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Design-based Research to Improve Learning Design and Learning Contents*

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This paper presents a practical study with design-based research that focuses on producing better educational practice through a cycle of constant improvements in learning design. With a story-centered curriculum (SCC), which is a new learning design approach in our country, we explored the possibilities and clues to apply an SCC in a preexisting curriculum, then summarized the knowledge we attained from our practice aiming at bringing deeper learning outcomes. Through constant improvement in the learning design in 2008 and 2009, we found that the SCC approach helped to facilitate the learners' reflection and to support their understanding of the contents. This resulted in an effect on both individual learners and the learners' community of this practice. To validate our practice and improve the design principle to widen the leverage of learning approaches, our plan is to collect the learners' voices about this SCC practice.

Key words : learning design, story-centered curriculum, and design-based research

1. INTRODUCTION

Although design-based research was conceptualized in the educational field in the early 1990's (Reeves 2005), it took long before it was accepted as a research methodology. Reeves (2004) pointed out that the weakness of the proceeding studies on online learning, because most of those were just comparisons between conventional form of learning in classrooms and online learning; he described the need for design-based research that guides the design principles to support online collaborative learning.

This paper presents a practical study of design-based research that focuses on producing a better educational practice through a series of constant improvement of the learning design. With a story-centered curriculum approach (SCC), which was a new learning design approach in our country, we explored possibilities and clues to apply the SCC in a preexisting curriculum. We then summarized knowledge attained from our practice aiming at bringing deeper learning outcomes. In this paper, our focus was to summarize the results of our SCC practice and the improvement process from the data collected from 2008 to 2009.

2. OVERVIEW OF DESIGN-BASED RESEARCH

Design-Based Research (DBR) is "a series of approaches, with the intention of producing new theories, artifacts, and practice that account for and potentially impact learning and teaching in naturalistic settings" (Brab and Squire 2004, p. 2). The DBR focuses on addressing complex issues in real contexts, with "technological affordance" (Reeves, Herrington and Oliver, 2004) that can be applicable for supporting learning with ICT. The DBR is to integrate existing or hypothetical design principles; to conduct flexible and constant design improvement; to explain a theory, phenomenon, or an outcome; and to find a design principle (Brab and Squire 2004; Reeves, Herrington and Oliver, 2004; Collins, Joseph, and Bielaczyc, 2004) (See Figure 1). By studying complex contexts in real settings and improving the practice, it is considered to have an effect on both local (targeted educational settings) and global (general) levels.

The forms of research outcomes from DBR vary: They can be recommendations (Brown 1992; McKenney 2008), or guidelines (Stuessy and Metty 2007; McKenney and Van Den Akker 2008)

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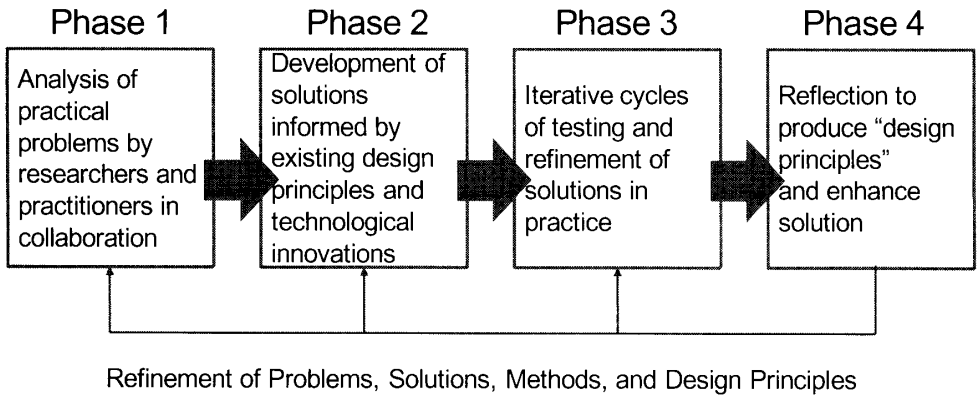

Fig. 1. Design Based Research Process

to apply findings in other instructional settings, or just a description of process that shows how the practice was improved. The data to be used also vary, depending on the purpose of the research. However, the findings are organized based on a preliminary literature review and specific situations and issues that the target practices faced, as well as the theory and typical situations for the DBR. For instance, Bannan-Ritland (2008) conducted a study, called "Teacher Design Research," for improving the teaching quality of middle school science teachers. She listed the types of gathered data, and the case description was the core of the analysis. In another research for a process development to encourage faculty members to accept cultural changes, the reports collected from teachers were selected as the core resource for the analysis, among various types of data (Wolf and Vasan 2008).

