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AUTHOR Brett, Clare; And Others
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ABSTRACT

This paper reports preliminary findings from an ongoing longitudinal study of preservice teachers mathematical knowledge and confidence. The subgroup for this study consists of 11 preservice teachers from a group of 60 students enrolled in the 2-year teacher education pilot program at the Ontario Institute for Studies in Education (OISE), Toronto (Canada). The learning environment is designed to promote a sense of community and includes the following elements: small group discussions in which participants work on math investigations, workshops on cooperative learning techniques, experiences with collaborative learning in a variety of subject areas, and access to shared electronic databases which includes conferences of commentaries on mathematics. There is also a program-wide emphasis on constructivist approaches to learning, and students are introduced to a number of different technology-based and cognitively-oriented approaches to learning. The interpretive framework of community "glue factors" (identity, function, discourse, and shared values) is used to relate the data to the development of a learning community. The preliminary results suggest that the use of a shared electronic database facilitates a learning community for the majority of participants. The different participation patterns also suggest a need for more variety in approaches to accommodate the variety of learning styles and need. (Contains 45 references.) (JLS)

Communities of Inquiry among Pre-service Teachers Investigating Mathematics.

by
Clare Brett, Earl Woodruff OISE/UT
Rod Nason, QUT

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Overview

This paper examines the conditions which supported pre-service teachers, use of a shared database to enhance the development of a mathematical knowledge building "community". This paper reports some preliminary findings from an ongoing longitudinal (3 year) study of preservice teachers' mathematical knowledge. Our data will focus on the first one and a half years of the students' two year certification program. The aspects of the learning environment designed to promote a sense of community comprised the following elements: Small group discussions in which participants worked on math investigations, workshops on cooperative learning techniques, numerous experiences with collaborative learning in a variety of subject areas, as well as access to shared electronic databases which included conferences of commentary on mathematics to which pre-service teachers, their professors and researchers could post ideas and comments. There was also a program-wide emphasis on constructivist approaches to learning, and students were introduced to a number of different technology based and cognitively oriented approaches to learning including CSILE (Computer Supported Intentional Learning Environments), the Adventures of Jasper Woodbury math series and Reciprocal Teaching. Examined in this paper are the conditions, practical, social and cognitive, under which progressive discourse (Bereiter,1994) emerged from these discussions. Progressive discourse here is being taken to mean advances in understanding through engagement and knowledge building.

We focus on a particular subgroup of preservice teachers from a cohort of 60 enrolled in the 2 year teacher education pilot program at OISE/UT. The subgroup consists of eleven female students who had identified mathematics as being an area of great concern to them on entering the program. All of the students reported a variety of negative experiences in their school mathematics classes. The goal was to provide a context in which they could become involved in mathematics and alter their attitudes through acquiring new knowledge in a collaborative community setting. We hypothesized they would alter their attitudes through initially relearning mathematics for themselves through math investigations and discourse, both face to face and electronic. These experiences were designed to help them feel part of a community of learners of mathematics. Then, as their confidence increased, they would be able to rethink their perspective on the teaching of mathematics. We analyzed the patterns of database use, as well as database content to see if changes in attitudes and learning were evident. In the discussion we address important issues about the kinds of learning experiences critical to supporting such shifts.

Background and literature review

In recent literature on teacher development, communities of inquiry have been utilized as an effective context in which to encourage teachers to reflect on their own practice, undertake action research projects and improve their teaching (e.g. Wells, 1994). This perspective is part of current trends in education towards thinking about learning and knowing as social as well as individual activities (Cobb, 1994; Lampert, Rittenhouse & Crumbaugh, 1995; Pea & Gomez, 1992). Acquiring knowledge is understood as a broadly social practice engaged in with peers and more knowledgeable others (Brown, 1989; Brown & Campione, 1993; Driver, Asoko, Leach, Mortimer & Scott, 1994; Lave & Wenger, 1991). Parallel to this, there have been recent trends within the discipline of mathematics towards viewing the doing of and thinking about mathematics as a social process of debate or of shared meanings (Kitcher, 1984). These notions about learning and knowing and about the nature of mathematics suggest that to understand mathematics, one must understand the activities or practice of persons who are makers or users of mathematics, deviating from the more conventional view that understanding mathematics is equivalent to understanding the structure of concepts and the principles in the domain (Stein, Silver & Smith, 1996).

The above viewpoints are reflected in most mathematics education reform documents (e.g., National Council for Teaching Mathematics (1991)) These documents place a great emphasis on changing the nature of classroom discourse to include authentic mathematical activity, collaborative mathematical thinking and "talk in the spirit of disciplinary work" (Lampert et al., 1995; Stein et al., 1996). In order to provide students with authentic mathematical activity, most mathematics reform documents are suggesting that instructional programs need to encourage the development mathematical communities of practice in which students engage in collaborative mathematical practice - sometimes working with each other in overt ways, and always working with peers and teachers as part of a shared community with shared norms for the practice of mathematical thinking and reasoning. There would be a shift in such classrooms away from teacher (or the computer or the textbook) being the sole authority for verification of answers towards classrooms where logic and mathematical evidence are used as the basis for verification (Lampert et. al, 1995) and students are helped to develop mathematical reasoning including conjecturing, inventing, problem-finding and problem-solving.

A great deal of cognitive instructional research seems to indicate that many existing cultures of schooling are quite antithetical to these changes (cf. Scardamalia & Bereiter, 1995). Thus, many educational commentators (e.g., Brown, Ash, Rutherford, Nakagawa, Gordon, & Campione, 1993; Marshall, 1988; and Scardamalia & Bereiter, 1995) are suggesting that in order for changes such as those being advocated by the reform documents to occur, new cultures of schooling need to be developed. One such new culture of schooling conceives of schools as knowledge-building communities. A knowledge-building community (e.g., a research team in the scientific community) is a group of individuals dedicated to sharing and advancing the knowledge of the collective. According to Bereiter (1994b), what defines a knowledge-building community is not formal association or physical proximity but rather a commitment amongst its members to invest their resources in the collective pursuit of understanding. Thus, in knowledge-building schools, the students are engaged in producing knowledge objects (e.g., ideas, theories, interpretations etc.) that can be discussed, tested, compared, hypothetically modified and so forth and the students see their main job as producing and improving such objects, not simply the completion of school tasks.

These changes in the environment of mathematics classrooms have implications for the teacher's role(s) within the classroom. Rather than being a transmitter of mathematics knowledge, the teacher instead is now expected to create a community of mathematical practice in which thinking and problem-solving of the kinds required for the discipline of mathematics is contributed by all members of the class (Pea & Gomez, 1992). In order to create this "community of mathematical practice", the teacher needs to be: (1) a transmitter of the mathematical culture who inducts her students into the community of mathematics practice (Driver et al., 1994; Brown, Collins & Duguid, 1989), (2) a guide, (3) a mentor, (4) a model genuinely engaged in authentic exploration of the mathematics subject-matter (Brown et al., 1989), (5) a facilitator of mathematical discourse, and (6) a highly knowledgeable member of the community of scholars in the classroom (Bereiter, 1994; Leinhardt & Fienberg, 1992).

A review of the discussions of the quality of teaching (e.g., Merseth, 1993; Kerr, 1981) and of the research literature on expert and novice teachers of mathematics (e.g., Leinhardt, Putnam, Stein, & Baxter, 1991; Leinhardt, 1989; Lampert, 1986) clearly indicates that in order for the teachers to be able to effectively perform all these diverse roles during their teaching, they need to have good repertoires of mathematics subject-matter knowledge and pedagogical knowledge (Shulman & Sykes, 1986). Subject-matter knowledge includes: (1) substantive mathematical knowledge such as facts, ideas, theorems, mathematical explanations, concepts, processes (and connections between these elements), (2) knowledge about the nature and discourse of mathematics, (3) knowledge about mathematics in culture and society, and (4) dispositions towards the discipline (Ball, 1990;1991; McDiarmid, 1988).

