A Window Into Mathematics Communities of Practice in Australia and New Zealand

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A teaching practice today requires an understanding of pedagogic thinking which prioritises the constitution of learning over the execution of teaching. Integral to that understanding is the idea that knowledge is constituted through the learner's active engagement with mathematics. This paper moves beyond an exploration of the way teachers' speak about their practice to explore teachers' actual creation of productive learning communities within their classrooms, as reported by preservice teachers in both Australia and New Zealand; thus providing valuable material for their mathematics education courses.

One of the most pervasive themes emerging from discussions amongst mathematics educators in recent years has been the issue of students' active engagement with mathematical ideas. The theme has been expressed in a variety of ways but more often than not revolves around the establishment of an inquiry-based classroom which allows for transformative relationships of knowledge production and exchange. The trend is not specific to Australasia's vision of teaching and learning which encourages student engagement—it has also been identified in official mathematics curriculum documents in, for example, the United States (National Council of Teachers of Mathematics, 1991, 2000), and the United Kingdom (OFSTED, 1994). This interest in active classroom engagement is related in part to a recognition that mathematics for many students is a series of hurdles and challenges, and a task confronted with continued failure and irrelevance.

These ideas are embedded in a larger effort from the international mathematics educational community to reform the teaching and learning of mathematics. The vision of curricula policy documents in both Australia (Australian Education Council, 1990; Department of Employment, Education and Training, 1989) and New Zealand (Ministry of Education, 1992) shifts the authority for verification and validation of mathematical ideas onto a mathematical community in which students themselves are cast as active participants. Students take on the role analogous to the role of mathematician: creating and evaluating the mathematics which has been created by members of the classroom mathematics community, and negotiating shared approaches to and standards for these activities. Their new role enables students to conceive of mathematics as created by communities of people based on the goals of the community and its accepted forms of practice. In addition, students' involvement in the creation and validation of ideas not only provides them with rich opportunities for new understandings of mathematics but also contributes to their own sense of self-worth.

These changes advance a close relationship between social classroom processes and conceptual development. Such epistemological-cultural connections are dependent upon the establishment of a community of inquiry. The notion of 'community of practice' together with 'the connectedness of knowing' are central features of Lave and Wenger's (1991) well-known theory of 'situated learning'. They write:

> A community of practice is a set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice. A community of practice is an intrinsic condition for the existence of knowledge, not least because it provides the interpretive

> support necessary for making sense of its heritage. Thus, participation in the cultural practice in which any knowledge exists is an epistemological principle of learning. (p. 98)

When mathematical activity is viewed as intrinsically social then what counts as legitimate mathematical practice has decidedly normative aspects (Bauersfeld, 1988; Cobb, Wood, & Yackel, 1993; Lave, 1988; Walkerdine, 1988), and is enabled by the current goals, suppositions, and assumptions of the classroom community (Yackel & Cobb, 1996). Boaler (1997) has shown how the meaning of, and grounding for, the construction of community differed for two schools in her study: "Amber Hill used a traditional approach to the teaching of mathematics, based upon teacher demonstration and student practice. The other school—Phoenix Park—required students to work on two-to-three-week-long, open-ended projects that the teachers had designed" (Boaler, 2002, p. 42). Phoenix Park teachers were more likely to find the authority for constructing community *in* their personal relationships with each student. For them, the construction of a normative community was a prerequisite for a successful student relationship to the teacher, or a successful experience in this teacher's classroom. Phoenix Park teachers tended to 'ground' the rules and norms in the relationship established between teacher and student. In contrast, the strong ideological commitment of Amber Hill teachers to the importance of the social community *of* the school plays out in their insistence that learning cannot go on unless students behave in a certain way.

One of the central issues emerging from Boaler's study is an understanding of the construction of classroom community and its implications for the production of mathematical ways of knowing. The work reported in this paper moves into the context of classroom practice. In the study we attempted to understand the overall coherence of teachers' practices, including the conceptions which drive those practices. This type of investigation which looks at teaching perspectives drawn from actual classroom practice can raise awareness of the complex processes involved in establishing classroom communities of inquiry (Simon, Tzur, Heinz, & Kinzel, 2000). To date there is insufficient understanding of "the role of the teacher within this type of learning" (Sfard & Kieran, 2001, p. 186). We provide data which led to our understanding of a perspective of pedagogy which successfully characterises the intent of mandated teaching principles. The question driving the investigation is as follows: What pedagogical approaches are teachers of mathematics developing to establish communities of inquiry in their classrooms?

