Building Learning Communities to Support Beginning Teachers' Use of Technology

Merrilyn Goos **Anne Bennison**

m.goos@mailbox.uq.edu.au **a.bennison@mailbox.uq.edu.au**

School of Education

The University of Queensland

St Lucia Qld 4072

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This paper reports on the early stages of a three year study that is investigating the impact of a technology-enriched teacher education program on beginning teachers' integration of computers, graphics calculators, and the internet into secondary school mathematics classrooms. Whereas much of the existing research on the role of technology in mathematics learning has been concerned with effects on curriculum content or student learning, less attention has been given to the relationship between technology use and issues of pedagogy, in particular the impact on teachers' professional learning in the context of specific classroom and school environments. Our research applies sociocultural theories of learning to consider how beginning teachers are initiated into a collaborative professional community featuring both web-based and face to face interaction, and how participation in such a community shapes their pedagogical beliefs and practices. The aim of this paper is to analyse processes through which the emerging community was established and sustained during the first year of the study. We examine features of this community in terms of identity formation, shifts in values and beliefs, and interaction patterns revealed in bulletin board discussion between students and lecturers.

Introduction

Although research on mathematics teacher education has grown rapidly in the past 10 to 20 years, there are those who argue that teacher education remains an under-theorised field of inquiry, lacking coherent conceptual frameworks that address the complexity of individuals acting in social situations (Cooney, 1994; Lerman, 2001a). For example, much of the literature on teacher socialisation identifies and analyses the beliefs that prospective teachers bring to the pre-service course - beliefs which arise largely from their experiences as students in classrooms and frequently are reinforced by their practicum observations and initial teaching experiences (Brown & Borko, 1992). Functionalist perspectives on teacher socialisation tend to view teachers as being passively moulded by external forces to fit the existing culture of schools, and hence unable to implement innovative approaches (e.g. those involving the use of educational technologies) they may have experienced during their pre-service courses (Loughran, Mitchell, Neale, & Toussaint, 2001). However, Lerman (2001a) claims that the study of teacher beliefs is too static and decontextualised to adequately describe how teachers acquire the attitudes, values, and knowledge structures of their professional culture. Instead he proposes that teachers' learning is better understood as increasing participation in sociocultural practices that develop their identities as teachers. Sociocultural theories view learning as a collective process of enculturation into the practices institutionalised by specific knowledge communities. While recent research in this theoretical tradition has investigated school students' learning in classroom communities (e.g. see Boaler & Greeno, 2000; Lerman, 2000; Lerman 2001b), the study described here develops the concept of *community of practice* in the context of pre-service teacher education and its interface with beginning teaching. This paper reports on the first year of a three year study investigating how pre-service and beginning teachers are initiated into a collaborative professional community featuring both web-based and face to face interaction, and how participation in such a community shapes their pedagogical beliefs and practices.

Learning in Communities

Few studies have applied sociocultural theories to teacher learning in general, and to pre-service teacher education in particular. Yet the community of practice model seems to hold promise for understanding how novices (i.e. pre-service and beginning teachers) gain access to professional knowledge through collaboration with more experienced members (i.e. teacher educators and supervising teachers), and gradually adopt the practices of the community. A community of practice is a sustained social network of individuals who share common beliefs, values, and practices in the pursuit of a mutual enterprise that is connected to the larger social system in which the community is nested. Such communities have a common cultural and historical heritage, and it is through the sharing and re-construction of this collective knowledge base that individuals come to define their identities in relationship to the community. Because communities of practice evolve over time they also have mechanisms for reproduction through which the community can maintain itself (Barab & Duffy, 2000; Lave & Wenger, 1991; Wenger, 1998).

Although communities of practice are generally constituted through face to face interaction, communication technologies such as the internet can provide an alternative medium for participation. Within mathematics education, there have been attempts to design such online communities so as to challenge prospective teachers' beliefs about learning, teaching, and the nature of mathematics (e.g. Schuck & Foley, 1999). Nevertheless, when student teachers move out of this community into practicum placements, they frequently find it difficult to sustain any shift in beliefs towards the less procedural, more investigative view of mathematics typically promoted by the university program. Enabling pre-service students to continue their participation in a technology-mediated community during the practicum may

assist them to critically reflect on the dilemmas of practice and persist with innovative teaching approaches (see Brett, Woodruff & Nason, 1997).

