TEAM LEARNING PROGRAM FOR INFORMATION TECHNOLOGY ENGINEERS USING PROJECT-BASED LEARNING

Case Study of the "Upper Process" in IT Engineering

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Abstract: This paper reports the case of an educational practice and evaluation of team learning in an Engineering course. This course uses project-based learning and is supported by a learning management system. Its subject is the "Upper Process" of Information Technology systems development. The course was conducted at a computer college which trains information technology engineers to meet the demands of industry. The course content consists of team practice sessions to understand "requests for proposals" (RFP) and to learn how to propose "requirement definitions". Student's communication skills are also taught throughout the team learning sessions. To assess what was learned, the results of the team learning sessions were evaluated and self evaluations of learning activities were conducted. After this, a feasibility study of the team learning activity was discussed. Also, the evaluation scores of the functions of the learning management system were correlated with the assessment scores.

1 INTRODUCTION

The development of engineers in various disciplines requires human resources training in the higher and vocational education systems and the improvement of the educational system (Japanese Ministry of Education, Sports, Culture, Science and Technology (MEXT), 2010). The development of educational programs and evaluation methodologies have been discussed and disseminated (Shinoda, 2011), resulting in many revisions to these programs.

Also in the area of information technology (IT), human resource development issues such as the amount of engineers needed and the quality of engineering performance (Information-Technology Agency, 2010) have been discussed. In particular, the IT industrial sector claims that information technology engineers should have systems development experience as members of a team which has practiced resolving problems while they were learning fundamental engineering theory. Additionally, it is often suggested that IT engineering graduates from departments of computer science have insufficient communication skills, leadership qualities and project management experience (Information-Technology Agency, 2010).

Since most IT engineers have been trained at computer colleges, these colleges have to develop educational program to meet the above requirements. Most college students in Japan are around 20 years old, and have little experience as engineers. Also, IT engineers have to learn business manners in order to better communicate with customers and business partners. One approach is to employ team learning as a form of project based learning (PBL). Team learning means that students work together as a project team, and resolve problems collectively. These teams require collaboration, and members have to play individual roles which are assigned in advance (Itoh, 2011). Therefore, team learning is different from group learning or collaborative learning (Ichikawa, 1995; Bransford et al., 2000). Team learning may consist of discussions, learning through experience, and teaching each other. There have been some discussions about team learning (Decuyper et al., 2010; Yazici, 2005), and the difference between team learning and other group learning styles is not clear. However, our purpose is not to clarify the difference. Stud-

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ies have reported that team learning can provide training which improves academic achievement and human performance, two measures of work related skills (Hanabusa, 2008). It can also be applied to various areas of engineering education (Shirabe, 2006). Online learning management systems can play a learning support role, as a kind of virtual learning environment (VLE), even for PBL (Leng et al., 2006). However, enhanced computer supported collaborative learning (CSCL) environments cannot always promote team learning as a form of PBL because some of the human factors of the teams are so important. Therefore, careful design and support will be important if team learning is to be effective.

In this paper, the feasibility of developing a team learning style for practical learning by IT engineers is examined, and also the interaction between team learning activities and functions of learning management system have been discussed. Team learning sometimes influences individual learning (Ellis et al., 2003), so a key point is whether it is feasable to measure the effectiveness of positive learning. Another hypothesis is that some functions of learning management systems may contribute to learning, such as the team learning requirement for discussion between participating members and the recording of their discussions.

This paper will address the following topics:

- The design and develop of an educational program to provide practical job experience in IT systems development using face to face and online learning, including communication skills training in response to customer's expectations. These are taught as a subject called the "Upper Process".
- The evaluation of learning performance during the course, by develping and using evaluation items to assess student's performance.
- The enhancement of team learning, by developing a learning management system. An evaluation of this system by students is conducted, and the relationship between learning performance and system evaluation is analyzed.