Included under the rubric of pedagogical knowledge are: (1) understanding the central topics in each subject-matter area as it is generally taught to children in each grade, (2) knowing core concepts, processes and skills that a topic has the potential of conveying to students, (3) knowing what aspects of a topic are most difficult for students to learn, (4) knowing what representations (e.g., analogies, metaphors, exemplars, demonstrations, simulations and manipulations) are most effective, and (5) knowing what student misconceptions are likely to get in the way of learning (Shulman & Sykes, 1986).

However, evidence from the research literature seems to indicate that many beginning teachers do not possess repertoires of subject-matter knowledge which would enable them to create communities of mathematical practice in their mathematics classrooms (Baturo & Nason, 1995; Reynolds, 1985). Why many beginning elementary teachers have inadequate repertoires of mathematics subject-matter knowledge and why a number of these teachers have such negative attitudes towards mathematics and the teaching of mathematics can probably traced back to a whole series of contributing factors, both in childhood and as adults. These likely include, for women, gender expectations about women's roles in mathematical culture, feelings of self doubt about the ability to do math, dislike of a subject which was perceived as a "masculine" subject, abstract and not related to the real world of experience, and perceptions of mathematics being an all or nothing subject, in which one was either smart or dumb (e.g. Barnes, 1995; Buerk, 1985). Additionally, the mathematical learning experiences of most of these teachers during their schooling were likely characterized by: a reliance on a recitation and seatwork presentation of data, a reliance on teacher presentation of new concepts and procedures, textbook-centered instruction with textbooks that lack developmental or instructional material for concept development, and instruction which places emphasis on algorithmic computation procedures and the "solution" of artificial "story problems". These teachers thus have had few (if any) chances during their schooling to legitimately participate in the community of mathematics practice and learn what it means to authentically do mathematics.

Some current teacher education programs (e.g., Peck & Connell, 1991; Wilcox, Schram, Lappan & Lanier 1991) have attempted to address the recommendation by requiring the pre-service teachers in mathematics content/methodology subjects to apply the principles of constructivist and social construction theories to themselves as a way of understanding the outcomes of their own learning. Thus, in these programs, the pre-service teachers are required to actively restructure their existing mathematical knowledge and expand their view of what understanding mathematics might involve. Often, they are given opportunities to restructure their own subject-matter knowledge using curriculum and instructional approaches similar to those which hopefully they will later use in their own classrooms (Peck & Connell, 1991). However, Wilcox et al. (1991) reported that, while the program was successful at the time, there was insufficient support outside the program to help new teachers maintain the perspectives they had developed in their preservice program, largely due to the pressure to return to traditional approaches which they experienced on entering schools as teachers.

We see an electronic learning community, developed during the preservice program and continuing after graduation as a potentially realistic and effective way to provide just such a support. However, to evaluate its potential for providing continuing support, it is important to see how such a resource is used as it is being developed---by whom and what kinds of support it offers. One hypothesis of the current study is that the degree to which students will enter into a computer-based community discussion will be a function both of access and ease with computers as well as comfort with other group members and a sense of how they might contribute to one's own learning. Thus (with computer training and guaranteed access to computers) the degree to which students actively participate on the network may be one measure of their sense of community.

The framework for the social component of these analyses is taken from a chapter by Woodruff, Chakavorty and Smith Lea (1996) on the Role of Technology in Educational Reform. In this paper they examine the notion of what community actually means, across a wide variety of disciplines and through this analysis derive four glue factors which seem consistent regardless of the particular type of community being studied. These are Function, Identity, Discourse and Shared Values. Function is the force which articulates the goals or objectives of the community--these may vary but the aim is always public. Identity is constructed though an understanding of member participation, without a shared identity groups will not have the emotional bond to maintain group cohesion, although there are very different views on what constitutes the relationship of the individual to the community. Discourse can be understood as the evolving script which creates and sustains the individual within the group. Discourse allows the development of the fourth glue factor, namely the development and sustaining of a framework of referents which are the Shared Values, thereby creating enough common ground for a shared discourse to emerge.

These four factors define the essence of community. Other research, such of Riel & Levin (1990) have identified participant structures necessary for effective computer networking. These structures can be related to the four "glue" factors mentioned above. For example, they identify the need for facilitation (which could be seen as supporting Discourse and helping to create Shared Values) , a shared goal and efficient network communications (Function). However, in the present study, we are trying to abstract the issues relevant to creating a learning community from a more complex array of data, including: tracking the amount and types of participation in the database (writing and reading); their prior attitudes towards mathematics and computer use; how they attribute the causes of their concerns about mathematics and the relationship among these factors on how they used the database to advance their learning. In the Analysis section, we will present data on these factors in the Discussion section these factors will be linked to each of the "glue" factors necessary for developing and maintaining an effective learning community.

Description of the Program and Participants

The participants in this research study were a cohort of pre-service teachers (N=60) from OISE/UT enrolled in an experimental 2 year certification course to teach from kindergarten to grade 10. Students were initially assigned to small groups for their investigative mathematics work, for discussion purposes. Groups were created with the following criteria: between 4-6 members, to allow for even participation and with not more than one male per group also to increase the participation of females. Two groups consisted only of females who had indicated mathematics to be an area of concern for them in their teaching. The participants came from a variety of ethnic backgrounds. All participants were given a computer account on the OISE/UT network and there were a number of computer labs available to use when they were at OISE/UT. During the course of the first year, basic VT100 terminals and modems were loaned to all participants who didn't already have a computer and modem. They were also given training sessions and support in using this technology. In the second year, more powerful laptops were given to participants, so that each school team had at least one more powerful machine. Use of the database and participation was not directly reflected in students grades, but, because a lot of the evaluation was based on individual and group Portfolios, as well as collaborative inquiry projects and other sorts of group-based and reflective assessments, the networked interaction was very relevant to ongoing learning as well as assessment.

For the purposes of this study, eleven participants were chosen to monitor through the course of the program. These participants were all female, and all had indicated at the beginning of the program that mathematics was an area of great concern for them in teaching. Data on some measures, such as a math test and incoming questionnaire on attitudes, as well as database contributions were collected from all class members. In March, after the end of the math investigation group work, and before students left for block classroom placements, interviews were conducted with the eleven participants to assess their reactions and reflections. In year 2 we continued to monitor and facilitate database use and carried out further interviews; one in the fall about their sense of community in the program and the second in the spring about reasons for their choice of specialization. For the final term, we will continue to monitor database use, administer a final math test, at least to those choosing the math Science and Technology specialist option, as well as a final interview about their current definition of mathematics, how they see the teaching of mathematics and how they evaluate themselves in relation to mathematics.

Data Sources

As outlined below, three data sources were utilized in this project.

(1) Shared Database analyses.

These include both qualitative and quantitative analyses of contributions to the databases to assess changes in participants understanding of the nature of how students learn and their own mathematical reasoning and understanding, such as their awareness of how assumptions change the nature of the problem; the aspects of group discussions they choose to take up and pursue on the database and the degree to which they took up ideas and experiences from class and implemented them in their classroom practica. It was also important to compare distribution of contributions among class members, and how that compared to computer accessibility, comfort with computer and comfort within their group.

(2) Tests of mathematical subject matter knowledge.

These tests are based on tests developed by Baturo and Nason (1995, in press) and Nason, Lawson and Chinnappan (1995) and on Ball's (1991, 1990) conceptualization of subject-matter knowledge. They were used at the beginning of the investigation to assess the pre-service teachers': (a) levels of substantive knowledge about Hindu-Arabic place value numeration system and the operations of addition, subtraction, multiplication and division upon this system and (b) levels of substantive knowledge about mathematical problem solving strategies. (Parallel tests will be given also at the end of the two year program to measure growth in mathematical knowledge.)

