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A COLLABORATIVE APPROACH TO TEACHING COGNITIVE SCIENCE TO UNDERGRADUATES: THE LEARNING SCIENCES AS A MEANS TO STUDY AND ENHANCE COLLEGE STUDENT LEARNING

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This paper reports on a new movement in cognitive studies that focuses on understanding and promoting collaborative learning. First, learning goals are redefined and a theoretical explanation of how collaboration works to achieve such goals is provided. A laboratory study to test this theoretical framework is then described. The study was integrated within a two-year curriculum which teaches introductory cognitive science, and which uses technological tools to enhance teaching and learning processes and outcomes. Two classes are described: one using a technique called "the jigsaw method" to teach the construct of semantic memory, and the other using a more complex design called "the dynamic jigsaw" to facilitate sophomores learning how to integrate 24 research findings into a coherent view of cognitive science. The results to date are promising while at the same time stimulating new research questions about how college students may be helped in their acquisition of not just basic academic knowledge but also skills for self-directed learning and collaborative work.

Key words: learning sciences, collaborative learning, the jigsaw method, mechanisms of constructive interaction

Recently, a new research field called "learning sciences" has been gaining popularity and redefining instructional practices worldwide. Learning sciences seek to establish theoretical understandings of what learning is, and to promote higher levels of learning. They iteratively refine learning-related theories and demonstrate the effectiveness of the devised methods through actual practices (Bransford, Brown, & Cocking, 1999; Bransford & Donovan, 2005; Miyake & Shirouzu, 2003).

Studies of how people can effectively learn have a long tradition because human beings have constantly been required to re-structure old experiences and to accommodate them to new situations. However, in the current age, where rapid changes are the norm, the degree to which this requirement occurs has increased more than ever. Students, for example, are required not only to acquire routine knowledge but also to apply what they learn to new situations, outside of school and in a distant future. To meet such requirements, new learning studies need new research methods which differ from those used in laboratory-based, conventional learning studies (Brown, 1992; Collins, 1992).

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One of the major changes introduced by learning sciences is a change in the outlook on learning: learning sciences view learning as a collaborative act, where people mutually enhance performance by influencing each other. There are two reasons for this change. One is that through many studies, collaboration has been proven to be effective in enhancing learning outcomes, in many disciplines and in different age groups. The other reason is that collaborative situations help promote in-depth, process-oriented research in learning. In collaborative learning situations (also in collaborative research and development situations) conversations are exchanged between multiple learners, making it possible to record and use various externalizations for mutual examinations of the various thinking processes that occur. In turn, this makes it possible to analyze intermediate processes which have so far been difficult to observe or study. The current rapid development of information recording technologies is playing a large role in such observation, recording, and analysis, and increases the likelihood of learning studies achieving their potential of bringing significant change to actual education and progressing our understanding of the learning processes themselves.

In the first part of this paper, we redefine learning goals for the kind of learning we wish to promote, and provide a theoretical framework that explains why collaboration can be a useful device for achieving such goals. In the second part, we describe a study conducted in our laboratory, to test the framework we are examining. The study was integrated within a two-year curriculum which teaches introductory cognitive science to freshmen and sophomores in a collaborative design enhanced by the use of technological tools. We focus on two classes, one that used a simple collaborative technique called "the jigsaw method" to teach the construct of semantic memory. The other used a more complex instructional design called "the dynamic jigsaw" where sophomores learned to integrate 24 research findings into a coherent view of "what cognitive science is".

NEW LEARNING GOALS

When we want to renovate learning, one good strategy is to take a close look at already successful learning. Studies on expertise (e.g., Chipman & Meyrowitz, 1993; Ericsson, Krampe, & Tesch-Romer, 1993), originating from the study of the memory of a grandmaster of chess (Chase & Simon, 1973; de Groot, 1978) and delving into many different skills like abacus use, piano playing, and sports, offer a lot of concrete features of the goals of learning. Some new studies are exploring a new construct called "adaptive expertise"[1] (Hatano & Inagaki, 1986) in concrete school subjects such as arithmetic (Baroody & Dowker, 2003). Literature on "situated learning"[2] (e.g., Lave & Wenger,

[1] In contrast to routine expertise, which demonstrates mainly the automatized, effective performance of routinely exercised activities, "adaptive expertise" refers to the expert state organized around more conceptually oriented understanding which allows the expert to flexibly adapt the knowledge to changes in the environment and to create new ideas.

