

Developing a communal identity as beginning teachers of mathematics: Emergence of an online community of practice

Merrilyn E. Goos · Anne Bennison

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Abstract The aim of this study is to investigate how a community of practice focused on becoming a teacher of secondary school mathematics emerged during a pre-service teacher education programme and was sustained after students graduated and began their first year of full-time teaching in schools. Bulletin board discussions of one pre-service cohort are analysed in terms of Wenger's (1998) three defining features of a community of practice: mutual engagement of participants, negotiation of a joint enterprise, and development of a shared repertoire for creating meaning. Emergence of the online community was associated with our own role in facilitating professional dialogue, the voluntary and unstructured nature of participation, initial face-to-face interaction that created familiarity and trust, and the convenience of using email rather than logging on to a website. The study shows that the emergent design of the community contributed to its sustainability in allowing the pre-service and beginning teachers to define their own professional goals and values.

Keywords Pre-service teacher education · Communities of practice · Online discussion

Research in mathematics teacher education is a complex and growing field that draws on a range of theoretical perspectives on the process of teacher learning and development. While much of this research has analysed professional learning in terms of teachers' beliefs and relations between beliefs and teaching practices, Lerman (2001) argues that socio-cultural theories offer more useful conceptual tools for understanding teachers' learning as increasing participation in the practices of a professional community. Mathematics education researchers are beginning to apply Wenger's (1998) social theory of learning, and in particular the notion of learning in *communities of practice*, to investigate teacher learning in professional development programmes that promote innovative practice (e.g. Gómez 2002; Graven 2004). The research reported here extends this work by developing the concept of a community of practice in pre-service teacher education and its interface with

M. E. Goos (✉) · A. Bennison
School of Education, The University of Queensland, Queensland, QLD 4072, Australia
e-mail: m.goos@uq.edu.au

beginning teaching of secondary school mathematics. The aim of the study is to analyse processes through which such a community is established and maintained, when interaction is online as well as face-to-face. This article uses pre-service and beginning teachers' bulletin board discussions to investigate how the community emerged during the teacher education programme and was sustained after graduation and into the first year of full-time teaching.

Communities of practice and online discussion in teacher education

Wenger (1998) outlines a social theory of learning that integrates four components—meaning (learning as experience), practice (learning as doing), community (learning as belonging) and identity (learning as becoming)—which he claims are necessary “to characterise social participation as a process of learning and of knowing” (pp. 4–5). That these components resonate strongly with current ways of understanding teachers' learning may explain why Wenger's ideas have been taken up so readily by researchers in our field, although some caution is needed in applying his perspective on learning as an informal and tacit process to learning in formal education settings, including pre-service teacher education (Graven and Lerman 2003). Neither is there any discussion in his theory of *teaching* in relation to learning. Wenger's model developed from studying learning in apprenticeship contexts, and the role of the “master” in these contexts—where teaching is incidental rather than deliberate—does not translate easily to that of the teacher educator in a university setting who is held accountable for ensuring successful learning. In this article, however, the spotlight is not on our role as teacher educators or the notion of “mastery” of mathematics teaching; instead, we follow Wenger in focusing on the concept of communities of practice as the primary unit of analysis for investigating teacher learning.

Wenger (1998) describes three defining characteristics of communities of practice as mutual engagement of participants, negotiation of a joint enterprise, and development of a shared repertoire of resources for creating meaning. Engagement need not require homogeneity, since productive relationships arise from diversity and these may involve tensions, disagreements and conflicts. However, participants are connected by their negotiation of an enterprise linked to the larger social system in which their community is nested. Such communities have a common cultural and historical heritage, and it is through the sharing and re-construction of this repertoire of resources that individuals come to define their identities in relationship to the community. Since communities of practice evolve over time, they also have mechanisms for maintenance and inclusion of new members.

While communities of practice are generally constituted through face-to-face interaction, technologies such as the Internet have opened up new possibilities for participation. Online discussion via email, bulletin boards, or web-based conferencing has become common in pre-service and in-service teacher education. Research in this area has identified a variety of purposes for which such online communities are used: to challenge pre-service teachers' beliefs (Schuck and Foley 1999); to enable pre-service teachers to maintain contact with each other and course lecturers during the practicum (Brett et al. 1997); to promote reflective dialogue and critical thinking about pre-service field experiences (Hough et al. 2004); to enable ongoing discussion following professional development workshops (Stephens and Hartmann 2004) and to share knowledge, experience and good practice (Selwyn 2000).

Research studies in this area that invoke the notion of *community of practice* highlight some of the difficulties in building communities involving online interaction. Selwyn

(2000) found that, when participants share few common interests or have little commitment to each other or the discussion forum, interaction consists mainly of information or empathetic exchanges or dwindles over time. He concludes that in these circumstances no virtual community is formed because participants are “disparate professionals whose sense of community lies elsewhere” (p. 774). A clear task focus and a sense of obligation to the task have also been identified as critical factors in building a professional community through online discussion. As Stephens and Hartmann (2004) discovered, this is difficult to achieve in professional development projects that also involve face-to-face interaction because teachers often prefer to collaborate in person rather than in a virtual environment. However, other research has found that initial face-to-face contact is important in building virtual communities, and that providing structured tasks involving mandatory contributions does not appear to sustain participants’ interest or improve the quality of reflection and critical thinking (Hough et al. 2004).

Underlying the difficulties reported by these studies are two additional issues, referred to in Wenger’s (1998) discussion of learning in communities of practice, which have been identified in research into online communities: the tension between designed and emergent communities, and the question of sustainability. Derry et al. (2004) recommended that any attempt to design an online community for pre-service teachers should respect the context and follow from a careful analysis of local conditions and the needs of members. Barab et al. (2001) acknowledge the inherent tension in managing the interplay between the designed and the emergent in building online communities of in-service and pre-service mathematics and science teachers. They maintain that it is preferable to create a framework and then facilitate the growth of a community by adopting an emergent design so that participants build the space, rather than imposing a design completely formulated in advance. In these circumstances, however, teacher educators can face difficult decisions about whether and how to intervene to ask questions, offer suggestions, or correct misconceptions (Schuck 2003). 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.