(3) Questionnaires and Interviews.

Questionnaires to assess their incoming attitudes towards mathematics, and their access to and experience with computers. Periodic interviews to ascertain their perceptions about the quality of collaboration within groups and within the program, changes in beliefs about teaching and learning of mathematics, feelings of preparedness and comfort to teach mathematics, and responses to the experiences with the electronic database.

Analyses

1. Mathematics Content Knowledge

In order to situate the focus group within the context of their class, we analyzed their incoming mathematics scores. This test focused on three components: place value and renaming, 2) operations and 3) patterns/rule-finding. Each subgroup yielded a score between 0-4 and the three scores were averaged to yield one score per participant. The average scores for the focus groups was 2.66 compared to 2.95 for the rest of the class average. This suggests that the perceptions of these students about being less knowledgeable in mathematics are partially congruent, but these results may well reflect having taken fewer mathematics courses at school and university.

2. Database Entries

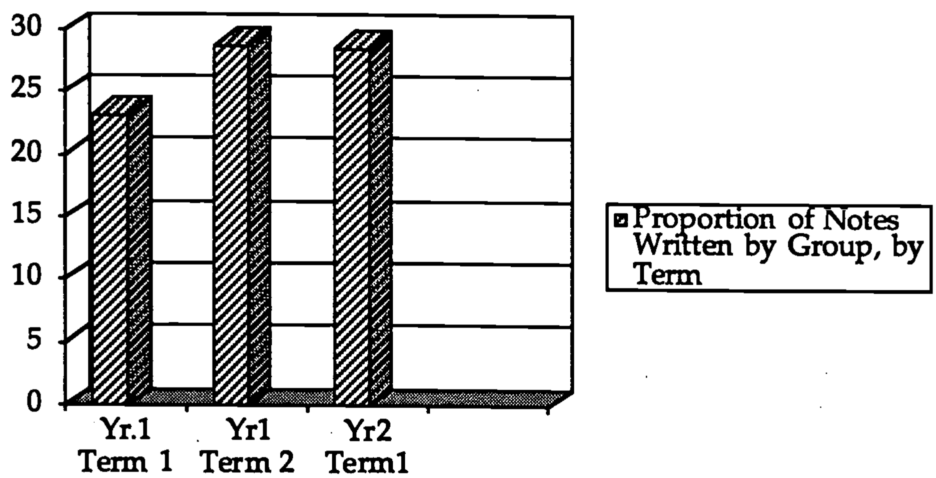
We looked at the entries for the focus group for each of the first three terms of the program. The last term is still in progress. We examined these entries on the following dimensions:

1. Number of entries for the three terms

The proportion of written contributions by the Focus group, shown in Figure 1, rose from Terms 1 to 2 in Year 1 and remained consistent into Year 2.

Proportion ofWritten Contributions by Focus Group by Term

Figure 1



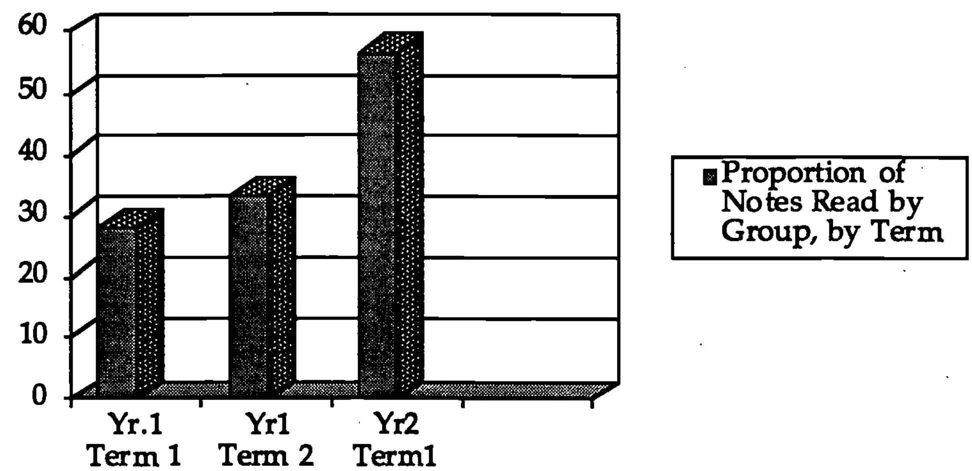
This is particularly interesting in the light of how the demands of the program changed between terms. Term 1 involved intensive small group math investigations in face to face groups, supported by the electronic discussions. In Term 2, more people had equipment allowing home access to the electronic discussions, and in Term 3 students were working within their specializations and had longer practica, thus reducing the amount of time available for extra work outside their program focus. Further the number of available conferences, of which Math Inquiry was but one, had grown to nineteen by the beginning of the second year, a daunting amount of information with which to keep up to date. In addition, two of the students who participated most in the second term had, by Year 2, joined a number of other, larger conferences such as Schoolnet, and were regularly contributing to those as well. In spite of all these shifts, participants still found time to continue to contribute electronically.

2. Proportion of database read during each term.

Looking at the group as a whole, we can see from Figure 2 that the proportion of the database being read by the focus group increases steadily each term from 28.0% in Term 1 to 56.4% in Term 3, indicating that students are reading more of the database. As there are no marks related to database use per se, and the workload is heavy and consistent, we think this is an indicator that the participants feel the database to be useful, and that they feel comfortable working within it.

Proportion of Contributions Read by Focus Group by Term

Figure 2

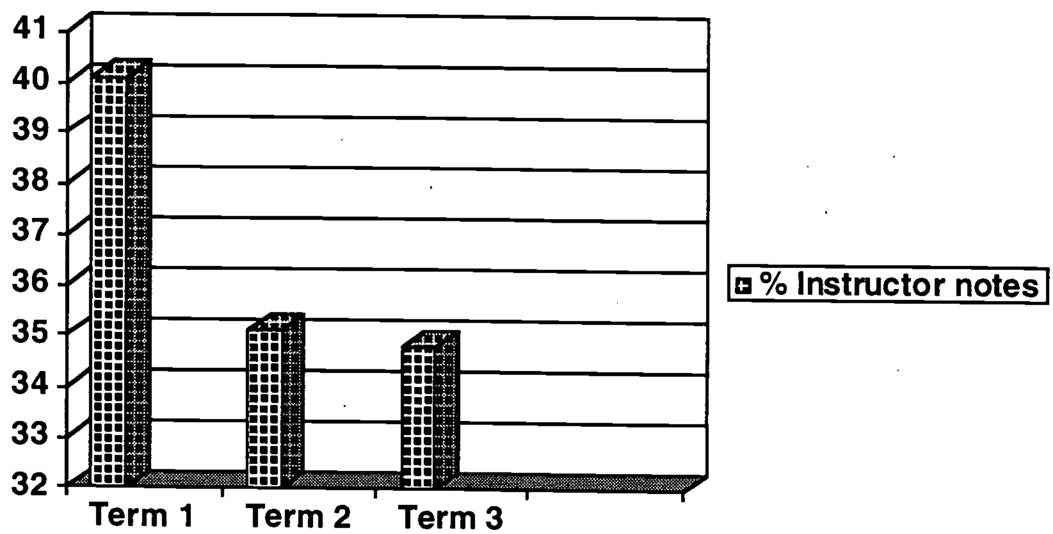


3. Relative proportion of student to instructor entries (a measure of class involvement and student ownership).

Switching briefly from a focus group measure to a whole class measure, we can see in Figure 3 a small shift in the class ratio of student to instructor entries. This ratio drops from 40% in Term 1 down to 34% in Term 3 suggesting students are starting to take a greater community role in the database--such as giving help and discussing issues. It also supports the idea that the class, as a whole, feels ownership and involvement in the database.

Percentage of entries contributed by Instructors across Terms.