Two additional difficulties identified in research into online communities concern the tension between designed and emergent communities, and the question of sustainability of such communities. For example, Derry, Lee, Kim and Seymour (2001) identified various forms of resistance to an online community designed for a cohort of secondary teacher education students. In imposing a structure on the operation of the community, the researchers incorrectly assumed that students and instructional staff shared their research goals. They concluded that any attempt to design a community should respect the context and follow from a careful analysis of local conditions and the needs of members. Likewise, Barab (2001) writes of the inherent tension in managing the interplay between the designed and the emergent in building online (or face to face) communities of in-service and pre-service mathematics and science teachers. He maintains that it is preferable to create a framework and then facilitate the growth of the community (i.e. adopt an emergent design) so that participants build the space, rather than imposing a design completely formulated in advance. The sustainability of a community of practice is related to the designed/emergent duality in that an emergent community is more likely to meet the needs of its members because they have played a part in its development and thus identify with its goals and values. Also, particularly in online communities, participation involves costs (investment of time, and effort in using the electronic tools) that may outweigh any benefits to members.

Our study differs from much previous research in that the community it is creating will expand longitudinally, over the three years of the project, to include not only pre-service students but also newly graduated beginning teachers and their professional mentors in schools. Thus the focus is not on a single cohort of pre-service students or the professional development of a particular group of teachers, but on inter-generational interaction emerging over time and how this shapes participants' beliefs about teaching and learning, and their own teaching practice. The aim of this paper is to analyse processes through which the emerging community was established and sustained during the first year of the study.

Technology and Teacher Education

In keeping with current developments in mathematics education, the function (or *mutual enterprise*) of this community of practice centres on integrating technology resources into the teaching of secondary school mathematics. One of the major themes in current debates on educational reform identifies the need for teachers to become more effective, confident, and creative users of technology in their teaching (e.g. Web-Based Education Commission, 2000). Similarly, there is growing recognition that pre-service teacher education programs must integrate technology into their own curricula to ensure beginning teachers are adequately prepared (e.g. McCoy, 1999). Within mathematics education, research studies have yielded descriptions of pre-service methods courses that help student teachers design technology intensive lessons using, for example, spreadsheets (e.g. Connell & Abramovich, 1999), multimedia (e.g. Bell, 1996; Kim, Sharp & Thompson, 1998), and the World Wide Web (e.g. Halpin & Kossegi, 1996). As graphics calculators are a relatively new technology their impact on such courses has yet received little attention, and this is a major focus of our study.

Research Design

Participants

Three successive cohorts of prospective secondary mathematics teachers (n = 16 in 2002) will participate in the study over its three year duration. These students are enrolled in a pre-

service Bachelor of Education (BEd) program available to undergraduates as a four year dual degree or to graduates as a single degree taken in four semesters over eighteen months. Students undertake mathematics curriculum studies as a single class group, in a one year course over the fourth year of the Dual Degree and the first two semesters of the Graduate Entry program. Twice during this year all students complete a seven week block of practice teaching. Data gathering involves all pre-service participants during the on-campus component of the BEd program, and selected participants during their practicum sessions and their first one or two years of teaching. In the third year of the study, supervising teachers or Heads of Department working with the selected students and graduates will be invited to join in a web-based professional development intervention centring on technology integration into mathematics teaching.

Pre-Service Course

We aim to create a learning environment in the pre-service course that is consistent with recent mathematics education research and curriculum reforms relating to learning mathematics in secondary schools (e.g. Australian Education Council 1991; Goos, Galbraith & Renshaw, 1999) in emphasising mathematical thinking and problem solving, communication and real world applications. There is growing agreement in the mathematics education community that learning to think mathematically involves not only acquiring knowledge, skills, and strategies, but also habits and dispositions of interpretation and meaning construction (Schoenfeld, 1994), that is, a mathematical point of view. Thus mathematics education is a process of enculturation into the practices of the discipline, and students' understanding of what mathematics is about is shaped by their participation in the classroom mathematical community of practice. Applying these ideas to teacher education, we involve our pre-service students in activities that immerse them in a culture of collaboration and mathematical sense-making. Our goal is to create a community of practice where interdependence can be nurtured, and shared purposes and values can be enacted. At the same time we want to challenge our pre-service students to adopt ways of working with students in their own classrooms that may differ substantially from their own experiences of learning mathematics at school.