In Japan, Miyake and Shirouzu (2003) introduced the characteristics of "design research" as a research methodology in learning sciences. At the annual conference of the Japan Society for Educational Technology, design research was adopted as a special session in 2004 (Ohshima, 2004). While Horino *et al.* (2005) reported on the same topic, not much of increase in the number of research reports has been observed since then.

There have been several ways to express DBR in different time periods and researchers (Van Den Akker, 1999; Van Den Akker, Gravemeijer, McKenney and Nieveen, 2006). Design experiment (Brown 1992), formative research (Reigeluth 1999), and engineering research are representative examples, and, in this paper, we use the DBR that is often employed in recent years.

3. THE TARGET OF THIS RESEARCH AND APPROACH

3.1. The Field

This study targeted a curriculum at a graduate school of K University in Japan. The master's program in this graduate school's program is offered fully online to train practitioners in education in general, and in e-learning in particular. This program's goal is to teach students how to design and develop higher quality education. By using information technology, which has become essential, and resources from a specific practical environment, such as curriculum design and support in higher education or course design for in-house training, the program aims the learners to be able to create educational programs within their work settings. The program has 12 core competencies that represent the basic knowledge and skills of e-learning professionals, to be fulfilled by completing the required courses, as well as 7 optional competencies to be fulfilled through elective courses. All the assignments in the required courses are mapped with one of the 12 competencies. Therefore, students can check the skills and knowledge they have obtained or will obtain in terms of the competencies (Kitamura *et al.* 2007). In this master's program we have employed an SCC approach, which is for the curriculum-level design as a way to advance the program systemically within the scope of the program purpose, and a way to embody higher level of practice skills and theoretical knowledge. SCC is an extension of an instructional design theory, called Goal-Based Scenarios (GBS), advocated by Schank *et al.* (1997) to curriculum design level (Suzuki *et al.*, 2008; Suzuki, 2009). The required courses of the first and second semesters of the first year master's program were

the target of the SCC.

3.2. *The Story-Centered Curriculum*

The SCC is one of the instructional design theories derived from GBS that provides architecture to the design of a curriculum with high scalability without losing the learning-by-doing nature of the GBS. Instead of offering individual courses in isolation, the SCC unites multiple courses, usually taken concurrently within a given semester, by introducing a story from a real-world situation common to the targeted courses. The story is taken from an authentic situation that the target students are expected to work as a professional. For students, to complete several course activities and assignments concurrently is not an easy task. Therefore, the SCC introduces a story to be used throughout the semester, and relates each course to the target story to unite multiple disciplines within a context.

The design policy of the SCC is to reduce the cost of a new production of e-learning contents; The SCC has the following characteristics to maintain the learning-by-doing nature of GBS:

1) SCC uses a real world environment, departing from a complex simulation within computer world of a GBS (by not developing dynamic contents that required immeasurable costs)
2) SCC moves feedback functions from the computer to live teachers and mentors
3) SCC requires learners to use existing tools and learning resources (e.g., a collection of web links and textbooks)
4) SCC requires learners to work in teams (team building is considered as one of the learning objectives)
5) SCC uses patterned templates for developing the contents (intended to cut cost by using static HTML)

The SCC has been successfully implemented at Carnegie Mellon University's (CMU) Software Engineering Institute (SEI), at the master's level. In this program, two professors play the role of executive vice presidents (engineering and marketing) who request the learners to create and submit a proposal. The vice president of marketing intentionally orders the learner to make a proposal that meets all of demands; the learner fails to manage the tasks to meet the deadline at the first trial. From this experience, the learner notices that a professional software engineer needs negotiation skills to focus the target functions to meet the deadline; we call this learning-by-doing and learning from making mistakes. Another key point in this SCC was to teach/help the learner to understand why following procedure and documenting all the steps are important for software engineers. Even though it takes effort to prepare, it is worth doing. Learning in a virtual environment is an advantage to use the SCC, because the students can make mistakes, similar to a real world setting, without the anxiety of being fired from the job. The learners can try out uncertain solutions, and experience failure in a virtual world; then, in the future, when they are in a real work setting, they will know how to avoid the mistakes they faced in the learning environment.