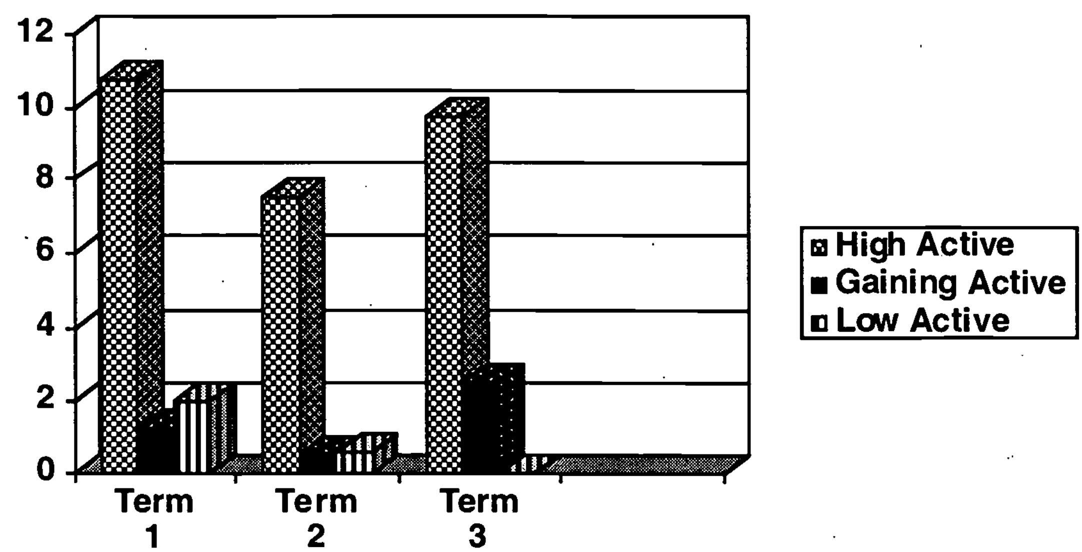
Figure 3



Overall, while the student data show a general trend among the focus group towards greater participation, there is also tremendous variability among individuals, and in fact the patterns of contributions among the eleven focus group students appear to fall into three distinct groups. The groups are compared in Figure 4 for writing and Figure 5 for reading.

Average Written Contributions each term by Group

Figure 4



Group 1 High Active:

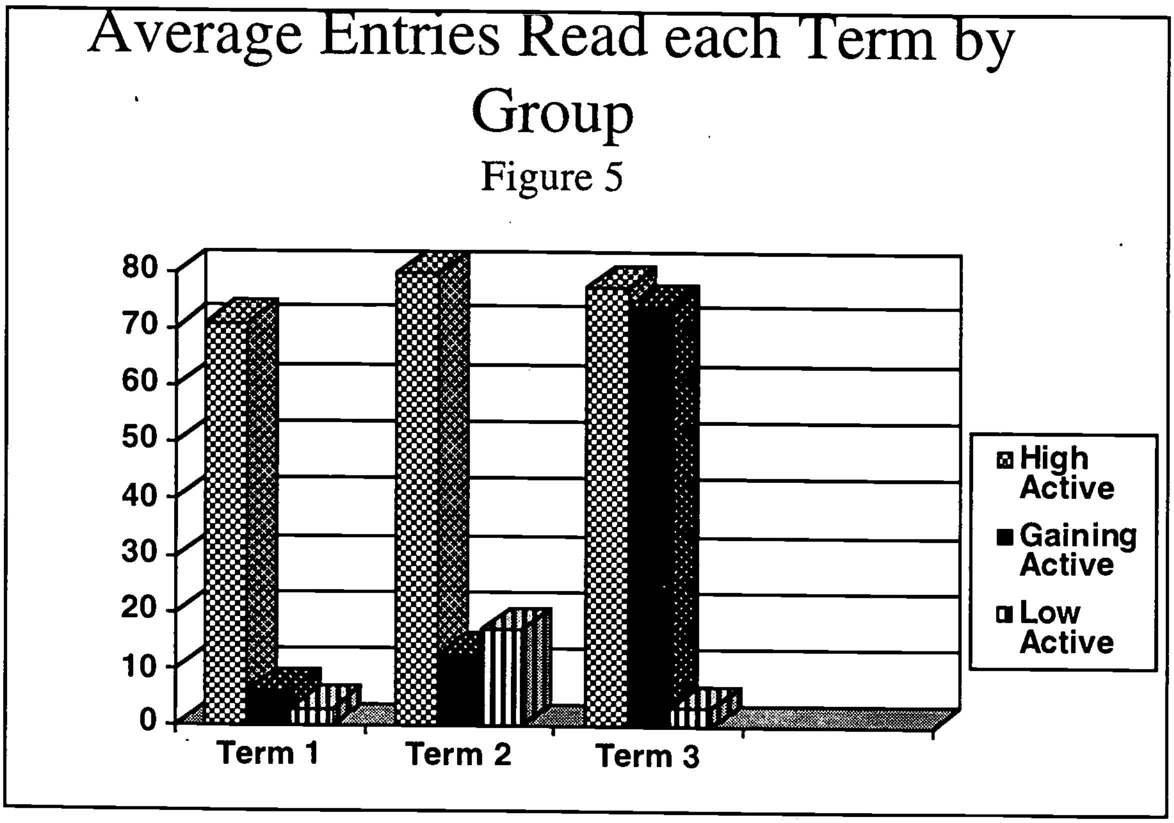
This group starts out with high levels of reading and writing, and increases or maintains involvement over the course of the three terms. Members seem to participate in other conferences also.

Group 2 Gaining Active:

This group changes most, particularly in relation to the amount of the database they are reading. They start out low but increase steadily over the course of the three terms. Their written contributions, however, still remain sporadic. From informally reviewing contributions to the other conferences, it appears that these participants have similar patterns of participation to that of the math inquiry conference, although with more written participation in one or two other conferences for particular projects.

Group 3 Low Active:

This group engages least, either in reading or writing. Again, from an informal review of the other conferences, this groups' pattern of engagement seems similar across the subject areas, although, like the gaining Active members, with more written participation in one or two other conferences for short periods of time.



Are there other factors which also reflect these group differences? To answer this questions, we will draw first upon particular questionnaire and interview responses, and later, return to an examination of the contents of the database contributions in more detail.

3. Questionnaire and Interview responses[1]

[1] Interview and questionnaire responses are italicized within indented blocks; database entries are in plain text in indented blocks.

The first, and most obvious practical issue to assess was participants initial level of computer access and computer experience.

1. Level of Computer access.

While all participants had accounts on the university system, and access to machines in the department, they did not all have computers at home during the first term. In fact, the 4 participants who had the highest participation rates (High Active), also had some kind of computer access at home (although none of them had an extensive amount of computer experience)
Home access is a critical factor, because it facilitates reflection (particularly for an area like mathematics which requires concentrated thought to write as well as read and respond), by providing time to focus and think through ideas. By the beginning of the second term in the first year however, everyone had been given a computer terminal and modems (VT 100 terminals) for home. In the second year, all participants reported regularly reading some conferences and using e-mail. Those in the High and Gaining Active groups reported spending one to two hours per night to review the various conferences. For those in Gaining Active, this sometimes meant some frustrating times while their terminals didn't work, or having such slow access that it took a very long time to get through a conference. Most members of the Gaining and Low Active groups tended to read and occasionally contribute to those conferences which were part of their specialization, (as well as e-mail to others in their specialization) particularly in Term 3 (Yr. 2), but reported wanting to keep up with other conferences, depending upon their workload. By contrast, those in High Active seemed to read and make written contributions to almost every conference.