The pre-service mathematics curriculum course is also enriched with the use of educational technologies, and students experience regular and intensive use of graphics calculators, computer software, and internet applications (see Goos, 1999). Integration of technology into mathematics education is emphasised through continuous personal access to a graphics calculator for the duration of the course (including the practicum), and assignment tasks that require preparation and presentation of technology-based classroom activities.

Data Collection Methods

Quantitative and qualitative measures are combined in the four components of the study:

(i) a large scale survey of secondary mathematics teachers' experience with and attitudes towards educational uses of technology (currently in progress);

(ii) cohort studies of pre-service students' beliefs about mathematics teaching and learning, their practicum experiences in technology integration, and the ways in which their shared experiences become part of the common culture and history of the pre-service community of practice;

(iii) individual case studies of selected students to gain in-depth understanding of issues in technology integration in specific school and classroom contexts;

(iv) a community-centred professional development intervention (in the third year of the study).

This paper draws only on data from component (ii), the cohort study of 2002.

As the conceptual framework for the study is derived from sociocultural theories of learning, particularly the concept of learning in communities of practice, the focus of the cohort studies is on identifying features of the emerging professional learning community in both its face to face and online forms. A mathematics community website has been established via Yahoo Groups, with membership restricted to current students (and graduates from 2003). The website offers access to bulletin board, email, and file sharing facilities. The advantage of such a community over web-based course tools used for flexible learning in university programs lies in its continued accessibility to members after graduation, when student email accounts are cancelled.

Messages posted to the bulletin board are automatically archived and thus available for analysis of interaction patterns. Bearing in mind the lessons from previous research on designed versus emergent online communities, we decided to impose minimal structure on bulletin board communication. This involved posting four questions to which students were asked to respond during the first practicum session, on the availability and accessibility of technology resources in their practicum schools, and the frequency and mode of use they observed during lessons and assessment tasks. (This contrasts with the approach imposed by most other courses in the Bachelor of Education, which require students to make a specified number of posts to a Web CT bulletin board as part of the course assessment program.) Students were also free to use the mathematics curriculum bulletin board (or its email equivalent) for any other purposes they chose.

Since shared beliefs are a feature of a community of practice, changes in students' mathematical and pedagogical beliefs over the first year of the study have been investigated by administering a questionnaire at the beginning and end of the one year course that focused on their beliefs about the nature of mathematics, mathematics teaching, and mathematics learning. The questionnaire (based on that designed by Frid, 2000) invites both open ended and structured responses. Students are first asked to describe what mathematics is to them, and then to explain why they think mathematics is taught in schools. The remainder of the questionnaire consists of 40 statements to which students respond using a Likert-type scale based on scores from 1 (Strongly Disagree) to 5 (Strongly Agree), with a score of 3 corresponding to Undecided. The statements are underpinned by current research on mathematics teaching and learning and are representative of the values enacted in the pre-service course.

Section 1 includes 14 statements about the nature of mathematics, Section 2 has 12 statements about mathematics teaching in secondary schools, and Section 3 has 14 statements on mathematics learning in secondary schools. Within each section, statements are paired to create positive and negative poles of a particular idea; for example, items 4 and 11 represent extreme positive and negative positions with respect to solution methods for mathematics problems:

4. There are often many different ways to solve a mathematics problem.

11. Mathematics problems can be solved in only one way.

In the literature these poles have been variously referred to as representing beliefs about mathematics being rule-based versus non-rule-based (Tharp, Fitzsimons & Ayers, 1997),

tramsmissive versus child-centred (Perry, Howard & Tracey, 1999), or closed versus open (Boaler, 1998).

Features of the Emerging Community of Practice

Feature of the community of practice as it took shape in the pre-service course during 2002 are analysed in terms of students' developing identities as mathematics teachers, shifts in their beliefs about mathematics and mathematics teaching and learning, and interaction patterns observed in bulletin board discussions.

Identity Formation

How did participation in the pre-service community of practice shape the students' developing identities? This question is considered in terms of two community features, *interdependence* - members' sense that they are part of a larger social system, or professional network- and a *reproductive cycle* - the way in which newcomers engage with the practices of 'old timers' to generate overlapping histories.