The ways in which teachers establish communities of inquiry within their classrooms are not currently well understood. Important contributions in understanding teachers' work have been made by researchers through the identification of key areas of teacher content knowledge (e.g., Stacey, Helme, Steinle, Baturo, Irwin, & Bana, 2001); the identification of pedagogical content knowledge (e.g., Ball, 1993); and the identification of beliefs (e.g., Simon & Schifter, 1991); and this work serves as a backdrop to this study. However we are mindful that the characterisations which teachers give of their work often do not correspond to observers' characterisations of that same practice (see Cooney, 2001, p. 11). Our approach is to focus on the 'enacted' rather than the 'espoused' forms of practice (Sfard & Kieran, 2001) by analysing the culture of the mathematics classroom as observed over an extended period by preservice teachers. Our own conceptualisation of knowledge and coming to know takes as its central tenet the idea that knowledge evolves with community and culture. This engagement with a characterisation of mathematics knowledge as socially constructed frames the questions we ask and those aspects in our data to which we pay attention.

Methodology

The school classroom is a complex environment, and mathematics activities within such a milieu are no less complex. By placing trained observers in mathematics classes we could attain a reasonable insight into the way such communities operate. However, a small window into these communities was available by questioning student teachers who had spent a 2-3 week practicum there, even though the data collection was post facto. This is the model that was used to collect the data for the study reported here. Thus there was obviously some loss of reliability due to the dependence on recall, rather than on direct observation.

The questionnaire used was one developed by Walshaw and Savell (2001) and included both open and closed questions. It was devised to collect information about aspects such as the planning and structure of observed mathematics lessons, and the students' own teaching of mathematics during the practicum. In both Australia and New Zealand it was administered on the one day to teacher education students who were undertaking a compulsory mathematics education course in the second year of their degree program and who had just completed a professional teaching practice in city and suburban schools. In the Australian case, 67 student teachers completed the questionnaire in relation to their 67 different associate teachers and classrooms after being on a two-week teaching practice in some 28 primary schools (Years 1-7). In the New Zealand case, 72 teachers completed the questionnaire after a three-week practice period in approximately 25 different primary (Years 1-6) and intermediate schools (Years 7-8). In both cases this was late in the third term of the school year. One of the major purposes of the exercise was to gather information which could be used to improve the content of the mathematics education courses that the students were undertaking; and since student teachers naturally find the practicum highly relevant, they were very willing to complete the questionnaire.

Results

The ways in which teachers engage students and construct a mathematical community necessarily involves decisions about teacher talk, how and when students offer contributions and about how those contributions are received. It also involves decisions about physical arrangements of furniture, about provision for students' access to materials and technology, and about the sorts of tasks students work at. Those decisions profoundly influence the individual's construction of mathematical ways of knowing by both supporting and constraining what can be done and what can be said.

To create a context for exploring those teacher decisions we firstly present some general information concerning the schools and the class settings. The majority of student teachers were placed in schools with enrolments in the 200-500 range. The majority of the schools accommodated several students, each of whom was allocated to an associate teacher for the duration of the practicum. Most mathematics lessons were held in the mornings—in 90 per cent of the Australian classes and 82 per cent of the New Zealand classes. The median weekly class time spent on mathematics was three hours and twelve minutes in New Zealand and markedly more in Australia with four hours and ten minutes; ranging up to five hours per week in both places.

Student teachers were asked to indicate the sources used by their associate teachers in planning mathematics lessons. Table 1 shows that in both countries the prescribed curriculum documents were a major reference. It is interesting to note that published teachers' guides were consulted by more than half the teachers in their planning. However,

there was also a strong reliance on the use of both textbooks and teacher-prepared worksheets.

Table 1
Sources Used by Teachers in Planning Mathematics Lessons

Planning Source	Australia %	New Zealand %
Curriculum document	83	78
School polices	12	7
Commercially produced teachers' guides	53	60
Textbooks	65	50
Teacher-prepared worksheets	56	55
Other publications	28	15
Teacher colleagues	34	48
Internet	7	6
Other	12	4

Note: All teachers used several sources.