2. Degree of comfort with a shared database.

For all of the participants, this was the first time they had used such an open computer communication system, and there was some initial hesitance, (and for some this feeling persisted) to contribute and thereby potentially expose oneself to possible criticism or ridicule. As one Low Active participant described the experience of using the computer (during the second term, Year 1) :

> *"..you are going back to being on your own again. You aren't in a group. You are putting an idea out and everyone knows its your idea because your name is right there...like going up to the board" (this refers to her own childhood experiences of being made to write answers which she knew were wrong on the board in front of the rest of the math class, and feeling utterly humiliated as a consequence).*

For a lot of the participants especially in Gaining and Low Active groups, using e-mail was a more direct and preferred means of communication. In the words of another Low Active member:

" It's a bit overwhelming. I do take part, but I'm more of a person who likes to read everything. Like I'm on it all the time and I use it for my e-mail stuff. I do a lot more personal e-mailing than putting things on (the conferences)".(Joan)

There was another attitude too, referred to occasionally by participants during the first term, which was that the people who participated a lot were doing this to impress the faculty, rather than through a genuine desire to get on top of the mathematics ideas and work through their anxiety. For example, one participant said:

"Could it be they just want their name there because they know they are being watched and they have to have some input?" (Megan, reporting this as being part of out of class (chat")

This suspicion seemed, however, to die out by the end of the first year. In part this may have been due to database participation not being used directly for grading purposes, making it seem more like a genuine resource for their own learning and development (which it was intended to be), and not a disguised form of evaluation.

By contrast, High Active members discussed their feelings openly from the beginning, about Math, the small group math investigations, and their teaching concerns, as illustrated in the examples below

1. Though I am a little confused by the events in class this morning I do not feel completely out of my depth. I found the lesson exciting and I like the style with which you are teaching the subject. I am one of the many that were taught Maths via the 'talk and chalk' method. I was awful and coloured my image of Maths. You are now breaking down that image, Thank you. (Judy)

2. B, I absolutely agree with you. How did any of us get out of high school not realizing that numbers are not rigid, static things. I too had a miserable math teacher in grade 12. I wonder what happens to grade 12 math teachers? What I find so terrific about this approach, is the opportunity to go right back and start "playing" with numbers again and not worry about whether my method is right or wrong. (Wendy)

There was also reference to using the database to help deepen understanding: e.g.

The past math sessions have been wonderful, but today's lesson brought out the fear in me again. I was pretty clear until I got to the point of explaining how we came about with our answer for the Mathematic's Investigation 1A: The Magic Show. When you put the explanation on the board I still replied to myself, "Huh?" Maybe I am missing something. I think I have always had difficulty in generating explanations to math problems, although my past history with the subject of math has been quite dreary! This could explain why I have the problems that I do today. <u>But I will continue to press on and read the math inquiry section to further develop my level of understanding. Thanks for elaborating on today's question in the database.</u> (Nora)

3. Level of mathematical confidence

While the whole group of 11 students began with low math confidence, they were differentially influenced by the small group math investigations which took place weekly during the first term. All participants found them helpful, and for the High Active participants the experience appeared to be sufficient to "jump-start" them into wanting to become involved deeply in the mathematical ideas as well as the pedagogy and self-reflection.

> *"We all brought different experiences with us...I became aware of what their difficulties were, and by recognizing that look at myself and say, "Well, do I feel this way?" and "Do I learn this way?' and "Is that something I could take and develop myself?" And then evolve in math that way, and then take it to the classroom level as well, of teaching students". (Judy)*

Another High Active participant who was less vocal in her group also had a positive and reflective reaction:

> *"I am in a challenging group...So I couldn't help feeling a little bit inadequate. I need time to be able to process. But in another way that really solidifies to me how I think about math, and how I process math. The input I gave from time to time in the group was very valuable to the group...So I saw that I didn't articulate as quickly and as overtly as they did, but my input was valuable and that was good for my confidence" (Megan).*

Members of the Gaining and Low Active groups tended to take longer to become used to the small group setting. For example:

> *"Math is at the bottom of my list of favorite subjects so working with a group in an area you're not too comfortable with was a little difficult....eventually after four or five session with them the comfort level seemed to increase slowly".(Lisa)*

However, a difference between the Gaining and Low Active groups was that the Gaining Active members seemed to see the group experience as have value because of the shared ideas as well as the shared identity of trying something difficult:

> *"..working in math groups makes math less stressful, as opposed to just being by yourself and pulling you hair out. Whereas when you have another person to work with, you can bounce ideas off each other and borrow each others knowledge and build upon it...And you end up being more confident because you felt as if you became more knowledgeable". (Marissa)*

Thus, for the Gaining Active members the group experience made them less intimidated by the mathematics content. However, the Low Active members continued to see the small group function primarily as one of confidence building.

"So when I did express how I felt, or what I thought the answer might be, I got everybody's feedback and they would say, "Oh, good idea", and that made me feel better and more confident". (Janet)

In an interview during the second term, participants were asked the question "How do you account for you feelings about yourself as a math learner based on your experiences as a child and as an adult"? High Active members were able to give very clear and detailed accounts of the external factors such as teachers attitudes and specific experiences which had caused them to feel inadequate mathematically. They all appeared to have reflected on this before, in detail, and had analyzed the causes rather than simply internalizing the negative experiences. For example:

When I was in elementary school I hated math. All through high school I couldn't stand math. I stopped taking math in Grade 11, Grade 12. It was just because I was so frustrated with it. If I wasn't getting the concept down, it was like, "Well then forget it. If you don't understand it then you aren't going to get the rest of it." But I don't know if my teachers gave me enough support when I was doing math in high school. Now I have math phobia. When I try and teach math I am afraid that I may make a mistake or some student may say to me, "How can that be right? We just learned this." Or whatever. That is a fear of mine. I hope that I can overcome it. ...Well I was a girl in the class. There were a lot of boys in my class and they all excelled....And the females who were in the classes really didn't make much of an impact on the teacher. The teacher was so impressed with what the boys could do........I didn't like to go to those little math sessions, to those little carrels and get help, because I felt that I didn't know anything. I felt stupid... It wasn't inviting at all because it seemed as if you were part of the stupid group or something. (Nora)

Gaining Active members in their responses to the same question, could identify aspects of their school environment such as teacher attitudes or the school requirement that all math questions only ever have one right answer, as being factors. But they also felt that they had contributed in part because they were less able in this area, for example:

I never did well in math. I always found myself ... I was sort of hazy, it was never very clear. And then I took a stats course in university. At first I didn't do very well, but then I motivated myself. It was a different environment, because in high school you are sort of on your own. Even last year, with the 2 year pilot ... I think, for me, I need that support from other people. And just knowing that it is okay if you don't get the right answer. And that there is not just one way to get the solution. And maybe my fear of math came from that, "There is only one way, and if you don't know it ..." And like I said, sometimes when I was dealing with math problems ... I don't know if it was the teacher's fault, or my own, probably both, both things were never really clear. (Alicia)

Also, like the High Active members, they reported experiencing at least occasional success in at least one mathematical context, either before or during the small group work in the current program.

By contrast, in the Low Active responses to this interview question they each blamed themselves for being unable to understand the mathematics they were taught in school. They also did not report any successful experiences with math at any time.

> *I think I have always thought of myself as bad at math. I think just from really early experiences, maybe not that I had bad teachers in math, but I don't think the teachers that I had enjoyed teaching math a lot of the time, even from really early.. it was always something I thought I am not good at. (Joan)*

> *Mmm, I feel even now I'm not very comfortable with it per se I never was, I always had difficulty. Maybe I blame myself for not excelling in that area. .. So areas I didn't excel in I shied away from and Math was one(Lisa).*

> *I was thinking about, all through school I was forced to give answers. I always felt very confused and I felt like everybody jumped to step 15 when I needed 1, 2, 3 and up to 15. So I always felt very pressured in math to move ahead and go fast, fast, fast. I couldn't do that. And I think that is why I had a fear of math. (Janet)*

It is interesting to note also that Low Active members did not have the lowest scores on the mathematics test given in the first term. Nevertheless, they seemed never to have experienced successes in Math which might have helped them alter their perspective on their own math abilities, nor did they show any of the externally directed anger and blaming of others shown by the responses of the High Active members.