2 METHOD

2.1 Learning Content

The "Upper Process" of IT systems development and consulting was selected as a subject to determine the feasibility of team learning using project-based learning. This topic was studied as project-based team learning, which is the detailed analysis of "requests for proposals" and the proposing of "requirement definitions" while students learned communication with customer skills, business manners, and problem solving methods involving teamwork. This course is originally designed for on-the-job training, and it has been modified for use in a college course, with consideration given to course content and evaluation criteria. The course consisted of 15 sessions in a computer college. One lecturer and one mentor organized participants, who were 40 students (5 teams $\times$ 8 members).

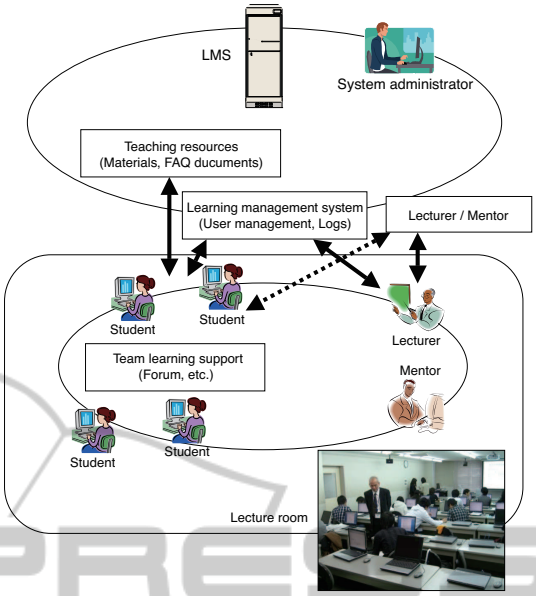

Figure 1: Experimental environment.

Table 1: Learning management system functions.

Item	Contents
Task summary	Objectives, required learning time
Task materials	The downloading of materials
Lecture materials	The downloading of materials
Questions about the task	Forum for questioning lecturer and mentor
Team discussion	Forum for discussion with team members
Individual session report	The uploading of report documents
Team products	Database of the team's final products
Self evaluation	Online questionnaire for self evaluation

The problem assigned involved the following two tasks.

1. The first task
   Analysis of "requests for proposals": The team members pointed out which questions should be asked to better understand the needs and recording detailed explanations while they talked with someone in the role of customer. 6 sessions $\times$ 90 minutes each.

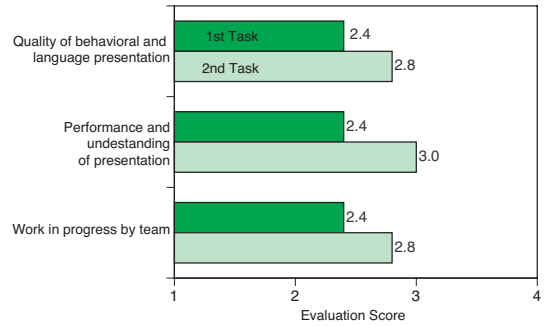

Figure 2: Mean evaluation scores for products of group work (N of teams=5).

2. The second task
   Preparation of a "requirement definition": The team members summarised the proposed system requirements after interviewing someone in the role of customer and then analyzing and understanding the request as a team. 6 sessions $\times$ 90 minutes.

These two tasks are independent of each other. Every team's activity was evaluated as follows:

- Analysis of documentation and interviews with customers
- Analysis of the session minutes which recorded team activity
- Individual session reports
- Individual self assessments of team learning
- Assessments of proposals resulting from team collaboration

Additionally, the first session was a course orientation, the 8th session was an intermediate discussion and the 15th session was used for overall reflection and assessment.

2.2 Learning Environment

All students in this course used their notebook PCs, which were connected together as a learning management system. A diagram of the system is illustrated in Figure 1. The system, which was developed using the Moodle system, provided learning materials and recorded the learning process, the session minutes and individual reports. The main function of the system is summarised in Table 1.

The role of each member was self assigned and the team working sessions were also conducted at each team's own pace in a normal classroom. The role of the customer was assigned to a lecturer, so that the lecturer could introduce various business skills, such as conventional communication formats during interviews. Students summarised the their work and reported their meeting minutes. They could discuss unresolved points using online forums after the face-to-face team working sessions.

