How can Asian educational psychologists contribute to the advancement of learning sciences?: Theories and Practices of Collaborative Learning for the Advanced Media Society

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The advanced media society of this age is demanding a completely novel education method. At the same time such society has a technical basis to allow development of such method. We need to study a new education method that effectively uses the technical basis and fosters advanced intellectual capabilities necessary for development of an information society. In the advanced media society, comfortable life will be brought by various new information environments. Such is an intelligent society developed with a strong infrastructure for free access and elaborate use of information. Therefore, the members of such society need to be engaged in various intelligent activities especially learning activities much more than before. In this sense, the advanced media society demands adaptive intellectual expertise that exceeds simple inheritance of heritage. Furthermore, the advanced media society that has a large-scale network as the foundation also enables and at the same time requires interpersonal interactions more than ever. That each person can solve their problem on their own is not the only factor to make up a good society. The present age is demanding a diverse yet collaborative society that helps people to share resources, create new ideas, and contribute to other people's problem solving. In order to build a healthy advanced media society worldwide, we urgently need to find an effective learning environment that enables fostering of collaborative and adaptive intellectual capabilities.

Recently, a field of study called learning science is becoming popular worldwide to meet this demand. Learning science attempts to widely understand learning and support learning by scientific knowledge like cognitive science and scientific utilization of information technologies. In order to develop a learning environment that realizes the objectives we described above and share study results internationally, we need to develop design principles based on learning science, to construct the theory and devise unique course materials and learning methods while referring to a wide range of other studies. Asian studies on concrete methods and theories of learning have contributed to the development of learning sciences. In this paper I will report two pieces of major contributions and present a study conducted in our lab to illustrate a case.

I. Learning Theory and Collaborative Learning Approach

I.I. Adaptive Expertise

In the world around us, there are people called experts such as grand masters of chess. These people have been drawing attention of researchers of cognitive studies from early stage. These people are examples of people who have successful learning process. What kind of knowledge do these experts have? In a study, researchers presented people with a number of physics problems to first sort problems into categories. The result was that specialists of physics categorized problems that can be solved by the same law of physics into a same category and beginners, on the other hand, categorized problems that superficially look alike into a same category. In this study, the researchers interviewed these people for three minutes and analyzed their comments on what was necessary to solve the problems. The results revealed that, while the beginners simply linked newly acquired knowledge, experts had well-structured knowledge especially knowledge of the laws of physics.

Now, how does a person structure and expertise their knowledge? If we can find this out, it will contribute to studies of learning science. However, only a few studies have been conducted on this subject. It has been said that expertise requires thousands of hours. Therefore, it is unrealistic to record and analyze the entire expertise process. Even so, interview data to pianists and athletes who have expertise level that they can compete in international competitions suggest that it is important for parents and teachers to provide intentional experience to children in a well planned way from early childhood in order to encourage their expertise process. With recent developments in information technology, we are now easier to record various cognitive behaviors. Thus, as in our study, we can also analyze weekly recorded data of college students' knowledge-building process when learning a new field of study. Studies on expertise process will soon shift to a very important stage.

As for expertise, researchers of cognitive cultural anthropology have been conducting different studies that use, for example, workers in the fields as study subjects since around 1980. These studies suggested that if a specific profession is specified, a person can be lead to expertise by providing an effective workplace and spending long time in expertise process. On the other hand, these studies suggested that it is difficult to foster such expertise unless "specific profession is specified". This raises a large issue when one considers school education. In schools, one of the major learning objectives is to help students understand specific subjects well and at the same time acquire general cognitive skill without being bound by specific subjects.

Hatano proposed "adaptive expertise" to solve this dilemma (Hatano, 1986). Hatano, through comparison with experts of other educational fields such as abacus and cooking, suggested that expertise in one educational field prepares the person with knowledge for problem solving and decision making in other educational fields. Hatano calls such expertise as adaptive expertise. This concept is currently under examinations in terms of possibility for elaboration and practice in various scenes, as one of strong hypotheses that should be clarified in the field of learning science. Hatano has not yet clarified the process to reach adaptive expertise; however according to their subsequent articles based on their studies, it is becoming clear that adaptive expertise is a result of highly social cognitive activities, for example, a piano performer is supported by a mental model with which he is able to prepare himself for various performance depending on the level of audience. They have already accumulated detailed data on learning process of music skill and craft skill. We are expecting to see further new findings.