Traditional teachers are probably no less desirous than constructivist teachers of having classrooms with actively engaged students who cultivate critical thinking and develop evidential bases for legitimating truth, but their methods of attaining this end differ. From a cognitive perspective, active engagement means that the student uses his or her existing cognitive structures to make sense of the raft of signals coming through the senses. The construction of community entails creating learning environments for *individual* students to explore. From a situative perspective, the student's active engagement is a connection to an ongoing social process (Collins, Brown, & Newman, 1989), and teaching is a practice involving fostering communities of learning.

To capture the perspective of teachers, we asked students to choose from a list of classroom activities the types of approaches used by their associate teachers in mathematics lessons. Students were also asked to indicate whether such an approach was used mostly, sometimes or rarely. The results given in Table 2 indicate the percentages of classes where particular activities were mostly used. In the Australian setting, teacher talk and exposition with the students listening was mostly used by 65 per cent of the teachers, while in New Zealand this was less in evidence with 49 per cent usage. Group work was much more in evidence in the New Zealand classrooms. Another marked difference was in the use of worksheets in the mathematics lesson—this being a more popular approach in the Australian classrooms. The use of equipment was also more prevalent in New Zealand classrooms. The extent of questioning and discussion was similar in both settings.

To enact the goals of their preferred teaching perspective, teachers set expectations for their own conduct and the conduct of their pupils within the classrooms. These expected modes of operating create a classroom that is a normative community, a community which imposes preferred ways of practice upon its members. Norms are collective understandings of the expectations and obligations that are constituted in the classroom and it is through their establishment that a classroom environment, conducive to the teaching perspective preferred by the teacher, is able to be maintained. These modes of operating are largely implicit understandings and are themselves in turn, influenced to some extent by what is legitimised as acceptable mathematical activity. What becomes sociomathematically

normative (Yackel & Cobb, 1996) in a classroom is constrained by the teacher's own perspective.

Table 2
Activities Mostly Used in the Teaching of Mathematics

Activity	Australia %	New Zealand %
Teacher talk & exposition	65	49
Group work & cooperative activities	33	50
Students engaged in whole-class discussion	33	32
Students asking questions	43	38
Students using hands-on equipment	30	44
Students completing a worksheet	55	37
Other	18	6

Note: All teachers used several approaches.

To explore preferred modes of operating in the classroom we asked student teachers to describe the components of a typical mathematics lesson by their associate teacher in terms of teacher actions and associated student actions. These descriptions were categorised into three main lesson stages of introduction, development and conclusion. Table 3 illustrates an expansion of these categories for both teachers and their students, as observed by the preservice teachers. In Australian schools most teachers took 5-10 minutes for the introductory stage, but 15 per cent proceeded to a given assignment with no introduction at all. The question must surely be raised as to whether pupils are being provided with sufficient learning activities through strategies such as questioning and discussion before being required to attempt exercises which are largely oriented towards practice. The concluding stage of mathematics lessons in the Australian setting was also rather brief with most teachers taking again taking 5-10 minutes. However, it is particularly surprising that 30 per cent of teachers provided no specific conclusion at all. In the introductory stage only 19 per cent of teachers engaged the students in discussion and questioning—strategies usually regarded as significant for promoting learning. Most teachers (41%) tended to use an expository approach rather than an interactive one in this stage of the lesson. The middle part of mathematics lessons constituted approximately 70 per cent of lesson time and tended to be taken up largely with assigned practice exercises.

The typical lesson in New Zealand classrooms for older primary students was similar to the Australian experience. The Years 7-8 classroom in New Zealand schools was routinely ungrouped, yet had often undergone inter-class grouping for mathematics. In these streaming or setting arrangements, teaching and learning approaches were directed at the whole class as for Australian classrooms. Time allocations were reasonably similar in both countries. However for classrooms of younger students with varying abilities, according to preservice teachers' observations, many teachers arranged the class work according to three ability groups. In these arrangements teaching was typically directed at the whole class at the beginning of the lesson, followed by more intensive tuition with one group followed by another group. Those students not working closely with the teacher worked at independent and consolidation activities. For 45-50 minute lessons, whole class introductory teaching and learning experiences usually lasted for 5-10 minutes, teacher's

work with the two separate groups took 30 minutes, and lesson conclusion was assigned 5-10 minutes.