The investigation reported in this article addresses the issue of sustainability of online communities and the tension between design and emergence of such communities. Our inquiry was prompted by the unanticipated ways in which our pre-service mathematics teacher education students used the course website and bulletin board, in particular their continued use of this discussion forum after the course ended and indeed after they graduated and moved into their first year of full-time teaching. Our analysis was guided by the following research questions:

1. What evidence exists in pre-service and beginning teachers’ bulletin board discussions of the formation of an online community of practice focused on becoming a teacher of secondary school mathematics?
2. What factors might influence the formation of such a community?

Research design and methodology

This research is part of a larger project that investigated the professional socialisation of beginning teachers of secondary school mathematics. Three successive cohorts of pre-service mathematics teachers participated in the study from 2002 to 2004. Previously, in

discussing the findings of this research, we were interested in identifying relationships between personal and contextual factors that shaped the pedagogical identities of individual teachers (Goos 2005a, b). In this article, we shift the focus from individual identity to communal identity to analyse the extent to which these pre-service and beginning teachers developed a sense of connectedness and belonging in relation to a community of practice focused on becoming a teacher of secondary school mathematics.

Participants and context

This article draws on data from the 2003 pre-service cohort ($n = 19$) and their interactions with the 2004 cohort. The pre-service teachers were enrolled in a Bachelor of Education (B.Ed) programme available to undergraduates as a 4-year dual degree or to graduates as a single degree taken in an accelerated programme that spans four semesters in 18 months.

The dual degree pathway overlaps the B.Ed with a 3-year non-education degree that provides the disciplinary knowledge for subject specialisation as a secondary school teacher. During this first degree, students must also take education courses that provide foundation knowledge of learning theories, adolescent development, and the sociology of education. They finish the B.Ed in a fourth year, known as the professional year, which is devoted solely to the study of practical and professional issues in education. Students enrolling in the graduate entry version of the B.Ed are typically mature age entrants who are changing careers, having already completed an undergraduate degree in areas such as engineering or information technology. The first year of the graduate entry B.Ed is identical to the fourth year (professional year) in the dual degree programme.

All pre-service mathematics teachers complete their curriculum studies as a single class group in a course that lasts for the duration of the professional year. The course (taught by the authors) aims to create a learning environment consistent with recent curriculum reforms (e.g. Australian Education Council 1991; National Council of Teachers of Mathematics 2000) and socioculturally oriented research in mathematics education (e.g. Goos 2004). During this common professional year, which runs from the beginning of February to the end of October, all pre-service teachers complete 15 weeks of practicum sessions: 1 week of observation in a primary school followed by two separate blocks of 7 weeks teaching in a secondary school. The mathematics curriculum class meets twice weekly for 3 h workshops during the remaining 17 weeks of the academic year. Pre-service teachers enrolled in the dual degree programme graduate at the end of the professional year, while those taking the graduate entry version of the B.Ed complete additional foundation education courses, similar to those offered in the dual degree programme, over an intensive summer semester (November–January), followed by a final semester comprising a ten week internship in schools (February–April) and further intensive post-internship coursework (May–June).

Data sources and analysis methods

Interaction between pre-service teachers and lecturers is both face-to-face and online. At the start of 2002, we established a mathematics community website via Yahoo Groups, with membership of the group restricted to ourselves and successive cohorts of pre-service teachers participating in the study. The website offers access to bulletin board, email,

calendar, file sharing and links to other educational websites. One advantage of such a community over web-based course management software used for flexible learning in university programmes (such as WebCT or Blackboard software) lies in its continued accessibility to members after graduation. Also, unlike university course discussion forums, our mathematics community website allows members to use email for sending messages to the entire group as an alternative to logging on to the website and posting messages to the bulletin board. All messages, whether sent via e-mail or posted directly to the website bulletin board, are sent to the individual e-mail addresses of all members of the group. They are also automatically archived on the website and thus available for analysis. (In this article we use the term “bulletin board” to refer to all messages, no matter how they were sent).

Our goals in establishing the website were to encourage professional discussion outside class times and during the practicum periods and to provide continuing support for our graduates, as they made the transition to full-time teaching in schools. In the light of previous research on designed versus emergent online communities, we decided to impose minimal structure on communication. This contrasts with the approach taken by most other Bachelor of Education courses, in which it is compulsory for pre-service teachers to make a specified number of posts to a course bulletin board as part of the assessment programme. We told the pre-service mathematics teachers that our Yahoo Groups bulletin board would be an important form of communication for the course and we reinforced this from the start of classes, for example, by inviting them to continue discussions about mathematics teaching begun during class, providing information about forthcoming workshops and forwarding messages that we found on other mathematics education e-mail discussion lists. The pre-service teachers were free to use the mathematics curriculum bulletin board for any other purposes they chose, including purposes not explicitly related to the teaching of mathematics.

As we had decided not to assess or grade the pre-service teachers’ bulletin board contributions, we were interested to know how and why they might choose to use this form of communication. At the end of the course, we conducted a semi-structured group interview to obtain feedback on their use of the mathematics community website, and we then posted our interview stimulus questions (listed below) to the course bulletin board and invited them to provide further comments via personal e-mail.

1. The website was used a lot in 2003. Why do you think this was so?
2. How much would you consider that you used the bulletin board/e-mail list to post messages? To read messages? (e.g. not at all, hardly ever, sometimes, regularly?)
3. Are there any benefits or disadvantages of using the website compared with the face-to-face communication that takes place in class? If so, what are they?
4. How did your use of the mathematics community website compare with your experiences of using WebCT in other Bachelor of Education courses? Better? Worse? Why?