[2] "Situated learning" refers to the learning that occurs within its natural context, where the learning outcome is immediately functional. See Lave & Wenger (1991) for a more detailed description of its various forms and the associated theoretical implications.

1991; Nasir, 2000) and on everyday situations (e.g., Inagaki & Hatano, 1989; Rogoff, 1990) has analyzed long-term learning in everyday situations and offers insights into how learning activities can and/or should be organized. From these studies, some features of successful learning can be identified. Below is a tentative list.

- Learners are strongly motivated to learn by themselves.
- It often requires several thousands of hours.
- It consists of active collection, accumulation, and construction of related information.
- Experiences of failures and successes have to be repeated, reflected on, and integrated to form an understanding at an abstracted, conceptual level.
- Intentional and systematic practice is often necessary.
- The goal is constantly re-examined and replaced by a new goal.
- There are others to learn from, mutually teach, and discuss with, not just the learning contents but also the processes of learning.
- There is an associated community with a mixture of members on different performance levels.
- The establishment of ego or social identity in the community is strongly connected to the results of learning.
- The community itself continually re-examines the goal and resets it.

Many of the features on this list are different from those one would normally expect to see in "school" learning. Based on this kind of "wish" list, a learning science research cycle is created as follows. To start with, we test whether some of the features are efficiently applicable in some real learning/teaching setting, based on a hypothesis that such application should produce a higher level outcome. If the results demonstrate improvement, the factors for such improvement are investigated so that they can be better understood through the analysis of the processes that occurred in the target practice situation. Then some of these findings are taken up to constitute the basis of learning theories that will be tested in other situations, with other students, for different subjects or learning goals. Current learning studies are often conducted in this manner. Because the methods used differ from the more traditional hypothesis-testing style, these studies are sometimes called "design studies" (Brown, 1992; Collins, 1992). The validity, and the effectiveness, of such design studies have been examined vigorously[3], and reports that summarize the consensus about the supporting methods are emerging (Engle & Conant, 2002).

One conspicuous feature of the above list is the emphasis on collaborative aspects of learning. In the real world, successful learning comes from communities, where motivation for learning can be socially nurtured, the mid- to long-term practice can be socially sustained, and the outcome of learning depends on and is fed into the structuring

[3] For example, a special issue of *Journal of the Learning Sciences* (2004, volume 13 issue 1) was devoted to design-based research.

and re-structuring of the community itself. Many of the learning science studies have thus focused on understanding the basic mechanisms of collaboration, and on how to take advantage of it to design and evaluate successful learning.

THEORETICAL FRAMEWORK FOR COLLABORATIVE LEARNING

Collaboration has been a topic of research for many years in different disciplines. At around the onset of CSCL (computer supported collaborative learning) and the learning sciences, some micro-genetic studies were tried out to understand the mechanisms of why some interactions worked out constructively for participating members (e.g., Miyake, 1986). Social psychological studies have a long history of studying the effects of pairs and small groups on puzzles and real world tasks (e.g., Hastie, 1986). Cognitive anthropologists have been studying naturally occurring everyday learning which are fundamentally collaborative (e.g., Hutchins, 1995). In this section, we will compare two micro-genetic analyses of the mechanisms of collaboration, in order to clarify the assumptions we take as the basis for our own studies.

Convergence Theory of Collaborative Learning

One of the most popular explanations of the effectiveness of collaboration is the "theory of convergence" (e.g., Roschelle, 1992). According to this theory, in a collaborative learning situation with multiple participants, various expressions are provided through speech, gestures, drawings, and so on, from multiple viewpoints. When the reflective process is applied to these, convergence activities (i.e., activities to summarize various viewpoints) are required and, as a result, an abstraction of solutions occurs. When conversations are carried on further, the level of abstraction and the standard of self evaluation rise and metacognition of a higher level is called for (for concrete examples of student conversations and analyses, see studies cited by Roschelle, 1992).

