

Online Community and Preservice Teachers' Conceptions of Learning Mathematics

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Abstract: This paper reports on how a mathematical knowledge-building community was used to facilitate changes to a group of preservice teachers' conceptions of learning mathematics.

Keywords: knowledge-building, mathematics, conceptions-of-learning

Introduction

Most current reforms to mathematics curricula are placing great emphasis on the need for teachers to create and maintain within their classrooms communities of mathematical practice in which thinking, problem solving and "talk in the spirit of disciplinary work" occur (Lampert, Rittenhouse, & Crumbaugh, 1995). In order to do this, teachers need to have good repertoires of mathematical subject matter and pedagogical content knowledge (Leinhardt, 1989). However, evidence from the research literature indicates that most beginning teachers do not possess such repertoires of knowledge (Batturo & Nason, 1996).

The goal of this study was to encourage preservice teachers enrolled in a two-year teacher education program to engage in a mathematical knowledge-building community. Communities of learning have been used effectively as means to promote reflective educational practice and now researchers are calling for these environments as means to advance the status of the profession (Seashore, Louis, Kruse, & Bryk, 1995). Brown and Campione (1990) suggest a learning community is defined as a group of individuals who engage in discourse for the purpose of advancing the knowledge of a collective--to participate in what Scardamalia and Bereiter (1991) call knowledge-building. It was envisaged that preservice teachers' participation in a mathematical knowledge-building community would facilitate the development of their subject matter and pedagogical-content knowledge.

This paper focuses on the preservice teachers' conceptions of learning mathematics, an important component of pedagogical-content knowledge. It also discusses some of the factors, which may have contributed to database participation. At the beginning of the study, most of the preservice teachers in questionnaires and interviews, saw learning mathematics as being the memorizations of facts, rules and formulae, a conception of learning quite antithetical to the socio-constructivist theories of learning underpinning current mathematics curricula. Therefore, one of our major aims was to facilitate change in the preservice teachers' conceptions of learning mathematics. In addition, most of the group disliked or felt anxious about learning and teaching mathematics.

Method

Participants

The twenty participants in this research study (19 female, 1 male) were purposely sampled (Patton, 1990) from a cohort of preservice teachers from a variety of ethnic backgrounds (N=57) enrolled in a 2 year certification course at OISE/ University of Toronto. Students were initially assigned to small groups for their investigative mathematics workshops, for discussion purposes. Math investigation groups were created with the following criteria: between 4-6 members, to allow for more equitable participation (with not more than one male per group in order to increase the participation of females). Two all female groups consisted of females who indicated mathematics to be an area of concern for them in their teaching. Participants from four of these groups, the two all-female groups and two other randomly chosen groups (20 participants in all) were asked to participate in a more detailed study that included periodic individual

interviews. 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.

Data sources

The investigation involved detailed analyses from three data sources: 1) Database entries from the electronic conferences across the 2 years; 2) Responses to questionnaires and periodic interviews about mathematics, the role of technology and their sense of community within the program; and 3) Portfolio entries submitted over a 2-year period in partial fulfillment of their degree requirement. The contents of the portfolio entries were composed of self-selected reflections of important experiences encountered by the OISE/UT students at any point during the program.

Procedure

Semester 1

A series of 8 two-hour workshops based on a sequence of open-ended mathematical investigations provided the core of this Semester's mathematics activities. The workshops also had the explicit aim of enhancing the quality of the preservice teachers' repertoires of substantive knowledge about the Hindu-Arabic base-ten place value system, the operations of addition/subtraction and multiplication/division, and problem solving heuristics. Concurrently with the workshops, the preservice teachers made entries to their portfolios and participated in Math Inquiry electronic conferences. In these electronic conferences, the preservice teachers were encouraged to: (a) articulate their concerns about the learning and teaching of mathematics; (b) further discuss ideas brought up in the workshops; (c) share their ideas and solutions to mathematical investigations with their peers; (d) ask for clarification and/or confirmation of ideas and solutions; and (e) discuss and critique points made during the workshops and/or on the electronic database. They also were given training sessions and support in using this technology. Because there was so much variability in prior computer experience as well as level of computer access--especially home access--considerable attention was given to providing equipment (Alex terminals in the first year and laptops in the second year) and in class training and practice so that people could get connected. Additionally, the first term's Math Inquiry notes were printed off and bound and given to all the class members so they could see the different kinds of entries being made and join in if they had not already. The preservice teachers' portfolios and their contributions to the electronic database conferences were quantitatively and qualitatively analyzed.