By the second year, the Gaining Active participants felt sufficiently involved, and saw the conference content as useful enough, that they increased their participation electronically through reading as well as occasional responses, in addition to e-mail.

For the Low Active members, however, perhaps because they didn't experience themselves as leaders within their groups, there was less impetus to work through ideas, and consequently they didn't develop such a proactive, reconstructive approach to their mathematical experience like those in High Active, but rather preferred to contribute electronically either through e-mail to specific people they felt close to or where they felt comfortable as the following remarks suggests:

> *"I think because I specialize in language, I tend to go into those more. I've been thinking recently that I should go into the math more because I could probably get more help, where math is something I need more help with teaching. But I tend to go into the language (conference) because I have something to offer" (Janet)*

Overall, it appears that their sense of the group was more fragile, and did not survive the move to an electronic environment.

One indicator of how High Active and 2 members' attitudes toward mathematics changed from the beginning of the program was in their choice of specialization in Year 2. Of the eleven, four students (two in High Active and two in Gaining Active) actually chose Math, Science and Technology (MST) as a specialization, two others were required by the program to select their subject area major (1 was in High Active and one in Low Active). because of the level they were teaching. The remaining five based their choice on prior likes and experience. However, one of these five (Judy, High Active) worked collaboratively with a MST specialist (Megan, High Active), each giving each other the resources from their specialization, so they could get the benefit of both. The people who chose MST gave reasons such as the following:

> *"I discovered I had an interest in those subjects as a result of the way the 2 year program presented to us--the focus on student investigation, discussion and the whole constructivist theory--made it all less intimidating to learn about. In that sense I took it on as a challenge and felt comfortable with this approach to MST" (Megan)*

> *"I was fascinated by how technology could be incorporated into so many aspects of the curriculum (e.g. communication, research, and discovery, knowledge building). Also, since math has never been my strength I felt challenged and compelled to build my skills in this area in order to be an effective teacher."(Alicia)*

> *"I selected MST because those were the 3 areas I knew least about. I assumed that if I could MST well, I could teach anything. I am really pleased with my choice. I have learned a lot. Most importantly, I now feel comfortable taking a risk in those areas and learning through exploration and experimentation." (Marissa)*

Before looking at patterns of Database use, it might be helpful to summarize the differences between the groups discussed so far

Summary of Group Differences:

There were three identifiable groups within the focus group of eleven participants.

<u>High Active: (n=4)</u> They read and made contributions from the beginning and continued throughout the three terms. They all had some kind of computer access from home, as well as some prior computer experience (although not beyond e-mail use). Further, they tended to be the more vocal members of their face-to-face groups..

<u>Gaining Active: (n=4)</u>Changed the most. They started off both reading and participating very little but increased their participation gradually and their reading quite a lot over the course of the three terms. Their actual contributions to the on-line discourse were fewer and shorter than those participants in High Active.

Low Active: (n=3) Changed the least. Had low participation and reading rates throughout the three terms. In interviews the all felt the small group math experiences had been very helpful particularly in showing them that other people shared their fear of math. They found this supportive. They also thought that small group experiences would be good to use in teaching math. However, they also tended to be the most quiet and least confident of the members within their groups. They had no computer at home at beginning of program, or had problems accessing the database because of long distance costs.

The next issue to be examined is how were the members from each group actually using the database, what were the issues they raised.

4. Patterns of database use:

Themes in the entries themselves addressed a number of issues related to mathematics, pedagogy and how participants identity themselves as part of a community of math inquirers. In particular, there are differences among the three groups in how they "speak" within the database. To illustrate, we will give examples from three areas: the nature of mathematics; how mathematics can be taught; and how they see themselves as learners in a mathematical community.

The nature of mathematics

Initially, through the small group math investigations, and reinforced through electronic discussion, participants changed their view of Mathematics. They began to see that there were elements of mathematical reasoning that needed to be considered, aside from merely memorizing algorithms. As a High Active member expressed it:

> The famous Fiona the frog math problem you gave us today generated a great deal of excitement in our group as we began to speculate on the last 0.5 metre before Fiona climbed out of the well. We could have spent hours examining different assumptions that lead us to different answers but the most valuable lesson for me was learning that every answer you get is based on a series of assumptions (some more valid than others).These assumptions need to be explored before the answer can be fully understood.
> So now I know that there is more to an answer than meets the eye! (Megan)

They also recognized that were important processes of mathematical investigation involving conjecturing, problem finding and discussion beyond just the learning of isolated concepts and procedures, as the following two excerpts, the first from a High Active member, and the second from a Low Active member illustrate:

These classes have been very good at validating all of us as mathematicians. They have done this by acknowledging that there is more than one way to get the right answer. I sometimes thought that the way I add things up in my head was cheating - but R has pointed out that the strategy is actually quite powerful and it was a relief to find out that some other people work things out the same way as I do. I think becoming aware of our attitudes and biases is tough. It really means staying conscious and asking yourself why you think the way you do......I think we need to talk about mathematics, how we work things out and get the answers we do and ask each other questions. This goes for both our math groupings and what we do in the classroom. (Wendy)

I'm really glad that we did this exercise. Like Nora, I was looking at the "facts" and quickly concluded that the answer was twenty. The resulting discussion in class made me realize that too often we have a very narrow view of math. I myself have been conditioned to believe that there is only one right answer, to stick with what you see on the page, and please don't do too much deep thinking about any problem. Before this, math for me was never even a subject that anybody could possibly have a discussion about. I am sure that without this class I would have gone on and taught my students in a very similar way that I was taught. (Joan)

How mathematics can be taught

Low Active members often wrote about positive experiences, a teaching episode or class experience that was helpful. They expressed great pleasure that they have found a way "in". e.g.

I always had trouble in math, but now I am coming to realize that I'm not the only one. I have taken a different approach towards this subject and I am really excited about. Seeing that the kids in my grade eight class react to math the same way I did when I was their age made me think about ways that might change their attitude. Making math fun is a start. If you approach it this way at the start of a lesson then you get more students interested in the subject. I have also started math journals with them which gives them an opportunity to express themselves any way they please. They love this because it's more informal then anything else. Lots of research on my part is being done to try and make all this work. Let's face it, we were all in these kids shoes at one time or another and I bet a lot of you felt the same way.....lets make math enjoyable. (Lisa)

They were also able to weigh up the issues involved in changing the pedagogy of traditional math class to one that was more discourse-based, as the following, collaboratively written, note shows:

It may be these discussions about the process that can help students to understand their math problems. It may be time consuming and teasing one's patience but the effects should be rewarding because the student could be showing success in their understandings. (collaborative note (Janet and Z)

Gaining Active members, while they also write entries about positive experiences, also frequently questioned and challenged ideas raised in class, and pursued their understanding in a more active way:

I also want to know if we teach our students to do math in this manner of blocks and visuals, how does that help them to move from concrete thinking to abstract thinking? I don't want to have my children coming to me when they are 19 to buy them graph paper because they need it to figure out how much tax would be on something. How will they move from seeing it on paper to figuring it out in their head? Using the grids is a good idea to introduce one concept by reviewing another to see any patterns or relationships, but with some aspects of math, I don't see it being easier. I see a lot more explanation and work on the teachers part and more confusion on the student's part. I'm curious to hear any ideas you may have to offer. (Anna)

However, they don't necessarily pursue those ideas in the database. Once a response is given they do not usually initiate another round of discussion. The High Active members, by contrast, do this a great deal, as the following examples illustrate:

> I have a question for you in regards to teaching how to count by tens. This was my dilemma on Thursday at my placement. This grade five class was given a review sheet which posed such questions as, "Count by tens starting at 510 to 810" or "Count by tens starting at 800 to 1,200". I considered these questions to be quite easy for their grade level simply because counting by tens, more often than not, is picked up quickly by students when learning multiplication. Well, my assumption was quickly corrected on Thursday. I have a few students who could not complete this task even though they knew how to count by tens starting with ten up to hundred. Yet, once they were asked to start counting by tens from 510 they could not complete the task. They simply could not count 510, 520, 530, 540 etc. unless I directed them through it. When we would get to 590 they were completely stuck as to what the next number would be. I tried to show them the pattern that was apparent in the numbers, but this did not help either. Was there something that I was doing wrong? I found myself getting frustrated because I could not explain this foundation in more simpler terms. My host teacher has informed me that they will be needing extra assistance in math and that I may want to refer to some new strategies for helping them along. Why is it that they can count by tens but not past 100??? (Nora)

At that point the teacher sent a detailed response to which Nora responded again:

> Thanks for the advice. I will be sure to put it to use next week and give you some feedback on how it goes. What is interesting is that yesterday while I was at the host school, I was working with one of the students I had mentioned and discovered that she does not have an understanding of place value as well. I would ask her what is in the 1000 column and she would reply with a number that is in the 10's column. I think that with this particular student I am going to have to go back to square one. This may explain why she can not seem to count by tens over one hundred. I do not believe she has an understanding of ones, tens, hundreds, thousands etc. I just do not understand how she has been getting by without this knowledge. I am afraid she may fall through the cracks and find herself way behind. Just this week she has been placed in a lower math group, so I will have more ample time to spend with her. I will try your strategies with her. (Nora)

This pattern of iteration, which often went on for a number of responses, was common for High Active members, both among peers, and between participants and faculty in the program.

How they see themselves as learners in a mathematical community

The High Active members were more likely to analyze issues in detail. They would lay out their thinking as clearly as they could in words--taking on the challenge of communicating mathematical thinking, as shown in the next example from a High Active member:

> What helped me understand this proof was when I realized that in using multiple representations of numbers you don't always have to describe the number in a fixed order of hundreds, tens, and ones. That you can say in this case 3 hundreds, 9 tens, and 5 ones OR 5 ones, 9 tens, 3 hundreds or possibly even 9 tens, 3 hundreds or 5 ones - it's still the same number.
> Therefore, if I was working with a group of young students I think I would want to get across not just the notion that you can say 85 is 85 or 8 tens and 5 ones or 6 tens and 25 ones but also 5 ones and 8 tens etc. That when you describe a number this way, the actual order of the numerals does affect the value the way it does when you are representing it the usual way.
> I think a lot of us, while we get the idea that you can break the number up in different ways, when you are describing it as hundreds, tens and ones it's still a leap to actually changing the "order" around, i.e. putting the ones first instead of last.
> I don't know if this will help anyone else. It seems to me using multiple representations of numbers actually makes them more flexible or manipulable.
> (Wendy)

In a collaborative response to the note above, the Gaining Active member supports the idea from the initial note and adds a context where the idea could be applied :

> G. and I both agree with you 100%. We too have been taught that 395 is 3 hundreds 9 tens and 5 ones. If you ask people after the test (math pretest), most got the question on place values wrong as a result of this. This helps me and I think it will help students as well. However, they first have to understand that they have to make and can make other groups from the same number and transfer it.
> This will help kids understand the concept and value of money. It's always the same amount but shown differently. Try re-arranging picture patterns in order for students to understand regrouping ,while the number or picture stays the same.
> (Anna)

The Low Active member in the response below (another collaborative note), elaborates why they felt the original note was so good:

> Wendy, it was interesting to see how you broke down your numbers (hundreds/tens/ones). It is great to see you applying what you have learned in class to your own teaching situations. We (Lisa and I) would have never thought of showing the students that they can rearrange the numbers and they will still remain the same. It seems like common sense, but it is something we would probably never have thought of.

As one reads these in sequence the High Active entry (this entry was part of an ongoing attempt to write up a proof of how the individual digits of multiples of 9 always add up to 9) is a reflective analysis of her understanding, what had helped and how that shift in understanding could be integrated into teaching. The Gaining Active response gives support but also extends the idea to another context (using money), thus extending the discourse. The Low Active entry is a reflection about their own learning and also a supportive comment. It adds socially to the discourse, but does not elaborate the ideas substantively. The differences between these responses was a general one found throughout the database. The High Active members seem to be the most active knowledge-builders; that is, they tried to construct their understanding of issues, identify problems and develop their understanding through cycles of dialogue.

Another facet of the database entries was the language use. Part of developing an identity in which mathematics could be approached using discourse was the notion, discussed in class, of being mathematicians within a community of practice. One see references to this issue among the High Active members, as the following examples illustrate:

> I am not sure that I have been very clear. If this doesn't make sense please ask me questions and perhaps it will help me find a better way to explain it.
> As for the other part of the question are all numbers whose digits add up to 9 multiples of 9, as far as I have tested it, this seems to be true. I haven't a clue why. I leave it to another mathematician. (Wendy)

> I agree with your comment about Rod's classes. I feel that I can say I AM A MATHEMATICIAN. OK. it may just be basic maths - but I can do it, I understand it and I'm excited by it. Is there something in my last sentence that can help us in the classroom? I'm thinking of assessment to outcomes and not by comparison to others. Should we give equal praise to the student who manages to work out the most complex of questions and the student who manages a page of straight multiplication - of course we should if they have both reached their full potential. But how can we do this? There are so many prejudices around that are working against us as teachers. These are just a few comments to keep the discussion going - what does everyone else think? (Judy)

Overall, we found that High Active participants, through their computer entries, developed the most insight about the origins of their own difficulties with mathematics, the nature of mathematics and the nature of mathematics teaching. They also actively participated and used the database as another tool to transform their ideas--reflecting on their learning, asking for feedback on plans, laying out their understandings of problems to see if they were right. They raised and responded to a variety of issues in the database; gave and received peer and teacher support, and shared personal teaching and learning experience in order to highlight important pedagogic issues or problems of understanding. They also saw that the effectiveness of their small group communities could extended to the mathematics classroom.

> ...Perhaps one way we can make everyone feel legitimate participants (in the classroom) is to actively encourage peer tutoring and praise. In my maths group we all work together on the problems. We praise each other when someone finds a solution or put forward a good suggestion and we help when someone is struggling. I have a safe, secure environment in which to say 'stop - I don't understand' Everyone then takes on some responsibility in trying to help the struggling member. I feel we co-operate well. We stated at the very beginning just how we felt about Maths and we respect each others feelings (Judy)

Finally, their view of mathematics also changed to one which included the use of discourse as a useful way to make math meaningful--a view which they not only espoused, (other groups did this too) but actually used themselves as they worked publicly on problems of understanding.

Discussion and Conclusions

To see how these data help us understand the development of a learning community, we will use the interpretive framework of community "glue" factors described in the introduction. These were Function, Identity Discourse and Shared Values--without all of these factors operating, a healthy community will not develop and thrive.