Constructive Interaction as a Mechanism for Collaborative Learning

Although the convergence theory is appealing, it does not explain why convergence is required when there are multiple expressions from multiple viewpoints. In order to answer this question, Miyake and her colleagues focused on individuals to understand the integrated effects of collaboration, while keeping the basic scope of analyses on the pair. In one of their studies, the task was to color the area of 2/3 of 3/4 of a piece of square paper (Shirouzu, Miyake, & Masukawa, 2002). This task can be correctly executed either by calculation and coloring, or by folding or marking the paper to get the area to color. People strongly prefer the latter, which relies on external resources, when solving this problem. In various conditions with different sizes and types of materials tested, less than 10% of the participants calculated the answer. When this task was followed by another task which asked for coloring 3/4 of 2/3 of the area (note that the order of the fractions was exchanged but that was the only difference), solo participants tended to use the same solution as they had used on the first task, but paired participants changed their approach

60% of the time to calculation. Thus, the collaborating pairs tended to shift their approach to the solution from one that was externally oriented and more concrete, to one that was internally oriented and more abstract.

When the individual contributions were analyzed in these "shifted" pairs, it became clear that while one person solved the task, the other person monitored the solution from a somewhat more abstract perspective and this "monitoring of the other's task-doing from an abstract viewpoint" appeared to be responsible for the shift. This role division of monitoring and task-doing alternated between the participants during the course of their interaction, giving each participant a chance to elevate his or her own reflective processes during the joint problem solving trials (Shirouzu et al., 2002).

This mechanism offers an explanation as to why there can be different learning outcomes for paired learners, because the abstraction level for each participant depends on the degree of integration of the shared task-doing and monitoring. This explanation has been confirmed in a study conducted in a small classroom with six children, where the second author acted as a teacher-researcher to teach the six 6th graders the commutative law of multiplication using the above-mentioned paper coloring task (Shirouzu, 2004). In the 45-minute class, all six students gained satisfactory understanding of the arithmetic law taught. However, when their recollection was examined 5 months later, there was a clear correlation between the amount and the quality of their verbalization observed during the class and what they could subsequently recall and describe (i.e., 5 months later).

These results, in conjunction with the role-exchange model described above imply that for the design of effective collaborative learning, it is important to encourage role exchange and to secure ample opportunities for each individual learner to both externalize the initial thoughts and to reflect upon the shared externalization. In the following sections, we report on a series of university level educational research studies conducted in our laboratory, to further examine and refine these assumptions.

TEACHING COGNITIVE SCIENCE THROUGH COLLABORATIVE REFLECTION

We have been developing and testing a collaborative undergraduate curriculum to teach cognitive science for nearly 7 years (Miyake, 2005a, 2005b; Miyake & Shirouzu, 2004; Miyake, Shirouzu, & Chukyo Learning Science Group, 2005). The learning objective is broad because we believe knowledge about cognitive science has pragmatic value for most of what we do in our everyday lives. Cognitive science explains how people solve problems, make judgments, memorize events and schematize them, and create new ideas. Knowing how people engage in such cognitive processes, with the associated strengths and weaknesses, helps in the development of a reflective, metacognitive viewpoint which can be utilized in the everyday practice of cognition.

Overall Description of Our Curriculum and Classroom Activities

The curriculum described here is for undergraduate students and covers two semesters per year for the first two years, taking four years to complete. In the first year, hands-on experiences of simple cognitive tasks are completed and analyzed by the students, first individually and then collectively, in the class. During their second year, these experience-based techniques are gradually meshed into reading activities of technical materials to help students gain a deeper level of comprehension as well as to grasp the breadth of research in cognitive science. In the third to fourth years they are encouraged to engage in more inquiry-oriented, project-based learning, leading to their thesis research.

Throughout the curriculum, we use the jigsaw method. A social psychologist, E. Aronson, devised this method in order to facilitate cultural merging in classrooms (Aronson & Patnoe, 1996). In his original design, a text may be divided into six parts and read by six members, each of whom is responsible for different parts. They then get together to answer questions covering all six parts which require their equal participation to correctly answer. This produces a natural setting to explain what one understands to others, often motivating students to further examine their assigned parts. In our curriculum, students are introduced to a simple jigsaw of two to three parts, gradually moving on to a more structured and dynamic jigsaw that covers twenty to thirty research findings.

Technological Scaffolds and Evaluation Materials

We use information technology as scaffolds for learning extensively for two purposes. One is implemented through a concept mapping tool to help students externalize their initial ideas easily so that they can engage in more productive interaction from the beginning. The other purpose is mainly to keep good records of their developing thoughts in the forms of voice recording, notes and comments written about their learning materials, and computer logs of their use of the concept mapping tool. Throughout the duration of the course, the records are accumulated and become a shareable knowledge base, both for the students and the teaching and research team members. We are currently expanding the system's capability to handle video materials of the classes and of experiments, which both researchers and students can use for reflective purposes.