Semesters 2, 3 and 4

During Semesters 2, the preservice teachers investigated how the Jasper Woodbury videodisc materials (Learning and Technology Center at Vanderbilt University, 1996) could be utilized to establish and maintain communities of mathematics practice in elementary school classrooms. Further participation in the electronic conferences and entries to their portfolios were encouraged. The participants were individually interviewed again near the end of Semester 2.

During Semester 3, the participants attended a sequence of mathematics education lecture/tutorials in which they were introduced to mathematics curricula and methods for teaching mathematics. A major component of this semester was a six-week block classroom placement. Thus, the major focus of their electronic database conferences during this semester was on issues related to preparation for their block classroom placement and/or issues and topics brought up during the formal mathematics education lecture/tutorials. In Semester 4, the preservice teachers had no formal mathematics education classes. 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 and assessment.

Throughout Semesters 3 and 4, we continued to monitor and facilitate database use, evaluate student portfolios, 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, as well as a final questionnaire about their current definition of mathematics, how they saw the teaching and learning of mathematics and how they evaluated themselves in relation to mathematics.

Results and discussion

Mathematics Discourse in the database

By the end of the study, the database discourse centred on three distinct conceptions of learning of mathematics. The first we have characterised as social assimilation. Much of this discourse consisted of sharing reactions to the small group experiences of the mathematical investigation workshops and to their positive practicum experiences such as a teaching episode or a class experience that was helpful. For example, the following excerpt is a typical example of this kind of discourse:

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 than 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 waylets make math enjoyable. (Lisa)

The second type of mathematics learning that emerged we have called social re-construction. Examples of this discourse includes entries about positive experiences, like that of the social assimilation discourse, and extension to the discourse to include questions and challenges to ideas raised in class:

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, participants engaged in this type of discourse didn't necessarily pursue those ideas in the computer-mediated database conferences. Once a response on a particular topic or issue had been inserted in the shared database, they tended not to initiate another round of discussion about the topic or issue. The third type of mathematical learning we have termed social de-construction and re-construction. This involves identifying problems, analysing topics/issues in detail, deconstructing and reconstructing ideas, examining assumptions and developing understanding of the topics/issues through cycles of dialogue. An example of de and reconstructing knowledge is well exemplified by Wendy in one of her contributions to the computer-mediated conference about the "Magic Show" investigation. In the initial part of this note, Wendy deconstructed specific multiples of nine to try to understand why if you add the digits of a multiple of nine, the total will be nine.

Let's look at those multiples of 9. We'll start with multiples of single digits. When we multiply any number by 9 we will get a number that is 10 less than 10 times that number plus the difference between that number and 10. So for example if we multiply 7 by 9 we get 63. 63 is ten less than 70, plus 10 - 7 or we can show it like this:

$$7 \times 9 = [(7 \times 10) - 10] + (10 - 7) = [70 - 10] + 3 = 60 + 3 = 63$$

Or we could say $7 \times 9 = (7 \text{ groups of } 10 - 1 \text{ group of } 10) + 10 - 7$

When we add the digits together we are adding the number of groups of ten and the number of ones. In the case of 63 we are adding 6 (there are six groups of ten in 63) plus 3 to get 9. Or if we look at the alternate representation of 63, (7 groups of 10 - 1 group of 10) + 10 - 7 what we will be adding is 7 - 1 + 10 - 7. The sevens then cancel each other out, leaving us with - 1 + 10 which equals 9.

Wendy then deconstructed two other examples. Following this, she then constructed the following algebraic generalization:

$$9x = (10x-10) + (10 - x)$$

To add the digits we would have to divide $(10x - 10)$ by 10 since we are adding the number of groups of 10 so the equation would look like this:

$$\begin{aligned} & \frac{(10x - 10)}{10} + (10 - x) \\ &= (x - 1) + (10 - x) \\ &= x - x - 1 + 10 \\ &= -1 + 10 \\ &= 9 \end{aligned}$$

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.

Considering that Wendy had indicated at the beginning of the study that she had found algebra difficult and rather threatening while she was at school many years previously, her attempt at constructing an algebraic generalization of her “proof” was a high-risk undertaking on her part.

The characteristics of these three conceptions of learning mathematics are summarized in Table 1 below.