Although they were under no obligation to do so, pre-service teachers continued to post messages to the course bulletin board after the mathematics curriculum course finished at the end of October 2003, and also after they graduated and began teaching in secondary schools. In addition, in January 2004 they decided to establish a separate Yahoo Group for their exclusive use (hereafter referred to as the student bulletin board¹) while still

¹ The pre-service teachers did not start posting messages to their own student bulletin board until March 2004.

interacting with the new 2004 cohort via the course bulletin board. The reason they gave for doing so was to carry on their own discussions in a different space so as not to overwhelm members of the new cohort with a large volume of messages from people who were strangers to them. Fourteen of the nineteen pre-service teachers in the 2003 cohort joined the new Yahoo Group. They invited us to join this new Group and gave permission to include discussions occurring here in our research study.

Our analysis examines message posted to both bulletin boards and thus spans the transition from pre-service to beginning teaching. In order to capture the complete B.Ed experience for all the mathematics pre-service teachers, we analyse messages sent to the course bulletin board for the entire duration of the B.Ed graduate entry programme, from February 2003 to June 2004. This time frame also includes the first semester of full-time teaching for dual degree graduates (January–June 2004), and allows for examination of interaction between the 2003 and 2004 pre-service cohorts. We additionally analyse messages sent to the student bulletin board during the first year it operated (January–December 2004), a time frame during which all participants, dual degree and graduate entry, began their teaching careers.

We addressed the first research question by analysing archived bulletin board messages, initially by recording the distribution of messages over time, who had posted them, and whether the message initiated a new topic or responded to an earlier message. Messages were then categorised in a two-way analysis according to the phase of the B.Ed programme during which they were posted and the purpose for sending the message. The following programme phases were identified from the perspective of pre-service teachers in the 2003 graduate entry programme, who comprised the majority of this cohort: *professional year coursework*; *practicum*; *summer semester*; *internship*; *post-internship coursework* and *post-graduation*. Programme phases were defined to include any vacation periods that immediately followed so that messages sent during these times could be included in the analysis. Five categories indicating purpose resulted from a content analysis of messages: *administrative*, *professional*, *advice*, *information*, and *social*. Administrative messages were related to course organisation, such as the timetabling of classes and pre-service teacher seminar presentations. Professional messages were concerned with theoretical or practical issues arising from readings, class discussions or field experiences. Participants sought or offered advice on a range of topics, such as completing course assessment tasks, handling teaching situations, or preparing for employment interviews, and they posted information about teaching resources and job vacancies. The purposes of social messages included organising class social gatherings and offering congratulations for personal achievements.

Content categories were generated via an iterative process that involved proposing a set of categories from an initial reading of a subset of messages, coding further subsets of messages, and refining the meaning of categories by comparing data within and between categories. This process sometimes resulted in categories being combined or deleted. Only one content category was assigned to each message according to our judgment of its primary purpose. Final coding of messages sent to the course bulletin board was carried out by the second author and validated by the first author, who independently coded a random sample of around 5% of messages. Because both authors collaborated in the initial development of categories, very few coding discrepancies were noted and these were resolved through discussion. The first author then coded messages sent to the student bulletin board.

The second research question, concerning factors that might influence the formation of an online community, was addressed in two ways. First, we examined the frequency,

content, and initiation–response patterns of bulletin board interactions to analyse our own role in shaping the community. Second, we sought the pre-service teachers’ perspectives via the group interview described earlier. Interview data consists of our written notes recorded during the interview and the follow-up e-mails that pre-service teachers sent to us in response to the questions we posted to the course bulletin board. In the remainder of the article we use this data to discuss how and why the community emerged and was sustained.

Emergence and sustainability of the community of practice

Drawing on Wenger’s (1998) framework, we analyse evidence that a community of practice emerged in terms of the extent and forms of mutual engagement between participants, the manner in which they negotiated the joint enterprise of becoming a teacher of secondary school mathematics, and the shared repertoire they developed for creating meaning from their experiences.

Mutual engagement

We derived quantitative measures of the extent of mutual engagement by counting how many messages were sent, when and by whom, and by identifying whether or not members responded to each other’s messages. Table 1 shows the number of messages posted to both bulletin boards by all participants in the time frame of the analysis. In the 17 months from February 2003 to June 2004, 932 messages were posted to the course bulletin board, including 208 messages sent by the two authors (the course lecturers) and 534 by the nineteen pre-service teachers in the 2003 cohort. During the 10 months from March to December 2004 a further 646 messages were posted to the student bulletin board: 80 by the two of us and 566 by the 14 pre-service and beginning teachers²

On the course bulletin board, the nineteen pre-service teachers made contributions ranging from 1 to 139 messages each: seven posted from 1 to 10 messages; five from 11 to 20 messages; three from 21 to 30 messages; and four posted more than 30 messages. On the student bulletin board, contributions from the 14 pre-service and beginning teachers ranged from 1 to 136 messages each: three posted from 1 to 10 messages; four from 11 to 20; and seven posted more than 30 messages. Although contributions per pre-service or beginning teacher were clearly unequal, simply counting the number of messages posted does not fully capture the notion of “engagement” because it excludes the various forms of peripheral participation—such as *reading* messages—that might legitimately characterise an online community of practice (Lave and Wenger 1991). In this regard it was noteworthy that in the group interview *all* pre-service teachers insisted they checked their e-mail regularly and read all messages, even if they did not always respond.

Another possible measure of the extent of mutual engagement involves comparing how many messages initiated a new topic with the number that responded to an earlier message

² Although pre-service teachers posted fewer messages per person to the course bulletin board than the authors, voluntary participation structures rarely elicit even this level of interaction in online discussion. For example, Schuck (2003) found that more than 60% of students in her pre-service mathematics education course did not use the bulletin board at all, while in-service mathematics teachers participating in Stephens and Hartmann’s (2004) study were also reluctant to use an online professional development forum.