A typical approach within pre-service teacher education is to invite practising teachers with expertise in a specific field to present guest workshops as part of the regular on-campus program. While this demonstrates to students that there is indeed a broader community of practising teachers beyond the university, the activities of the workshop do not necessarily allow them to make a contribution to the community of practitioners - the social system in which the pre-service community is nested. Thus, while we did occasionally call on the expertise of school-based teaching colleagues to offer workshops on graphics calculators, data logging equipment, and newly released mathematical software packages, we also explicitly encouraged students to transform materials they created in course assignments into professional development workshops and journal articles on technology-enriched mathematics learning. For example, in 2002 two pairs of pre-service students presented workshops in a technology seminar organised by the Queensland Association of Mathematics Teachers, and they will offer these workshops again at the forthcoming biennial conference of the Australian Association of Mathematics Teachers in January 2003. Thus there is potential for pre-service students' identities-in-practice to develop through legitimate participation in the greater community - where their interdependence is demonstrated through producing, rather than consuming, professional knowledge.

A community of practice reproduces itself through the enculturation of new members who appropriate the community's common heritage through interaction with more mature members. Such interaction is possible if the pre-service community maintains itself through inter-generational communication, rather than being created anew with each successive cohort. Although this is the first year of the study in the formal sense, the pre-service community has evolved over several years and members already have multiple overlapping histories. One feature of the reproductive cycle involves recent graduates now teaching mathematics in schools sending us technology-enriched materials they have developed for their own classrooms to share with current BEd pre-service students via the mathematics curriculum website. This year we have uploaded materials created by graduates of the classes of 2000 (an interactive spreadsheet for introducing the trapezoidal rule in integral calculus) and 2001 (an assignment on three-dimensional vectors that investigates the question of who shot John F. Kennedy). Face to face engagement of newcomers and 'old timers' has occurred when recent graduates were invited to give pre-practicum and end-of-year advice to the current cohort of BEd students.

While the latter interactions have to some extent been structured by us - either by our use of the website or our invitation for graduates to return - there have also been instances of

spontaneous engagement between new and old community members in ways that further create a shared history. A pair of students devised an inventive graphics calculator activity, based on solving the murder of a pre-historic mammoth, which was published in a professional journal (Parente & Wethereld, 2000). The following year, a student in the new BEd cohort chose this as an exemplary article to review for a course assignment, thus legitimising the published material as part of the knowledge base of the broader professional community. Another student from this group adapted the murdered mammoth task for use with his own Year 8 students in 2002, and invited the current BEd mathematics cohort to observe and participate in a lesson in which the school students completed part of the mammoth investigation. Each of these inter-generational interactions involved more than transmission of knowledge; rather, individuals shared and re-constructed a particular experience in the process of developing their own identities as teachers.

Shifts in Beliefs

It is widely recognised that teachers' beliefs about the nature of mathematics and how it is learned influence features of the classroom environment they create (Thompson, 1992). In particular, general pedagogical beliefs of mathematics teachers seem to be reflected in the ways they use technologies such as graphics calculators in the classroom (Simmt, 1997; Tharp, Fitzsimmons & Ayers, 1997). For example, teachers who view mathematics as more rule-based and procedural, and mathematics learning as involving memorisation and symbol manipulation, are more likely to be unconvinced that graphics calculators can enhance students' learning and to use calculators only as a checking device or graphing tool. On the other hand, teachers with more inquiry-based views about mathematics are more likely to use calculators as a means of developing students' conceptual understanding.

Pre-service students' espoused beliefs were investigated via the Mathematical Beliefs Questionnaire described previously. Here we consider only responses to structured items in Sections 1, 2 and 3. Since the item scores ranged from 1 (Strongly Disagree) to 5 (Strongly Agree), and there were 12 students who completed questionnaire both pre-course and post-course, the total score on any item could vary from 12 to 60. Table 1 displays these totals for item pairs (i.e. negative and positive versions of the same construct) in each Section. The magnitude of scores is important for indicating the degree of support for each statement. We identify scores of 48 or more, and 24 or less, as indicating general agreement and general disagreement respectively with particular statements. These statements, and corresponding pre- and post-course scores, are shown by shaded cells in Table 1. Also, we consider a shift in scores of 6 - equivalent to half the class changing their score by 1 in the same direction - as worth looking into. Statements where there was such a shift, together with pre- and post-course scores, are shown in bold type in Table 1.