Characteristics	Social Assimilation	Social re-construction	Social de- and re-construction
Locus of learning	Predominantly in social contexts where the participants in a community share mathematical ideas whilst in the process of collaboratively solving problems face to face	Predominantly in social contexts where the participants in a community not only share ideas whilst in the process of collaboratively solving problems but also socially reconstruct mathematical ideas	Predominantly in social contexts where the participants in a community not only share ideas whilst in the process of collaboratively solving problems but also socially de-construct and re-construct mathematical ideas
Processes of learning	1. assimilation	1. assimilation 2. local, surface-level accommodation	1. assimilation 2. global, deep-level accommodation
Notions of Mathematical authenticity	Defined in terms of how well the newly-acquired knowledge relates to the real-world and interests of the learner	Defined in terms of how well the newly-acquired knowledge relates to the real-world and interests of the learner	Defined not just in terms of how well the newly-acquired knowledge relates to the real-world and interests of the learner but also in terms of legitimate mathematical activity
Outcomes of learning	New information added to or assimilated into each learner's repertoire of knowledge	Re-constructed knowledge which tends to be non-principled in nature, and <u>not</u> represent Kuhnian-like paradigm shift reconstructions of knowledge	De- and re-constructed knowledge which tends to be principled in nature and represent Kuhnian-like paradigm shift reconstructions of knowledge

¹ After receiving feedback from other participants and her lecturer, Wendy was able to produce a mathematically elegant and correct algebraic generalization.

Participation Patterns in the database

Analysis of the data about the participants' involvement in the Math Inquiry conferences identified four sub-groups (Woodruff, Brett, MacDonald & Nason; 1998):

Engaged (n=5): This sub-group started out with the highest levels of reading (>60% of others' notes) and writing (>10 notes per year), and increased or maintained involvement over the course of the four semesters.

Emergent (n=6): This sub-group changed most, particularly in relation to the number of math entries they read. Their levels of reading started out low but increased steadily over the course of the four semesters (>20% increase between Year 1 and Year 2). Their written contributions to the math inquiry conference, however, were still low but increased (>2 notes) between Year 1 and Year 2.

Withdrawing (n= 6): This sub-group's levels of written contributions to the math inquiry conference decreased (or remained very low and unchanged) over the course of the four semesters (a drop of < or = 1). Most of their participation was confined to the reading the contributions of others, although this too decreased between year 1 and year 2 except for two people (a drop of 10%-60%).

Disengaged (n=3): This sub-group engaged minimally in the math inquiry conference in both years, either in reading (< 1%) or writing < or =1 note).

To put these participation rates in perspective, it should be remembered that the Math Inquiry conference was but one of 6 conferences in the first year, and one of 24 in the second year! Participants typically participated in many conferences, and, because this activity was not directly used for evaluation purposes, it constituted an additional learning context that participants took on themselves.

Nevertheless, there were interesting differences in content as well as the amount of participation in relation to mathematical ideas. Only the Engaged participants espoused social de- and re-construction conceptions of learning mathematics. This was not only reflected in their computer-mediated and portfolio notes about how children learn mathematics but also in the ways in which they constructed mathematical knowledge themselves. Typical of all of the Engaged participants was the exploratory de-construction a mathematical idea embedded within an unfamiliar conceptual problem. This type of exploration facilitated global and deep-level accommodations to their knowledge structures and seemed to form an essential component of their knowledge building of mathematical objects.

The Emergent and the Withdrawing participants espoused the social reconstruction conceptions of learning mathematics. This was reflected in their computer-mediated and portfolio notes about how children learn mathematics and also in the ways in which they constructed mathematical knowledge themselves. These two sub-groups did less knowledge-building of mathematical objects. It was felt that much of this could be attributed to the local and surface-level nature of their accommodation processes. The Disengaged participants espoused the social assimilation conceptions of learning mathematics. Member of this group tended to conduct private, e-mail conversations with one or two of their friends. The focus of their use of the community was to provide and/or receive face to face individual support. Thus while they appeared "disengaged" from the electronic community, this is not to suggest that they had no ties to the community in other contexts, but rather that these tended to be expressed within smaller group and one to one contexts.

