

Engaging Secondary Mathematics Teachers in Collaborative Instruction:  
An Adaptation of Japanese Lesson Study in the U.S.

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Introduction

U.S. teachers frequently experience a sense of isolation in their professional lives in schools (DuFour, 1999; Rogers & Babinski, 1999; National Council of Teachers of Mathematics (NCTM), 2000). This routine of school life prevents teachers from engaging in collegial relationships with other teachers; for example, sharing, discussing, reflecting and planning with colleagues (Cochran-Smith & Lytle, 1993; Hyde, Ormiston & Hyde, 1994; Little, 1987). Efforts are being made to transform this common culture of teachers from one of isolation and individualism to one of professional community. As part of this effort, educators have examined cultures of teaching and teacher professional development outside of the U.S., and many teachers and providers of professional development have become interested in Lesson Study, a form of professional development typically used in Japanese elementary schools (Stigler & Hiebert, 1998).

In Japan, *research lesson* or *study lesson* refers to lessons that teachers jointly plan, observe and discuss. The same two words in reverse order, *lesson research* or *lesson study*, refer to an instructional improvement process of which the research lesson is the heart (Lewis, 2000). When a Japanese school engages in *Lesson Study*, teachers form *Lesson Study Groups* (LSGs). The entire school has a general theme for the Lesson Study and each of these LSG develops a lesson that relates to that theme. These study lessons are then taught in regular classrooms. An implemented lesson is observed by many teachers in the school and is followed by a discussion of the lesson with the planning group. [See Lewis, 2000 for an extended discussion of LSGs and the process of Lesson Study.] LSGs engage in cycles of planning, implementation, reflection, and revision that ultimately result in public sharing and dissemination of lesson materials. This process leads to gradual, incremental improvement in teaching and learning over time. Not only do individual teachers improve their techniques, but the teaching profession as a whole benefits as carefully researched and developed lessons are shared and accumulate over time.

Characteristics of Lesson Study that may contribute to its usefulness as a tool for improvement of teaching and learning include; (1) viewing the improvement of teaching as a long-term, incremental process, (2) focusing on student thinking and student learning, (3) examining teaching as it occurs in the classroom (in its full complexity), and (4) engaging teachers in working with other teachers to develop knowledge about teaching for themselves and for the professional community as a whole (Stigler & Hiebert, 1999). These characteristics of Lesson Study stand in sharp contrast to those of traditional professional development activities in the U.S. that tend to separate the

working of teaching, the work of learning about teaching, and the work developing new teaching methods and materials.

Lesson Study is an integral part of the culture of teaching in Japan and cannot simply be imported into U.S. schools with expectations of results similar to those found in Japan. We believe, however, that the principles and processes of Lesson Study may be adapted in the U.S. in ways that help shift the culture of teaching away from individualism and isolation and toward a more collaborative, professional community. The remainder of this paper discusses a professional development project designed to adapt Lesson Study in one U.S. school district. The primary purpose of the project is to build a more collaborative community of secondary mathematics teachers engaged in improving mathematics teaching and learning in their classrooms. Additionally, the project seeks to support the development of a partnership between mathematics teachers and university mathematicians and mathematics educators. In the sections that follow, we first describe the activities of the project and highlight the issues that were confronted over the past three years. We then describe several ways in which we have studied the activities of the participants and address issues that we confronted when trying to understand what this adaptation of Lesson Study has been and what it has accomplished. Our descriptions are grounded in not only our own participation in project activities but also analysis of transcripts of audio and video tapes of these activities and of artifacts such as lesson plans and communication that was web-based. We intend this description of both activities and research to provide a basis for critical discussion of the difficulty of studying professional development that is embedded in the work of teachers and that takes place in diverse settings and activities.

### Collaboration for the Enhancement of Mathematics Instruction (CEMI)

The Collaboration for Enhancing Mathematics Instruction (CEMI), funded by Lucent Technologies Foundation has engaged in the process of adapting Lesson Study with a group of secondary mathematics teachers in the United States since the fall of 2000 and continues today. It is the goal of the CEMI project to adapt the Japan lesson study model for several purposes, including the professional development of project participants and bringing together people with diverse perspectives (secondary mathematics in-service teachers, secondary mathematics pre-service teachers, mathematics teacher educators, university mathematicians) who share the common goal of providing secondary students with quality mathematics education. The research component of the project seeks to understand these activities and their impact on the participants and the participants' classroom teaching. We have not yet gone the extra step to trying to understand how this impacts student learning. The following description of the CEMI project activities and issues is organized into two time periods: (1) Year 1 and 2 (Fall 2000 – Spring 2002), and (2) Year 3 (Summer 2002 – Present).

