

From CSCL Classroom to Real-World Settings through Project-Based Learning

Naoko Osada

Graduate School of Literature
Aoyama Gakuin University
d1203001@cc.aoyama.ac.jp

Naomi Miyake

School of Computer and Cognitive Sciences
Chukyo University
nmiyake@sccs.chukyo-u.ac.jp

Abstract. A number of studies indicate that project-based learning enhances a student's motivation and in-depth understanding, while the CSCL environment promotes collaboration within the project. However, we know little about how teachers or curriculum designers should design a course utilizing the project-based learning approach according to real-world activities. In this study, we investigate an undergraduate cognitive science course that combines CSCL classroom activities with observational project activities in educational fields. As a result we identified three requirements of a project-based learning design to promote integration between classroom knowledge and authentic field activities: 1) Parallel-structured course involving both disciplinary and project activities; 2) Reality of the project activities; and 3) accessibility of the project content. In the conclusion, we discuss how these findings should guide the development of CSCL-based, project-oriented courses.

Keywords: Project-based learning, knowledge integration, teaching cognitive science

INTRODUCTION

Project-based learning (PBL) is a popular instructional method in classrooms all over the world. It is now generally accepted that projects play an important role in furthering the learning process. The importance of project activities that developed for a real-world purpose was pointed out in the first quarter of the last century (Kilpatrick, 1918). Many studies in the CSCL research field have discussed how to facilitate collaboration within the project. To ensure the pragmatic value of the knowledge integrated in the CSCL environment, we should also consider how to integrate classroom and real-world activities through PBL. Thus we seek to determine the design of a PBL course and the kinds of project settings that are suitable for students. This study describes the design of a concentrated elective course for undergraduates majoring in cognitive science. In this course, students engaged in class observational projects in educational fields based on knowledge-integration activities in their classroom, which were strongly supported by the CSCL environment.

DESIGNING PROJECTS

Although there have been many informative studies about PBL, most have been within the context of science classrooms. These studies indicate that projects promote a higher degree of engagement and inquiry (e.g., Linn & Hsi, 2000; Kolodner, et al., 2003). Because the fields of cognitive science are highly interdisciplinary and activity structures in the fields vary within their individual domains, we are attempting to identify a PBL design that will be able to integrate classroom knowledge with authentic field activities.

Three important elements of project design need to be considered. First is the timing of the project. In an interdisciplinary field, it is not practical to wait until the end of the course to conduct a consequential project. It would be more profitable for students to bring their questions from the field of the project back to the classroom, determine the disciplinary problem, and then proceed to the inquiry phase. Therefore, we propose a parallel-structured course composed of project and disciplinary activities. The second consideration is the project setting. The students should be able to apply disciplinary knowledge to the field based on a relevant understanding of the activity structure. Therefore, we are particularly concerned with the reality of the project. We believe facts observed in the field are useful in linking parallel activities and promote collaborative learning. It is important to observe the field carefully in the project activities. The third consideration is the content of the project, especially from the standpoint of its accessibility by the student. It is important that students be allowed to select and undertake projects based on their individual interests and ideas. We maintain that diverse, well-designed field activities and an appropriate level of content are important factors in achieving accessibility of the project.

Finally, in this study we decided to develop parallel-structured course that includes a variety of class-observation projects. We investigated whether the project activities in a parallel-structured course with high reality and accessibility would promote knowledge integration between classroom learning and field activities.

RESEARCH CONTEXT

Course Overview

A three-day concentrated elective course based on the CSCL environment began in 1998 (Miyake, et al., 2001). In a two-month course term, three classroom activity days are allocated between intervals. The course objective for the 2004 program was to “Observe and evaluate the class from the cognitive science point of view and make suggestions to improve the class.” A total of twenty-five students attended the entire 2004 course. Every student had studied the basic concepts and findings of cognitive science in prior courses. Three teaching assistants (TAs) attended this course. The first author was a TA and the second author was a lecturer in this course.

To equip the students with a basic knowledge of the project, this course exploited several CSCL methods and tools. The students used video clippings and a commenting system called Commentable Movie Sheet (CMS). Through the CMS, they could review the streaming of resources and clip the important points out with their comments (Miyake & Shirouzu, 2004). They used a reflective note-sharing system called ReCoNote to summarize the essence of the resources for a jigsaw session. The jigsaw sessions, called complex jigsaw, were structured to guide effective interdisciplinary knowledge integration (Miyake, et al., 2001).