Adaptive expertise suggests acquirement of general intellectual capability that is not bound by a specific field. However, a relationship between expertise in a specific field and general intellectual capability is still unclear. It is an issue for future expertise studies to find out how expertise in a specific educational field or subject actually prepares knowledge and skills applicable to other educational fields. Studies on expertise process are increasing and shifting toward a full-scale stage. With our research groups, we believe that Japanese researchers can contribute to this field worldwide.

I.II. Conceptual Understanding by Collaboration: Constructive Interaction Theory by Division of Roles

In order to study long-term true learning process such as expertise process, as the foundation, we need to consider the mechanism of a person to acquire knowledge, reconstruct the knowledge, and further extend the range of application. In practical studies of learning science, collaborative activities are weighed heavily as one of the basic factors that cause such mechanism and are currently examined through practices. The backgrounds of these studies include studies of cognitive science on joint problem solving and collaborative creative process by leading researchers in 1980s. Many Japanese researchers are also contributing to studies in this field.

A basic form of collaborative process, some assume constructive interaction process. We believe that this process has the following mechanism of conceptual understanding. In other words, when more than one participant try to solve a same problem, each participant tries to solve the problem based on his/her own understanding; therefore, each comes up with a solution from different perspective. Therefore, each participant tries to comprehensively understand various solutions by all participants in comparison to his/her hypothesis and deepens his/her understanding (Miyake, 1986).

Furthermore, in a collaborative problem-solving scene, division of roles occurs more naturally because one person's activity is monitored by others in such circumstance. Therefore, in such scene, solution by one person that is appropriate for a concrete circumstance is re-interpreted by others at more abstract level. By repeating this process, each participant gains abstract form of understanding (Shirouzu *et al.*, 2002). Therefore, it is also an important factor for conceptual understanding to exchange roles of participants in collaborative scenes.

It is necessary to generate knowledge-building process in actual learning environment by incorporating the mechanism that has been clarified in studies on collaborative learning activities such as this study and furthermore clarify details of expertise process where knowledge reconstruction is repeated for a long time. In this study, we incorporate activities that learners explain their ideas to other students, draw diagrams, and build models in collaborative learning scenes into a curriculum. This accelerates externalization of comprehension process and provides learners conditions that promote mutual reflection on each other's comprehension process and meta-cognition. This, at the same time, provides researchers an opportunity to observe and analyze internal process that occurs on the scene. In this study, we support such externalization by using support tools, record the externalization, and effectively use collaborative comprehension process much better than before. At the same time, we will upgrade the theory on collaborative learning itself.

II. A case of collaborative learning approach at a Japanese university

A new teaching method cannot be established without fully examining the contents of what is to be taught and how, as well as the cognition theory to support the design of the educational environment. We have devised original teaching materials and learning methods while developing the theoretical base through its own basic research (Miyake, *et al.*, 2003, Shirouzu & Miyake, 2003; Miyake, 2002; Miyake & Shirouzu, 2002a, 2002b). By selecting cognitive sciences as the subject area, we designed an educational environment for teaching cognitive sciences to first- and second-year students. We developed contents while verifying them practically in actual teaching settings. At the same time, we further developed the theories on collaborative cognition activities of humans that have been clarified by conventional research of cognitive studies. Based on these findings, we designed collaborative learning activities and the tools to support such activities and repeated improvement while using and evaluating them in the class where students learn cognitive sciences collaboratively over a two-year period.

As the basis for practice, two concepts of organization, adaptive expertise and collaborative learning through constructive interaction, both touched upon above, were used. By repeating the cycle of implementing teaching based on them, refining the theory based on the outcome obtained from such teaching, and implementing the next improved practice, we sought to refine the theory while improving the quality of practice. Development of a curriculum that incorporates these learning activities will provide the principles for designing learning environment.