#### *The First Two Years of the CEMI Project*

*Activities during 2000-01.* In the fall of 2000, prior to beginning lesson study, project participants engaged in activities designed to acquaint them with various perspectives on

mathematics teaching and learning and professional development. Foci included *Principles and Standards for School Mathematics* (NCTM, 2000), Lesson Study in Japan (Lewis & Tsuchida, 1998), and the Mathematical Task Framework (Stein, Grover, & Henningsen, 1996). Participants also learned to use various tools available on the Inquiry Learning Forum (ILF) website (<http://ilf.crlt.indiana.edu>) such as a document builder and a discussion forum. Next, discussion groups were formed with each group consisting of a high school mathematics teacher, a university mathematician or instructor (a graduate level mathematics student), a mathematics educator, and several pre-service teachers (two to four per discussion group). Each discussion group member was asked to view a multimedia case of mathematics instruction (*Making Weighty Decisions* (Bowers, Doerr, Masingila, & McClain, 2000)) individually and then engage in face-to-face and online discussions. The primary goal of this activity was to help participants understand each other's perspectives on mathematics teaching and learning, and further develop their abilities to communicate with each other, prior to beginning collaborative lesson planning (the first stage in lesson study). The discussions occurred over a five-week period and included two face-to-face meetings.

After this period of establishing some understanding of each other's views of mathematics teaching and learning, participants were assigned to the six Lesson Study Groups (LSGs) that would work together throughout the rest of the fall semester. Each LSG contained at least one of each of the following types of people: secondary mathematics teachers, university mathematicians, university mathematics teacher educators, and pre-service secondary mathematics teachers. Each LSG determined the topic it would address and set its own meeting schedule and interactions took place both face-to-face and online on the ILF. Groups focused on developing one or two lessons on a very specific mathematics topic, such as angles formed by two parallel lines and a transversal. We hoped that each LSG would be able to pass through the five phases – planning, implementation, reflecting and revising, re-teaching, and dissemination of the lesson plan – during the fall semester. However, for various reasons, including time limitations, some of the LSGs did not re-teach the lesson and no lesson plans were formally disseminated, although plans are available online.

CEMI supported three LSGs in the spring of 2001. In an initial whole-group meeting, project participants agreed that lessons planned by LSGs that semester should embody “Communication and Connections” as discussed in the NCTM’s *Principles and Standards* (NCTM, 2000). By having this overarching goal, participants hoped that all lessons could be critiqued with respect to a common goal. Each LSG was charged with developing at least one lesson collaboratively, teaching the lesson, revising the lesson, teaching the lesson again, and revising the lesson again. LSGs consisted of two teachers (one LSG had one teacher), one or two mathematicians, one to three mathematics teacher educators (some mathematics education faculty and some mathematics education doctoral students), and one or two pre-service teachers. Although there was an overarching theme, each group selected a specific topic to teach, for example “introduction to geometric sequences.” At the end of the spring semester, after each group had completed a lesson study cycle, LSG members met as a whole group and shared their lesson plans and reflections on the lessons.

During the summer of 2001, it was hoped that LSG members would work together to create a summary of their lesson studies that could be made available on the ILF. Although several teachers and others expressed interest in doing so, no LSG made progress toward this goal. One pair of teachers intended to present the lessons their LSG developed during the spring at a state conference in the fall and spent some time in the summer preparing a PowerPoint presentation on these lessons. Two new teachers joined CEMI and formed the core of a LSG that worked through the summer, preparing lessons to be taught the following fall.

*Activities during AY2001 - 02.* LSG group work continued during the fall semester of 2001. Several new members (teachers and mathematics education graduate students, primarily) were added and groups reconfigured according to individual interests and teachers' teaching assignments. LSGs determined their own goals for the first semester and most focused on planning a lesson or series of lesson on a traditionally problematic topic. No overarching theme was adopted. During this semester, the mathematics educators (professors and graduate students) examined data on the lesson studies conducted to that point and became concerned about the nature of the lessons planned and the level of reflection and critique that LSGs were able to achieve. While critical reflection is an integral component of lesson study in Japan, it is not commonly a part of the practice of teaching in the U.S. The project leader raised the issue in a whole-group meeting near the end of the semester and suggested that it might be useful to temporarily suspend LSG activities in order to read and discuss books related to important issues in mathematics education and to try to understand what makes lesson study useful in Japan. Project participants voiced support for the idea and agreed that they were somewhat dissatisfied with the quality of their lessons and their reflection on the lessons.

