The EMU experience: Developing communities of mathematics practice in pre-service teachers

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This paper examines the conditions which supported the use by pre-service teachers' of a shared database to enhance the development of a mathematical knowledge-building 'community'. We focus on a cohort of 100 students enrolled in the 4th year of the BEd(primary) program at QUT. 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 measurement workshops as well as access to shared electronic data bases which included conferences of commentary on mathematics to which pre-service teachers, their lecturers and researchers could post ideas and comments. 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.

Background

Within the education community, there currently is a trend 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, in press).

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., in press). In order to provide students with authentic mathematical activity, most mathematics reform documents are suggesting that instructional programs need to encourage the development of 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. The reform documents also imply that there should be a shift away from classrooms in which the

teacher (or the computer or the textbook) are 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.

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: (a) a transmitter of the mathematical culture who inducts her students into the community of mathematics practice (Driver et al., 1994; Brown, Collins & Duguid, 1989), (b) a guide, (c) a mentor, (d) a model genuinely engaged in authentic exploration of the mathematics subject-matter (Brown et al., 1989), (e) a facilitator of mathematical discourse, and (f) a highly knowledgeable member of the community of scholars in the classroom (Bereiter, 1994; Leinhardt & Fienberg, 1992).

A review of the discussions about the quality of teaching (e.g., Merseth, 1993) 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 mathematical subject-matter knowledge and pedagogical content knowledge (Shulman & Sykes, 1986). Subject-matter knowledge includes: (a) substantive mathematical knowledge such as facts, ideas, theorems, mathematical explanations, concepts, processes (and connections between these elements); (b) knowledge about the nature and discourse of mathematics; (c) knowledge about mathematics in culture and society; and (d) 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 or pedagogical content knowledge which would enable them to create knowledge-building communities of mathematical practice in their mathematics classrooms (Baturo & Nason, 1996; Reynolds, 1985). Why many beginning primary school teachers have inadequate repertoires of mathematics subject-matter knowledge and pedagogical content knowledge and why a number of these teachers also have 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 (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.

We see a computer-mediated knowledge-building community, developed during a preservice course and continuing after graduation as a potentially realistic and effective way to improve the quality of graduating teacher education students' repertoires of mathematics subject-matter knowledge and pedagogical content knowledge. According to Bereiter (1994), 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, during knowledge-building, the learners 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.

In this paper, we describe our initial attempts to establish a knowledge-building community amongst a cohort of fourth year BEd(Primary) teacher education students. As this is still work in progress, many of the findings presented in this paper are tentative in nature.

Description of the Program and Participants

The participants in this program were a cohort of Year 4 pre-service teachers (N=100) enrolled in a B.Ed (Primary) unit in Mathematics and Technology education at the Queensland University of Technology during Semester 1, 1997. This unit focused on information technology in education issues and mathematics education issues concerned with the teaching and learning of measurement, problem solving and probability and statistics.

One of the major issues explored in the lectures and the tutorial/workshops was collaborative learning. In particular, many discussions focused on how information technology could be used to facilitate collaborative learning. For example, all students were required to read and reflect on a set of seminal papers in the fields of computer-mediated collaborative learning (e.g., Bereiter, 1994; Pea and Gomez, 1992) and social construction of knowledge (e.g., Cobb, 1994).

In order to operationalize the notion of computer-mediated collaborative learning, a computer-mediated shared database in which the participants could conduct asynchronous

conferences was established. In this shared database, the participants were required to post prior to their team's workshop presentation on a measurement topic, the aide memoires their team had produced for that workshop presentation. They also were encouraged to make critical but supportive comments about the aide memoires and the workshop presentations of other teams, to pose questions and to share ideas.

The shared database enabled each pre-service teacher to read all of the aide memoires, comments and notes posted on the database. However, unless they were given editorial access by the authors, they were not able to make modifications to the aide memoires, comments or notes. This enabled the authors to retain a sense of ownership. For example, a few students put drafts of their paper on the database inviting comments and suggestions from other students. But only they were able to edit the drafts of their paper.

The teams typically consisted of two or three participants who at the beginning of the semester had been assigned a measurement topic to investigate. In their investigations, each team was required to review the research literature about their topic and produce a one-two page aide memoire in which the key theoretical and practical issues about the topic were broached. They were also required to prepare and lead a thirty minute workshop in which some of the key ideas about the topic listed in the aide memoire were elaborated on and/or exemplified. Two weeks after the presentation, each team was required to submit a 2000-2500 word paper in which they reviewed relevant research literature and discussed the important issues concerning the teaching and learning of their topic.

The measurement topics investigated in the four weeks of measurement are listed in Table 1 below. During each workshop, three presentations about the topic of the week were made. One team focused on teaching and learning of the topic in Grades 1-2 (Early Childhood): a second team focused on teaching and learning of the topic in Grades 3-5 (Middle Primary); and a third team focused on teaching and learning of the topic in Grades 6-7 (Upper Primary). Thus, by the end of each workshop session, the teaching and learning of the topic in all primary school grades had been covered.

Early ChildhoodMiddle PrimaryUpper PrimaryWeek 1LengthLengthLengthWeek 2AreaAreaAreaWeek 3Mass/VolumeMass/VolumeMass/VolumeWeek 4Time/MoneyTime/MoneyTime/MoneyTable 1 Measurement Workshop TopicsBecause the cohort of pre-service teachers had been allocated to four tutorial groups (N = approximately 25), four sets of aide memoires were posted in the shared computer-mediated database. This enabled the pre-service teachers to not only peruse the aide memoires presented to their tutorial group, but also the aide memoires presented to the pre-service teachers in the other three tutorial groups. Furthermore, it enabled each team to compare their aide memoire about a particular topic with those produced by other teams of students.