II.I. The design of learning activities

The study on adaptive expertise suggests that it is important to incorporate the following activities in order to achieve effective learning:

- Long-term intentional, proactive, and continuous activities
- Repeated application of acquired knowledge and skills to various scenes

Furthermore, from the standpoint of the theory of conceptual understanding by constructive interaction, activities and environment that facilitate followings should be prepared:

- Externalization and sharing of initial ideas
- Comparison and collaborative reflection of various solutions, perspectives, and opinions
- Building and deepening of general knowledge by integration of various experiences
- Repeated application of the cycle (collection of various ideas, solutions, and perspectives, collaborative reflection, and generalization) to slightly different scopes.

In this study, we have developed the following collaborative learning methods that realize these objectives. In the following paragraphs, we will explain each activity and the corresponding objective.

■ Hands-on

Activities: Using a puzzle or a memory experiment in a classroom, we provide adequate time to students so that they can acquire enough experience to create meta-cognitive reflection on their experience and ask themselves, "how am I solving this problem?" When the goal is to solve Tower of Hanoi puzzle, we provide one set of puzzle, a video camera, and a record sheet to each group of two or three students so that they can videotape and review their process of solving the puzzle on the scene as in

Fig.1. Hands-on Activity in an Actual Classroom

Fig.1. Allow two 90-minute classes for students to work on 8-plate puzzle that requires 127 steps to solve. Everyone becomes able to solve this puzzle in two to three minutes in the end.
Aims: Become familiar with the idea that considers a “problem” as a state of having a start and a goal and “problem solving” as a transition from the start to the goal within a problem space. Discuss and summarize various solutions suggested by different groups and understand there are representation method that uses algorithm to represent problem solving process and conceptual representation method that also concerns reflection structure.
Goals of the Activities: These activities satisfy (c) because they prepare a situation where students can naturally externalize their solutions as an “initial hypothesis”. In addition, these activities also realize (d) and (e) through experience to collect an initial hypothesis from each group, compare them, and classify hypotheses that have common characteristics into a same category. Furthermore, (a) and (b) may be also satisfied for a simple reason that students do not get bored with these activities because they enjoy solving a puzzle on their own rather than listening to a lecture (Miyake, *et al.*, 2004).

■ Aggressive Reading
Activities: Students divide a text material into several components without destroying the structure, summarize each component, reconnect the components in a consistent way (based on each student’s view), compare their interpretation with the opinion of the author, and finally summarize what they understood from this process. If using one section of a book, students are asked to think about what they would say if they are summarizing the number of study examples contained in this section, and in addition to reflect on their understanding by comparing their interpretation with the opinion of the author and summarized ideas of the other students.
Aims: Students divide a technical text into components, carefully read the components, and compare their interpretation with other students’ interpretations. Clearly understand that each student understands differently even when reading the same material and that collaborative activity to read materials and exchange interpretation is not a meaningless activity. This prepares students for Jigsaw methods to be explained later.
Goals of the Activities: Repeating activities of (c), (d), and (e) using a short material may prepare students for Jigsaw methods. (a) may be also supported by re-interpreting a potentially passive “read & understand” activity as a positive construction activity.

■ Learning from Lectures for Comprehension
Activities: Divide a lecture video into several-minute video clips, follow teachers’ instruction and decompose the lecture into components, and re-construct and reach an interpretation. Concrete activities may include watching a part of the lecture and recollecting what happened

before and after that part and extracting and reviewing a specific video clip to understand how each student reached his/her solution to the question provided by the teacher at the beginning of the lecture. In addition, repeat discussions and questions and answers on a bulletin board for each video clip using CMSonBBS, review the lecture content, and come up with more advanced questions.

Aims: It is difficult to review a lecture; therefore difficult to understand that a lecture also has a structure. By positively working on the material and asking themselves questions about the materials, students will experience deep understanding of the material content. This is similar to aggressive reading we explained above.

Goals of the Activities: Activities of (c), (d), and (e) are satisfied as in the case of aggressive reading. Students attend lectures on a daily basis at their college; therefore these activities may also satisfy (b) and (f) to train students' cognitive skill acquired from lectures. In addition, (a) may be also satisfied as a strategy to positively listen to lectures.

