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A Professional Experience Learning Community for Pre-service Secondary Mathematics Teachers

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Abstract: This paper reports the development and implementation of a collaborative professional experience learning community for a group of nine pre-service secondary mathematics teachers. The pre-service teachers and their methods lecturer made 12 school visits over one academic year to a local secondary school. The pre-service teachers observed and co-taught problem-solving lessons in two Year 8 classes. They discussed the lessons with the teacher and the university lecturer, and later posted reflective comments to an online forum. Data from questionnaires, interviews, and reflections indicate that participation in the learning community helped pre-service teachers make stronger links between theory and practice, learn from each other, and become more reflective about problem-solving teaching approaches.

Introduction

Professional experience or the practicum is typically regarded by teachers as one of the most important aspects of their preparation for the classroom (Le Cornu, 2012). Moreover, in recent years, the proportion of time allocated to fieldwork in teacher education programs has increased (Hennissen, Crasborn, Brouwer, Korthagen, & Bergen, 2011). The greater emphasis on professional experience in teacher education programs requires the development of new kinds of school partnerships (Deed, Cox, & Prain, 2011). This paper describes a university-school partnership to establish a learning community for a group of pre-service teachers who were preparing to teach secondary mathematics. The learning community was designed around a coordinated program of university methods workshops and professional experiences in the school. The research reported here focuses on the kinds of knowledge about practice the pre-service teachers developed through their participation in this professional experience learning community and the features of the learning community that facilitated the development of this knowledge.

Reframing teacher education programs

Pre-service teachers often begin teacher education programs with strongly held beliefs about learning and teaching. Their own school experiences exert a powerful influence on their conceptions about the curriculum and how best to teach it and they invariably want to teach as they were taught (Scherrf & Singer, 2012). This is a critical issue in secondary mathematics because most pre-service teachers have themselves learned mathematics in a traditional manner (Ebby, 2000) so they are unfamiliar with alternative pedagogical approaches and tend to want to teach very teacher-centred lessons. The situation is

exacerbated because rather than challenge pre-service teachers' prior understandings, some teacher education courses and field experiences have been found to reinforce them (Zeichner, 2010).

Wubbels, Korthagen, and Broekman (1997) refer to a didactic teaching-learning-teaching cycle in which teacher education programs do not provide pre-service teachers with opportunities to critically analyse their own schooling. In addition, professional experience placements may not provide pre-service teachers with opportunities to observe or teach using student-centred approaches. Consequently, pre-service teachers may simply replicate the kinds of teaching they received in their own schooling without carefully considering alternative approaches.

Some of the difficulties with traditional approaches to professional experience programs may relate to the fragmentation of coursework and classroom practice (Eames & Coll, 2010). Consequently, many pre-service teachers do not find it easy to integrate what they are learning at university with what they are experiencing at the school. In addition, the nature of the mentoring from professional experience supervisors available to pre-service teachers can be inconsistent (Atputhasamy, 2005; Wilson, 2006). As noted by Sim (2006, p.78) traditionally-oriented supervisory practices may provide only limited support for pre-service teachers to "explore, discuss, and reflect on their developing understandings".

The challenge for teacher educators is to devise new kinds of professional experience programs that help pre-service teachers integrate theory and practice (Eames & Coll, 2010). It is also important that pre-service teachers are given multiple opportunities to experiment with novel teaching approaches that are perhaps quite different from those they experienced when they were students themselves. In doing so, pre-service teachers will be better able to appreciate the importance of a variety of mathematics pedagogies and reframe their ideas about what constitutes quality learning and teaching (Star & Strickland, 2008). One crucial element in helping prospective teachers to identify some of the shortcomings in traditional teaching practices and encourage them to broaden their range of pedagogical approaches is by engaging in critical reflection on the lessons they observe and teach (Chamoso, Cáceres, & Azcárate, 2012).

In their analysis of field experience models, Blanton, Berenson and Norwood (2001) note that historically the supervision of student teachers has been largely evaluative in nature. Evaluative supervision is primarily concerned with assessment of current teaching practices, particularly classroom management and organisation (Goos, 2008). University staff typically make infrequent classroom visits which does not promote the development of productive school partnerships or help to develop pre-service teachers' situated knowledge (Cuenca, Schmeichel, Butler, Dinkelman, & Nichols, 2011). In contrast, educative supervision is based on the notion of 'educative mentoring' which is designed to purposefully challenge pre-service teachers' existing beliefs and practices (Feiman-Nemser, 2001) through prolonged interactions and extensive classroom observations by university supervisors.