Data Sources

Three data sources were used in this Pilot Study:

(1) Shared database materials

The aide memoires and the comments written in the shared database were analysed qualitatively to assess how well the teams were able to collect and organise information about the teaching and learning of their topic.

(2) Interviews

Interviews were held with a sample of 20 pre-service teachers from one tutorial group at the end of the semester to ascertain: (a) how they utilised the shared database, (b) problems associated with the use of the shared database, and (c) how the shared database helped them prepare for the end of semester examination.

(3) 2000-2500 Word Paper

This paper was analysed to assess how well each team had reflected on their topic during and after their workshop presentation and what conceptual advances had been made.

Results

Due to a number of technical problems such as computer network breakdowns, software-hardware incompatibilities, the deep level and reiterative discourse about each topic which we envisaged would happen during the semester did not occur. For example, many of the participants found the task of attaching the files containing their aide memoires to the computer database a frustrating and stressful activity because the collaborative database software did not accept their word processing software code. Because of this particular problem, some of the participants never got around to posting their aide memoires. Another problem which confronted the participants was access to networked computers. Unfortunately, our license for the collaborative database software was limited to 50 users. Therefore, only one computer laboratory at QUT allowed the pre-service teachers access to the shared database.

However, despite these technical difficulties, most pre-service teachers did read the information placed in the shared database. Data collected from the interviews indicated that the pre-service teachers had a number of different reasons for reading the shared database. For example, many students perused the other aide memoires posted on their topic. They commented that they found this very helpful for the following reasons:

(1) it helped them to locate new references in the mathematics education and general education literatures;

(2) it helped them to identify new ways of organizing and presenting information about their topics;

(3) it helped them to gain a K-7 overview of their topic; and

(4) it helped to confirm whether they had an in-depth understanding of their topic.

A second major reason for reading the database was to help prepare the final draft of their paper. Unfortunately, most of the students were not willing (or were not confident enough) to post draft versions of their papers on the shared database. Most students instead read the aide memoires and comments and used this information plus the verbal feedback they received during and after the workshop sessions to revise their papers. Some students expressed the fear that if they had posted drafts of their paper on the shared database, then some of their best ideas may have been purloined by other students. Their competitive urges seem to have overcome their notions of collaborative knowledge-building.

Another purpose for reading the database was to help better prepare for the end of semester examination. Some students when referring to a particularly weak workshop presentation and aide memoire on the measurement of time indicated that they were very relieved that they were able to refer to two other aide memoires produced by students in two other tutorial groups. They stated that being able to read and print out these aide memoires saved them many hours of work. Even if the aide memoires and presentations of a topic in their tutorial group were good, these students felt it was prudent to review all of the aide memoires.

Some pre-service teachers did contribute more than their aide memoires to the shared database. However, in most cases, their comments were more about encouragemment and support rather than providing the context for deconstructing and reconstructing ideas. Thus, little knowledge-building as it is defined by Bereiter (1994) occurred as a result of the computer-mediated discourse. Most knowledge-building tended to occur in the face-to-face workshops and/or during the face-to-face discourse the members of each team had during the preparation of their 2000-2500 word paper.

In the Future

The initial attempts to establish a knowledge-building community amongst a cohort of fourth year BEd(Primary) teacher education students has been a salatory experience for both lecturers and students. However, now that the technical problems that plagued the establishment of the shared computer-mediated database seem to have been resolved, we approach the main study phase of this research project with confidence.

However, as was alluded to above, not all of the problems faced during the Pilot Study were technical in nature. If we are to establish and maintain a computer-mediated knowledge building community with our cohort of Year 4 BEd(Primary) students in 1998, then the following two non-technical problems will need to be resolved:

(1) How to develop commenting skills in the student teachers;

(2) How to overcome many student teachers' fears that they have little to offer to the discourse about mathematics education;

In 1998, we intend to present tutorials in which the pre-service teacher education students will be asked to analyse comments made by experienced teachers to primary school students involved in mathematical investigations. Then each team of student teachers will be asked to generate and attach comments on the notes posted by a group of primary school children conducting an electronically-mediated mathematical investigation. Their comments then will be commented on by both their tutor and the experienced teachers supervising the children's mathematical investigation. Thus, it is envisaged that by the second half of the semester when the measurement workshops and their associated aide memoires are to be presented, most of the student teachers will have developed adequate commenting skills to contribute to the collaborative knowledge-building of the group.

How to overcome many of the student teachers' fears that they have little to offer to the discourse about any mathematics education topic is a much more difficult problem to overcome. Based on experiences gained by Brett, Woodruff and Nason (1996), we intend to confront this problem by starting a mathematic resources and ideas folder where the student teachers will be encouraged to share ideas and resources which can be used in their block teaching practicum in the middle of the semester. When this was done at the University of Toronto by Brett, Woodruff and Nason, many issues such as the efficacy of using calculators arose which generated much vigorous computer-mediated discourse. Brett, Woodruff and Nason found that issues identified as being immediately relevant to pre-service teachers greatly increased the levels of participation in computer-mediated discourse.

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