Table 1 Frequency count of messages posted to course and student bulletin boards

Participants	Programme phase					
	Prof. year coursework	Practicum	Summer semester	Internship ^a	Post-internship coursework ^b	Post-graduation
Lecturers						
Course bbd	45	36	43	24	60	–
Student bbd	–	–	–	9	41	30
2003 cohort						
Course bbd	51	87	180	110	106	–
Student bbd	–	–	–	80	228	258
2004 cohort						
Course bbd	–	–	–	31	159	–
Total	96	123	223	254	594	288

^a Corresponds to the first period of Professional Year coursework for the 2004 cohort

^b Corresponds to the first practicum for the 2004 cohort

Table 2 Percentage of initiating and responding messages posted to both bulletin boards

Message type	Course bulletin board (%)	Student bulletin board (%)
Lecturer initiated	9.8	2.3
Student ^a initiated	21.9	21.4
Lecturer response to student	12.2	10.1
Student response to lecturer	11.7	4.8
Student response to student	44.1	61.4
Lecturer response to lecturer	0.3	0.0
Total	100.0	100.0

^a For brevity we use the generic term “student” to refer to pre-service and beginning teachers

(see Table 2)³ We found that around one third of messages posted to the course bulletin board were initiations by either ourselves (9.8% of all messages) or the pre-service teachers (21.9% of all messages), and around two-thirds were classed as responses. Of the latter, 23.9% were lecturer-student interactions (lecturer responses to students and student responses to lecturers) and 44.1% were student-student interactions (student responses to students). Discussions were even more interactive on the student bulletin board, where around one quarter of messages initiated a topic (2.3% were initiated by ourselves and 21.4% by the pre-service and beginning teachers) and three quarters were responses (14.9% were lecturer-student interactions and 61.4% student-student interactions).

³ In online discussions conducted entirely on a web-based bulletin board, this analysis involves counting and categorising messages in each thread of the discussion. However, the Yahoo Groups website also allows members to send messages via e-mail, and this was the mode of communication favoured by all participants. A member who wanted to initiate a new discussion topic almost always did so by replying to an earlier e-mail because this avoided the necessity of memorising the Group e-mail list address. This meant that e-mail subject lines rarely matched the content of the message, thus making identification and analysis of discussion threads extremely difficult. The figures quoted here are based on a manual analysis of the content of each e-mail message.

Table 3 Percentage of initiating and responding messages posted by programme phase

Message type	Programme phase ^a					
	Prof. year coursework (%)	Practicum (%)	Summer semester (%)	Internship (%)	Post-internship coursework (%)	Post-graduation (%)
Lecturer initiated	32.3	15.4	7.2	4.5	3.0	1.0
Student ^b initiated	19.8	30.1	21.5	32.6	20.8	18.4
Lecturer response to student	14.6	13.8	11.2	5.6	12.3	9.4
Student response to lecturer	15.6	9.8	11.7	5.6	4.1	5.2
Student response to student	17.7	30.9	47.5	51.7	59.9	66.0
Lecturer response to lecturer	0.0	0.0	0.9	0.0	0.0	0.0
Total	100.0 ^c	100.0	100.0	100.0	100.1	100.0

^a Source of messages is course bulletin board for professional year coursework, practicum, summer semester, and student bulletin board for internship, post-internship coursework, post-graduation

^b For brevity we use the generic term “student” to refer to pre-service and beginning teachers

^c Totals may not add to 100% due to rounding errors

Mutual engagement also increased over time and lasted well beyond the end of the mathematics curriculum course we taught in the professional year. Table 3 records the percentages of initiating and responding messages posted in each phase of the B.Ed programme from the perspective of the 2003 cohort. This includes messages sent to the course bulletin board in the first three programme phases (professional year coursework, practicum and summer semester) and to the student bulletin board in the remaining phases (internship, post-internship coursework, post-graduation)⁴ This analysis shows that the proportion of lecturer-initiated messages steadily declined (from 32.3% in professional year coursework to 1.0% post-graduation) and that student-student interaction increased (from 17.7 to 66.0% of messages in the same time frame) as the 2003 pre-service cohort moved through the B.Ed programme and into their first year of full-time teaching in schools.

As frequency counts are a relatively crude measure of engagement, it is more informative to examine the content of messages in order to characterise particular forms of engagement. One of the most significant of these involves the manner in which newcomers were integrated into the community via “generational encounters” (Wenger 1998, p. 99)

⁴ This phase by phase quantitative analysis is designed to follow the trajectory of the 2003 pre-service cohort. In the first three phases of the B.Ed (professional year coursework, practicum, summer semester) they posted messages only to the course bulletin board, as they had not yet established their own student bulletin board. Because the remaining phases overlapped with the arrival of the new 2004 cohort and the introduction of this cohort to the course bulletin board, the analysis of initiating and responding messages takes the student bulletin board as the source of messages posted by the 2003 cohort in the internship, post-internship coursework, and post-graduation phases.

between “old timers”—members of the 2003 cohort—and pre-service teachers entering the mathematics curriculum course in 2004. During the first period of professional year coursework for the 2004 cohort (which corresponded to the internship phase for the 2003 cohort, see Table 1), 35% of messages involved conversations between newcomers and old timers. The content of these interactions related to discussion of internship experiences, organisation of a post-internship debriefing session (described in a later section), and requests from newcomers for advice on teaching strategies. The example below is illustrative of the latter type of generational encounter. It was initiated by Steve (all names are pseudonyms), a pre-service teacher in the new 2004 cohort.