3.3. *Curriculum Design*

We introduced an SCC-based integrated curriculum as the first case in Japan by connecting a scenario with several courses taken concurrently. The story selected was an authentic context likely to occur in practices (e.g., e-learning business). To use preexisting course contents for the SCC, accommodating the contents of all the target courses was essential and required additional effort in the design. However, previous studies of the SCC have demonstrated that the activity-driven curricula helped students to apply acquired skills in their professional practices. Therefore, we chose the SCC approach as a way to improve the quality of our graduate program. Specifically, based on the sequential dependency of the preexisting assignments and rearranged study sequence of the assignments, a cover story was depicted to cover all the courses. By not developing a story for the SCC, from scratch, we focused on employing all the preexisting assignments and activities of all the target courses and aligning the story with those assignments with minimum modification. We chose this approach to save time and be ready to deliver the first year SCC in 6 months. Because the design of our program was based on graduation competencies, it was relatively easy to develop the SCC by connecting preexisting assignments of the target courses, which had already tied to the competencies.

3.4. *The Design of the First Semester: Considering the Flow of Learning Sequence*

In the first semester, we decided to include the five required courses in the SCC. Each course was divided into several block units, which was

aligned to form a story line (See Figure 2). The student could concentrate on one block unit of a course in each week to help them to deepen their understandings (See Table 1).

3.5. *The Design of the Second Semester: Flexible schedule that centers on a group activity*

We decided to offer all required courses in the second semester as the SCC, except the course for writing the master's thesis. We set up a story around "Practicum in e-Learning I" (Nemoto *et al.* 2010), a required course for designing blended undergraduate course. Students formed groups and worked as a group with an assigned client, under the supervision of our course instructors. The mission of the students in the practicum was to design and manage the development of an e-learning course for the assigned client who was a professor from another department. In the SCC of 2008, the students worked as interns at K University for completing "Practicum in e-Learning I," and worked as an employee of an e-learning company to complete other courses. In 2009, we shifted all the courses to the intern scenario and added a project-based progress table, as shown in Figure 3, to help the student get an overview of the schedule.

3.6. *Operation*

There is one key point of an SCC to assure scalability of the GBS design policy, namely, "SCC moves feedback functions from the computer to live teachers and mentors." To embody this idea into the practice, we prepared a "support room" with a discussion board to communicate with the supervisor of the story and a "café room" to communicate with peers. Also, we provided a web page accessing to the SCC contents, which made access to the discussion space easier.