Such records are constantly examined for formative evaluation. We also interview the students 6 months to 1 year after the end of the classes. During such retrospective interviews, we have found that students sometimes come to realize new aspects or structures of their learned materials. These data suggest that the learning involved is a spontaneous, long-lasting process, the outcomes of which we do not yet have a satisfactory cognitive method to evaluate.

STUDY 1: A CASE OF LEARNING ABOUT SEMANTIC MEMORY REPRESENTATION

In this section, we present one of our approaches conducted in 2000, in which students learned the basic constructs of human memory, as an illustrative case of a beginning collaborative class. Seventy-eight students in this class gradually analyzed research findings on "semantic network representation"[4] using the jigsaw method, and integrated the outcomes with a previous task of analyzing data taken from a classic psychology experiment.

Sequence of Class Activities

In three 90-minute classes of "Cognitive Science & Experimental Design," we required the sophomores to learn information provided in three sections about memory from a standard textbook (Anderson, 1980): "Elaborations and their network representations," "Depth of processing," and "Inferential reconstruction in recall." Prior to these sessions, the students had spent five weeks analyzing data created for the class to grasp the main results of a research study reported by Bransford and Johnson (1972).

In the first class, we introduced the three textbook sections about memory. The 78 students in the class were divided into three groups, and each student read one of the three sections. Three students who read different sections then convened to share their understanding of the reading (the first "jigsaw").

In the second class, the students were again divided into three groups to work in separate rooms, to become "experts" in their assigned sections. The students worked with teaching assistants (TAs) in small groups to answer questions about the hypotheses, experimental designs, results, and implications of the studies in the assigned section. Then they practiced summarizing the section by paraphrasing the summary given in the textbook using their own words.

In the third and final class, the students assembled in one room to share their sections, again using the jigsaw method (the second "jigsaw"). They were asked to integrate the main points of all the sections in order to answer the question, "What is memory and how does it work?" To conclude, they were asked to reconsider the measures they had used to analyze the Bransford and Johnson data.

Observed Learning Processes

At the end of the first class (the first "jigsaw"), half of the students stated that they did not understand the material. This motivated them to explore further. In the second class, during which they worked in "expert" groups, they were observed to actively reconstruct semantic networks and extract experimental results from the texts. During the second jigsaw (in the third class), they were able to use concrete examples more often than in the first class. When we analyzed the contents of their conversations, we found that 63% of the students could produce an accurate summary, mentioning that previous knowledge was used to construct networked knowledge to keep memory longer. The distribution of the identified statements are shown in Table 1.

At the end of the third class, the students were asked which aspect of memory they should focus more on in order to test how well a person memorizes something. Before the jigsaw, 62% of the students thought verbatim memory was more important. After the

[4] A semantic network is often used as a form of knowledge representation. It is a directed graph consisting of nodes which represent concepts and links representing semantic relationships between the concepts. Semantic networks are a common type of machine-readable dictionary.

Table 1. Identified Statements About the Functions of Memory in Students' Summaries

Elaboration facilitates recall	39%
Processing of meaning promotes elaboration	41%
Previous knowledge is used to reconstruct the networked knowledge for memory	63%

Table 2. Pre- and Post-jigsaw Comparison of the Students' Understanding of What Is Important in Memory

	Verbatim	Gist	Reconstruction
Pre-Jigsaw	62.0%	43.0%	3.8%
Post-Jigsaw	13.7%	68.6%	15.7%

jigsaw, this rate dropped to 13.7% , while the rate of students who thought reconstructed memory, even though it might be different in form to the original, could be semantically more accurate increased to 15.7%. The results are shown in Table 2.

By the end of the class, forty-two of the students (54%) referred to the functions of networked representation accurately. The post-jigsaw percentages in the "gist" and "reconstruction" categories were substantially higher than those observed in classes where traditional methods of teaching had been used.

When we interviewed 25 students six months later, they could still verbalize the main points or recreate them from memory. Overall, by utilizing collaborative and active reading of scientific materials, the students gained a lasting understanding of the main points, which could be used as a resource for later reconstruction.