Table 1(a). Pre- and post-course responses to Mathematical Beliefs Questionnaire Section 1: Nature of mathematics (n = 12)

Totals		Section 1. Nature of mathematics		Totals	
Pre	Post	Item (positive)	Item (negative)	Pre	Post
49	50	1. The ideas of mathematics can be explained in everyday words that anyone could understand.	8. Technical mathematical language and special terms are needed to explain mathematics.	32	32

45	**53**	**9. In mathematics there are often several different ways to interpret something.**	**2. In mathematics something is either right or it is wrong.**	**39**	**31**
50	46	10. Mathematics is an evolving, creative human endeavour in which there is much yet to be known.	3. Everything important about mathematics is already known by mathematicians.	23	20
54	55	4. There are often many different ways to solve a mathematics problem.	11. Mathematics problems can be solved in only one way.	18	19
38	39	5. As computers increase in sophistication, mathematicians become more important to society.	12. Mathematicians are hired mainly to make precise measurements and calculations for scientists and other people.	26	25
37	**43**	**13. In different cultures around the world there are different forms of mathematics.**	**6. Mathematics is essentially the same everywhere in the world.**	**49**	**41**
54	52	7. Doing mathematics involves creativity, thinking, and trial-and-error.	14. Solving a mathematics problem usually involves finding a rule or formula that applies.	41	37

Note. Item totals are sums of scores for the 12 students who completed the questionnaire pre-course and post-course. Strongly Agree = 5, Agree = 4, Undecided = 3, Disagree = 2, Strongly Disagree =1.

The results of this analysis suggest that this group of students entered the pre-service course with mathematical beliefs that were relatively non-rule-based, open, and student-centred, and - more importantly - that they tended to maintain or strengthen these beliefs throughout the course. For example, students generally viewed mathematics as an accessible human endeavour involving creative thinking and flexible problem solving approaches. They expressed support for teaching approaches based on cooperative work involving activities that encourage students to share their thinking and explore different ways of tackling problems. Their ideas about mathematics learning centred on the importance of building understanding through the use of real life examples, physical objects, and technology resources.

Table 1(b). Pre- and post-course responses to Mathematical Beliefs Questionnaire Section 2: Mathematics teaching in secondary schools (n = 12)

Totals		Section 2. Mathematics teaching in secondary schools		Totals	
Pre	Post	Item (positive)	Item (negative)	Pre	Post
54	51	21. Good mathematics teachers show students lots of different ways to look at the same question.	15. Good mathematics teachers show students the proper procedures to answer mathematics questions.	44	42
50	52	16. Cooperative group work and class discussions are important aspects of good mathematics teaching.	22. Good mathematics teachers plan so that students regularly spend time working individually to practise doing mathematics.	46	44
52	55	17. The role of the mathematics teacher is to provide students with activities that encourage them to wonder about and explore mathematics.	23. Good mathematics teachers only teach what is important for mathematics tests.	24	21
34	**41**	**24. Teachers should let students determine if their methods and answers are right or wrong.**	18. Teachers should provide problem solutions and answers when they are not in the back of the textbook.	45	49
50	50	19. Teachers should regularly devote time to allow students to find their own methods for solving problems.	**25. The teacher should provide examples of problem solutions and help students learn to replicate them when doing problems.**	**42**	**36**
47	**53**	**20. Good mathematics teaching involves class discussion in which students share ideas and negotiate meanings.**	**26. Good mathematics lessons progress step-by-step in a planned sequence towards the lesson objectives.**	**47**	**38**

Note. Item totals are sums of scores for the 12 students who completed the questionnaire pre-course and post-course. Strongly Agree = 5, Agree = 4, Undecided = 3, Disagree = 2, Strongly Disagree =1.

In addition, there were many shifts in beliefs towards a more open and constructive view of mathematics and mathematics teaching and learning. Students moved away from viewing mathematics as something that is either right or wrong, best learned by replication of procedures demonstrated by the teacher and practice on lots of problems, where success is judged by getting the right answers. Similarly, there was a shift towards encouraging multiple interpretations and helping learners determine the validity of their methods and answers. Ideas about what constitutes good mathematics teaching moved away from teacher-centred lessons towards discussion based lessons to facilitate the sharing and negotiation of meanings. Students also became more aware of culturally diverse ways of knowing and doing mathematics.