Thus, rather than meeting in their individual LSGs in the Spring of 2002, CEMI participants met five times as a whole group to discuss three books (agreed upon by the participants): *Beyond Formulas in Mathematics Teaching and Learning* (Chazan, 2000), *The Learning Gap* (Stevenson & Stigler, 1992), and *The Teaching Gap* (Stigler & Hiebert, 1999). Discussion of the books also took place on line using the discussion forum available on the Inquiry Learning Forum (ILF). Typically, participants discussed a portion of a book on the ILF discussion forum for 2 or 3 weeks before having a face-to-face discussion.

*Issues from Years 1 and 2.* A number of issues emerged as project leaders reviewed the CEMI activities of Years 1 and 2. Our description of the issues is quite superficial here, although some of the issues have been systematically analyzed in the research we describe later. The issues seem to cluster around three themes: participation in collaboration; communication; and faithfulness to Lesson Study.

The CEMI project aims at creating a university-school collaboration for the improvement of mathematics teaching and learning. Along with this goal, the project coordinators believe that building community is an important product of the project. By the end of year two, collaborations among project participants were beginning to develop and we

found evidence that “communities of practice” (Wenger, 1998) might evolve out of the LSG work (specific findings are discussed in the Research section of this paper). However, we had hoped that these collaborations would include faculty and graduate students from the Mathematics Department as well as from the School of Education. Although three professors and several graduate students from Math participated fairly regularly during the first year, there was almost no participation during year two. Additionally, sustaining participation by preservice teachers, aside from participation required by a course, proved difficult. At the end of year two, although teachers believed that participation in CEMI would benefit their colleagues, they were divided in their opinions about whether the addition of new teachers at that point in the project would be good for the current participants. Because the approximately ten teachers who had regularly participated had developed trust and ways of working together with which they were comfortable, they struggled with the pros and cons of introducing new participants. (Ultimately it was decided that the proposal for the project had promised new participants each year and so it was necessary to recruit additional teachers.)

Communication is one of the key factors in collaboration; therefore CEMI tries to benefit from all available mediums that facilitate communication. As noted earlier, the CEMI project was supported in a variety of ways by the Inquiry Learning Form (ILF) an NSF-funded project with a web site with which our project participants could communicate and work on-line. Support from the ILF allowed us to integrate computer and Internet technologies into the project. Project participants made use of the ILF to help them communicate with each other more frequently than face-to-face meetings would allow, and also as a means of sharing work with each other and making their work available to other LSGs. As part of their LSG work during year 1 and 2, groups developed their lessons on the ILF web site collaboratively using a document building tool available there. The teachers implemented the lessons in their classrooms, and those implementations were recorded by audio- and videotapes. Lessons from years 1 and 2 are compiled in a “library” consisting of video- and audiotapes of the implementations of the lesson plans and the transcripts of the implementation. These are available on the CEMI website and are accessible by all CEMI participants. We plan to publish the lesson plans on the ILF website to disseminate the project products with the greater education community, but this effort is moving much more slowly than was anticipated. Communication with other teachers did not seem to be a high priority for CEMI participants.

CEMI participants had anticipated that adapting the Japanese form of Lesson Study to the U.S. would be difficult because of the cultural differences in society and more specifically in education. There were at least two critical aspects of Lesson Study that participants, particularly teachers, found difficult. First, the effort expended on the planning and teaching of one or two lessons seemed excessive to participants. Although they agreed that the lessons taught were better than they would have been without the collaborative effort, teachers wondered how this might help their teaching more broadly. Secondly, no LSG had non-LSG members observe and critique their lessons and most groups had difficulty even getting other LSG members to observe and debrief on the lessons taught.

### *The Third Year of CEMI*

In the spring of 2002, Lucent Technologies Foundation sponsored a meeting of project directors to help the Foundation consider how it might best spend its limited funds. The meeting was facilitated by two women from the National School Reform Faculty (NSRF) and the CEMI project director (Brown) was impressed with the facilitation and since NSRF activities are administered from Bloomington, she began to investigate how NSRF might help facilitate CEMI activities and help us address the issues raised in the first two years.