From: “Steve” (2004 student e-mail address)
 Date: Wed Apr 7, 2004 4:23 pm (2003 cohort Internship phase; 2004 cohort PY coursework phase)
 Subject: Logarithms (Course bulletin board message #792)

Hi all,

For those of you who don't know me, I am one of the 2004 batch of maths students. I was wondering if anyone could help me. I am currently tutoring a grade 11 Maths student and last week we started to cover logarithms. He didn't get it. He couldn't understand them and I will admit I wasn't too flash at explaining them. Does anyone have any strategies for this particular abstract concept or know where I could look?

Members of the 2003 cohort, who at that time had recently started full-time teaching or were completing their internship in schools, responded with strategies that had worked for them, such as explaining why we use logarithms, approaching the concept via graphing inverse functions, and checking the boy's understanding of exponents (message #794 below):

From: “Chinh” (2003 student e-mail address)
 Date: Wed Apr 7, 2004 7:36 pm (2003 cohort Internship phase; 2004 cohort PY coursework phase)
 Subject: Re: Logarithms (Course bulletin board message #794)

If it was me, I would try to find out why the student did not understand it (you probably know why). The steps I would take could be to check if the student understands the concept of power, exponential (power of e) and related mathematical manipulations. And especially, if you can make that student believe that they can do it then you are halfway to get the concept understood by the student.

From: “Steve” (2004 student e-mail address)
 Date: Sat Apr 10, 2004 9:36 am (2003 cohort Internship phase; 2004 cohort PY coursework phase)
 Subject: Logarithms (Course bulletin board message #799)

Thanks for your ideas all. It's a tough concept, but I think both he (and I) are heading in the right direction now.

The kind of mutual engagement between cohorts illustrated above served to expand the pre-service community by integrating new members and sharing practices across generations.

Joint enterprise

From the perspective of pre-service and beginning teachers, the enterprise of becoming a teacher of secondary school mathematics is enacted in two distinct contexts: the *university context*, in which they complete pre-service coursework and associated assessment tasks;

and the *professional context*, which comprises supervised practice teaching sessions and their initial professional experiences in schools. In the present study, the university context corresponds to the professional year coursework, summer semester, and post-internship coursework phases of the B.Ed programme, while the professional context corresponds to the practicum, internship, and post-graduation phases.

Tables 4 and 5 record the number of messages in each content category posted by the 2003 cohort and ourselves respectively to both bulletin boards during the time frame chosen for analysis. Although all content categories are represented across all B.Ed programme phases, the patterns of bulletin board use imply that the enterprise of becoming a teacher of secondary school mathematics was defined differently as the pre-service teachers moved between the university and professional contexts. We investigated the way in which they negotiated this enterprise by examining how the most common purposes of bulletin board messages changed over time and across contexts.

Before proceeding, we note one obvious trend in the high incidence of *social* messages during the post-internship coursework and post-graduation phases, that is, towards the end of the B.Ed programme for the graduate entry majority and in the early months of all participants' teaching careers. Social exchanges helped to maintain community cohesion at this time, when members were faced with the prospect of losing the regular face-to-face contact afforded by university classes and dispersing to different locations, often separated by hundreds of kilometres, to take up teaching positions. A simple numerical count of these messages substantially over-represents their importance in relation to other messages, since most were brief responses from each member of the online community to suggested dates

Table 4 Content of messages sent by 2003 pre-service cohort to both bulletin boards

Content category	Programme phase						Total
	Prof. year coursework	Practicum	Summer semester	Internship	Post-internship coursework	Post-graduation	
Administrative	13	8	27	50	29	3	130
Professional	10	52	28	73	56	69	288
Advice	12	4	61	52	68	38	235
Information	4	5	21	6	41	25	102
Social	12	18	43	9	140	123	345
Total	51	87	180	190	334	258	1100

Table 5 Content of messages sent by lecturers to both bulletin boards

Content category	Programme phase						Total
	Prof. year coursework	Practicum	Summer semester	Internship	Post-internship coursework	Post-graduation	
Administrative	24	9	15	19	29	0	96
Professional	4	12	1	2	12	4	35
Advice	4	2	9	3	9	3	30
Information	9	10	7	8	16	6	56
Social	4	3	11	1	35	17	71
Total	45	36	43	33	101	30	288

and venues for social meetings. Nevertheless, a qualitative analysis of the purposes of these social messages demonstrated their theoretical significance in forging a shared repertoire of resources, and this is elaborated in a later section.

University context

When the pre-service teachers were attending classes on campus, it seems that the joint enterprise that was negotiated was mainly related to the practice of being a university student. Messages sent in the professional year coursework phase were mostly *administrative* (37 out of 96 messages sent by students and lecturers), while messages sent most frequently during the other coursework phases sought or gave *advice* (70 out of 223 messages sent by students and lecturers during summer semester; 77 out of 260 non-social messages during post-internship coursework). The content of these types of messages reflected what Wenger (1998) describes as relations of mutual accountability amongst participants. These relations include:

... what matters and what does not, what is important and why it is important, what to do and not to do, what to pay attention to and what to ignore, what to talk about and what to leave unsaid, what to justify and what to take for granted, what to display and what to withhold, when actions and artefacts are good enough and when they need improvement or refinement (p. 81).

Administrative messages were mostly posted by ourselves and typically comprised reminders and information about the organisation of our coursework or assessment tasks. After the professional year ended, however, “what matters” and “what to talk about” changed. While this marked the completion of the dual degree B.Ed degree for four pre-service teachers in the group, the graduate entry majority moved straight into summer semester where they were scattered amongst cross-curricular tutorial groups. Now that they no longer met as a mathematics curriculum class group, they found a new purpose for the bulletin board in helping each other cope with three intensive courses of study on the sociology of education. The joint enterprise was now characterised by seeking and giving *advice* (see Table 4). One pre-service teacher’s query was pivotal in that it prompted the group to divide the required course readings amongst members and post chapter summaries to the bulletin board so all could benefit. His salutation, “Hi Maths squad 2003”, also signifies his continuing sense of identification with fellow pre-service mathematics teachers:

From: “Chinh” <2003 student e-mail address>
 Date: Tue Nov 4, 2003 8:25 am (*Summer semester phase*)
 Subject: RE: [course code] (*Course bulletin board message #436*)
 Hi Maths squad 2003!