■Concept mapping

Activities: Suggest an activity to write down ideas and draw a concept map when students started to express their ideas after reading a material or listening to a lecture. At first, this activity is often conducted in small groups using sticky notes and a mount board. In the latter semester of freshman year, encourage students to draw a concept map on ReCoNote. This is because they have already acquired skills to share concept maps with other students and also to review their concept maps. Encourage such mutual reflection and editing activities in classroom. In the early stage of concept mapping, the teacher may provide the whole class an opportunity to think about meaning of each simple arrangement in terms of relationship.

Aims: In the early stage when students started to externalize their ideas, sometimes it is difficult for the students to express their ideas in writing although they can explain the ideas orally. Oral explanation is effective as one form of externalization; however it is difficult to track such externalization. Writing short text on sticky notes and computerized cards and arranging these notes in a space should support students' externalization in the early stage. This method supports a hierarchically-structured knowledge-building activity that students first draw a simple concept map with a few components, gradually edit the map, increase the number of materials incorporated into the map, and finally create a concept map that has other concept maps inside. Fig.2 shows the actual example of students' concept mapping.

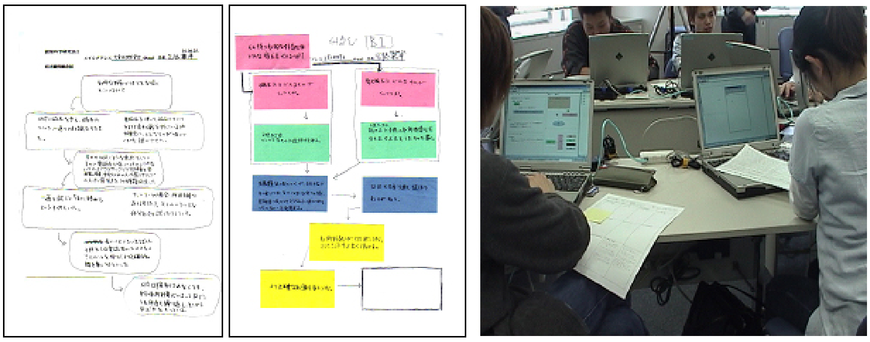


Fig.2. Concept Mapping Using Sticky Notes and the System

Goals of the Activities: These activities mainly aim satisfaction of (c). Concept maps have flexibility that enables mutual reflection from various perspectives such as content and arrangement of each sticky note when shared by a number of students. In addition, concept maps such as those created in ReCoNote can be edited electronically and also can be repeatedly edited and improved in a long time. For this reason, potentially, (d), (e), and (f) may be also satisfied.

■ Simple Jigsaw

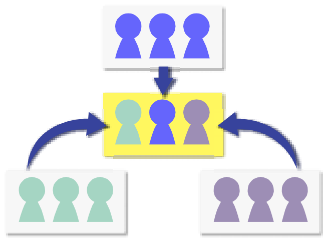


Fig.3 Simple Jigsaw

Activities: Encourage students' understanding of the part of the material he/she was in charge and also the entire material by asking students to read closely related short materials or divide a material into several parts and mutually exchange interpretation with other students. To schematically explain this method, each of three students takes charge of three different materials (different parts of an original material) and becomes an "expert" of the material or part he/she is in charge. Take one student from each of three expert groups and form a jigsaw group comprised of members, each in charge of different materials. Exchange opinion in the jigsaw group (Fig. 3). This is a method comprised of various aspects including number of materials (parts), number of members, time spent in expert group activities, method of exchanging opinions in jigsaw group, and types of project conducted in the group. Therefore, this method can have great diversity. Fig. 3 shows the simplest of this method. In this example, students divide a short material (size of one A4 sheet or less) into three parts in the early stage of learning process, each student takes charge of a part readable in 10 to 15 minutes, and the group of three students read the parts together and discuss and come up with an opinion on the entire materials incorporating interpretations of all three parts.

Aims: Because it is obvious that each member of a jigsaw group came from different expert group, it artificially and easily creates a situation where each member has a different opinion and the whole group mutually reflects on the opinions. This situation is the foundation for collaborative activities. By exchanging different opinions with other students and becoming used to a state where each student comes up with a different opinion, collaborative activities are smoothly introduced to students.

Goal of the Activities: For the reasons we explained in the previous method, these activities are expected to satisfy especially (d) and (e).