The third year of the project began in June of 2002 with a meeting of most participants to reflect on the first two years of the project and to consider having facilitation of the third year activities provided by Daniel Baron, co-director of the National School Reform Faculty. Baron could guide us in the use of practices and protocols developed by the NSRF (for more information about the NSRF and related activities, see their web site <http://www.nsrffharmony.org/>) for use in Critical Friends Groups (CFGs). CFGs, like LSGs, work collaboratively to improve student learning in schools. (For more information on the work of CFGs, see the NSRF website.) At this meeting, Baron demonstrated the power of protocols by guiding participants through a process by which the group provided feedback on a lesson plan developed by an LSG in the fall of 2001. He then facilitated a discussion on the needs of CEMI and how he might help us meet those needs. CEMI participants later agreed that it would be useful to have Daniel and another CFG coach facilitate our meetings and guide our work together. We were struck by how similar the goals and practices of CFGs and Japanese LSGs were.

During this summer, like other summers, participants expressed intentions to create a form of their work that could be “published” on the ILF. Some progress was made, but no group completed this phase of our version of lesson study.

### *Fall 2002-Present.*

The number of teachers participating in the third year of CEMI was up from 10 to about 20, approximately 50% of the secondary math teachers in the district. Participants agreed to meet regularly from 4 to 5:30 on the first and third Wednesdays of each month. The fall semester was spent determining the topics on which LSGs would work and developing plans for that work. The facilitator used CFG protocols to structure the participants’ interactions and focus their work. Three LSGs were formed around three topics that were much broader than those previously selected: integrating technology; integrating multiple representations; and mathematical proof. Bi-weekly meetings included using various protocols to help LSGs set goals and develop plans to achieve those goals. Protocols were also used during meetings to help the entire group learn to talk productively when discussing broad, complex issues about the teaching and learning of mathematics. The protocols were used not only to assist the participants to move forward on the lesson study agenda, but also to provide them with new ways to encourage constructive dialogue in their own classrooms. For example, “Chalk Talk” is an activity

in which participants carry on a discussion using only writing – no talking is allowed. On a chalk/white board or on newsprint, an essential question or issue is presented (e.g., What are the essential components of an effective mathematics lesson?) and participants write their responses to this and to other participants' comments. The "discussion" is over when the writing ceases. CEMI participants did this activity and then the Proof LSG members used this method to get their students discussing "What is the role of proof in mathematics?"

Early in the second semester, each LSG was provided an entire meeting to share and receive feedback on their goals and plans to meet their goals. Facilitated by Baron, these meetings helped each LSG "tune" its goals and plans before implementing them, and also provided an opportunity for other participants to learn from that LSG's work. Subsequent meetings have continued to help participants learn additional interaction protocols but also provided time for LSGs to work. It appears that most LSGs are also meeting regularly on the Wednesdays that CEMI does not meeting and that considerable progress is being made in planning lessons and the rest of the LSG process.

### *Addressing Year 1-2 Issues and Issues new to Year 3.*

In Year 3, there appear to have been some significant changes in CEMI related to the issues that had emerged in the first two years: collaboration; communication; and faithfulness to Lesson Study, although we have provided little detail in the description above to allow the reader to understand the subtleties of the changes. On the other hand, some things have not changed.

There has been no participation from the mathematics department and little from preservice teachers during the third year, but also little attempt to encourage participation from these groups. Perhaps CEMI was trying to do too much for too many. A stronger collaboration among teachers and mathematics educators has developed, with much more leadership from teachers than before. The members of LSGs meet almost weekly and are spending considerable time observing and critiquing each other's lessons. Some participants have commented that the themes of the LSGs are broader and thus all members sense that they are benefiting from the lessons being developed. Lessons that embody general principles and pedagogies are the goals, whereas early lesson studies resulted in lessons that might only be taught once a year, or not again by LSG members.

The quality of face-to-face communication has been improved by the facilitators' structuring of CEMI meeting times. Participants are learning to talk with each other about difficult issues. The use of technology for communication varies from LSG to LSG. Some LSGs are using the ILF for document building and for electronic communication; others have done very little on line except sending informational e-mails. Interestingly, all of the LSGs had a goal of communicating what they learn to other teachers. For example, the proof group is hopeful that they can create a conversation with all mathematics teachers in the district about the role of proof in the secondary curriculum. The multiple representation and technology groups plan to create guides for teachers who want to improve these aspects of their instruction.

