

Learning Behind the Scenes: Development of Mentors through Their Participation in Design Research

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Abstract: We report how our design group members as mentors developed their pedagogical content knowledge and epistemology through their participation in design research practice. In designing a pre-service teacher course curriculum for four years, we have been also concerned with a *hidden curriculum* for mentors to develop their knowledge in their community. Based on twelve determinants of knowledge building community (Scardamalia, 2002), we embodied four design frameworks for our design group as a dynamic knowledge building community: (1) learning through participation in authentic problem solving, (2) learning through collaboration, (3) learning by taking collective cognitive responsibility, and (4) learning by explaining. Results of analyses on two students who succeeded in developing pedagogical content knowledge and epistemology manifested that their development was based on the change in authenticity to participate in the practice (from preparation for future teaching work to engagement in the design research) and their concerns with the organizational structure of the design group as a community of practice.

Research Background and Purposes

We have engaged in design research to improve teacher education program in Japanese universities since 2000 (e.g., Oshima, & Oshima, 2002a, 2002b). The main goal in our design research has been to develop pre-service teachers' pedagogical content knowledge by introducing a new epistemological perspective on human learning (Bransford, Brown, & Cocking, 2000). The curriculum design for this purpose has been developed by implementing activities that students are involved in transferring their subject matter knowledge into pedagogical content knowledge (Shulman, 1987) through exerting their learned epistemology. Pre-service teachers in our designed course are involved in collaborative learning as a practice for advancing their knowledge, learn how CSCL technologies support such a learning activity, and plan lessons in the time for integrated studies in schools (a new curriculum introduced in 2002 by the ministry of Education and Science) to discuss their pedagogical content knowledge based on their understanding of the epistemological perspective on human learning.

Although our main aim has been at improving the course curriculum and evaluating our challenge for further improvement, we have also been recognizing that the development of design group itself is a crucial issue in the design research. Through our involvement in the design research, we as a group develop our pedagogical knowledge and deepen understanding on design principles for facilitating student knowledge building. When dealing with teacher education or pre-service education, in particular, the design research gives learners and design groups similar learning opportunities to reflect upon and develop knowledge related to learning and instruction (Oshima, Oshima, Inagaki, Takenaka, Nakayama, Yamaguchi, & Murayama, 2003). In our design group, this issue is remarkably important because members other than the first and the second authors are students (graduates and undergraduates) supervised by the first author in the faculty of education. Our students do not intend to become educational researchers but teachers at elementary or junior high schools, or to work at IT-based education companies. In the first year of their involvement in the design research, they come to the design group as new comers with a little knowledge and epistemology which we consider are better than those by students taking the course but not sufficient. We, therefore, consider that our design research is a learning opportunity for them to advance their pedagogical knowledge and epistemology. They start to engage in the design research at their third year of undergraduate program then continue their involvement until their graduation. They, therefore, participate in the design research for two years if they leave the university after completing their undergraduate program or four years if they decide to study in the graduate program (M.A. course). Thus, the life cycle of our design community is short and dynamic. To keep knowledge on design principles in our design group for continuously improving the course design, we should establish the

community of our design group where new comers to the cultural practice effectively learn their needed knowledge, challenge to advance knowledge, and consider how to prevail their developed knowledge to new comers after them (see Figure 1). In three years (2001-2003), we, as principal investigators, have been engaged in this *hidden design research* with the purpose of facilitating the development of our design group as a dynamic knowledge building community (Bereiter, & Scardamalia, 1993; Scardamalia, 2002). In this paper, we report what scaffolds and how we deployed in our design group for facilitating the development of group members as knowledge builders, and what consequences we have found so far through descriptive analyses of two successful students.

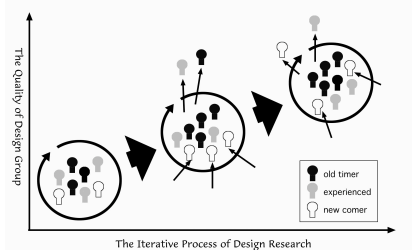


Figure 1. Development of the design group through the design research practice.