I just realised that we have to read five chapters to prepare for the first tutorial. I have read chapters 1 and 2 of [textbook #1] (only 29 pages). But chapter 1 of [textbook #2] is amazing. If you have read chapter 1 could you tell us what they are saying in the middle of the chapter, please. Also I would like some advice on how to read and make the most out of sociology text books, your advice will be much appreciated. Thank you and welcome to summer semester (Oh, boyz!!!!)

During the post-internship coursework phase, pre-service teachers had to complete a similar set of sociologically oriented courses, one of which was assessed by writing and presenting articles in a simulated conference format. As this was a new experience for most

of them, they used their own student bulletin board to request advice and to edit each other's work. Although this course content was not directly concerned with mathematics education, the pre-service teachers maintained their communal identity as *mathematics* teachers by posting the conference programme to the bulletin board and making a commitment to attend each other's article presentations, described by one of them as a sign of "collegial support". Exchanges such as this suggest that the pre-service teachers were starting to see accountability as involving more than an obligation to meet university course requirements; instead, they were beginning to define their own goals and values regarding professional accountability to each other.

Professional context

The joint enterprise was defined differently by the pre-service teachers when they moved from the university context into the professional context of schools for their supervised practice teaching and internship sessions, and after graduation when they began their teaching careers. Now the enterprise they negotiated was related to the practice of teaching mathematics in schools, and this is reflected in bulletin board discussions that were most commonly concerned with *professional* issues (64 out of 123 messages sent by students and lecturers during the practicum phase; 75 out of 223 during the internship phase; 73 out of 148 non-social messages during the post-graduation phase).

Professional discussions were not limited to issues around mathematical content, and the example that follows is illustrative in this regard. The exchange between two beginning teachers suggests that they were beginning to develop the types of professional knowledge, attributes, and practices needed by effective teachers of mathematics, as defined by the Australian Association of Mathematics Teachers' (2002) professional standards framework. The first domain of this framework defines *professional knowledge* as knowledge of students' individual characteristics as well as their social and cultural contexts, knowledge of the mathematics appropriate to the students they teach, and knowledge of how students learn mathematics. The second domain outlines desirable *professional attributes*, such as enthusiasm for mathematics, a commitment to personal professional development, and an interest in improving mathematics teaching by sharing knowledge and practices with colleagues. The third domain encompasses *professional practice* in terms of learning environments established by effective teachers of mathematics, the lessons they plan, their teaching strategies, and the ways in which they assess student learning.

From: "David" (2003 student e-mail address)

Date: Wed Nov 17, 2004 12:16 pm (*Post-graduation phase*)

Subject: Re: maths in the news (*Student bulletin board message #611*)

Interesting case: I am tutoring a girl that was at my prac school. She was in the extension maths class in grade 10 and now is doing [an advanced mathematics subject] in grade 11. And she is hopeless at the distributive and associative laws. (...) Instances like this cause me to doubt the validity of any maths programme which puts context and breadth over a paradigm of "drill and grill". (...) Mathematics is a fundamental societal construct, and I feel we have pandered too long to issues of relevance and value. These compromise mathematics teaching by watering down the emphasis of the necessity for adult competence, and further make the assumption that all children have the maturity and foresight to determine what is needed and even what is fun, and that all that is worthwhile can be made entertaining or engaging.

From: "Adam" <2003 student e-mail address>

Date: Wed Nov 17, 2004 5:20 pm (*Post-graduation phase*)

Subject: RE: maths in the news (*Student bulletin board message #613*)

Well David, you have, of course, written an e-mail that demands a reply ... I believe the kids in my classes have fun (most of the time) and they may even believe they are in charge of their learning, but it is at MY direction. The content that has lent itself to exploration-based activities has generally been better understood as the students gain ownership over the ideas. I am not just talking about using "cups" (variables that hold an unknown number of tokens) and "tokens" (constants) to create a rule that might be called the distributive law [an approach Adam mentioned in an earlier message], but also using technological explorations to understand the effect of constants on a function in senior school maths. The kids really seem to engage with this kind of activity, which then means the transition into "drill and practice" is easier and makes more sense. I know that this type of teaching has meant I now understand the WHY of some things in maths that up until now I had just simply believed because the teacher wrote it on the board and I did 100 questions about it. Anyway, I will jump off my soapbox now.

From: "David" <2003 student e-mail address>

Date: Wed Nov 17, 2004 7:58 pm (*Post-graduation phase*)

Subject: Re: maths in the news (*Student bulletin board message #614*)

I do not disagree with you here. IF the process drilling and grilling can be dressed up to be fun then so be it. However, this is more a testament to the resources of the teacher (and your own skill) than the structure of the curriculum and the whole attitude between discipline and self development.

P.S. Adam, I should get a copy of what you are doing. Sounds useful.

From: "Adam" <2003 student e-mail address>

Date: Thu Nov 18, 2004 9:04 am (*Post-graduation phase*)

Subject: Cups and tokens (*Student bulletin board message #615*)

The cups and tokens idea works for solving equations, factorising and distributive law. Here's a quick run down:

Students work in pairs or groups and get a couple of cups and a handful of tokens. You get them to "make up" say 2 cups and 1 token. You then ask them to "double" this amount and write in pictures on the board what is happening. After several attempts you draw out a pattern and can then begin talking about cups being variables and tokens being constants.

David, hope this helps.