Research has identified that teacher education program goals need to focus on developing dispositions that enable student teachers to learn *in* and *from* practice (Ball & Cohen, 1999). Among the characteristics of powerful teacher education identified by Darling-Hammond (2006) is the requirement for "extended clinical experiences [that] are carefully developed to support the ideas and practices presented in simultaneous, closely interwoven course work" (p. 41). These clinical experiences must expose student teachers to the complex nature of the classroom and provide opportunities for them to implement alternative approaches, discuss their experiences, and learn from each other (Harding & Parsons, 2011). However, while positioning part of the teacher education program in schools may ensure a greater situated understanding (Kennedy, 1999), if these clinical placements simply reinforce past experiences they are likely to position student teachers as passive receivers rather than co-creators of knowledge about teaching (Darling-Hammond, 2006).

The present study is distinctive because it includes sustained opportunities for co-teaching, peer observation, and collaborative reflection. These activities have been specifically designed to help pre-service teachers make stronger links between their university studies and their school-based professional experience program, and to broaden the range of pedagogical approaches in which they participate. The aim of the study was to investigate the participants' views about the learning community and identify if it helped the pre-service teachers to develop their professional practice.

Theoretical framework

Le Cornu and Ewing (2008) devised a framework for describing field experience. They argue that these programs are conceptualised, structured and supervised in three different orientations which they term traditional, reflective and learning communities. The traditional orientation is based on a theory-practice dichotomy. It emphasises that newly acquired knowledge gained at the university is put into practice at the school, but done so in such a way that prospective teachers are largely passive participants in their field experiences. The goal is for pre-service teachers to master the technical skills of teaching since traditional supervision models grew out of a focus on the learning of observable skills. Hence traditional supervision is predominantly evaluative.

In reflective professional experience, Le Cornu and Ewing (2008) suggest there is an expectation that student teachers will advance beyond a basic consideration of teaching skills to examine some of the moral and ethical issues of learning and teaching in a specific social context. Pre-service teachers are no longer passive recipients of their professional experiences; they accept greater control over and responsibility for their learning. The primary focus is to reflect in and on practice, and learning to teach is considered only part of learning to be a teacher. Pre-service teachers collaborate and support each other and supervision is conceived primarily as facilitating a reflective practice.

The notion of a learning community is framed by the concept of a community of practice found in the work of Lave and Wenger (1991) and Wenger (1998). Communities of practice recognise that learning is situated in the work, not so much of individuals, but through co-participation of all members (Leiken, 2008). Professional experience then becomes a learning community where the focus shifts from the sole practice of the individual to a shared experience. All participants, pre-service and partner teachers and university supervisors, are positioned as potential learners. Student teachers not only develop their own reflective practice but also support others as well. There are greater opportunities for team teaching and shared risk taking. Supervision practices are also more collaborative, with university and school staff working together as facilitators of reflection. Hence there is a joint construction of the fundamental aspects of teaching (Kenny, 2012).

A learning community is a group of people "involved in some kind of activity that learn together and, more importantly, learn from each other" (Ponte et al, 2009, p. 197). Jaworski (2004) notes the importance of stability of membership in a learning community and activity which is sustained over time so that relationships among members can be enriched and members can begin to learn together and from each other. To emphasise this interderpendence, Davis and colleagues (2009) describe the relations among learning community members as "a "collective we" rather than a "collection of me's"" (p. 155).

Learning communities can be homogeneous or characterised by diversity of membership, such as the learning community described in this paper which was comprised of experienced practitioners as well as a group of pre-service teachers from a broad range of backgrounds. If managed well, diversity can be advantageous for learning communities because it can lead to more fruitful sharing of different viewpoints, experiences and expertise which can produce deeper and more sustained learning. However, diversity also presents

challenges for learning communities, such as finding a common language and adjusting to ways of working with others (Ponte et al., 2009).