Do CEMI participants feel they are closer to what the Japanese do in Lesson Study? Are the CEMI LSGs doing Lesson Study? There are striking similarities to the kinds of activities that the Critical Friends Groups of the National School Reform Faculty and what Japanese teachers do in Lesson Study. It appears that the NSRF protocols are teaching CEMI participants to do what Japanese teachers learn in teacher education and from their teacher colleagues. CEMI leadership has noted that every LSG seems to have drawn much more on research than in previous years. Participants have looked carefully at state standards and NCTM documents, but also at articles in research journals and practitioner journals, in order to establish their goals and their action plans. Teachers in particular, seem grateful for the excuse to actually examine some of what research might tell them about practice. There were some complaints during the first semester that things were moving too slowly, and in fact a couple teachers stopped participating. However, participants note now that they have a much greater sense of their purpose and also a feeling of informed action than they had in the past.

The previous sections provide some sense of the activities and issues of CEMI during its three years of existence. We now shift gears and discuss some of the research we have conducted in hopes of understanding what is actually happening in LSGs and how it is impacting teachers and their teaching.

### Research on CEMI

The research component of the CEMI project seeks to understand the ways in which participants engage in and experience Lesson Study, the influence of supporting activities (e.g., discussions of a multimedia case, book readings/discussions, the use of the critical friends protocols) on Lesson Study, and the impact of the various project components on participants and on the participants' classroom teaching. An enormous amount of data is available, including audio and/or video tape of each stage in the lesson study cycles of each LSG and of many of the whole-group meetings; transcripts of on-line discussions of the multi-media case and of the books and other work done on the ILF; and lesson plans and various other "artifacts" from the lesson study process.

Thus far, we have used several different, but we believe complementary, theoretical perspectives and frameworks for analyses of various segments of the CEMI data. In particular, we have considered the content and structure of the on-line and face-to-face discussions of the multimedia case and the nature of participant interaction during lesson study group meetings and book discussions. In this section of the paper, we briefly describe these segments of our research and how it informs our current (Year 3) project work.

#### *Analyses of participants' discussions of a multimedia case*

Prior to engaging in lesson study, CEMI project participants viewed and discussed the multimedia case *Making Weighty Decisions* (Bowers, et al., 2000). The central components of the *Making Weighty Decisions* case are two related mathematical tasks:

the “sneaker problem” and “crime statistics problem”. The sneaker problem involves students in developing criteria for purchasing sneakers, ranking the criteria in small groups and then aggregating the rankings of each group into a whole class ranking. The crime statistics problem involves using crime statistics to analyze data, rank data, aggregate ranked data and weight ranks. This multimedia CD was particularly useful as a basis for CEMI participant discussion of teaching and learning because it provided them with the opportunity to follow a lesson from planning and implementation to analysis of students’ work and teachers’ reflections.

Each of six discussion groups (consisting of secondary in-service and per-service mathematics teachers, university mathematicians, and mathematics teacher educators) engaged in two online discussions. The first discussion lasted two weeks (from 09/11/2000 to 09/25/2000) and then members met face-to-face to discuss the CD for approximately one hour. Next, another three-week online discussion took place (from 09/25/2000 to 10/16/2000). Finally, a second face-to-face meeting provided an opportunity for the participants to share their ideas.

The goal of the discussions was to encourage talk among the participants that was focused on mathematics teaching and learning. Since they had diverse backgrounds in teaching and learning mathematics, development of a way of talking about mathematics education among them was necessary. It was hypothesized that talking about teaching and learning would be an effective means of building a common language among the participants with diverse backgrounds-- mathematics teachers, pre-service mathematics teachers, university mathematicians and mathematics educators. Also, it was thought that on-line discussion opportunities could produce more discussions and have more participants be engaged in the discussions. In addition, on-line communication would attract more participation from the group members who do not participate well in face-to-face communication. On-line discussions took place within the Inquiry Learning Forum (ILF) (<http://ilf.crlt.indiana.edu>). The ILF, hosted at Indiana University, “is a web-based professional development tool designed to support a community of in-service and pre-service mathematics and science teachers creating, sharing, and improving inquiry-based pedagogical practices” (Barab, Makinster, Moore, Cunningham & the ILF Design Team, 2001, p. 3).