STUDY 2: THE DYNAMIC JIGSAW: REPEATED EXPLANATION SUPPORT FOR COLLABORATIVE LEARNING OF COGNITIVE SCIENCE

Toward the end of their sophomore year, we introduce a more complex jigsaw which requires students to repeatedly articulate and revise their explanations of learning materials they are provided. The method we report here involves repeated, collaborative reading and explaining of short descriptions of basic research findings. This enables the students to draw general and abstract implications that are applicable to everyday cognitive tasks. Their collaborative activities are supported by a concept-mapping tool they can use through the Internet. Concept maps, term-reports, and protocols of the participants' exchanges and discussions have been recorded and analyzed to evaluate the course as well as to examine the micro-genetic patterns of the students' knowledge construction.

Curriculum Structure

Cognitive science covers many functions and mechanisms of cognition using multidisciplinary methodology. It is thus important to form an integrated view of research findings to understand its implications. To facilitate this integration process, we decompose the process into the following three steps.

Step 1. Comprehend many research findings in terms of their themes, evidential data, and conclusions.
Step 2. Form an initial or hypothetical "theory" to integrate the above research findings in terms of implications.
Step 3. Find possible applications of the theory so that they are usable in the future.

We have implemented these steps in a 13-class term for the sophomores in our study. The course involves collaborative understanding of 24 learning materials, each representing classic research in three different domains of cognitive science. The students collaboratively read, explain, exchange, and discuss the material to integrate it, in the hope of forming an abstracted view. Specifically, we use a method we call the dynamic jigsaw. The dynamic jigsaw models common activities of real world researchers. Professional researchers take different responsibilities to study a common theme and exchange their findings so that each member could construct his/her own interpretation. They most often do this repeatedly, explaining their findings to different audiences so that they can examine them from different perspectives for different integration possibilities, to achieve coherent comprehension. The dynamic jigsaw models this process and requires each participating student to first become an expert of one of the learning materials as his/her core, then repeatedly explain the core to different audiences, receive others' explanations, and integrate these explanations with their own to form a new explanation to improve understanding.

Learning Materials

In the class in 2004, the participating students studied some 24 technical texts or "research reports." Each text was taken from cognitive science textbooks to convey one research theme in 24 topic areas and was rewritten by us (from the original text) to fit onto two pages for ease of reading. The 24 topic areas were categorized into three domains: (1) language acquisition and developmental studies, (2) interactive features of knowledge processing, and (3) social and cultural biases in cognition. Each domain consisted of eight texts.

To illustrate, we provide concrete examples of some of the contents. In 2004, in the third domain, "Social and cultural biases in cognition," there were eight texts numbered 17 to 24 covering different research reports. Two reports in each pair, even and odd numbered texts, were relatively closely related: for example, No. 17 was on confirmation bias and No. 18 was about epistemic egocentrism. The reports were on typical biases human beings exhibit in problem solving, so by integrating them, it was possible to better understand biases in general. Two adjacent pairs of texts, like [17, 18] and [19, 20], formed a "half domain" representing a sub-topic area in the domain, and so on. Table 3 shows the structure of the dynamic activities across the 10 weeks of the 2004 class, and

Table 3. The Dynamic Jigsaw Curriculum

Task/objective	Time allocation
Assignment of the core	First week
Becoming "experts" of the assigned core	2nd to 5th weeks
Integrating adjacent text to the core (1 by 1)	6th week
Two by two exchange to integrate half domain	7th week
Four by four exchange to integrate a domain	8th week
Cross domain jigsaw (eight by eight) I	9th week
Cross domain jigsaw (eight by eight) II	10th week

the explanations of the phases follow.

Becoming an expert: During the weeks devoted to this, the students reading the same text studied it together by answering questions posed on a wiki[5] to help them comprehend the structural elements of the text. The answers were then transferred onto a concept mapping tool called ReCoNote (Reflective Collaboration Note) for ease of externalization and sharing. During this phase, the students were encouraged to ask questions as well as to give a practice explanation to a TA or an instructor.

First pairing: While they prepared the initial concept map of their cores, they were also encouraged to practice sharing/exchanging their explanations with members of a group working on the "paired" text, and relate the others' explanations to their core, to form an integrated understanding of the pairs (such as 17 and 18, or 19 and 20). After these activities, the maps, contributed by the entire class and covering all 24 research reports were kept on the web for sharing and modifying, both in and outside of class. By the end of this phase, all the students were expected to know, and be able to explain, at least two research descriptions.