■ Structured Jigsaw

Activity: Restructure a simple jigsaw as a collaborative reading of m x n materials that cover m themes by n study approaches.

Aim: Support integration of materials by explaining structure of materials first and providing a guideline for the order of exchanging materials.

Goal of the Activity: The main goal is to satisfy objectives of (e) and (f) (Miyake, *et al.*, 2001).

■ Dynamic Jigsaw

Activities: In a class of a large number of students, students divide and share many materials, carefully read these materials, create concept maps, and exchange interpretation with other students who read similar materials. For example, let's think about a case of understanding Material 24. At first, students gain firm understanding of one or two materials in a group of two or three students by comparing concept maps. Fig.4 illustrates the sequence.

Fig.4. Diagram of a Dynamic Jigsaw Activity in which Students Exchanged 24 Materials that Covers 3 Areas in 10 Sequential Classes

Then, each student in the same group explains his/her material to the other students in the group. After students exchanged their materials and when the whole class reached the stage each student is integrating four to six materials, students start to exchange their interpretation of four to six materials, rather than content of individual material. After that, students exchange their interpretations about eight materials they have integrated. Through such a process, the whole class covers 20 to 30 materials in the end. This activity takes 10 to 12 weeks as a whole. Fig.4 shows a diagram of a dynamic jigsaw in which approximately 60 students exchanged 24 materials listed in Appendix 1 in 10 sequential classes of Advanced Cognitive Science course in 9 weeks in the fall semester of 2004 (the latter half of sophomore year).

Aims: Normally, a teacher can explain 20 to 30 materials in a single semester. In the above example, the objective is that instead of listening to lectures by a teacher, students gain understanding of the equivalent amount of materials by mutually explaining and exchanging these materials with the other sophomore students in the same class. In this method, students construct a schema instead of simply listening to the summary created by others and improve quality of the schema by mutually reflecting on adequacy of its composition. Such a method to build comprehension of a new field of study is one of the basic forms of learning when a person tries to learn on his/her own. Students are expected to acquire knowledge-building method itself through collaborative knowledge-building experience we described above.

Goal of the Activities: The main goal of these activities is satisfaction of (f). This approach covers all objectives from (a) to (f) as a comprehensive collaborative learning method (Miyake & Shirouzu, 205; Miyake, 2005).

■ Two-Year Super Curriculum Comprised of Four Sequential Semesters

Activities: In order to help students learn various aspects of cognitive science, encourage students to gain meta-cognition mainly by hands-on activities in the first semester of freshman year, help them become familiar with the basic knowledge through activities such as aggressive reading and learning from lectures for comprehension from the second semester of freshman year through the first semester of sophomore year, and in the second semester of sophomore year, encourage students' knowledge-building process through dynamic jigsaw activities especially using materials they are interested among various basic study cases. At present, the super curriculum we developed in this study is comprised of four semesters (two years) in order to engage students in these activities intentionally and continuously.

Aims: The unique aim of dynamic jigsaw method is to understand a broad range of basic materials. At the same time, this method is expected to contribute to deep constructive understanding of material content through repeated explanation of his/her materials to other students. In addition, this activity starts with observation and exchange of initial hypothesis that enables collaborative learning. One of the large learning objectives of this curriculum is to help students acquire a skill to build collaborative knowledge. With this skill, students are able to mutually reflect on their ideas to develop the ideas to more reliable ones.

Goal of this activity: The super curriculum explicitly aims for (a) and (b). In order to incorporate expertise process into learning activities, it is necessary to review the current system to design one course (one semester) independently. We should construct a continuous curriculum that provides adequate time for conducting activities to achieve learning objectives.

II.II. Teaching portfolio

This study has yielded a teaching portfolio which contains almost all data required for implementing teaching, such as teaching ideas and scenarios, work notes for student activities, reports describing how teaching was conducted, and data related to the contents of teaching. This portfolio enables implementation of similar teaching in other institutions.