Table 2: Evaluation of team products for the first task (N of teams=5).

Evaluation item	Mean
Understanding the assigned task procedure	
Understanding the relationship between the task trigger and the product	2.2
Recognition of the causal relationship between the current situation and background issues	
Issues about preparing a written estimate	2.8
Issues regarding a long-term contract	2.6
Issues about responding to obstacles	2.0
Managing an account book and work progresses record	2.2
Evaluation of the team's ability to discover original problems	1.6

Table 3: Evaluation of team products for the second task (N of teams=5).

Evaluation item	Mean
Presentation of solutions to meet the requirements	
There is a written proposal which meets the requirements	2.0
The propositions are created by the lecturers	2.4
Proposals for coping with obstacles	1.6
Proposals to confirm the progress of work	2.2
Evaluation of team's original proposals	1.6
Appropriate description of the task flow	2.6
Missions of system operators are clearly indicated	2.4
New jobs are clearly listed in the proposal	2.2

2.3 Evaluation Methodology

The evaluation criteria of the two tasks were different because the objectives were different. The evaluation standard for student activities were designed in advance as a rubric (Shinoda, 2011). The following two types of team activities were rated using a 4-point scale (1=the worst, 4=the best).

1. Evaluation of the team's products
   The number of evaluation items was 9 for the first task and 11 for the second task. Three of these were common for both evaluations: (1) Quality of behavioral and language presentation (2) Performance and understanding of presentations (3) Progress of work as a team, individual session reports and the meeting minutes.
2. Self evaluation
   Students were asked to evaluate their learning activities themselves twice, using questionnaires. The first questionnaire contained 10 questions and the second questionnaire contained 12.

Table 4: Self evaluation results for the first and second tasks (N of participants=40).

No.	Question item	1st task	2nd task
1	Can you extract unclear points from the RFP document on your own?	**2.20(0.76)**#	2.35(0.66)
2	Can you clarify documents intended for meetings with customers using team discussions?	**2.85(0.70)***	**2.75(0.59)***
3	Can you retrieve sufficient responses to your questions in the customer interviews?	2.33(0.80)	2.43(0.68)
4	Can you resolve the unclear points through summarizing responses in customer interviews using team discussions?	**2.78(0.66)***	**2.78(0.77)***
5	Can you state your opinion or have significant discussions in the online forum?	2.63(0.93)	2.45(0.96)
6	Can you play the role of a good business person with appropriate behavior and speech?	**2.18(0.75)**#	2.48(0.72)
7	Can you make documents such as session reports and session minutes?	**2.78(0.73)***	**2.95(0.60)***
8	Can you propose an appropriate solution plan?	2.33(0.66)	**2.10(0.63)**#
9	Can you propose a solution plan for a long-term contract?	2.33(0.69)	2.43(0.81)
10	Can you propose a solution plan to overcome obstacles?	2.30(0.69)	**2.13(0.85)**#
11	Did you consider requirements which are out of scope?	–	**2.13(0.72)**#
12	Did you consider the feasibility of the proposed solution?	–	**2.13(0.69)**#

Mean (STD): **Bold***: significantly higher, **Bold**#: significantly lower than the median

Table 5: Result of factor analysis (factor loading).

No.	Question item	Load
2	Can you clarify documents for meetings with customer using team discussions?	0.63
3	Can you obtain sufficient responses to your questions in the customer interview?	0.69
4	Can you resolve the unclear points through summarizing responses of customer interviews using team discussions?	0.51
5	Can you state your opinion or have significant discussions in the on-line forum?	0.37
6	Can you play the role of a good business person with appropriate behavior and speech?	0.42
7	Can you make documents such as session reports and session minutes?	0.37
	Chronbach α coefficient	0.73

2.4 Evaluation of Learning Environment

The usability of the learning environment may affect the effectiveness of team learning and self evaluation, so five aspects of the system are evaluated in 13 of the questions. The five system aspects are:

1. Team discussion forums
2. Individual session reports
3. Team product uploads
4. Schedule management
5. Overall evaluation

Though students assessed their own grades, the responses were scored using a 4-point scale (1=the worst, 4=the best). The questionnaires were given to 40 participants after the completion of the course.