Ponte and colleagues (2009) identify four key issues for learning communities. First, is the purpose of the group and how closely the members identify with it since, for the learning community to flourish, the goals and purpose of the group need to be clearly articulated for all. This is particularly important for learning communities such as those of pre-service teachers, which are somewhat artificially formed. Second, is the knowledge that develops from the activity of the learning community which includes the shared practices and common actions of the group. Negotiation of meanings, particularly in learning communities characterised by a diversity of membership, can be a slow and complex process; hence the need for stability of membership and activity which is sustained over time. Third, is how learning happens in the learning community. For a community of pre-service teachers, learning can occur through a variety of means such as teaching lessons, discussing classroom practice, and reflecting on lesson episodes. But no matter what kinds of learning activities take place, there must always be opportunities for members to discuss, reflect, negotiate and share their developing knowledge of practice. Fourth are the roles and relationships of group members, especially their mutual involvement and commitment to the group's progress. In particular, members of the learning community must appreciate the importance of mutual engagement and commitment to the progress of the group and their core responsibility of helping others learn.

The purpose of the learning community developed for the present study was for the pre-service teachers to develop their professional practice through a variety of activities including peer observation and co-teaching and reflection on practice. The opportunities for developing pre-service teachers' reflective practice occurred principally through group discussion which occurred following each lesson and individual written reflections which were posted to an online discussion forum. The learning community further encouraged the mutual involvement of participants through activities deigned to promote *reciprocity* or "the development within learning communities of learners' commitment to and responsibility for their own learning as well as that of other members of the community" (Le Cornu & Ewing, 2008, p. 1808).

Encouraging a climate of reciprocity among the participants was a central consideration in the design of the learning community. The teacher and the university academic met regularly to strengthen the school-university partnership so that it became more mutually beneficial. We envisaged the supervision of the pre-service teachers during the program as collaborative, with university and school staff working closely together. The learning community focused on *teaching* rather than *teachers* (Hiebert, Morris, & Glass, 2003) to include the features of an educative rather than an evaluative professional experience identified earlier in the paper. The on-going engagement of the university supervisor was included to create stronger links between the methods workshop activities and the pre-service teachers' classroom experiences. The learning community also reflected important aspects of the *Standards for Excellence in Teaching Mathematics in Australian Schools* (Australian Association of Mathematics Teachers [AAMT], 2006), particularly Standard 2.2 "active exploration of new teaching ideas" and Standard 2.3 "actively engaging and collaborating with colleagues … sharing insights, practices and resources; supporting and mentoring others; and providing feedback" (AAMT, 2006).

Zeichner (2010) recently noted that there were few research studies on the impact of new models of coursework and field experiences on prospective teachers' perspectives and practices. This paper reports some outcomes of a learning community structured around a coordinated program of university study and field experience designed to promote collaboration between student teachers, an experienced classroom teacher and a university supervisor. The learning community was developed in response to two common issues which previous cohorts of pre-service secondary mathematics teachers had consistently raised

during interviews and informal discussions (see Cavanagh & Prescott, 2010). First, they reported that there were few, if any, opportunities during their field experience to observe and implement the kinds of reform teaching practices they heard about at university. Second, they expressed a desire for more regular and detailed feedback on their teaching.

The learning community was established for practising and pre-service teachers. It provided them with a chance to learn and work together in trying new teaching strategies in an environment with sufficient structure to scaffold their learning and cooperation. The research questions for the present study focus on the second and third issues identified by Ponte et al. (2009), namely: What kinds of knowledge about practice did the pre-service teachers develop through their participation in this professional experience learning community? What features of the learning community facilitated the development of this knowledge?

The following section describes in detail the structure of the learning community program and how the data for the present study were collected and analysed.

Method

Participants

This study was conducted over the course of a single academic year. The participants included nine pre-service teachers (five females and four males) who comprised the entire cohort for secondary mathematics in a one-year Graduate Diploma of Education program at a large university in metropolitan Sydney. The student teachers had completed a bachelor or higher degree in mathematics or a related field such as engineering or actuarial studies.

The partner teacher, the second author of this paper, was the Head Teacher of mathematics at the local high school where the field experience component of the learning community took place. He had taught secondary mathematics for 27 years and had supervised approximately 20 pre-service teachers when the study commenced. He had initiated the program of problem-solving lessons at the school and wished to establish a partnership with the university by inviting the university supervisor and the secondary mathematics pre-services teachers to participate. The government school was a comprehensive boys secondary school with an enrolment of just over 1 100 students, approximately 60% of whom were from a non-English speaking background. The methods lecturer had previously taught secondary mathematics for 20 years and had been a teacher-educator for 7 years

Prior to the commencement of the study, the teacher and methods lecturer agreed to establish a learning community partnership between the school and the university. They envisioned the learning community as an extended series of school visits (incorporating lesson observations, co-teaching, and sustained opportunities for discussion and critical reflection) combined with complementary activities during the university methods workshops.