Design Group and Its Practice

Our design group starts to discuss how to design the course curriculum four months before (the time when a new academic year starts so that new laboratory members come to us). Ten to twelve members including the authors participate in research meetings for: (1) principal investigators and old timers explain new comers about the aim of the design research and what we have done before the year, (2) we reflect upon previous designs, results of analyses on student performance, learning activities and interviews, and group members reports in the post meetings to consider how to improve the year's course curriculum, and (3) we decide who would be responsible for which tasks of the course design. Several sub groups with old timers as group leaders engage in tasks such as network configuration in the classroom, creation of digital materials, consideration of specific instructional techniques, and so on. At every research meeting, progress by each sub group is discussed by all the group members to coordinate and revise each other's work. During the course is being held, group members other than the first and the second authors work as mentors in pairs for facilitating and videotaping (for data collection) student performance in collaborative learning. After the class every day, we have a staff meeting to monitor how our course curriculum has functioned with our instructional goals and revise our curriculum for the next day if needed. We also have several post meetings based on reports by mentors to totally reflect upon our course curriculum of the year and discuss how to improve it for the next year.

Scaffolds for Design Group as Knowledge Building Community

For considering scaffolds for our design group to function as a knowledge building community, we have referred to determinants of knowledge building community by Scardamalia (2002) as design principles. We describe here what scaffolds we have implemented after briefly explaining determinants we have based for the implementation.

Determinants of Knowledge Building Community

Based on long-standing research by her and her colleagues (e.g., Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989), Scardamalia (2002) summarizes socio-cognitive conditions under which people work in a knowledge building community. First, in a knowledge building community, community members are concerned with understanding based on authentic inquiries. Problems in teacher education program are usually far from students' real concerns with the world they will live in ("*Real ideas, and authentic problems*"). Second, members' ideas and problems are regarded as improvable. Ideas are objectified and shared as conceptual artifacts (Bereiter, 2002) so that members can engage in discourse around them ("*Improvable ideas*"). Third, the diversity of ideas raised by members is a natural and necessary context of knowledge building. In the knowledge building community, members themselves take on the responsibility for managing their ideas to improve collective understanding ("*Idea diversity*"). Fourth, through the improvement of ideas or understanding, members create more inclusive syntheses or super-ordinate concepts by summarizing previous ideas. The new perspectives should have more power to explain and conceive than do previous ones ("*Rise above*"). Fifth, members themselves manage how their

knowledge advances. They coordinate their personal ideas with those of others and also monitor how their collaborative efforts proceed. These tasks require them to exert cognitive strategies for collaborative problem solving (“*Epistemic agency*”). Sixth, members’ contribution to improving their collective knowledge in the community is the primary purpose of knowledge building. The shift in their recognition from ‘learning as the improvement of individual knowledge’ to ‘learning as individual contributions to the collective understanding’ is crucial (“*Community knowledge, collective responsibility*”). Seventh, all the individuals present contribute to the knowledge advancement in their community in various ways (“*Democratizing knowledge*”). Eighth, a goal for knowledge building communities is that individuals and organizations actively working to advance their knowledge also have their advances serve to advance the knowledge of others. Thus there is reciprocity in knowledge work, with the outputs of one group helping another group, and creating a whole that is greater than the sum of the parts (“*Symmetric knowledge advancement*”). Ninth, students acquire a disposition to contribute to collective knowledge building. It is not something they do at special moments, or in special classes, or during particular curriculum activities. Rather it is integral to how they approach all knowledge problems and is extensible across contexts, grades and working contexts (“*Pervasive knowledge building*”). Tenth, in the knowledge building community, members are encouraged to use resources as conceptual artifacts that are treated as objects of inquiry and juxtaposed against their personally constructed artifacts (“*Constructive uses of authoritative sources*”). Eleventh, students are engaged in discourse to objectify their ideas, to share with each other, and to improve the knowledge advancement in the classroom. Scientific discourse is a typical form of knowledge building discourse. Conceptual artifacts in scientific discourse are frequently objectified as propositional knowledge. There are strategic discourse patterns for improving the conceptual artifacts (Bereiter, 1994b; 2002) (“*Knowledge building discourse*”). Finally, for knowledge advancement, appropriate monitoring is crucial. Members need a total view of their understanding to decide how to proceed, especially when problems of understanding arise. They do not wait for outside experts to evaluate them, but rather evaluate their own progress on an ongoing basis. This collective effort by members to reflect on their collective knowledge is facilitated by the engagement of the leader as a member of the knowledge building community, not the sole community member responsible for evaluating progress (“*Concurrent, embedded and transformative assessment*”).