While these results illustrate one feature of an emergent community of practice - an increasing commitment to shared beliefs about mathematics teaching and learning (i.e. those embedded in the pre-service course), some caution is needed in interpreting the questionnaire responses. Lerman (2001a) points out that beliefs are highly contextualised, so it is important also to analyse relationships between espoused beliefs and the constraints and affordances of the practice teaching environments experienced by the pre-service students, to examine how their identities as teachers developed as involvement in practice increased. Such an analysis is planned for the individual case studies conducted in 2002 (see Goos, 2002, for a similar analysis in an earlier study).

Table 1(c). Pre- and post-course responses to Mathematical Beliefs Questionnaire Section 3: Mathematics learning in secondary schools (n = 12)

Totals		Section 3. Mathematics learning in secondary schools		Totals	
Pre	Post	Item (positive)	Item (negative)	Pre	Post
50	49	34. Understanding ideas and procedures is essential in mathematics learning.	**27. Mathematics learning is about learning to get the right answers.**	**38**	**29**
47	49	28. Students should be encouraged to build their own mathematical ideas, even if their attempts contain much trial and error.	35. Students learn mathematics by being shown the correct ways to interpret mathematical symbols, situations and procedures.	41	39
42	**48**	**36. Mathematics learning is enhanced if students are encouraged to use their own interpretations of ideas and their own**	29. Being able to memorise mathematical facts and procedures is important for mathematics learning.	40	42

		procedures.			
46	48	30. Calculators can assist mathematics learning by serving as tools for exploration and consolidation of ideas.	37. Students who have access to calculators learn to depend on them and do not learn computational skills properly.	36	34
44	47	31. Students' mathematics errors often reflect their current understandings of ideas or procedures.	38. Students' mathematical mistakes are usually caused by a lack of practice.	37	39
48	51	39. Teachers should value periods of uncertainty, conflict, confusion or surprise when students are learning mathematics.	32. Students learn mathematics best if they are shown clear, precise procedures for doing things.	47	42
55	54	33. Use of physical objects and real life examples to introduce mathematics ideas is an essential component of learning mathematics.	**40. Doing lots of problems is the best way for students to learn mathematics.**	**44**	**37**

Note. Item totals are sums of scores for the 12 students who completed the questionnaire pre-course and post-course. Strongly Agree = 5, Agree = 4, Undecided = 3, Disagree = 2, Strongly Disagree =1.

Interaction Patterns

We established the website bulletin board as a relatively unstructured medium for communication throughout the duration of the course (and beyond into 2003 and 2004). Between launching the website (12 February 2002) and the conclusion of classes (4 November 2002), 155 messages had been posted to the bulletin board. The distribution of messages by month is shown in Table 2.

Table 2. Distribution of bulletin board messages

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2002		6	14	48	37	4	25	14	3	2	2	

Students posted 79 of the messages, with the remainder being posted by the two teaching staff (43 and 26 respectively). Ten students posted 1 to 5 messages, five students posted 6 to 10 messages, and one student posted more than 10 messages. Interaction was usually initiated by course lecturers rather than students.

The distribution in Table 2 shows three months when interaction peaked: in April and May, which coincided with the first practicum, and in July, when students were preparing for an assignment that involved a seminar presentation. A content analysis of messages revealed three main themes during these times. Interaction in April consisted mainly of questions from students about practicum requirements and school placements. In May, discussion was triggered by the lecturers posting two sets of questions asking students about technology usage in their practicum schools (on 29 April and 6 May respectively). Virtually all students simply supplied the information requested, with no real interaction between students themselves. Messages in July largely arose from the need to organise presentations of the students' technology seminars at a time when classes were not in session. Students notified lecturers of their seminar partners, inquired about the availability of a data projector and link cables for transferring information between computers and graphics calculators, and negotiated the timetable for their presentations. Eleven of these messages were posted by lecturers and nine by students.

Thus the bulletin board was used mainly for administrative purposes, or when lecturers posed specific questions to which students had to respond. Most interactions consisted of only two elements, an initiation and a response. Clearly, students did not see a need to interact online when the option of face to face communication was also available. In addition, we noticed some resistance to bulletin board communication in general arising from students' dislike of another BEd course in which they were obliged to post a minimum number of messages to satisfy course assessment requirements. That the content of these messages was also assessed was another source of dissatisfaction amongst students. Students may not experience any real benefits from using our mathematics course bulletin board and website until they graduate and begin teaching, when access to resources, ideas, and advice becomes crucial.