3 RESULTS

3.1 Learning Evaluation

The lecturer rated the products of the 5 teams using evaluation items which were designed in advance as a rubric. First, the means of three common items across the two tasks are summarised in Figure 2. All means for the first task are comparable with the median 2.5, but the ones for the second task have increased slightly. Though practical education may provide a few improvements, there are no significant differences between means for the two tasks.

Second, the means for the other items are summarised separately in Tables 2 and 3, because their evaluation points are different. To confirm the differences across the evaluation items, interval estimation is conducted. In the results, all means are not significantly different from the median of 2.5. Therefore, as all evaluations are located around the median rate, this suggests that all team performances are acceptable by the lecturer. Additionally, these means suggest that the lecturer does not reject the team products.

The means of self evaluation across 10 question items were calculated for both the first and second tasks, and for the two additional questions in the second task. The results are summarised in Table 4. Means for some questions are higher than the median, such as those regarding team discussions, session reports and minute reports. Again, interval estimation was conducted for all means. Symbols are used for mean values significantly higher or lower than the median. "*" represents mean values that are significantly higher, and "#" represents mean values that are significantly lower. As the results show, some negative

results from the first task improved significantly in the second task. In particular, means for questions from the second task (Nos. 10-12) are significantly smaller than the median, so that participants may have recognized that they have not performed these tasks sufficiently.

To extract factors of self evaluation, exploratory factor analysis was conducted for responses to common and identical questions about the two tasks. As a result, one factor model consisting of 6 items is extracted in Table 5. The internal consistency is evaluated using a Chronbach α coefficient, where α is 0.73. Therefore, the sum of these rates can be defined as an index of self evaluation. The mean scores for each task are calculated as 2.59 for the first task and 2.64 for the second task. There is no significant difference between scores of the two tasks, and they are also comparable with the median. Though the tasks are independent of each other, the scores are comparable, and the sums of the two scores are calculated as the self evaluation score.

3.2 Effectiveness of Learning Support Systems

Five major functions of the learning environment were evaluated using 4-point scale questionnaires. The 13 question items are listed in Table 6. Mean scores for the 5 major functions were calculated and are shown in Figure 3. The error bars in the figure show standard errors. The mean for the team discussion forum is the highest, and the means for individual session reports, team product database and overall evaluations are also high. According to the results of interval estimation, the four means for the above functions are significantly higher than the median ($p < 0.05$). However, the mean for the schedule management function is significantly lower than the median. The team sessions were conducted periodically, so that additional scheduling might not be required. As most means for functions are relatively high, students have positively evaluated this system.

According to the results of the system evaluation, students agreed that the functions of the LMS as a learning environment helps their team learning activities. It is hypothesized that there are some correlational relationships between team learning performance and system evaluation. The correlation coefficients between these were calculated. The results are summarised in Figure 4. First, the coefficient for evaluation of team products and the function of the team product database is the highest, at 0.44. This means that members of teams whose presented products which scored highly evaluated the function of

Table 6: Question items for system evaluation.

No.	Question items
	Team discussion forum
1	Records of team discussion dialogs were useful for team learning
2	This function was easy to use to summarise team discussions
	Individual session reports
3	This function was easy to use to present session reports to the lecturer
	Team product database
4	This function was easy to use to submit team products
5	The function of reviewing the results of other teams was useful
6	This function was easy to use to review products of other teams
	Schedule management
7	The schedule management function was useful
8	This function was useful to manage the team schedule
	Overall evaluation
9	I would like to use this system frequently
10	I found this system unnecessary complex (reverse scoring)
11	This system was easy to use
12	This system provided many functions
13	Most students would learn to use this system very quickly

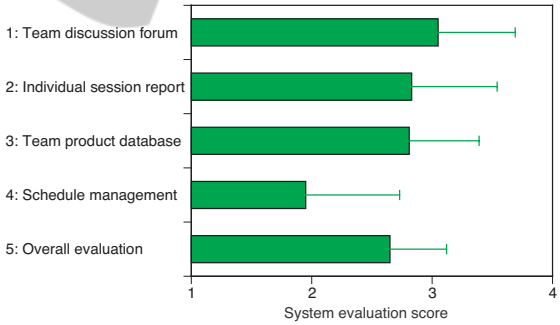

Figure 3: Mean score of system evaluations (N of participants=40) [All values are significantly different from the median score (2.5)($p < 0.05$)].

team product database positively. The system may contribute to the results of team work activities. However, as the coefficients for other functions are relatively small, their effectiveness may be small.