Learning through Participation in Authentic Problem Solving

The four following design frameworks are applied to embody the twelve principles in our design group. The first framework is that the design of pre-service education is a *really authentic* context of knowledge building for the group members who want to be teachers or work in its related area. Problems we have to face in our design research are not given to members by principal investigators, but those they have been recognizing and concerned with. With such real problems, the members are involved in problem solving activities: designing the course curriculum, engaging in teaching as mentors, observing student performance, and reflecting upon their course curriculum to discuss how to improve the curriculum further. At every phase of their problem solving, the members share their ideas on the course curriculum as further *improvable*. Their motivation for future career leads them to deep engagement in advancing their knowledge. Being in the real context of instruction as mentors makes them legitimately participate in reflection on their designed course curriculum. Such reflection or assessment happens at anytime in formal or informal meetings if they recognize they need to do so.

Learning through Collaboration

We consider collaboration as a main activity through which *diverse ideas* show up and members engage in coordinating or *rising above* different perspectives on the same problems to produce more powerful solutions. We are concerned with the structure of collaboration in our design group in such a way that it should be *democratic* and *symmetric*. For our group collaboration to be symmetric or transactional, we analyze the task structure in research meetings so that *every single member in the group can contribute with their level of expertise* and divide the main task into several sub tasks each of which a sub group of old timers and new comers takes charge of. In the task structure where different sub groups are responsible for different but interrelated sub tasks, collaboration between sub groups stimulates collaboration within sub groups, and vice versa. In the groupwork where people with *different levels of expertise* are involved, it is difficult to maintain the democracy that every member, new comers in particular, feel free to express their ideas and contribute to the group accomplishment. The democracy problem is still a big issue in Japanese culture when people with different ages collaborate with each other. In our design group, this problem is solved by making members recognize that they are working in a community of practice. Because the life

cycle of our design community is relatively short, it is easier for every member to see the total activity structure in the practice. Old timers (graduate students, particularly) think of how to educate new comers whom would take responsibilities they have currently in the future, whereas new comers expect their behaviors in the future by observing old timers through collaboration.

Learning by Taking Collective Cognitive Responsibility

As described in the second scaffold we implemented in our groupwork, all members are required of taking their responsibility to contribute to the group accomplishment. Having such *collective responsibility* facilitates group members to exert a different type of *epistemic agency* from that they usually use in their individual learning. The goal of their work is not only to complete their own tasks, but also to contribute to the group accomplishment. The group accomplishment here is not just a compilation of individual accomplishments, but a superordinate structure of ideas related to each other. For their group accomplishment, they need to monitor what ideas others are thinking and how the others are developing the ideas as well as how their own ideas are related to the final goal as a group. This type of epistemic agency leads members to engage in building knowledge in World 3 (Popper, 1972), or conceptual artifacts (Bereiter, 2002).

Learning by Explaining

For supporting members to engage in knowledge building, we frequently give them opportunities to explain their ideas to other members. In our design research practice, explanatory discourse by members is required of contributing to solutions to problems they have in the curriculum design activity and making others sufficiently understand so that the others can go further in their work based on their understanding. In collaborative works through the design activity, members have two types of opportunities to be involved in explanatory discourse. One of the opportunities is discourse within each sub group. Since each sub group is comprised of members with different levels of knowledge, old timers have to explain their ideas to new comers, and new comers have to ask old timers what they do not understand. The other opportunity is discourse between sub groups in research meetings. Sub groups are required of explaining their progress and problems to other groups, and all members put ideas on. Principal investigators facilitate their discourse by prompting metacognitive questions for them to reflect on what they think, paraphrasing ideas they report so that the ideas could be more sharable and improvable, and so on. Through their engagement in explanatory discourse, members have frequent opportunities to reflect on and articulate their ideas.