Conclusion

In this paper we have reported on the early stages of a three year project investigating the impact of a community-based, technology-enriched pre-service teacher education program on beginning teachers' integration of educational technologies into secondary school mathematics classrooms. The study extends previous research that has applied sociocultural theories of learning to developing models of pedagogy for secondary school mathematics, by applying the notion of a community of practice to teacher education settings. Our aim here has been to analyse processes through which the emerging pre-service community of practice was established during the first year of the study. In particular, we considered how participation in this community shaped pre-service students' pedagogical beliefs and their developing identities as teachers.

A community of practice has a history based on shared experiences, beliefs, and purposes, so that members develop a sense of interdependence within the community as well as with the broader society of which the community is part. We noted that interdependence and mechanisms for sharing the pre-service community's history and practices was sometimes structured by the designers (i.e. course lecturers/researchers), but could also take shape spontaneously when the work of recent graduates was integrated into the community's fund of resources. Integral to this community were pedagogical and disciplinary beliefs that we endeavoured to embed within the pre-service course. We found that the students came to share many of these beliefs and often strengthened their espoused commitment to open,

investigative, non-rule-based views of mathematics and mathematics teaching and learning. Such beliefs seem to be vital to productive use of technology in supporting learner's conceptual understanding of mathematics; however, the ways in which these beliefs interact with classroom environments in shaping actual teaching practice are yet to be investigated for this group of pre-service students.

A key question that remains concerns the tension between design and emergence in establishing communities of practice, and conditions that favour sustainability of the community. While we created a framework that attempted to facilitate growth (e.g. in engaging students in activities that exemplified certain pedagogical values and beliefs), the lack of structure imposed on bulletin board interaction meant that students made little use of this mediating resource. Clearly, when there was a choice, students decided that the costs involved in using digital tools outweighed any benefits. The issue of sustainability will come to the fore in 2003 and 2004, when students who have graduated from the course are beginning teaching and coming to terms with environments that may not adequately support technology integration. As no community can truly be 'designed', we anticipate that this project will provide rich data on the emergence and sustainability (or otherwise) of communities of practice situated at the interface of pre-service teacher education and the initial professional experience of secondary school mathematics teachers.

References

Australian Education Council (1991). *A national statement on mathematics for Australian schools*. Melbourne: Australian Education Council and Curriculum Corporation.

Barab, S. (2001). *The Internet Learning Forum: Building online communities of practice.* Paper presented at the Annual Meeting of the American Educational Research Association, Seattle, WA, 10-14 April, 2001.

Barab, S. & Duffy, T. (2000). From practice fields to communities of practice. In D. Jonassen and S. Land (Eds.), *Theoretical foundations of learning environments* (pp.25-55). Mahwah, NJ: Erlbaum.

Bell, C. (1996). *Introducing preservice mathematics teachers to hypermedia*. Paper presented at the Annual Conference on the Teaching of Mathematics, Baltimore, MD, 21-22 June, 1996. [online] Available http://archives.math.utk.edu/CTM/FIFTH/Bell/paper.pdf.

Boaler, J. (1998). Open and closed mathematics: Student experiences and understanding. *Journal for Research in Mathematics Education*, *29*(1), 41-62.

Boaler, J. & Greeno, J. (2000). Identity, agency, and knowing in mathematics worlds. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning* (pp. 171-200). Westport, CT: Ablex Publishing.

Brett, C., Woodruff, E. & Nason, R. (1997). *Communities of inquiry among pre-service teachers investigating mathematics*. Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March 24-28, 1997). (EDRS Document Number ED408255).

Brown, C. A. & Borko, H. (1992). Becoming a mathematics teacher. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 209-239). New York: Macmillan.

Connell, M. L. & Abramovich, S. (1999). New tools for new thoughts: Effects of changing the "Tools-To-Think-With" on the elementary mathematics methods course. In *SITE99: Society for Information Technology & Teacher Education 10th International Conferen*ce (San Antonio, TX, February 28-March 4, 1999). (EDRS Document Number ED432267).

Cooney, T. J. (1994). Research and teacher education: In search of common ground. *Journal for Research in Mathematics Education*, *25*, 608-636.

