to improve their motivations for software engineering.

The following tendencies were observed for the students of Konan University.

- The students were really motivated by using 3D character data received from Osaka University of Arts in the game system under development.
- Some students were discouraged by a severe review by the students of Osaka University of Arts.
- Many students could recognize the importance of communications in software development projects through CPBL.
- Many students' understanding of object oriented programming and design were developed through CPBL.

For the students of Osaka University of Arts, the following tendencies were observed.

- Predetermined genre of the game helped the students imagine their characters to be created.
- Through online meetings, they could recognize their roles and specialties, and it enhanced their motivations.
- On the other hand, sometimes efficiency of their work was reduced due to their lacks of understanding of the process of online meetings.
- Their motivations for learning and training 3D geometry and 3D modeling tool were maintained at a high level because of its applicability to 3D modeling of the game characters.
- They could design 3D characters which can be animated by the game programs by being aware of the goal of the project.
- It is considered that they can objectively self-evaluate the quality of their characters since the characters are able to be animated in the game system.

From these observations, we think that students' recognitions of their own fields became deeper and their

motivations were enhanced by collaborations between two different fields, computer science and arts.

RELATED WORK

A lot of work has been done in using computer game development projects for PBL [1]-[4]. However, to our knowledge, there is no PBL to develop a computer game in cooperate with a faculty of computer science and a faculty of arts. We think such cooperation will bring many educational benefits other than to motivate the students.

Some introductory programming courses for students who are non-majors in computer science have been proposed [9], [10]. Through CPBL, arts students cannot directly learn computer programming, but they can learn many practical topics in computer science such as a concrete process of software development and how to create contents which are available for computer programs, and so on.

CONCLUSION AND FUTURE WORK

We have proposed a PBL course, CPBL which can be practiced in cooperation with a faculty of computer science and a faculty of arts. Also we practiced the PBL course to develop a 3D fighting game from a collaboration of a PBL course in faculty of Intelligence and Information in Konan University and character design training courses in faculty of Arts in Osaka University of Arts. The six online meeting in the collaboration worked effectively. The evaluation of the practice of the PBL suggests that our approach will strengthen students' expertise of their own field and enhance their motivations.

By the practice, also several problems of the approach are revealed. First, a severe review by the students of the other faculty will significantly improve the quality of the products and will incorporate a realistic tension into the learning environment, but may discourage the reviewed students. Second, too many online meetings may reduce the productivities of both game system and game contents, but too less online meetings may yield defects of the products and additional work. Finding an appropriate frequency of online meetings is generally hard. Along with online meetings, to use a project-specific wiki may be helpful. Last, in the practice, several tasks initially to be scheduled to complete remained undone. Specifically, some specifications of the game remained unimplemented, and 3D animation data of the game characters could not be created. A method to efficiently and easily create a large amount of 3D animation data is needed. The efficiency of the implementation can be improved by using the application framework for 3D games which was developed in the last year's project. We intend to open the source codes of the application framework for pedagogical use.

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