Two Cases of Successful Development of Mentors

Here, we describe how two mentors who have engaged in our design research for three years developed their knowledge and evaluate whether and how our design frameworks facilitated their development. We do not intend to clarify any one-to-one correspondence between their changes in knowledge and epistemology, and our designed frameworks because this is a design study where we implemented various scaffolds simultaneously. Rather, by describing deeply their behaviors in research meetings videotaped for the purpose of the research (100 hours) and our filed notes, we attempt to report profiles of the two mentors and their development.

Development of Pedagogical Content Knowledge by H.T.

H.T. had engaged in our design research from 2000 to 2002 (from his fourth year of the undergraduate program to the final year of his M.A. program). H.T. is the only person who had engaged in the design research from the first year of the research project and for a relatively long period of time (i.e., three years). He thought of being a teacher as his final career. But, he did think that he needed experiences as a businessman before getting into the education field since he believed that the teacher should have a variety of working experiences. After his graduation of M.A. program, he is currently working at a software development company as his first career. In 2000, we did not expect design group members to play a role of mentor but technical help desk. Therefore, we did not have research meetings with members frequently. We had meetings a couple of times before the course started, and told them what we wanted them to do, such as “Stay in the classroom just in case that students have questions of how to use computers and the system we implement in the course.” The members did not positively communicate with students in the course, but waited for their questions. They did not use their epistemological understanding to help students be involved in productive learning. H.T. was one of the members in his fourth year of the undergraduate program. Based on our reflection on the practice in 2000 (e.g., Oshima, & Oshima, 2002b), from 2001, we changed our perspective on the design group community itself as described in previous

sections. H.T. was in the first year of his M.A. program and the oldest in members. He decided in discussion with the first and the second authors to choose the design research as his M.A. thesis project, and engaged in all the processes of the design research practice. *Involvement in the decision making process from his educational perspective (seen in 2001)*. By referring to “the community of learners (Brown, 1992; Brown, & Campione, 1996),” we have designed the course curriculum as project-based (Oshima, & Oshima, 2002b). Students in the course were divided into small groups (4 or 5 students each) and engaged in collaborative problem solving tasks and lesson planning projects. Through their experiences as groups, we expected students to recognize that collaborative problem solving is a practice to improve their knowledge. During the class hours, mentors observed how groups were involved in their collaboration and helped them reflect on their activities for thinking how to make their groupwork more productive. A small population of the students in the course (very small but stably existing every year) did not have sufficient social skills to communicate with others in their groups and could not participate in collaborative problem solving. In 2001, one of such students came to the course instructor (the second author) to ask her to let him study alone during the course. Mentors including H.T. also recognized through their observation that the student had a problem with his social skills and could not participate in the groupwork. In the staff meeting after the class, we were concerned with this problem, i.e., how we should take care of students who are not good at social skills to manage their collaborative work with others. We were inclined to conclude for the solution to the problem that we should care about him at the individual level, i.e., providing more scaffolds for him to manage his collaboration problem. While we were likely to convince ourselves of making such a decision, H.T. expressed his opinion as follows:

“Our current solution would be surely one of considerable alternatives. I personally think that his request (to let him study alone) is reasonable for person who is not good at managing the groupwork like him. Studying alone could be another style of learning. But, on the other hand, I think that *we have to educate him so that he can manage this type of situation for his future.*”