Participation through Reading

The amount of the online conferences read by the participants in the math inquiry conference was compared to an average of all other conferences for years 1 and 2. Results suggest that the Engaged and Emergent groups increase their reading in both contexts, while the Withdrawing and even the Disengaged group members increase their reading for other conferences, but decrease it for math. This finding suggests that the source of the unwillingness to engage might be partially demonstrated through participation patterns. Specifically, in the Withdrawing group, feeling unable to contribute substantively in mathematics (an oft-repeated concern expressed in interviews with members of this group² places one outside that community to a certain extent, something reflected in their reduced reading. However, a reaction to technological fears and problems may play a greater role for some people, for example, the Disengaged

² Further details of these qualitative analyses are reported in Woodruff, E., Brett, C. & McDonald, R. (1998) *Participation in knowledge-building communities to promote teaching competency in mathematics*. Paper presented at CSSE Conference, Ottawa, May.

group, whose overall rate is very low in both contexts. The Engaged group, by contrast, show consistently high written and reading involvement in both the Math Inquiry and other conferences. The Emergent group also show a reading increase between years 1 and 2. However, they show less of an increase through writing, but their *amount* of reading indicates an increased level of involvement. Their ambivalence towards mathematics, which they talk about in interviews, seems to be reflected in their "distanced" and greater frequency of later reading (reading entries more than 5 days after posting). This group is particularly interesting because their participation in general increased from Year 1 to Year 2. In math, this is significant because the small group work, which everyone found so supportive during year 1 had finished, so there was less face-to-face support for mathematics discussion. Those who had gained most confidence from that experience (the members of the Engaged and Emergent groups) seemed to be able to either maintain (in the case of the Engaged group) or develop (in the case of the Emergent group) a sense of community support in the virtual context of the database. However, among the Emergent group, either their beliefs about the level of their content knowledge, or their comfort with discussing mathematical ideas held them back from fully participating through both reading and writing.

Other Factors influencing participation:

Analyses of the responses to the questionnaires and the interviews revealed four factors, which influenced the levels of participation in the community:

1. Access to computers;
2. Degree of comfort with the shared database; and
3. Influence of mathematical investigation workshops
4. Attribution for negative feelings about mathematics.

Access to computers

Home access to the computer-mediated database conferences was found to be a critical factor. This was particularly so during Semester 1 when not all of the participants had access to the conferences from home. According to those participants who had home access to the conferences, this facility provided them with time to focus on and think about the topics and issues being discussed, thus facilitating the process of reflection. They also reported that having home access enabled them to participate in the discourse when the ideas they wished to contribute to a conference were fresh in their minds. The participants who did not have home access reiterated this viewpoint. Although all participants had access to computers at the University of Toronto, many of the participants without home access claimed that they had difficulty in participating because of lack of time and unavailability of computers during their time at the university campus.

The problem of lack of home access was alleviated at the beginning of the second semester when everyone was given a computer terminal (VT 100 terminals) and modems for home. Thus, in theory at least, all participants then had equal access to the computer-mediated database conferences. Unfortunately, this was not so in practice. Many participants, especially those from the Emergent and the Withdrawing sub-groups, reported technical difficulties such as terminals malfunctioning and having very slow access to a conference, which they claimed, had negative effects on the quantity and quality of their participation in the conferences. However, the Emergent participants seemed more prepared to cope with these technical difficulties and more fully participate in the conferences than the Withdrawing participants.

Degree of comfort with the 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 Disengaged participant described the experience of using the computer (during Semester 2) :

“..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 many of the participants, especially in the Emergent, Withdrawing and Disengaged sub-groups, using e-mail was a more direct and preferred means of communication. In the words of another Disengaged participant:

“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 semester, 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 mathematical 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 Semester 2. In part this may have been due to database conference 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, Engaged participants discussed their feelings openly from the beginning, about mathematics, the small group math investigations, and their teaching concerns, as illustrated in the examples below:

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. It was awful and coloured my image of Maths. You are now breaking down that image, Thank you. (Judy)

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)

Influence of mathematical investigation workshops

The members of the focus group of twenty participants were differentially influenced by the small group math investigations, which took place weekly during Semester 1. All participants found them helpful, and for the Engaged sub-group 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 Engaged sub-group 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 Emergent, Withdrawing and Disengaged sub-groups tended to take longer to become used to the small group setting. For example, one Emergent sub-group participant, Lisa commented:

“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 Emergent and Disengaged sub-groups was that the Emergent participants seemed to see the group experience as having 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 Emergent sub-group members, the group experience made them less intimidated by the mathematics content. However, the Disengaged sub-group 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)