Identity:

In order to work out Identity within a group, one needs to participate. While the members of all the groups participated in the small group work, their different experiences within that first term, combined with prior mathematics experiences, likely defined their sense of how far the felt they could get. High Active members participated proactively in both face to face and electronic situations, and an important part of their identity which changed was the notion that they were now "mathematicians"-- if not in knowledge, then in their ability to discuss mathematical ideas in a community, rethink and relearn from other mathematicians and more knowledgeable peers. This accords with Lave and Wenger's (1991) description of legitimate peripheral participation in a community of practice. By contrast Low Active members participated least in the Math Inquiry database. Their term of greatest contribution was Term 1, which also coincided with the most concentrated small group math investigation work. This face-to-face experience may have helped them feel more of an identity with the group at that time because of the personal support. This may have enabled them to enter contributions, but perhaps not enough, because their electronic contributions lessened when the small group math work stopped during the second term. Their potential for initially developing an identity as part of a mathematical discourse group may well have been limited by blaming their own ability for their prior mathematics experiences, thus causing them to hang back

and interpret their difficulties (many of which were shared by most of the class) as further evidence of their mathematical limitations. This may have reduced their participation in the small groups and also reduced the relevance of the math electronic discussions. As one Low Active member put it, she would rather go to another subject area discussion "because I have something to offer" (Janet). Lack of memories of mathematical success at any time, would likely reduce one's belief that one could make significant progress, and prompt one to choose instead an area in which one felt confident.
The Gaining Active members had mixed experiences in the small group discussions, as well as various kinds of computer difficulties, but all shared a determination to succeed, which may have in part been due to interpreting their prior math difficulties as at least partly not their fault. Additionally, they all seemed to have some successful mathematics experiences at some point in their lives, and this may have helped motivate them through the difficult times. They were able to raise questions, seek explanations to help them work out their role as teachers and participants in the electronic community.

While computer access and comfort level as well as concerns about mathematics are certainly factors in determining the amount of database activity in which participants engaged, there may well be other factors involved, including dispositions to engage with the material in deep ways, such as suggested in Salomon's concept of Mindfulness (1991). However, there is also an important social component in the contributions of the High Active members--they explicitly value the input from others and ask for feedback on their understandings, suggesting that the community forum is providing the impetus for their involvement over and above their own tendency to engage, or not engage, in mindful thinking.

Function

This refers to the goal or objective of the community. The goal of the mathematics experiences from OISE/UT's perspective was to provide participants with an opportunity to rethink and relearn mathematics ideas in a more flexible way, based on real understanding, rather than reliance on rote procedures. The electronic community provided a context for extending and reflecting on the various in-class and pedagogic experiences participants underwent. The High Active members seemed to catch onto this and extended it further. They were able to share the process of their understanding in a public way (explanations and proofs became knowledge objects in the database), asking for feedback and reflecting on and reworking ideas on the basis of that feedback. Through this process of knowledge building, they extended both their understanding of math and mathematical community and teaching.

The Gaining Active members also participated, responded to others, were supportive, shared positive experiences and asked significant questions. However, they made fewer contributions, and also made fewer iterations of their ideas publicly in the database. Typically they would write one comment or question, then read the response or responses, but usually did not initiate a second round of discussion.

For Low Active members, their contributions were primarily related to their attitudes and beliefs--expressions of relief that others shared their anxiety, pleasure at grasping an idea and realization that they were able to approach math differently through discourse. However, they tended not to ask questions through the public conference, or attempt to extend the definition of the community in the way the other groups did.

Discourse

Discourse is the language of the community, that evolves through being involved in the community. Gee (1990) claims that the knowledge required for Discourse membership is acquired only as a result of participation. Without direct participation, such skills, knowledge and concepts cannot be learned. A Discourse serves as a social "identity kit" (Trathen & Moorman, 1996) which determines how to talk, act and think in order to be a member. These would be the "literacies' (Gee, 1990) required for membership in the discourse. From a social constructivist perspective, the goal of teacher education is to help new members learn to engage in the dialogues that form the Discourse of professional teacher communities.

In this study, the electronic commentary allowed the Discourses to be both made explicit, and become objects for reflection, questioning and revision. The working out of participants identities--such as "being mathematicians" enabled the establishment of Shared Values and the defining of the community's Function. Additionally, discourse allowed participants to develop new ways of thinking about mathematics as well as how to teach it. We see from the patterns of contributions an increase in the amount of involvement in the database with time, an indicator of growing community. Even among people who participated less, that information remains available for reflection and commentary, leaving open the possibility that they may contribute further at another time.

An informal support for the importance of this discourse is that many of the students (both within the focus group and in the rest of the class) have asked faculty members if the electronic discourse can continue after the program finishes, saying that they have built up such a strong bond among the whole cohort, that it would very valuable to maintain that support.

A question remains though--do people who mainly only read the Discourses of the community interaction actually become members in the same way that more active contributors seem to? . The evidence from the current data suggest that they do up to a point. By reading extensively members are at least exposed to the model of reflective discourse in which they may decide to participate as their own experiences and knowledge deepen through reading, course work and practicum experiences in the classroom. The differences between the High and Gaining Active members lies mainly in the iterations of their ideas as well as the detailed nature of their explanations. These aspects of their contributions define the Function of the community and in particular serve to extend or deepen the discourse. Without these contributions, the discourses would primarily serve social functions as well as sharing of curriculum ideas, but it would lack the model of problem identification and analysis available in the High Active contributions in particular, which enable the development of reflective practice about pedagogy and subject matter at the heart of a learning community.

Shared Values

Looking at the themes and language used throughout the database, a number of shared values emerged:
1. The importance of a mathematical discourse community (which can develop in both face to face, and electronic contexts)
2. The validity of using discourse as a way to deepen understanding and share mathematical understanding.
3. The need for strong social support for peers in their teaching experiences: encouraging risk-taking and offering substantive help.
3. A view of math which extend beyond algorithmic computation
4. A view of teaching mathematics in which teachers create safe and positive learning environments and support the exploration and development of mathematical ideas through small group discourse, direct experience and authentic mathematics exploration.
5. A view of pedagogy which starts where the students are. Understanding the need to appreciate the students understanding of a concept as a starting point for effective teaching.
6. Everyone is a learner.
Each of these values can be identified somewhere within the database contributions or interview responses of members from each of the three groups. In addition, the High Active members added the last value, one shared by the Faculty and mathematicians working in the electronic database, but not yet by some of the Gaining Active and Low Active members.

7. Knowledge building through identifying problems of understanding and working these through in a public manner.

In conclusion, these data suggest that the electronic database can offer the conditions necessary for maintaining community, at least for the majority of participants. Some participants found it provided a context for building their knowledge about mathematics and pedagogy. Everyone found it provided social support and ideas for lessons as well a forum to pose questions about different pedagogical and content issues. The different patterns of database use shown by the various groups suggests too that it offers a different kind of community for some people, than found within face-to-face interaction, but one that with time, and support for both technical issues as well as discourse, can provide a place for a wide variety of people. Further, the different participation patterns of the three groups suggest the need for more intensive or extended small group experiences with mathematics to give particularly the Low Active members successful experiences which could help them build enough confidence and sense of belonging to allow them to engage in the more extended discourse and reflection of the rest of the community.

In the final phase of this program we plan to continue data collection in the following ways.

1. Some participants in the MST specialization will be working in CSILE classrooms during their next practicum, and we expect that the exposure to student mathematical thinking will offer an important source of information for them to use in order to reflect on their pedagogy. We will conduct interviews on their experience during this practicum, as well as a final Mathematics test.
2. Continue to monitor the database contributions to the Math Inquiry conference to see if experiences in other parts of the program affect Gaining Active and Low Active members' participation in it.
3. Conduct final interviews with all the participants, in order to assess changes in their attitudes towards math, computers and their own role in the electronic discussions.
4. We are also looking into the possibility of maintaining this inquiry database, after participants graduate to provide support during their first year of teaching.

Once the data collection is complete we will also be carrying out more detailed quantitative analyses of the patterns of interaction of the many different factors involved in this program. The importance of technology for teaching and learning within the program is considerable, and while it is less domain specific than other technology-enhanced learning environments such as Earth Lab (Newman, 1990) or Pea's (1993) Optic Project, it appears to have similar systemic effects to these technology-intensive learning environments (TILE's) described by Salomon, 1996. Such an approach to studying "differences in patterns" as opposed to "patterns of differences" (p370) may well yield a more detailed understanding of how cohesive communities emerge in this kind of learning context.

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