Following his utterance, our solution for the student was considered again for him to learn how to act as a member in a community of learners. Finally, we decided to share this issue with other students as members in the same community and to have time for the students to reflect on their activities. After expressing his problems with social skills to other members in the community, the student who claimed to study alone was more positively engaged in collaboration at his pace. As a scaffold for him to engage in the groupwork, we arranged the member configuration in regrouping scheduled in the middle of the course so that he and students with high social skills were in the same group. After our intervention, the student had not shown any claims to us and was found to talk with other members through problem solving in video records. What we found as the development of H.T. in this utterance and the following discussion are as follows. First, it was not predictable for us to hear his opinion like the above. We had identified through our experiences with him as an undergraduate for four years that he was good at systematically managing events but not likely to consider others’ problems from the educational perspective. In his utterance, however, he clearly showed his concern with the future of the claiming student. Secondary, his proposed solution fitted more into our instructional goals for the course than what we had been inclined to conclude. He was more directed to an issue of how the claiming student develops through his participation in the community. Thus, in the second year of his participation in our design research, he was found to be more epistemological and educational than the first year. *Pedagogical approach as a mentor based on experiences (seen in 2001)*. In the staff meeting during the course, a main theme in discussion by mentors was how to approach to students being engaged in their groupworks. The mentors had two goals in their intervention: (1) helping them manage their collaborative problem solving, and (2) collecting data for their performance for the research purpose. The mentors in pairs observed and videotaped student activities in their groups, and interviewed with them several times for prompting their reflection on their own activities as well as collecting the data. The mentors usually did intervene with students even if students were deeply engaged in their collaboration. H.T. gave the following utterances on this issue in the staff meeting.

H.T.: I was feeling uncomfortable when I was trying to cut in their discussion if they were concentrated on their conversation.

R.O. (the second author): Do you think it was? But, H.W. (a student whom H.T. was taking care of) was easy to cut in, wasn’t he? Because he always looked like daydreaming all the time...

H.T.: Yeah, he looked like..., but it was difficult to cut in discussion if he deeply engaged in it.

R.O.: Uh...

H.T.: I felt that he rejected me when I muscled in their discussion for the interview.

Here, H.T. showed his concern with the timing for him to cut in students' discussion. In his utterances, we found that he monitored his intervention with the groupworks as both a mentor and a research assistant. What he did when he thought that students were concentrated on their discussion was not to muscle in their conversation, but rather to wait for them to cease. His decision manifested us that he took the pedagogical approach to student learning. The data collection was also important. But when the data collecting activities were found to keep students from their deep engagement in their learning, we should let them go further without any disturbance. This approach was not found in other mentors. *Leadership and take-over (seen in 2002)*. The year of 2002 was the final year for H.T. to engage in our design research. We (the first and the second author) discussed with him about how his knowledge and roles could be taken over to other members, particularly R.H. (a member who would be a group leader in 2003). His way of involvement in the design research practice in his final year was found to be different from his engagement in 2002 in that he more clearly contributed to develop our community itself as well as to improve the course curriculum. Events that we found his engagement different from that in 2002 were seen in the staff meeting during the course. After finishing agendas we discussed on the course curriculum and our mentoring activities on the day, H.T. proposed another meeting for mentors only.

"May I ask your attention again? It is already late at night [11:00pm], so I think that everybody wants to go home. But can I ask you to have another meeting for mentors to share problems with supporting students? Why do not we report our own activities as mentors team by team? Do you have any mistakes or questions you want to share with others?"

This type of engagement by H.T. was not found in 2001, and the first and the second authors took control of meetings. As seen in this utterance, H.T. attempted to make other mentors have frequent opportunities to reflect on their own activities. He was also concerned with the development of mentors as a community by asking them to have informal meetings other than official staff meetings with the principal investigators. The approach to establishing the community of mentors by H.T. was embodied in the following utterances more clearly. On the next day, he started to take control of discussion at the official meeting as well. Main agenda for the official meeting was that mentors reported student performances they observed and helped with seeing videos they recorded, and discuss whether we could go further with course curriculum we had planned before starting the course and how we had to revise it if needed. Mentors reported their observations and opinions in the group number order. After R.H., a mentor who would be a leader next year, reported his observation and opinions, H.T. gave the following utterance.