Seeking to understand how participants engaged in discussion around the multimedia case, we considered both what was discussed and how participants talked – that is, *which* participants talked about what, and when and how did they talk about it. To help us make sense of what was discussed, we used the Mathematical Task Framework (Stein, et al., 1996), which describes the evolution of tasks from their appearance in curriculum materials to their implementation by students in the classroom, to guide one of our analyses of discussions of the multimedia case. This framework provided us with a method for describing the activities represented in the multimedia case (results reported here); we could also use this framework to categorize the contributions of different participants (this piece of our work is yet to be completed). To help us further understand how different participants contributed to the discussion, we used discourse analysis methodologies to examine participation rates and types of speech acts during on-line

discussions (initial results reported here), and to consider differences in the nature of on-line versus face-to-face discussions (analysis is on-going).

We found that CEMI participants discussed issues related to the teaching and learning of mathematics that could fit into each of the components of the Math Task Framework (the task as represented in instructional materials, factors influencing how the teacher sets up the task in the classroom, the task as set up in the classroom, factors influencing student implementation, the task as implemented by students, and student learning outcomes) (Stein, et al., 1996). Participants discussed the extent to which the tasks were or were not real world and motivating for students, the degree to which the task matched the intended mathematics and the extent to which the mathematical learning goals seemed appropriate for these students. CEMI participants discussed teacher responsiveness versus planfulness, the ways in which this teacher put her knowledge of students to use in planning how to set up the task, and the length of task set up and whether or not the teacher focused on the mathematics enough during the set up. In terms of factors influencing implementation, participants reflected on their own instructional dispositions, specifically their uncomfortableness with students leaving the classroom with misconceptions or incomplete understandings and their desire to wrap things up for students at the end of the period. Participants also discussed students' beliefs about the nature of mathematics and their (students') low tolerance for uncertainty.

Discussion of task implementation focused on teacher-student and student-student interaction and the ways they support or inhibit student thinking. For example, the extent to which teachers should let students struggle, ways to intercede without telling students how to solve the problem, and how to manage group work so all students engage in thinking about the problem. Discussion of student learning focused on individual student understandings that did or did not appear on the CD, as well as general concerns over what counts as knowledge, what counts as evidence of knowledge, and what should be the goals of tasks such as these. Overall, the multimedia case did seem to stimulate discussion about many important aspects of planning, setting up, and implementing high-level mathematical tasks. Discussion of specific facets of the CD seemed to lead to more general discussions of these important issues.

In order to understand how individuals did or did not participate in the multimedia case discussions, we used computer mediated discourse analysis (CMDA) and examined both on-line and face-to-face discussions. Use of this discourse analysis methodology is also currently helping us to explore differences in patterns of interaction in on-line and face-to-face discussions. Computer-mediated discourse analysis (CMDA) is a discourse analysis method used to identify patterns of structure and meaning in language use in computer-mediated communication (Herring, 1996). CMDA utilizes various data analysis tools, including rate of participation and speech acts. Rate of participation includes counting the number of messages, sentences, and words said/posted by the individuals. Speech act is an utterance conceived as an act by which the speaker does something. Some of the frequently used speech acts are informative, inquire, neutral proposal, conclusion, confirm, qualify, directive, comment, and prompt (Francis & Hunston, 1992).

To analyze transcripts of the multimedia discussions, we used the exchange structure of Francis and Hunston (1992), originally developed by Sinclair and Coulthard (1975) for the analysis of classroom discourse. Exchange structures are sequences of speech acts (agree, inquire, inform, react, etc.) produced when individuals are engaging in conversation. The model was developed for face-to-face conversation, but has been applied to educational computer-mediated communication by Herring and Nix (1997).

Analysis using CMDA is on-going, but we can report some initial results here. The average numbers of messages per individual for the first and second on-line discussions were 3.81 and 2.50, respectively. Interestingly, in the first discussion, the average number of messages per mathematician (5.00 messages) was significantly higher than the average number for the entire population in discussion1 (3.81 messages). The mathematics educators posted only two messages during the first discussion (average= .67 messages), lowering the overall average for that discussion. Overall, participants were engaged in 678 speech acts throughout the online discussions. Speech act analyses indicate that generally the participants were informing each other, sharing their observations, and inquiring and commenting on their own statements as they discuss the multimedia case study. These results are consistent with the findings of Herring and Nix (1997) for a distance education course. However, unlike in Herring and Nix's study, the participants use very few directive speech acts, suggesting a relatively polite and egalitarian environment.