In this discussion, the beginning teachers came to terms with their differences as they articulated and defended their own positions. They drew on their *professional knowledge* of students (the mathematics students know, their preferred ways of learning) and how they learn mathematics (exploration, drill and practice, use of appropriate representations and models involving manipulables and technology). They debated aspects of *professional practice* through references to learning environments that foster engagement as well as autonomy, and to specific teaching approaches. Their discussion also shows their interest in sharing knowledge and practice with colleagues, an important *professional attribute* of effective mathematics teachers.

Shared repertoire

In the course of its existence, a community of practice develops a shared repertoire of resources for negotiating meaning by “producing or adopting tools, artefacts, representations; recording and recalling events ... telling and retelling stories; creating and breaking routines” (Wenger 1998, p. 95). In this case, the shared repertoire does not refer to physical resources for teaching mathematics, but instead to actions, habits, and concepts that community members developed to make sense of their experiences as pre-service and beginning teachers. The online participation structures provided by the Yahoo Group bulletin boards were an important part of this repertoire, as indicated by the analyses presented in previous sections. However, the bulletin boards also became a means of developing other participation structures that created professional and social routines, based on telling stories and recalling events, that supported the pre-service teachers during their university studies and after graduation.

Professional routines

During their internship session at the start of 2004, the 2003 cohort of graduate entry pre-service teachers decided to meet once again as a mathematics curriculum class group to conduct a debriefing session after they returned to the university. They used the course bulletin board to organise the debriefing and negotiate the agenda, and they invited newcomers—the 2004 cohort of pre-service mathematics teachers—to attend:

From: “Chinh” <2003 student e-mail address>
Date: Sun Mar 7, 2004 12:26 pm (*Internship phase*)
Subject: Re: Debrief (*Course bulletin board message #717*)
Hello everyone!
I just wonder if we can have a debrief after the internship among us sometime, because I would love to hear more stories and experience from everyone—I think listening to a story is more interesting than reading one.
PS: all Merrilyn and Anne’s students are also welcome.

Members of the 2003 group invited us to the debriefing session, and a date during the Easter vacation was chosen to enable dual degree graduates, who had started teaching, to participate. The debriefing was attended by ten graduate entry pre-service teachers from the 2003 cohort, two beginning teachers from the same cohort who were dual degree graduates, and six pre-service teachers from the new 2004 cohort. The observation notes we took during this session record that the pre-service and beginning teachers discussed pedagogical challenges they had experienced during the internship and their first months of full-time teaching, identified sources of assistance, compared the effectiveness of approaches for teaching poorly understood mathematical concepts such as perimeter and area, and offered strategies for building positive relationships with students who were disengaged from mathematics. They later provided a summary of the debriefing on the course bulletin board for all who had been unable to participate. The following year, pre-service teachers in the 2004 cohort organised a similar internship debriefing that was attended by members of the 2005 cohort. This suggests to us that an internship debriefing, organised by the interns themselves for the benefit of both old timers and newcomers, may become a professional routine and part of the shared history of the community.

Social routines

A second kind of routine relates to the function of social gatherings as a means of expressing community membership and negotiating professional identities. Tables 4 and 5 show that social interactions accounted for a large proportion of messages at the end of the B.Ed programme and in the first 6 months of teaching post-graduation. After finding employment as teachers, members of the 2003 cohort used the student bulletin board to maintain professional relationships and to organise outings and dinners—to which we were also invited—during school vacation periods. When we attended these events we discovered that they served more than social purposes as they also provided occasions for beginning teachers to initiate quite detailed analyses and comparisons of teaching experiences in different schools, similar to those we observed in the internship debriefing session.

Factors influencing the emergence of the community

We discuss factors that may have influenced the formation of the online community from two perspectives. First, we reflect on our own role in shaping interactions between participants, and second, we analyse the pre-service teachers' perspectives expressed in the group interview conducted at the end of the B.Ed professional year.

Teacher educator perspectives

Data previously presented summarising the frequency and content of bulletin board messages (Tables 1–5) suggests that our role as participants served two purposes—to ensure the effective organisation of the course and to facilitate professional dialogue amongst the pre-service teachers.

Our organisational role is evident in the most common type of lecturer-initiated messages, more than half of which dealt with *administrative* matters related to the course that we were teaching. For example, we reminded students to bring required reading material to class, we posted information about class schedules and assessment tasks, we invited them to e-mail us to find out their assignment grades, and we sought feedback on aspects of the course. Similarly, lecturer–student interactions were most often *administrative*, with approximately one third being of this type.

Our professional facilitation role is more subtly expressed in encouraging the pre-service teachers to initiate and participate in bulletin board discussions and to use the course website to share teaching resources. Closer examination of the content of all messages sent by lecturers shows that we did this in three main ways. First, we offered models of online professional exchanges by forwarding messages from other e-mail discussion lists used by mathematics teachers. Second, we encouraged the pre-service teachers to share teaching resources via the course website, for example, by creating folders for them to store their work and by forwarding the URLs of useful websites for mathematics teachers. Third, we invited the pre-service teachers to share their mathematics teaching experiences during the practicum and internship, and after graduation.

In responding to this modelling and encouragement, the pre-service teachers began to post messages with links to mathematics teaching websites, upload teaching resources they had produced, and use the bulletin board as a forum for sharing their practice teaching

experiences. They maintained the momentum for these professional discussions themselves through messages such as the one below:

From: “Suzie” (2003 student e-mail address)
Date: Thu Aug 28, 2003 5:13 pm (*practicum phase*)
Subject: Catching up (*Course bulletin board message #355*)
I was just thinking today that I hadn’t heard from many of my fellow maths-teachers-to-be lately. How’s everybody going out there?

The extent to which we were successful in facilitating professional dialogue can be measured by the most common type of student-initiated messages and student–student interactions, more than one third of which focused on *professional* issues related to mathematics teaching in schools.