Dynamic expansion of the jigsaw: When the students were ready to explain the core-based pair of texts, they began to exchange their explanations with neighboring pairs. At the end of this phase, each student was expected to know four texts, two of his/her own plus two more explained by another student, to cover a half domain. In the next phase, a student was then required to exchange explanations of the four texts he/she had integrated with another student's four texts, to cover eight texts of the domain containing his/her core. By the end of this, each student was an "expert" with regard to eight texts in one of the domains. Toward the end of the term, such domain experts were grouped in pairs to share/exchange explanations of the domains. The class was 90 minute long, and met once

[5] A *wiki* is a type of website that allows users to easily add, remove, or edit all content, very quickly and easily, sometimes without the need for registration. This ease of interaction and operation makes a wiki an effective tool for collaborative writing. It was first created in 1994 and now used worldwide.

a week for the first eight weeks, and twice a week in the last two weeks.

Outcome Measures

For this class, the students' final concept maps as well as their term papers were used as measures of their course performance using three indices. One index was the degree of integration or structural coherence of the final concept maps the students created after the course, before the deadline of the term papers. The maps were categorized into four groups according to their structural coherence and given scores ranging from 1 to 4, with 4 indicating the highest coherence. Another index was taken from the term papers. It measured the conciseness and the correctness of the descriptions of the research findings they reported. The final index, also measured using the term papers, was the relationship between the implications they drew from what they had learned and their descriptions of possible usage in everyday life. We called this measure "extendibility."

Major Outcomes

We found that the integrity measures of the concept maps were generally high. Forty-two percent of the final concept maps were categorized as achieving high integrity, close to the performance of novice graduate students.

All 24 learning materials were covered in 83% of the term papers, out of which 56% were deemed as being "concise descriptions" with the necessary components in an expected order. This indicated that the majority of the students had learned both the basic contents of the learning materials as well as how to provide concise summaries.

The extendibility measure, or the degree to which the students could connect what they had learned to their daily experiences, was found to be positively correlated with the quality of the concept maps ($r = .44$, $p < .05$, for a randomly selected group of 22 students), suggesting that the learning activity of externalizing their integration efforts had a positive effect of guiding their thinking toward applications of what they had learned.

The protocol analysis of the students' conversations during the class revealed that the students' explanations became more concise in terms of both the amount of time used and the content covered. To take three students as a representative example: their first explanation of one research paper took 400 to 500 utterances on average, which decreased to 20 to 30 utterances toward the end of the term, without losing any necessary components. Their first explanation attempts were closer in wording to the texts of the learning materials than their later explanations, yet the first explanations involved more incorrect, vague, or confused statements. Such confusions about the meanings of the learning materials tended to be resolved during the discussions that occurred while the students were integrating their materials with those of other students.

We also found some cases where the students, in their junior years, talked about their experiences of the dynamic jigsaw as a source of acquiring various research skills (e.g., taking notes, writing reports, and questioning) (see Miyake, 2005a). These are encouraging signs for further exploration of the conditions that make collaborative learning situations more productive and beneficial to those who participate in them.

DISCUSSION

Collaborative learning activities, we propose, have a high potential for changing the quality of learning that occurs at college level educational settings. As we have shown so far, a simple scheme like the jigsaw creates an environment in which each student becomes an independent agent who constructs her/his own knowledge by carefully examining and explaining his/her learning materials (assigned on the basis of the students' expressed preferences) to others. New technology, which makes this examination and explanation easier by providing tools for students to keep good record of their processes, greatly enhances the chances of this change occurring.

We have listed in the earlier part of this paper some newly defined learning outcomes we wish to pursue. The list includes a base knowledge for adaptive expertise, conceptually oriented understanding of the learning materials, and the skills for self-directed learning, as well as the ability to learn and work collaboratively. The dynamic jigsaw has been our tentative answer to approaching these learning goals. Through their discussion of the learning materials with classmates, we have observed that students, particularly toward the end of their second year, engage in intensive reflection about each other's understanding of the course materials. Students often report to us, after completing this 2-year course, that they feel they gain skills to more effectively listen to others, and question others when necessary. In their third year, we have often observed students from our curriculum getting together to prepare reports for their classes. We also hear from our students that they feel confident in our classes to explain their ideas to others and to ask questions, but that they do not feel the same degree of confidence in other classes with different atmospheres. We therefore receive both positive and negative pieces of evidence like these, drawing us back to detailed analyses of the learning processes of the students so that we can identify which factors interact to support which learning. We are starting to understand how it may be possible to create a new "community for learners." Our current hope is to go a bit further, to specify exactly how we might be able to help students to design a learning environment on their own, outside of the educational institution environment, so that they can create their own "community of learners" whenever necessary, at places they choose.

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