Our analyses revealed that males shared their observations more than females (45 to 31 times, respectively), but females asked more open-ended questions. Pre-service teachers shared their observations more than any other group (47 out of 76 times). This may be because as students they regularly prepare assignments including reflections, descriptions and observations.

Our initial results suggest that the on-line and face-to-face discussions of the case study promoted questioning, answering and informing among the participants. The initial findings included only qualitative representations of the data. We plan to accompany future qualitative reports with quantitative findings. Also, we plan to compare and contrast on-line and face-to-face discussions.

#### *Analyses of Participants Interaction Through Lesson Study*

Data used in these analyses was collected in the spring semester of 2001 and are data on one of three Lesson Study Groups (hereafter LSG1) active during that semester. In February 2001, all the teachers and mathematics educators participating in the CEMI project met to decide on an overarching theme for the semester's lesson studies. It was determined that every group would try to pay particular attention to those aspects of teaching and learning emphasized in the Connection and Communication standards of *Principles and Standards for School Mathematics* (NCTM, 2000). Each LSG was to determine the topic of its lesson study and the scheduling of both LSG meetings and the teaching. The members LSG1 were two in-service secondary mathematics teachers, two pre-service secondary mathematics teachers, one university mathematician, one mathematics education professor, and two mathematics education doctoral students.

LSG1 activities included four planning meetings, a lesson implementation (over two days with a reflection session after the first day) in one of the teacher's classrooms, a reflection/revision meeting, a second lesson implementation in the other teacher's classroom, another reflection/revision session, a sharing session with other CEMI LSGs, planning and presenting at a state conference, and online communication among members that occurred throughout the other activities. Although a wide range of data was produced and informed analysis, results presented here are based primarily upon a detailed analyses of LSG1's planning and reflection/revision meetings.

Thus far, we have analyzed CEMI participant lesson study work in two ways. First we used Tharp and Gallimore's (1988) characterization of "teaching as assisted performance" and the five characteristics of good assistance activities (Brown, Stein, & Forman, 1996) to consider the quality of lesson study as an assistance activity. Second, we looked at community development within one lesson study groups and used Wenger's (1998) indicators of "community of practice" to better understand the extent to which such communities can be developed through lesson study.

Tharp and Gallimore (1988) proposed a theory of teaching that they characterized as "teaching as assisted performance." As part of the framework, Tharp and Gallimore propose that learning occurs in *activity settings* and that those settings can form units of analysis that support deep understanding of the social context of assisted performance. They theorize that assisted performance does not occur randomly, nor do the activity settings that support assisted performance; instead, they argue, assisted performance only occurs in the context of goal-directed action. The following five characteristics of good assistance activities are suggested by Tharp and Gallimore's work and provide an organizational frame for our analysis: mutual respect and trust; intersubjectivity; responsiveness; joint projective activity; and reciprocity (Brown, et al., 1996). Our examination of the data for evidence of these characteristics revealed considerable information about the activities in which members of LSG1 participated and the potential for these activities to provide assistance to all of the members of the group.

For example, we found evidence of responsiveness in instances in which members would offer suggestions to the group for improvements in the lesson based on the actions, statements, or queries of other group members. With respect to joint productive activity, we found evidence that members did feel that they were engaged in working together on an authentic task. For instance, members spent a considerable amount of time talking about and working toward the creation of materials that they planned to "publish" online. We also found evidence of reciprocity, i.e. individuals both assisting and being assisted, in the LSG1 data. After the first lesson implementation, LSG1 members assisted the teacher in reflecting on the lesson, and then, after the other teacher implemented, the first teacher became the assistor. We found evidence of movement between these two roles in small segments of LSG1 conversations, as well.