H.T.: OK, now. Why don't you take this role, Gacha [nickname of R.H.]? I take the chair over to him. [H.T. went to backside of the room and took a seat.]
R.H.: Yeah, right. So, the next person, please.

At this moment, H.T. for the first time asked R.H. to take the leadership in the community of mentors. H.T. had known that R.H. recognized the role in the next year and observed his chairing behaviors very carefully. From our interview with H.T., we found that he was looking for an opportunity to take over the leadership to R.H. in the meetings so that others who would remain in the community could recognize R.H. as a future leader and establish a structure of the future community.

Development of Pedagogical Content Knowledge by R.H.

R.H. started his engagement in our design group from his third year of the undergraduate program (the year of 2001) and currently (as of 2003) has been involved in the design research practice as a graduate student for three years. His goal of career is an educational consultant who collaboratively works with teachers in planning lessons and designing computer network environments. He wants to start his career as a teacher at an elementary school after his graduation of M.A. program. In 2001, he worked in pair with H.T. as mentors. His main task was to videotape student performance in collaborative works and interviews with them by H.T. We thought that it was enough in the first year for him to legitimately participate in the practice in a peripheral way, i.e., helping H.T. by taking a role of videotaping. We also asked him to set up the computer network configuration by helping another senior undergraduate for the purpose of learning the theoretical structure of network configuration. By his legitimate peripheral participation in the practice (Lave, & Wenger, 1990), we expected him to learn how our design research practice went on through observation of core members like H.T. In the second year for R.H. (the year of 2002), we found the development of his pedagogical knowledge and epistemology in the following excerpts of his utterances at the staff meetings and research meetings. *Involvement in decision making based on his pedagogical knowledge (seen in 2002)*. A scaffold that we embodied in designing the

classroom was regrouping, i.e., restructuring of members in groups. This was conducted for two reasons. The first was that students were rearranged from homogeneous (i.e., majoring in the same subjects) to heterogeneous groups for managing various ideas and subject matter knowledge for the purpose of considering their lesson plans for the time for integrated studies. The second reason was that we, as design group, wanted to restructure groups so that students could be engaged in more productive social dynamics. We had to group the students at the beginning without information on their characteristics. Some group could create nice social dynamics in their collaborative problem solving, but this was not necessarily the case. Based on mentors' observation and videotaped records, we had a staff meeting to decide the re-arrangement of groups. In 2002, H.T., a leader of mentors, took a role of chairing the meeting. R.H. cognitively contributed to the decision-making process by engaging in dialogue with H.T. and the course instructor (the second author). The topic of the dialogue was how to arrange a student (named "Watanabe") whom most mentors recognized having a leadership in a new group.

- R.H.: [He was giving his impression on Watanabe-san in her first group.] Well, I am still concerned with her leadership in her first group. I wonder whether she would be able to give such a lot of ideas in her group if another person like Sato-san (taking a supporting role for Watanabe-san) is not in the group...
- R.O. (the second author): She looks so tough, does not she?
- R.H.: Yeah, she is tough. She gave lots of ideas and opinions in the group discussion. But those were *her* opinions and ideas. She never attempted to *wrap up those ideas with others'*.
- R.O.: So, she looks like a politician. [laugh]
- R.H.: Yes.
- H.T.: So, shall we put her in the same group with Nishimura-kun (another politician-like)?
- R.H.: It may be an interesting idea...
- H.T.: I guess you [R.H.] should make a decision on this.
- R.H.: But, we should be careful of putting her in the same group with him. She [Watanabe] is not strongly social like him [Nishimura]. She talked a lot within the group, but we never saw her raise her hand to speak in the whole class. He is much stronger than she is.
- H.T.: I do not think that we should care about it, though.
- R.H.: What I am concerned with is that Watanabe-san cannot get up again when her idea is strongly rejected by Nishimura-kun in a group.
- R.O.: Then, she will be frustrated...
- R.H.: Yeah, she will. [nodding] In her current group, there are no such strong persons. So, she can express herself quite nicely.
- H.T.: She will change...
- R.H.: Yes, she will. This is my concern with her...