By the end of the 2003 program, the objective of the project activities in this course was to design and propose a class based on the findings of cognitive science. Even though students integrated the findings of cognitive science for the projects using the CSCL environment, their outputs indicated that it was difficult for them to connect class design elements and the findings of cognitive science (Masukawa, 2003). They tended to rely on their experience in the CSCL environment or try to impose their cognitive science knowledge on the design. We recognized that students did not sufficiently understand the activity structure in the field and did not have the opportunity to observe concrete facts to link the project with their classroom knowledge. Therefore, in the 2004 program, we rearranged the project and disciplinary activities and set the class observation in the first part of the parallel-structured course. In this way the students could bring their observed facts back from the field before proceeding to the disciplinary activities in the classroom to analyze the problem.

Table 1 Structured course activities (Activities are numbered from #1 to #21 in sequential order.)

	[Disciplinary Activities]			[Project Activities]
	Observe the class	+ Integrate cognitive science findings	⇒ Integrate class observation and cognitive science findings	
Phase 1	#2. Think about Japanese science classes		#4. Link the positive points of the class to evidence from cognitive science [A]	#1. Introduce the projects
	#3. Analyze the activity structure of Japanese science classes		#7. Clarify the evidence of goodness of the class [B]	#5. Kick off the projects
	#6. Think about the best practices			#8. Plan the field activities [C]
Interval 1				#9. Observe the class
Phase 2		#11. Integrate cognitive science pieces of work about human learning through the complex jigsaw	#12. Point out the important cognitive science findings to evaluate the class [D] #13. Organize cognitive science findings to evaluate the class [E]	#10. Interim session
				#14. Reanalyze the observed class [F] #15. Reflect and reorganize the project [G]
				#16. Project activities
Interval 2				
Phase 3			#17. Review the preliminary presentation <i>Focus of analysis</i>	#18. Prepare for the final presentation
				#19. Final session
				#20. Reflect of the project #21. Plan the future work

Course Design and Projects

Next we describe how we implemented our three design requirements: parallel-structured course, reality of the project, and project accessibility. We allocated parallel disciplinary and project activities in a three-phased course structure, as shown in Table 1. We designated three substructures in disciplinary activities to undertake the project. The first aspect was class observation; the second involved the findings of cognitive science about human learning. In addition to these, we allocated a third to integrate the knowledge gained from both aspects. The students engaged in a total of twenty-one activities within this parallel structure.

The objectives of each phase were as follows. The objective of Phase 1 was to observe and evaluate the class. At the end of the class activities they made a plan of observation and observed the class in Interval 1. The objective of Phase 2 was to evaluate the class using evidence from the cognitive science point of view after the interim project report session. The objective of Phase 3 was to make suggestions to improve the class design. In the final session, students presented project reports that included class analysis, evaluations, and suggestions.

Each student participated with the disciplinary activities in the group other than the project group. After every activity, each student wrote personal ideas on the activity worksheet with brief prompts as scaffoldings. We supposed that the items on each sheet represented the student's knowledge-integration levels of disciplinary and project activities. We selected seven worksheets designated as A to G in Table 1, as well as the project reports in the interim and final sessions, to focus of our investigation of students' knowledge-integration activities.

As for the projects, diverse, well-designed educational settings were selected from lectures in school, classes in the Nagoya City Science Museum (NCSM), and exhibitions also in the NCSM. On the first day of the course, each student selected one project from eight alternatives, based on their interests. The kinds of field activities selected were up to each student, to respect their individual motivation and ideas. Finally seven projects were formed. In this study we focused on the following four projects that observed the class or exhibition in the NCSM. The Advanced Science Workshop (ASW) was an organized class of the NCSM for students at the high-school level and above. The aim of this workshop was to obtain a thorough understanding of physics through experiments and discussion. The Manufacturing Lab (ML) was a class for elementary and junior high school students at the laboratory corner in the NCSM. The students of the lab crafted a toy that was a paper plate attached to a motor. The vibration of the motor is transferred to the plate, and the miniatures on the plate begin to swing and turn. "Life on the Earth (LIFE)" is a regular exhibit in the NCSM. This corner shows how people adapt to the local climate. There are two adjacent glass-sided rooms called "heat room" and "cold room." Visitors can enter each room and experience the climate. "Let's touch a Tornado (TOR)" is another regular NCSM exhibit. Visitors can watch and experience the sensation of a tornado produced by a generator positioned in the center of the exhibit.