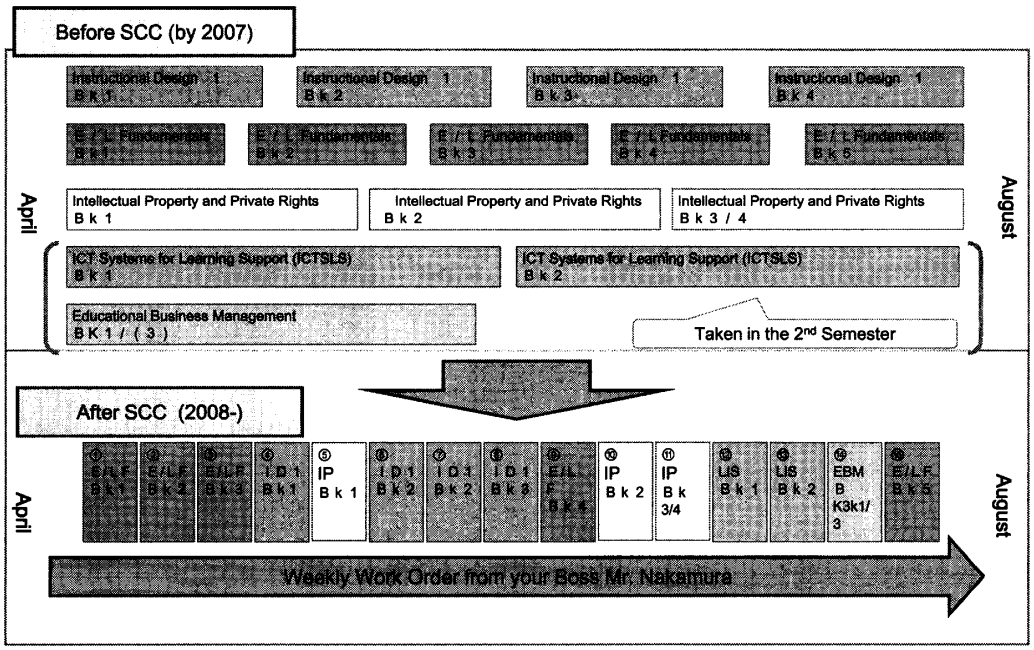

Fig. 2. Structure of the First Semester

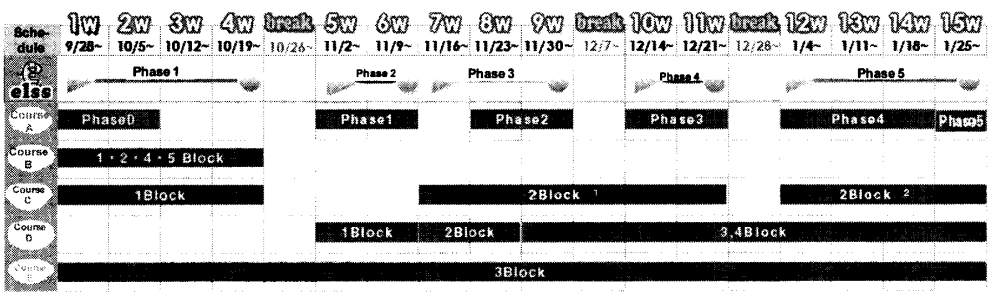

Fig. 3. An Image of the schedule of the Second Semester

Among the students who selected the SCC (18 in 2008, 17 in 2007), the total number of students who completed the study with the SCC was 17 (in 2008) and 14 (in 2009). The number of respondents of the questionnaire used in this study, among those who completed the SCC, was 16 (in 2008) and 8 (in 2009). The reason for any students who discontinued the SCC was external,

Table 1. Design Comparison Between 2008 and 2009

FY	Aspect	Fiscal year 2008	Fiscal year 2009
The First Semester of the SCC	Developmental regime	• Ordered an original story by CMU Graduate	• Developed by an independent SCC team formed by members of our graduate school
	Design	• Followed the CMU design policy • Designed SCC with use of existing contents and recourses • Organized the SCC including "4I" policy (ID, IT, IP, and IM) • Made the content with a course, "e-Learning Fundamental"	• Followed the design policy of the first year
	Storyline	• Developed a story based on the CMU's (Learning Science) • Story: the participant works at eLearning development section of A company, and responds to the manager's request	• Followed the storyline of the first year (Minimum modification only)
	Teaching strategies	• Guided by a secretary and a faculty who are dispatched from K university as a training in charge	• Developed "learning sketch graph tool" as a reflection tool
	Operation	• Developed an original learning portal (SCC HOME) for the learners • Provided two types of contents for SCC students and non-SCC students	• Simplified assignment information • Introduced senior mentors (students volunteered)
		• Changed the order of the course contents with a weekly story	• Followed the first year design • Provided a trial session of the SCC in the "online orientation" that all students take before the program starts
The Second Semester of the SCC	Developmental regime	• Developed originally by the SCC team	
	Design	• Put "e-Learning Practicum I" in the center of the story	• Adjusted the relationship with courses
	Storyline	• Developed two original stories from scratch • Two stories: Intern activities of K university and office works at MTM	• Simplified the story by unifying the story (intern only (1))
	Teaching strategies	• Added weekly reports as reflection activities • Released excellent reports by student • Formed a MTM consult team to support students	• Developed "learning Sketch graph tool" as a reflection tool
		• Developed an original learning portal (SCC HOME) for the learners • Provided two types of contents for the SCC student and non-SCC student	• Offered intern guide every term (2) • Offered intern messages weekly from the support section (2) • Provided weekly reports as a set of planning and completion report • Expanded the area covered by the weekly report • Embedded reflection activities as the SCC contents
	Operation	• Provided stories for two week together when possible	• Expanded flexibility for students for planning • Changed progress to a gun chart • Added team activities • Introduced the SCC of the second semester in the summer camp

such as a busy business schedule.

4. EVALUATION AND MODIFICATION

4.1. Evaluation of Introducing the SCC

The learning outcomes of each course maintained at a satisfactory level, and some gains were achieved by the SCC. As shown in Table 2, academic results after the SCC introduction (2008 and 2009) were comparable to the results before the SCC (in 2007).