In the above dialogue, R.H. manifested his pedagogical knowledge on the characteristics of one student he had observed as a mentor. He gave us his opinion based on his observation data, and his logic was very convincing. This type of utterances was not seen in his first year of engagement. His proposals were not based on any data, but impression. Further, through dialogue with others, R.H. incorporated others' ideas with his original idea by translating the others' in his words (e.g., "Yeah, she is tough. She gave lots of ideas and opinions in the group discussion. But those were *her* opinions and ideas."). *Leadership and concern with the community development (seen in 2003)*. After graduation of H.T., R.H. recognized himself as a group leader. In the third year of his engagement in the design research practice, R.H. was concerned with the development of the design group as a community of practice as well as his own development. We found many events in which he manifested the development of his pedagogical content knowledge based on the new epistemology. Furthermore, his activities through the design research practice was more focused on how smoothly the organizational structure of our design group was established and how much responsibility he could take over to other new comers. One of remarkable evidence that he was more directed to the organizational development by educating new comers was found in our conversation with him in informal settings. Our design group was comprised of students supervised by the first author. Students who were involved in the design research, therefore, shared their office in which a variety of jobs other than the design research were performed through their collaboration. R.H. always saw others from his pedagogical point of view, and talked to us about what expertise would be developed in whom (e.g., "He is very much interested in editing video clips. His sense of making clips is very good."), and who could take which roles in the design research (e.g., "She would be able to take the mentoring role with another first-time student although this is also the first time for her."). From our interview with him after the third year, we found that his approach to our design group as a community of practice was based on his experiences with H.T. R.H. had seen how H.T. had been taking his leadership in the group and had discussed about how a group of students could work as a community with him. R.H. was not just copying

the approach by H.T., but developing his own approach to the community development. He told us in the interview with him:

R.H.: H.T. always said to me, "This is my way. So, you should be able to develop this community in your own way." I really thought it was true.

Discussion

Based on our descriptions of two successful mentors who developed pedagogical content knowledge through their participation in the design research practice, we like to discuss how our design frameworks affected their successful changes. As they engaged in the practice repeatedly, their commitment to the design group was remarkably increased. The participation in the practice was authentic and based on their real problems at early stage in that they could experience real teaching. Through iterative participation, however, it was found that they came to be more interested in the design research itself. They seemed to enjoy participating in the practice for the purpose of producing new findings to revise their curriculum next year, i.e., knowledge building. Our preparation of the authenticity in our design group was only a trigger by which they started exploring in the new practice and further developed their own authenticity. Collaboration also played an important role to pervade the knowledge building goal in the community. The interaction between members with different levels of awareness of the instructional goals and the research purposes produced many opportunities to consider more deeply the meaning of their participation in the practice. These opportunities were happening mainly in informal meetings where members attempted to reflect on their activities in teams for sub-tasks. There were their collective cognitive responsibilities behind their intentional reflection on the meaning of their participation in the practice. They discussed the design of course curriculum and planned their own works by dividing the main tasks into sub-tasks so that every member knew why s/he was doing her/his task and how her/his work was related to the main goal of the instructional design. Their responsibilities to contribute to the main goal attainment facilitated them to talk to others about questions, problems, and proposals they had. All the members were required of being involved in explanatory discourse for knowledge advancement. We, as principal investigators, prompted them to express their ideas with reasons and how their ideas were related to the improvement of our design research practice. The metacognitive prompts by us led them to engaging in discourse by which they collaboratively improve their ideas. We found in the two cases of students described, particularly, that they successfully internalized the knowledge building discourse and applied it to their thinking process. In this paper, we reported how students participating in the design research as mentors succeeded in developing their pedagogical content knowledge. We think that the design research could be applied to pre-service teacher development or in-service teacher development like the lesson study. The design research practice is not only an opportunity for researchers to find design principles, but also for practitioners to develop their pedagogical content knowledge.

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