RESULTS

According to our "focus of analysis" depicted in Table 1, we analyzed 421 items on 140 worksheets. We selected 42 items from the reports of the interim session and 85 items from the final session. To evaluate the level of items, we used a single scale shown in Table 2, in accordance with the course objective. To address the transition of the level, we calculated the weighted average level of items using the points in Table 2. Inter-coder agreement rates between three independent coders were 85% to 90%. We were able to negotiate all discrepancies.

Transition of Item Level

Transition of the weighted average level of the worksheets demonstrated that the knowledge-integration level became higher in Phase 2 (A: 1.88, B: 2.20, C: 1.67, D: 2.71, E: 2.29, F: 2.34, and G: 2.26). The weighted average levels of both sessions (interim session 2.19, final session 3.01) demonstrated that the preceding activities in the parallel-structured course were relevant to these sessions. In the final session, there were 31 items at point level 4: 21 items were at L4, and 10 at S4 in the entire class.

Table 2 Integration level of items

Level	Description	Point
L0	Irrelevant words	0
L1	Keywords or phrases only	1
L2	Explanations of the class or exhibition	2
L3	Explanations from the cognitive science point of view	3
L4	Evaluations of the class or exhibition supported by cognitive science findings	4
S2	Ideas for improvement	2
S3	Preliminary suggestions for the class or exhibition	3
S4	Suggestions for the class or exhibition supported by cognitive science findings	4

Activity Process

We analyzed all worksheets to find in each project the first mention of the concepts that were clearly related to the final items. By the end of the interim session, 43 of the final 85 items (50.59%) were mentioned in a student's worksheet or project output in all levels. As for the level 4 items, 19 of the final 31 items (61.29%) were mentioned by the end of the interim session. These results indicate that level 4 items in the final session were raised in the early stage of each project, and the group improved on those items through parallel activities.

To investigate the activity process in detail, we organized all the items on the worksheets in relation to the final 85 items. Table 3 is one of the ML project activities. In this process, four members thought about the uses of a motor. In the ML class, the children made a toy using the vibration of a motor. However, project members wondered if that application of a motor was for turning rather than for vibrating. Table 3 shows that members wrote about the motor instruction with a variety of expressions, and they reconstructed their ideas. They also linked their observed facts to the findings of cognitive science that they had integrated in disciplinary activities. It is notable that Worksheets D and E were the disciplinary activity sheets, and each member of the ML project engaged in these disciplinary activities in a group other than the project group. In the final session they offered suggestions about instruction focusing on a motor, as the S4 item. Observed facts effectively promoted the students' collaborative learning process. Accordingly, two of our design requirements, parallel-structured course and reality of the project, successfully contributed to effective knowledge integration.

Class Design vs. Class Observation

In the equivalent three-phased 2003 course, students engaged in a class design project. It was a kind of imaginary project at the end of the course; that is, they hadn't conducted any field observations. Each project had a poster session in Phase 3; in this session each project group presented a detailed lecture plan and its advantages. It was expected that by presenting the advantages during the poster session, students would be able to demonstrate how they integrated the findings of cognitive science into their design. However, 16 of 30 advantage items (53.33%) were based on their existing classroom experiences (e.g., to utilize jigsaw session, group activity, or discussion board). These results from the 2003 study told us that a class design project did not provide concrete observable facts. For this reason, students tended to rely on their existing experiences in the CSCL classroom.

Characteristics of Projects

There were seven projects in this course. Each project group improved their output toward the final session, but there were differences among the project groups. To clarify the differences, we summarized the characteristics of the four NCSM projects in Table 4. As shown in Table 4, the starting levels of the project at the interim session and the number of the project members aren't directly related to the final levels. These differences come from two sources, the level of content and the profile of the field activities.

The final levels and the improvement of the ML and LIFE projects are high. It could be that the contents of the ML class and LIFE exhibition were at the appropriate level for each project. The improvement in these two projects suggests that students could have gained concrete facts through their observations and they had exploited the facts to promote their activities. Comparing the difference between the two projects of the NCSM exhibitions,

Table 3 Items on each worksheet about a motor in the ML project

Sheet	Student U	Student O	Student S	Student N
D	Did the teacher teach how can they use it in another context?	Teach the relation between this craft and subjects like math or science.		
E	Can they apply this to a more general problem?		Integrating knowledge that can be used in a broader area.	
F	The rule of vibration can be generalized later.	It was better to begin with thinking about the principle of a motor or making a motor.	Make the principle clear. That class was for lower grade of elementary school, so there wasn't a detailed explanation of the motor. Applying the motor to another context.	Did they understand the principle? Perhaps not. Did the teacher give enough information?
G			When we teach the principles to kids, what is the appropriate instruction level?	
Final	More general applications of a motor should be taught in the class. In that class, students engaged in crafts using a motor, but they knew little about how to use a motor. It is better to show how we can use a motor as a tool to do things. For example, it would be better to introduce another toy that uses a motor, so that they can see how it is used.			