There were some courses that students could not complete by the end of the semester, before the SCC introduction, because the workload of the activities was heavy. The number of repeaters who took a course included in the SCC twice was reduced from 4 (in 2007) to 1 (in 2008), and 0 (in 2009). The result implies one of the positive effects of the SCC's equalization of workload and schedule. Because of the explicit schedule and its implementation period, the use of the SCC has not only been a benefit for the students, but also for the faculty who worked systematically.

Having confirmed that there was no difference between the academic results with the SCC and the non-SCC, this study reviewed the results of questionnaire regarding the effects of SCC on improving learning environment, integration of courses, and student recognition of importance. Tables 3 and 4 show the results of the questionnaire conducted in reflection of the SCC activities at the end of the second semester of the first year. The purpose of these activities was to set up the time for the learner to reflect on his or her learning experiences. They show the awareness of the reflection by comparing to the first and second semester.

Table 2. Change of the Academic Score*

	2007	2008	2009
A	98	86	73
B	24	42	33
C	6	7	10
D	0	0	0
NA	0	0	0
Discard	0	0	0

*The total of SCC related courses

The questions were intended to confirm the learning activities of the SCC from three points: strength of the application (item A), integration of the courses (item B), and learning support by the story (item C). Item A was to see how the design that intended to improve application skills into the practice contributed to the learner's knowledge and skills development; item B was to see how the student felt the seamless learning flow of the SCC helped him or her to focus on the learning contents and to understand the relationship among the courses; item C was to see whether the learning design with a story makes a contribution to provide a sustainable and concentrated learning environment. All questions were answered using a five-point Likert scale with a space to write the reason for each answer.

4.2. Improvement for 2009

After the first trial in 2008, we reviewed the results from the learners' reflection, questionnaire, and informal interview (e.g., Shibata *et al.* 2009, Oyamada *et al.* 2009). Table 1 is the comparison

Table 3. The Result of the SCC Questionnaire

Questions	FY 2008		FY 2009	
	First semester	Second semester	First semester	Second semester
A-1) I became aware how to apply the knowledge and skills attained from the SCC.	3.63 (0.87)	4.00 (0.89)	4.13 (0.60)	3.13 (1.54)
A-2) I improved the application skill with skills and knowledge attained from the SCC.	3.63 (0.81)	3.81 (0.83)	4.25 (0.43)	2.63 (1.22)
B-1) I became aware of the relationships among the target courses by the SCC.	3.56 (0.96)	3.13 (1.02)	4.13 (0.60)	3.50 (0.87)
B-2) I felt the assignments became clearer and the contents became easier to focus on by the SCC.	3.94 (0.93)	3.69 (1.14)	3.63 (0.48)	3.25 (0.97)
C-1) I thought the story contributed to my continuous learning.	3.81 (0.98)	3.38 (0.96)	3.75 (0.83)	2.75 (1.30)
C-2) I thought the story contributed to devote myself to the learning environment.	3.56 (0.96)	3.38 (0.96)	3.13 (0.78)	2.50 (1.00)
	(N=16)	(N=16)	(N=8)	(N=8)

Table 4. Representative Comments about the SCC Use

Question	FY	Representative Comments
A-1) I became aware how to apply knowledge and skills attained from the SCC.	2008	Became aware of the application (7), Not sure if the effect came from SCC or course contents(2)
	2009	Became aware of the application (3), It helps for future reference (1), not the SCC effect, but the course (1)
A-2) I improved the application skill with skills and knowledge attained from the SCC.	2008	Improved the application skill (6), More theoretical and academic in the first semester(1 each), Need experiences in real world (1), improved my understanding (1)
	2009	Improved the application skill (2), Accustomed to think application situations (1), needs additional reflection (1), a gap exists to make it difficult to judge how the content will be applied in a real situation (1).
B-1) I became aware of the relationships among the target courses by the SCC.	2008	Poor combustion [complexity, over workload, not enough time for reflection] (4), became conscious of the relationship (4), did not become conscious of the relationship (3)
	2009	Became conscious of the relationship (5; 2 each for the first and second semester only), unclearness of the relationship (3)
B-2) I felt assignments became clearer and the contents became easier to focus on by the SCC.	2008	Focused (10), not focused (2; 1 for the second semester only), focused but not sure if it was the effect of the SCC (3)
	2009	Focused (4; 3 for the second semester only), not focused (2 for the second semester only)
C-1) I thought the story contributed to my continuous learning.	2008	Attained successive flow (6), successive flow by the scheduling, not by the story (4), had impact (2), not successive flow (2), had fun (2)
	2009	Attained successive learning by the team activities, not by the story (3), difficult to say if this result was due to the story (1), could study without the story (1)
C-2) I thought the story contributed to devote myself to the learning environment.	2008	Cannot say devoted (6; 1 for the second semester only), devoted to the learning (2 by team activities, and 1 by a realistic story)
	2009	Cannot say devoted (2), devoted but not by the story (2), disagree with some parts of the story (2), and devoted by the team activities (2)