Our second analysis of LSG1, an analysis of community development, was based upon Wenger's (1998) description of "communities of practice." Communities of practice are communities developed out of and defined by members' collective engagement in a joint

enterprise (Wenger 1998). It is through this engagement that meanings are negotiated and a shared repertoire of routines, words, tools, and ways of doing things are developed. Because communities of practice are typically informal structures, indicators that they have formed can be found in the ways members interact, rather than in formal statements or the attainment of specified goals. Some indicators that a community of practice has formed include: (1) shared ways of engaging in doing things, (2) the rapid flow of information among members, (3) the absence of introductory preambles, (4) the quick setup of a problem to be discussed, (5) knowing what others can contribute, (6) ability to assess the appropriateness of actions or products, (7) specific tools, representations, and other artifacts, (8) local lore, shared stories, and inside jokes, and (9) jargon and shortcuts to communication (Wenger, 1998). Using these indicators, we considered the extent to which the work of LSG1 has resulted, or could result, in the formation of a community of practice.

Indicators of community of practice, such as the lack of introductory preambles, the rapid flow of information among members, and the use of tools, and artifacts, were noticeably absent from the early meetings of LSG1, but were more prevalent in later meetings. During initial meetings, members spent time describing their individual interests and concerns with respect to teaching the chosen topic, various methods for organizing classroom activities, and the ways in which they felt they could contribute to the group. During later meetings, we found instances of members making use of artifacts from previous meetings, and moving more quickly into the joint enterprise. As the LSG1 meetings progressed, we also found evidence of members using shortcuts to communicate, or jargon, to refer to ideas discussed in detail during earlier meetings.

For this analysis, we also drew upon the notion of *pseudocommunity* (Grossman, Wineburg, & Woolworth, 2001). In pseudocommunities, individuals do not question or challenge each other. Speaking in generalities without negotiating meanings allows individuals to maintain a superficial level of agreement during conversations. Behaviors associated with pseudocommunity are expected when a group of individuals is first brought together; however, if true community is to form, then individuals must begin to press for clarification, raise alternative viewpoints, or in some way attempt to negotiate shared, collective, community-level meanings and modes of action. We found evidence across LSG1 meetings of members challenging one another. For example, LSG1 members engaged in a protracted debate about whether to allow students to use graph paper to divide shapes into fractional parts (students would then find the sum of the parts as a way to estimate the sum of an infinite series). They were willing to make statements that might put themselves in conflict with other group members for the sake of the joint enterprise. Such exchanges occurred not only in the planning phase but also after implementation, during the reflection/revision stage.

Overall, as we consider the activities of this LSG, we find not a community of practice, but a group of individuals engaged in a joint enterprise and beginning to develop a shared repertoire of words, tools, and ways of doing things. Identifying some precursors to the indicators of community of practice described by Wenger (1998), we would characterize this LSG as having the potential for community development.

## *Summary*

As previously stated, the research component of the CEMI project seeks to understand the ways in which participants engage in and experience Lesson Study, the influence of supporting activities (e.g., discussions of a multimedia case, book readings/discussions, the use of the critical friends protocols) on Lesson Study, and the impact of the various project components on participants and on the participants' classroom teaching.

Studying professional development that includes activities that are as diverse as those of the CEMI project requires research methods that are also diverse. Thus far we have attempted to use several and have segmented project activities into manageable chunks, such as the on-line discussions or the activities of a single LSG over a certain period of time. But have we really captured what teachers have learned? What do they do differently? Perhaps what is more important at this point is to understand how participants in the CEMI project, including the project staff, are learning to do lesson studies. Discourse analysis is a very micro-level analysis but it may provide us with insights into how teachers talk about mathematics teaching and learning and how that talk can be influenced. Our analysis of face-to-face and on-line discourse helps us understand this discourse better and consider ways of changing the discourse patterns. Examining an LSG's activities using sociocultural frameworks helps us look at the bigger picture of how LSG participants engage in activities and how these activities fit into their lives as teachers. There are many other analyses that need to be completed.

## Conclusion

As we noted in the beginning of this paper, the primary purpose of the CEMI project is to build a more collaborative community of secondary mathematics teachers engaged in improving mathematics teaching and learning in their classrooms. Additionally, the project seeks to support the development of a partnership between mathematics teachers and university mathematicians and mathematics educators. In Japan, the work of elementary teachers includes participating in Lesson Study. It is a part of the culture of teaching that they can not imagine being without. The activities and goals of Lesson Study are not part of the everyday work of U. S. teachers, particularly secondary teachers. As we continue to collect data and live through the third year of the CEMI project and analyze the data we have, we must also figure out what research methodologies and conceptual frameworks can help us understand if and how CEMI teachers are engaging in a form of Lesson Study that is useful to them and their students. Of equal importance will be understanding how participants have learned to do Lesson Study.

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