These types of learning activities that are used repeatedly in teaching are summarized as collaborative learning methods. To implement the collaborative learning promoted in this curriculum, it is necessary to read the selected data and understand it to be able to explain it to others. Also, activities to deepen the result of understanding through discussions with others become necessary. As a method for thoroughly reading data, we have developed and examined the method called Aggressive Reading, where the reader extracts cognitive facts out of the contents of data and deepens understanding by interpreting and reorganizing them by himself independent of the summarization adopted by the author, and through examination of and comparisons with the author's way of thought. Also, with regard to lectures, we developed a contents understanding supporting method where the lecture is cut into short clips to allow adding comments on the web, and the lecture is reorganized while keeping the relations between video clips in mind. As a collaborative learning method, we improved the Jigsaw method with which individuals deepen understanding of data read and interpreted according to their own interest by introducing it to others. We also developed the Structured jigsaw method where knowledge is integrated while keeping interrelations between multiple items of data in mind, and the Dynamic jigsaw where knowledge building of individuals is promoted within a class size of 80 students.

II.III. Learning activity support tools

The main tools developed in this study, and used and evaluated in the classroom, include a data-sharing and examination environment to handle multimedia materials, the Multimedia

Document System (MMD); a video comment tool to enable sharing and examining comments on, and abstracts of, video teaching materials, Commentable Movie Sheet (CMS); and a conceptual map type note-sharing and examination environment that supports collaborative mutual examination through externalization, sharing, and association of diversified ideas, called Reflective Collaboration Note (ReCoNote). These tools are designed to incorporate universality to allow independent use of each tool and are widely applicable to other institutions and other courses of study as well.

The Multimedia Document System (MMD) enables pasting video, voice, graphics, or text on the sheet as a card (Fig. 5). Cards can be associated with each other through links, and comments can be added to any card, sheet, or link. These are all laid out in a three-dimensional space and can be viewed from an arbitrary direction.

The Commentable Movie Sheet (CMS) is a tool for adding comments to arbitrary portions of a movie, such as a lecture video (Fig. 6). Furthermore, it can use data on the MMD. Data generated by the MMD or CMS are managed collectively in the data storage system called the "repository" to allow viewing data through web browsers and sharing of data among users. History management is applied to all data allowing retrieval of images as well as total retrieval of text. For the CMS data on the repository, an interface message board that enables viewing of movies through web browsers and adding comments is provided (Fig. 7). This usage as a message board enables dividing the contents of teaching a conventional lecture into video clips, and implementing such teaching where students conform and understand the contents while reorganizing the lecture (Miyake & Shirouzu, 2004; Shirouzu & Miyake, 2005).

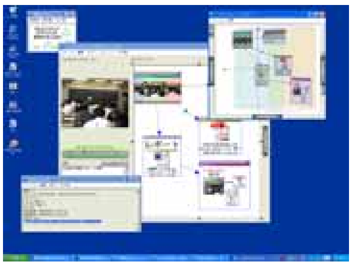


Fig.5 Multimedia Document System

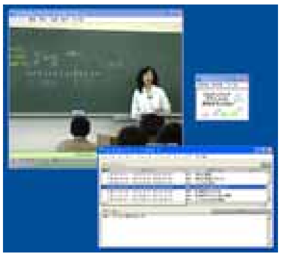


Fig.6 Commentable Movie Sheet

Fig.7 CMS message board

In addition, we developed ReCoNote, a collaborative note-sharing learning-support system that can adapt to group activities by flexibly utilizing a conceptual map. Links can be stretched between the notes laid out on the sheet and comments can be added to all notes (Fig. 8).