of the core implementation in 2008 and 2009. Ideas for improvement were considered in the regular meeting of the SCC team, and the subset of the analysis result was reported by Oyamada *et al.* (2009). After determining a course of action from semester to semester, we made decisions for the modification based on the analysis results.

(1) The first semester

We minimized the modifications because the score of all question items were over 3.5 for the first semester of 2008. We focused on the modification about the explicitness and enhancement of the learning supports. For example, we changed navigation functions and added moderators on the discussion board (called a café room) to create more comfortable environment to ask questions easily.

(2) The second semester

We began by discussing why items B-1, C-1, and C-2 were lower than others. We thought the main reason was the complexity of the storyline. In order for giving the learners various types of cases, the story emphasized a reality in the second semester. However, it resulted in negative comments on the questionnaire. Therefore, we simplified the story from two concurrent parts in the first year to just one (See underscore (1) of Table 1). This was for the learner to be able to concentrate on the story of working as an intern.

We also added a system guideline to show how to attack and complete the assignments, and we sent weekly messages that reminded the learners of the story in relationship to the courses (See underscore (2) of Table 1).

4.3. Evaluation of the Design Improvement

We confirmed, as in 2008, the students' responses from the questionnaire items through the reflection activity in 2009. There was statistically no significant difference, but the results of the first year were higher than that of 2009.

(1) The first semester

We confirmed stable results for the first semester because it proceeded relatively smoothly. From the multiple-choice questions, the result of the first semester was relatively high (the average score of the first semester in 2008 and 2009 was 3.7), and there was statistically no significant difference between the averages of 2008 and 2009

(t (142)=.891, nsd).

For the three questions ("A-1: I became aware how to apply the knowledge and skills attained"; "B-1: I became aware of the relationships among the target courses by the SCC"; and "B-2: I felt the assignments became clearer and the contents became easier to focus on by the SCC"), there was no significant difference for the average scores of the first semester, but the score of 2009 was higher than that of 2008. We concluded that the increase was due to the improved details, such as the navigation flow and by introducing communication places.

We designed the first semester based on the CMU practice, which allowed a relatively smooth development and a sense of stability in the second year.

(2) The second semester

The design of the second semester was very original for our SCC, because no practice was similar in the previous studies. The result of the second semester in 2009 was lower than that of 2008, thus the effect of improvement was not shown (Table 3). Some results in written descriptions were positive, but they were not apparent in the differences of the quantitative data.

From question A-1, there was no statistically significant difference between the two years, but the main effect of the course (F(1, 44)=7.22, p<.05) and the interaction between the semester and the year (F(1, 44)=11.48, p<.05) were statistically significant for that question.

Regarding a perspective that the SCC was useful to strengthen their application skills in a practical setting, the students of 2009 had a lower awareness, which was a similar tendency in question A-2. We cannot specify, from the written description, the explicit reason for this result, but some hints were found. For questions A-1 and A-2, among the students in 2009, four students evaluated 2-point higher for the first semester over the second semester, which implied some felt that the first semester of the SCC helped more in strengthening their application skills. In the first semester, it was easy to distinguish between the story and courses. However, in the second semester, students were expected to apply the knowledge attained in the first semester, and because the courses were more integrated into the story, it was difficult to determine what effect the SCC had on the learning.

The total result for question B-1 for 2009 had a higher tendency (See Figure 4), and the

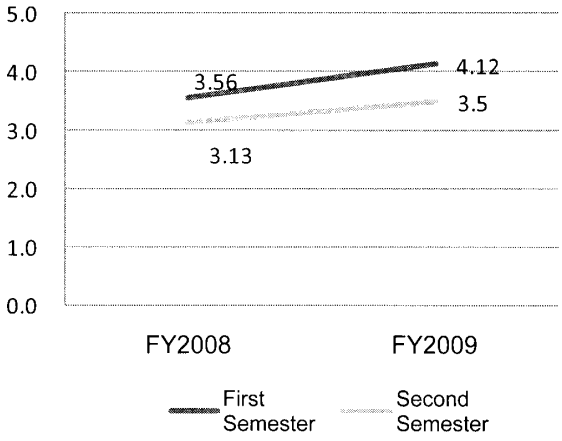

Fig. 4. Questionnaire Result of B-1

modifications for the second semester, such as adding guidelines and weekly messages (See underlined section (2) of Table 1), facilitated the positive result.