Derry, S., Lee, J., Kim, J. & Seymour, J. (2001). *From ambitious vision to partially satisfying reality: Community and collaboration in teacher education.*Paper presented at the Annual Meeting of the American Educational Research Association, Seattle, WA, 10-14 April, 2001.

Frid, S. (2000). Constructivism and reflective practice in practice: Challenges and dilemmas of a mathematics educator. *Mathematics Teacher Education and Development*, *2*, 17-33.

Goos, M. (1999). Technology for tomorrow's teachers - Pre-service education as professional development. *AAMT Virtual Conference 99 Proceedings* (CD-ROM). Adelaide: Australian Association of Mathematics Teachers.

Goos, M. (2002). Beginning teachers and technology: Developing identities as teachers. In B. Barton, K. Irwin, M. Pfannkuch & M. Thomas (Eds.),*Mathematics Education in the South Pacific: Proceedings of the 25th Annual Conference of the Mathematics Education Research Group of Australasia, Auckland, 7-10 July 2002* (pp. 309-317). MERGA: Sydney.

Goos, M., Galbraith, P., & Renshaw, P. (1999). Establishing a community of practice in a secondary mathematics classroom. In L. Burton (Ed.), *Learning mathematics: From hierarchies to networks* (pp. 36-61). London: Falmer Press.

Halpin, P. & Kossegi, J. (1996). The WWW, preservice teachers and their mathematics courses. In *Association of Small Computer Users in Education (ASCUE) Summer Conference Proceedings* (North Myrtle Beach, SC, June 9-13, 1996). (EDRS Document Number ED405819).

Kim, M., Sharp, J. & Thompson, A. (1998). Effects of integrating problem solving, interactive multimedia, and constructivism in teacher education. *Journal of Educational Computing Research*, *19*(1), 83-108.

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. New York: Cambridge University Press.

Lerman, S. (2000).The social turn in mathematics education research. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning* (pp. 19-44). Westport, CT: Ablex Publishing.

Lerman, S. (2001a). A review of research perspectives on mathematics teacher education. In F. Lin & T. J. Cooney (Eds.), *Making sense of mathematics teacher education* (pp. 33-52). Dordrecht: Kluwer.

Lerman, S. (2001b). A cultural/discursive psychology for mathematics teaching and learning. In. B. Atweh, H. Forgasz, & B, Nebres (Eds.), *Sociocultural research on mathematics education* (pp. 3-17). Mahwah, NJ: Erlbaum.

Loughran, J., Mitchell, I., Neale, R., & Toussaint, J. (2001). PEEL and the beginning teacher. *Australian Educational Researcher*, *28*(2), 29-52.

McCoy, A. H. (1999). Integration of technology in to higher education teacher preparation programs. Paper presented at the tenth international conference of the Society for Information Technology and Teacher Education (SITE), San Antonio, TX, February 28-March 4, 1999. (EDRS Document Number ED432272).

Parente, M. & Wethereld, A. (2000). The murdered mammoth mystery. *Teaching Mathematics*, *25*(3), 32-37.

Perry, B., Howard, P. & Tracey, D. (1999). Head teachers' beliefs about the learning and teaching of mathematics. *Mathematics Education Research Journal*,*11*(1), 39-53.

Schoenfeld, A. (1994). Reflections on doing and teaching mathematics. In A. Schoenfeld (Ed.), *Mathematical thinking and problem solving* (pp. 53-70). Hillsdale, NJ: Erlbaum.

Schuck, S. & Foley, G. (1999). Viewing mathematics in new ways: Can electronic learning communities assist? *Mathematics Teacher Education and Development*, *1*, 22-37.

Simmt, E. (1997). Graphing calculators in high school mathematics. *Journal of Computers in Mathematics and Science Teaching*, *16*(2/3), 269-289.

Tharp, M. L., Fitzsimmons, J. A., & Ayers, R. L. B. (1997). Negotiating a technological shift: Teacher perception of the implementation of graphing calculators. *Journal of Computers in Mathematics and Science Teaching*, *16*, 551-575.

Thompson, A. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 127-146). New York: Macmillan

Web-Based Education Commission (R. Kerry, Chair) (2000). The power of the internet for learning: Moving from promise to practice. Final report of the Web-Based Education Commission to the President and the Congress of the United States. [online] Availablehttp://www.ed.gov/offices/AC/WBEC/FinalReport. [Accessed 23 January 2001].

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, MA: Cambridge University Press.