Table 3
Typical Mathematics Lessons

Introduction – Teacher Actions	Introduction – Student Actions	Aus%	NZ%
Explaining	Listening	41	67
Revising	Listening/responding/marking	19	5
Administering mental computation	Responding/writing/marking	19	7
Demonstrating	Observing	7	2
Discussing & questioning	Listening/Responding	11	5
Other	Other	5	2
No introduction	Commencing assigned work	15	12
Development – Teacher Actions	**Development – Student Actions**	**Aus%**	**NZ%**
Supervising	Doing assigned work	35	21
Providing assistance	As above/seeking help	44	12
Demonstrating on board	Listening/observing	17	34
Going through worksheets/text	Listening/checking worksheet	24	38
Explaining/discussing/questioning	Listening/commenting/responding	52	41
Demonstrating concretely	Listening/observing/manipulating	14	5
Assessing	Working/responding/marking	20	7
Conclusion – Teacher Actions	**Conclusion – Student Actions**	**Aus%**	**NZ%**
Discussing	Listening/responding	9	5
Summarising/concluding	Listening/questioning	20	38
Checking knowledge/understanding	Listening/explaining	11	34
Reviewing/recapitulating/clarifying	Listening/questioning	20	16
Reviewing solutions/marking work	Responding/marking work	24	31
Giving a new activity	Listening/engaging in activity	11	8
Organising packing away	Packing books & materials away	7	16
No definite conclusion	N/A	30	42

Note: Some teachers engaged in more than one approach in each lesson stage, so totals are more than 100%.

Preservice course work in both countries makes explicit engagements with national and state documents. Through those engagements students had learned what theories of knowledge and learning are advocated and promoted. The course work had established through official representations of pedagogy, a benchmark for what will count as 'doing mathematics'. It is within this frame that students interpret classroom practice and determine how the practicum meets their expectations. In the Australian setting 51 per cent stated that their expectations were well met; the comments of 26 per cent were classed as neutral or moderate; while 23 per cent felt their expectations were not met. New Zealand preservice teachers were not so readily satisfied with their practicum experiences. For 30 per cent, the practicum did not meet expectations; and 28 per cent were only moderately

satisfied. Expectations were fully met for 42 per cent. What follow are typical comments from each of these three categories. Firstly, two examples of well satisfied student teachers:

> The teacher provided plenty of support as well as introducing me to a variety of resources and also gave me some original ideas.
>
> I was surprised at the way the teacher taught maths. The children were always involved and actively learning.

Secondly, two comments from students who rated the support as moderate or in neutral terms:

> The teacher shared ideas about ways to motivate children to learn maths.
>
> I was provided with basic ideas.

Finally, the comments of two who were dissatisfied with the experience:

> Bitterly disappointed that maths was still being taught the way I learnt it at school. I wanted it to be fun but it wasn't. Teacher's ethos was, 'don't rock the boat'.
>
> Seemed very boring for students. Mainly worksheets and blackboard work. Very little concrete work.

Conclusion

The observations of Australian and New Zealand mathematics classrooms by student teachers have highlighted a number of interesting comparisons. In both settings teachers relied heavily on curriculum documents as well as textbooks and worksheets in planning their lessons. Worksheets were used more in the Australian classrooms than in the New Zealand ones, whereas cooperative activities and group work were more prevalent in the New Zealand setting. In both cases there was much teacher talk but very little discussion and questioning. Yet discussion and questioning is widely recognised as an essential vehicle for students to actively engage in their learning. As many educators have noted, in order to engage in instruction which supports mathematical sense-making, teachers need to focus their attention away from their own individual performance, and attend instead to the interactive processes of meaning construction, by creating intellectual communities with the students in their classrooms (see Wood, Scott-Nelson, & Warfield, 2001).

The significance of this study lies in its potential for improving not only mathematics education programs for preservice teachers but also professional development courses for practising teachers. Through those improvements teachers can begin to make differences within their classrooms and begin to provide students with opportunities which allow them to see that they are indeed capable of creating mathematics.

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