Table 4 Comparison of the projects in the NCSM

Project	Interim	Final	Improve	Number of members	Class type	Content level	Field activities
ASW	2.00	2.75	0.75	4	Lecture	High	Observation with a video camera and interview with students and staff.
ML	2.17	3.75	1.58	4	Lecture	Medium	Observation with voice recorders and interview with volunteers.
LIFE	2.00	3.54	1.54	2	Exhibition	All	Observation of the corner and interview with various visitors.
TOR	2.17	2.53	0.37	4	Exhibition	All	Observation of the unit.

the profiles of their field activities were different from each other. The LIFE project engaged in a greater variety of activities than the TOR project. The output level of the TOR project improved, but to a lesser degree. This might indicate that the variability of the field activities of the LIFE project was one of the effective frameworks to evaluate the class. As for the ASW project, the members repeatedly mentioned the same concepts on their worksheets, but reconstruction and refinement of the idea were insufficient. The level of the content of the ASW classes was high; therefore project members may not have a sufficient understanding of the contents to apply the findings of cognitive science. In high-level content projects, there were many worksheet items that did not show up in the final session. It is possible that the students were unable to finish their evaluations.

From the comparison of the four projects, while it appears that the accessibility of the project primarily stems from the level of the content, it is also enhanced by the variety of activities undertaken by the students.

DISCUSSION

We investigated the connection between the CSCL classroom and real-world settings through PBL. The results positively indicate the parallel-structured PBL course, reality of the project, and accessibility of the content of the project are important to promote a successful linkage between classroom knowledge and real-world settings. The disciplinary activities of students in this study were strongly supported by the CSCL environment. Multimedia resources, technology for knowledge integration, and structured collaborative learning activities were the key factors in the students' progress. In addition to these, we pointed out three important design conditions to transfer classroom knowledge to the real world. Our three design requirements should be the key principles in the development of CSCL-based, project-oriented courses. It is particularly important to implement project activities that provide concrete observable facts in the CSCL environment.

Finally, we would like to address the question-and-answer sessions in the interim and final sessions. There were seven project groups in the classroom, and each group had its own field activities. The varied project settings corresponded to distributed expertise in the CSCL classroom. Discussions during the two sessions allowed the project groups to interact. Especially in the final session they brought up additional questions based on their own project and thoughts about future work through the interaction among the projects. Varied project settings may well be another design requirements in the CSCL environment to promote sustained inquiry.

ACKNOWLEDGMENTS

The authors would like to thank the curators and staff of the Nagoya City Science Museum for their kind cooperation. Critical comments from Hiroyuki Masukawa contributed to the improvement of the manuscript.

REFERENCES

- Kilpatrick, W.H. (1918) The project method. *Teachers College Record*, **19**, 4, 319-335.
- Kolodner, J.L., Camp, P.J., Crismond, D., Fasse, B., Gray, J., Holbrook, J., Puntambekar, S., and Ryan, M. (2003) Problem-based learning meets case-based reasoning in the middle-school science classroom: putting Learning by Design™ into practice. *The Journal of the Learning Sciences*, **12**, 4, 495-547.
- Linn, M. C., and Hsi, S. (2000) *Computer, Teacher, Peers: Science Learning Partners*. Lawrence Erlbaum Associates, Inc, Mahwah, NJ.
- Miyake, N., Masukawa, H., and Shirouzu, H. (2001) The complex jigsaw as an enhancer of collaborative knowledge building in undergraduate introductory cognitive science courses. *Euro-CSCL*, 454-461.
- Miyake, N., and Shirouzu, H. (2004) Learning from lectures for comprehension. *International Conference of the Learning Sciences 2004*.
- Masukawa, H. (2003) Reforming university curriculum through design experiment approach. *The 20th Annual Meeting of the Japanese Cognitive Science Society 2003*, 368-369. (in Japanese)