The written descriptions on each question item showed the tangible change. For example, in question B-1, there were many opinions about the study workload and complexity of the story. The reason students felt this burden was the complexity of the story, which consisted of two concurrent parts. To address this issue, as shown in Table 1, we simplified the story to allow students to plan and control their team schedules. This modification reduced the negative comments in question B-1 in 2009.

4.4. *Awareness and Outcome other than What the Designers Intended*

Since the number of participants in this practice was small so that the results from the quantitative data was limited; but we discovered a new perspective from the students' written comments. Eighty to 90% of the respondents gave some answers to the written description, which showed their enthusiastic attitude toward the SCC. We used Sato's approach (2008) to analyze the qualitative data.

The following three items were obtained as the common results to all six questions:

(1) Outcome from collaborative learning, not from the story *per se*, was apparent; timely feedback and other support activities were important factors as well as how students' tackled the assigned learning activities along with a story.

SCC employs collaborative activities when it is difficult to automate as in GBS (Schank 2007). We confirmed the students'

impression about the provided story in question item C: many of the respondents touched upon the effect on "team activities," especially among the students of 2009. This suggests the design of the collaborative activities was successful.

(2) As students who want to be an educational designer, they found useful hints in the learning experiences. There were comments such as "it provided me a reference to implement," and "I got a hint to design my own story." The students of our program are pursuing an education profession; the attitude that they are planning to apply the new approach in the future is a preferable outcome by itself. There were three students in the first year and one in the second year, who chose the SCC or GBS as the topic of their master's thesis.

(3) SCC served as an external motivator. We confirmed that the constant message delivery of the first semester and the project-based collaborative learning style of the second semester promoted the learners' motivation as an external motivator. As the activities progressed, even the students who felt constrained to participate in the SCC thought the SCC promoted steady progress in their learning. Some also felt that they completed all the target courses in a year, as scheduled, because of the SCC.

In DBR, the designers are expected, along with the participants, to conduct and improve the practice systematically and purposefully. They need to analyze the data immediately and continuously, and to refine designs continually. It was true in this case, in which DBR guided our practice to show the need of more studies using this methodology.

4.5. Future Challenges that the SCC Faces

We confirmed that there was a certain outcome from the two-year development and implementation, with some improvements based on earlier results. However, there is a limitation on how to separate each factor for improvement, because the SCC consists of various learning elements. We need to review and modify based on the students' voice continuously.

The comments of students varied; it is hard to determine one conclusive answer to any question. For instance, some felt that the approach that students can experience a case through sequential learning activities was helpful, while others felt that it was the constant deadlines of the assignment that helped the most as a milestone. About the second semester, some felt it was difficult to focus, but others thought that having a greater goal of developing an e-learning content was easy to understand. Others even said that they could get the same result without the SCC.

In our practice, we have provided the chance for students to learn with the SCC or without the SCC. In addition, we left the decision to the learner to determine how and how often to use the cafe for discussion, and we stressed the development of the learner-centered environment. Other approaches can be considered in the future to fulfill various needs of the future participants.

5. SUMMARY OF FUTURE CHALLENGES

5.1. Summary

In this paper, we discussed a practical study with design-based research that focuses on producing better educational practices through the cycle of constant improvements of the learning design.

Based on the learners' reflection, questionnaire, and informal interviews, we improved the design by focusing on the students' needs; the SCC provided students with an environment to concentrate on the learning activity. We also confirmed the improvements had some effects on the individual learner as well as the learner's community.

We sometimes faced a case in which a story that we planned for educational practice was not accepted by the students. Therefore, we need to clarify the purpose of education and the method of intervention before the practice implementation and to seek success factors for future practice.

5.2. Future Challenges

This practice is in the last stage of the third cycle. With the implementation and result of 2009, we need to review how the modifications affected the result of the third year. An insufficient amount of research reports of SCC exists in both domestic and overseas educational institutions. To expand the use of this new learning approach, we need to propose our findings as a set of design principles and keep collecting real voices from the students' experiences.

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