Pre-service teacher perspectives

From our group interview with the 2003 cohort at the end of the mathematics curriculum course we can identify three significant factors that—according to the pre-service teachers—contributed to the emergence of the community. First, they claimed that the voluntary, non-assessable nature of their participation led to a different usage pattern compared with other university course websites where it was compulsory for them to post a specified number of messages in response to the course readings provided, which were then graded for assessment. In criticising the latter approach, one pre-service teacher said: “I posted my minimum allocation and didn’t read much of what others had to say”. In a follow-up e-mail (sent to us privately rather than posted to the bulletin board) another explained why this might have happened:

The idea with WebCT [the course management software used in other university courses] was to create an online community (or at least that’s my impression), however, mandating the use of discussion lists and then basing grades upon this has led to a false sense of collegiality. Unfortunately, discussion has been stifled by the need to produce X ‘original’ postings in order to achieve Y percent. [The Yahoo Group mathematics website] on the other hand is totally voluntary. This shifts the focus away from simply meeting criteria to pass a subject, and towards developing a sense of community.

Second, the pre-service teachers explained that having face-to-face as well as online interaction in a small class was crucial in creating familiarity and trust so that the bulletin board became, in the words of one of them, “an outlet for discussion of ideas/problems, and a relief valve for stress”. They contrasted this with their experience of web-based discussion forums in other B.Ed courses, where up to 200 pre-service teachers might be posting messages on a wide range of topics unrelated to the teaching of mathematics. In fact, one pre-service teacher commented that using WebCT reminded her she was a *student*, whereas using the mathematics community website and bulletin board made her feel like a *professional*. Third, the pre-service teachers said they appreciated the convenience of having Yahoo Group messages automatically delivered to their e-mail inboxes—unlike WebCT, where students can only post and read messages by logging on to the university website. They explained that because checking e-mail was part of their daily routine it was easy to receive and respond to messages from the Yahoo Group.

Discussion

The increasing use of online discussion forums in teacher education seems to be based on the premise that a “virtual community” will support learning; however this premise is not always examined to discover whether such a community really exists and what exactly it is achieving. In this article, we analysed evidence from bulletin board discussions to argue that an online community of practice focused on becoming a teacher of secondary school mathematics emerged during a pre-service teacher education course, and that the community was sustained by its members throughout the remainder of the degree programme and in the first year of full-time mathematics teaching in secondary schools. Wenger’s (1998) three dimensions of practice—mutual engagement, joint enterprise, and shared repertoire—provided the analytical framework for characterising the activities of the community and tracing its emergent structure.

From the literature on online communities of practice we identified two issues that were highly relevant to our goal of creating a community website where pre-service mathematics teachers could initiate professional discussions during and after the university programme: the designed/emergent duality, and the potential difficulty of sustaining online interaction when participation is not mandatory. In line with the arguments advanced by Barab et al. (2001), we attempted to manage the tension between design and emergence by creating a framework in the form of the mathematics education course website and bulletin board, modelling ways of building the space, but allowing the pre-service teachers to use it in ways that would meet their needs. We regard their appropriation of the course bulletin board to their own purposes and their establishment of an alternative Yahoo Group as convincing evidence of the sustainability of this community of practice. Our analysis also showed that members of the 2003 cohort increasingly took the initiative in engaging with each other and expanding the community through generational encounters with newcomers, defining their own academic and professional goals and values, and constructing a repertoire of participation structures and routines for maintaining their community beyond graduation.

We attempted to facilitate the formation of the online community by modelling and encouraging professional discussion and sharing of teaching resources. In the eyes of the pre-service teachers, emergence of this community was associated with the voluntary, unstructured, non-assessable and unmoderated nature of participation, the critical importance of initial face-to-face interaction in creating familiarity and trust, and the convenience of having messages delivered to their e-mail inboxes without having to log on to the website.

It is worth commenting further on the role that our own bulletin board contributions played in influencing the emergence of the online community. Our intention was to refrain from entering into online discussions of professional issues in a substantive way unless the pre-service and beginning teachers explicitly directed a question to us. Nevertheless, like Schuck (2003), we found it difficult at times to decide whether to join in a discussion when pre-service and beginning teachers were exploring alternative interpretations of a problem or classroom experience (such as the exchange between David and Adam presented earlier). Our uncertainty reflects the dilemma of acknowledging Wenger’s (1998) argument that a community cannot be fully designed, while fulfilling our responsibilities as teacher educators who deliberately set out to ensure that successful learning occurs. Although the research presented here contributes to knowledge of how an online community of practice is created and maintained amongst pre-service teachers, it does not address the challenge of

developing Wenger's theory further so that it accounts for the role of a teacher educator in such a community.

This study followed a particular cohort of pre-service mathematics teachers and selected a time frame for analysis of bulletin board messages that aligned with the timing and logic of the enterprise in which they were engaged, in particular the transition from pre-service to beginning teaching. Defining the scope of the study in this way did not permit discussion in this article of how the community might have continued to evolve as "old timers" left and newcomers joined and became full participants. We can only note here that pre-service teachers in the 2004 cohort used the course bulletin board in much the same way as their predecessors, but a full analysis of this cohort's online messages is beyond the scope of this article.

Members of the 2003 cohort remain in contact with us and with each other, but they now post few messages to the course and student bulletin boards. Nevertheless, in Wenger's (1998) terms, this does not mean that the online community of practice has ceased to exist. Instead, it is continually re-populated with new members as each cohort of pre-service teachers completes our mathematics education course. Communities do not rely on fixed membership; they have life cycles that reflect a social structure where successive forms of participation create learning trajectories that eventually lead members out of the community and into new relationships, new positions in the world, and other communities of practice. A challenge for future research is to investigate these trajectories as they apply to beginning mathematics teachers and the formation of individual and communal identities in practice.

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