To confirm the relationship between self evaluation and system evaluation, correlation coefficients for each function were calculated. The variation in these coefficients is illustrated as a bar graph in Figure 5. The coefficients for team discussion forums, individual session reports and overall evaluations of the system are higher than 0.4. The system performance may affect individual self evaluation.

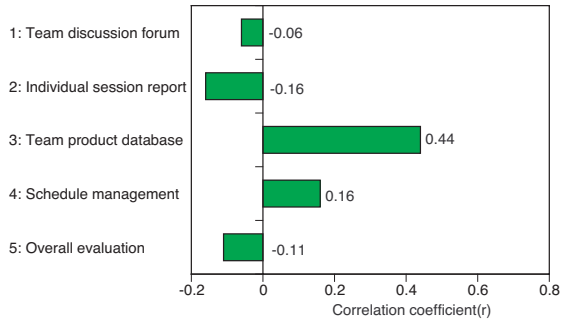

Figure 4: Correlation coefficients between assessments of group's products and system evaluation scores (N of participants=40).

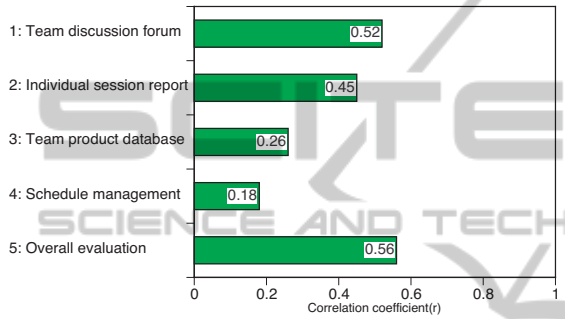

Figure 5: Correlation coefficients between self evaluation scores and system evaluation scores (N of participants=40).

4 SUMMARY

This study examined a course which used team learning in a project based learning course to develop IT engineers who could adapt to the requirements of the industry. The course was conducted at a computer college, and the evaluation of team products used rubric criteria. Self evaluation by students and their evaluation of a learning management system were also conducted.

As a result of the team learning work observed in the study, team product proposals reached an acceptable level of competence, and students reflected appropriately on their learning activity. Certainly, both lecturer and mentor had to provide detailed instruction and support to promote team learning activities, as they had designed the course content and prepared the materials. Also, they were able to evaluate student learning activities using the rubric. As a result, the possibility of a team learning approach to IT system development education was confirmed.

Also, a learning management system (LMS) was introduced to promote team learning. The system was used frequently and most functions of the system were positively evaluated. In additional, the scores of system evaluations correlated with both the evaluations of team products and with student's self assessments. These results provide evidence that since a learning management system can assist students with their education, a more appropriate system may bring even better performance. This suggests that consideration of the design of the system is quite important.

As these results are from a case study, it is not easy to find the most appropriate way to conduct team learning and design the learning environment. The key design factors should be extracted and analyzed using other educational topics. These processes will be a subject of our further study.

Table 7: Correlation coefficients of evaluations between Learning Management System and self assessment of learning (N of participants=40).

System evaluation	Team products		Self evaluation	
	1st	2nd	1st	2nd
Team discussion forum	0.20	-.24	**0.42***	**0.49***
Individual session reports	0.06	-.28	**0.37***	**0.42***
Team product database	**0.59***	0.19	0.11	0.33
Schedule management	**0.34***	-.03	0.12	0.19
Overall evaluation	0.11	-.25	**0.44***	**0.53***

*: Level of significance coefficient: 5%

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