The Withdrawing sub-group members had much in common with both the Emergent and the Disengaged sub-group members. Like the Emergent participants, they too seemed to see the group experience as having value because of the shared ideas as well as the shared identity of trying something difficult. But, like the Disengaged participants, they also felt that the confidence building function of the small group mathematical investigations was very important. These feelings are epitomised by Annabelle’s comment:

I don't know if anyone feels the way I do right now, but I think I got the hang of the math. Take it from me, I never thought math could be made so easy! Especially for someone like me who has to struggle with every calculation. Being in a groups was a terrific idea because many sides of the coin were given and if I didn't get something, each member was kind enough to stop and explain things. The tension of having to teach math, let alone understand it, has been eased off my back. (Annabelle)

Attribution for negative feelings about mathematics

In an interview during the second semester, the 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?” Engaged participants 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 analysed 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)

Emergent and Withdrawing participants 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 Engaged participants, 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 their responses to this interview question, the Disengaged participants 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).

It is interesting to note also that the Disengaged participants did not have the lowest scores on an incoming mathematics test given at the beginning of Semester 1. Nevertheless, they seemed never to have experienced successes in mathematics 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 Engaged participants.

Conclusions and Implications

The findings from this study indicate that the approach of establishing and maintaining a community of mathematics practice within preservice mathematics education programs shows some promise. Paradigmatically, the conceptions of learning manifested by the Emergent, Withdrawing and the Disengaged sub-groups corresponded closely with models of knowledge-sharing posited by Lave and Wenger (1991) in which members newly inducted in a discourse community often emulate, or appropriate conventions of communal discourse without having a full conceptual understanding. Most participants substantially changed their conceptions of learning mathematics from transmission/absorption models to ones approaching socio-constructivist models. However, only the Engaged participants had developed conceptions of learning mathematics that would enable them to adequately understand the socio-constructivist assumptions underlying the reforms in mathematics curricula. Therefore, a productive line for further research would be to investigate how a greater proportion of preservice teachers enrolled in mathematics education programs can be encouraged to fully participate (like the Engaged sub-group) in communities of mathematics practice. The analysis of data from this study indicates that continuing face-to-face encounters throughout the course of a program and introducing electronic conferences later on in a program after the preservice teachers have had the opportunity to develop higher level collaborative skills are factors worthy of investigation.

Bibliography

- Baturo, A. & Nason, R.A. (1996). Student teachers' subject-matter knowledge within the domain of the measurement of area. *Educational Studies in Mathematics*, 31(3), 235-268.
- Brown, A., & Campione, J. (1990). Communities of learning and thinking, or a context by any other name. *Contributions to Human Development*, Vol. 21, 108-126.
- Lampert, M. (1988). What Can Research on Teacher Education Tell Us about Improving Quality in Mathematics Education? *Teaching and Teacher Education*, 4 (2), 157-170.
- Lampert, M., Rittenhouse, P., & Crumbaugh, C. (1995). Agreeing to disagree: developing sociable mathematical discourse. In D. Olson & N. Torrance (Eds.), *Handbook of Education and Human Development: New Models of Learning, Teaching and Schooling* (pp. 731-764). Oxford: Basil Blackwell.
- Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.
- Learning and Technology Center, Vanderbilt University. (1996). *The new adventures of Jasper Woodbury: Make mathematics meaningful* [Videodisc]. Mahwah, NJ: Learning Inc.
- Leinhardt, G. (1989). Math Lessons: a Contrast of Novice and Expert Performance. *Journal of Research in Mathematics Education*, 20 (1), 53-75.
- Patton, M.Q. (1990). *Qualitative evaluation and research methods* (2nd.) London: Sage.
- Seashore Louis, K., Kruse, S., & Bryk, A. (1995). Professionalism and Community: What is it and why is it important in urban schools? (p. 3-24) In K. Seashore Louis and S. Kruse (Eds.), *Professionalism and community: Perspectives on reforming urban schools*. New York: Sage.
- Scardamalia, M., & Bereiter, C. (1991). Higher levels of agency for children in knowledge building: A challenge for the design of new knowledge media. *The Journal of the Learning Sciences*. Vol. 1, 37-68.
- Woodruff, E., Brett, C., McDonald, R. & Nason, R. (1998) *Participation in knowledge-building communities to promote teaching competency in mathematics*. Paper presented at CSSE Conference, Ottawa, May.

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