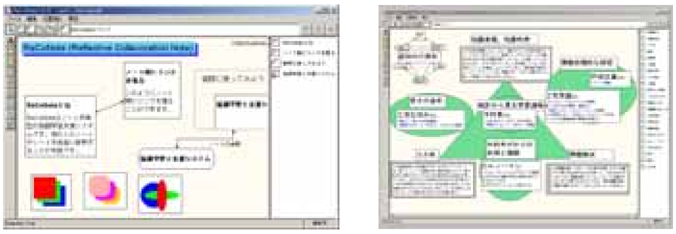


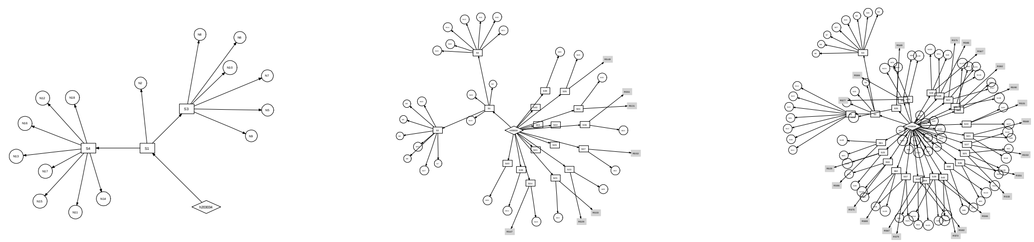
Fig. 8　Reflective Collaboration Note

II.IV.　Research Portfolio

This portfolio stores learning record data, including video records of teaching, and audio records of group activities of students, written records on work notes answered by students during school hours, data generated on the system, and various types of logs.　Some of the logs are subjected to processing, such as forming into protocol (language recording logs) and encoding of behavior categories.　 Processes followed by students over a two-year period to build conceptual knowledge of the new area of cognitive sciences are accumulated in week units during the teaching period. There are few examples of recording and analysis of detailed learning processes over such a long period among recent research on learning sciences.　By analyzing these data in the future, construction of theories of adaptive intellectual skills based on conceptual understanding, clarification of the roles that collaborative cognitive activities play in building knowledge, and the establishment of practical design principles for designing a learning environment with higher effectiveness based on those findings will become possible.

As a result of comparing the outcomes of practical teaching in this study in terms of the quality of general reports of each school year accumulated in the research portfolio, a gradual increasing trend from the beginning of this study in 1990 until 2003 can be observed. This trend suggests that the rate of quality improvement rises as knowledge associating activities on the ReCoNote become more active, suggesting the possibility that the utilization of tools induces highly efficient collaborative learning activities.

The research portfolio contains abundant learning process data, so it is possible that its analysis enables clarification of actual states of learning in large sizes and fine textures that have never before been analyzed, such as a long-time process of knowledge acquisition. The learning progress by the Jigsaw method (Dynamic jigsaw) to repeat cycles of step-by-step explanation and re-examination of many items of data in diversified areas by work division among all students in the class is traced in Fig. 9 from the viewpoint of a single student. The interrelations between sheets and notes on the conceptual map created on each ReCoNote in the initial, middle, and final stage of Jigsaw activities are shown schematically from the top to the bottom on the right side of Fig. 9. Squares (□) represent ground sheets and circles (○) represent notes placed on them. Sheets include those that were prepared by others. The figure in the left-side column of Fig. 9 depicts the conceptual diagrams that appear on the screen when each sheet of the schematic diagram in the middle stage is opened by associating part of those conceptual maps to nodes. The method of extending the range of understanding can be seen, although only two items of data under their own charge are associated on a sheet in the initial stage (the original form remains in the upper left sheet on the left-side column of Fig. 9), they are associated with data of many others in the middle and final stages.



Early Stage　　Medium Stage　　Later Stage

Fig.9　Development of a Concept Map

It is clear from these analyses that positive learning over a longer time than what is usually assumed for average teaching in ordinary universities is required for students to integrate new knowledge to the extent that they can explain it themselves. However, knowledge once built by expending a long time is sophisticated and reorganized gradually, even after completion of teaching, and can be transferred to other areas. Experiences in collaborative learning over a long time tend to promote the acquisition of collaborative cognition skills, such as those for solving problems through discussion and confirmation with others.

III. Future prospects

There are many factors to enhance the quality of learning, and they are assumed to be mutually affecting in a complex manner. We will clarify those interactions individually by proceeding with the analysis of data in the research portfolio. Furthermore, we will aim at providing the present outcome widely as a learning practicing theory with a higher universality, and as an educational environment with actual effectiveness by making necessary modifications of the system, expanding the subject of learning, and achieving the results of application in other institutions. Therefore, we will mount new interfaces on the current tools to enable mutual reference of diversified data, including the cases of implementation of education and the result of analysis and evaluation accumulated over a five-year period, as well as records of learning processes, for facilitating the transfer of outcomes and making them usable for clarification of learning as a complex cognition process.

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