School visits

Each fortnight during the two 13-week university semesters, the pre-service teachers visited the school for a Year 8 lesson. Rather than forming a single group, they attended in two groups (one of four and another of five pre-service teachers) to increase the opportunities for participation and engagement by the student teachers. Each group was matched to one of the Year 8 classes (either the highest ability class or the second-highest ability class) and made six school visits each semester, giving a total of 12 visits for each group over the year. The university supervisor attended all school visits for both groups.

There were approximately 30 students in each Year 8 class. The lessons were of 70 minutes' duration and generally followed a similar pattern. The teacher introduced the lesson by demonstration or questioning to ensure that students understood the problem. Students attempted the problem in pairs and after about 20 minutes the teacher led a class discussion on any preliminary results. Boys who completed the task early could attempt an extension problem. Later, a final discussion took place during which students shared their results. In the remaining 10 minutes, the boys individually wrote a short reflection on their impressions of the lesson and what they had learned. Three or four students then read their reflections for the class. While the students were working, the student teachers were able to move freely around the room and interact with them.

In the first semester, the student teachers observed six problem-solving lessons from the partner teacher. In the second semester, pairs of student teachers co-taught the lessons; each student teacher co-taught two or three lessons with a different partner each time. Previous studies (e.g., Bobis, 2007) have demonstrated the value of co-teaching for pre-service teachers. Co-teaching was a key element in the conceptualisation of the learning community because it provided opportunities for reciprocity among the group. Bessette (2008) describes co-teaching as a process for

> jointly planning, coordinating, implementing, and evaluating … It implies not only technical, interpersonal, and pedagogical responsibilities, but opportunities for professional development and growth. … [it] can make the teaching enterprise more fulfilling and more satisfying, as co-teachers form bonds, teach and learn from one another, and provide mutual support. (p. 53)

Following each observed or co-taught class, the partner teacher, the university supervisor, and the pre-service teachers discussed the lesson. These interactions were led by the partner teacher and typically lasted about 15 minutes. Within one or two days following the lesson, the pre-service teachers wrote a personal reflection, which they posted to an online university discussion forum, about their impressions of the lesson and what they had learned in the subsequent de-briefing session. They could read and comment upon the reflective posts of their peers if they wished. Neither the partner teacher nor the university supervisor contributed to the online forum.

The university supervisor's primary role in the learning community was to act as an observer and facilitator. He attended all of the school visits to observe the lessons and participated in the post-lesson discussions, though mainly to encourage contributions from the pre-service teachers. He made field notes during each school visit which were used to frame the methodology workshop discussions and formed part of the data for this study. He also provided detailed written observation notes to the co-teaching pairs on each lesson they taught.

Methods workshops

The involvement of the university methods lecturer in the learning community provided a unique opportunity to address the theory-practice divide identified in the literature. The workshops included group discussions which took place so that pre-service teachers could reflect on what they had observed and learned during the school visit in the previous week. These discussions were led by the methods lecturer and continued for about 20 minutes as the students reacted to these introductory remarks and shared their own reflections. Although the student teachers had not all witnessed the same lesson, the problem-solving activity was identical for both classes, so it was possible for everyone to contribute their ideas and be understood by the group.

Data collection and analysis

Data sources were chosen with the two research questions in mind. They comprised student teacher questionnaires administered at the end of each semester, and audio-recordings of a 35-minute focus group interview with the 9 student teachers and a 20-minute individual interview with the partner teacher, both held at the end of the year. A questionnaire was used so participants could "write a free account in their own terms, to explain and qualify their responses and avoid the limitations of pre-set categories of response" (Cohen, Manion, & Morrison, 2007, p. 321). The questionnaire, which took 15 - 20 minutes to complete, comprised four open-ended questions about the pre-service teachers' views about the learning community, how it compared to their other concurrent professional experience activities, how the program might be improved, and any further comments they wished to make. Focus group interviews stimulate discussion from multiple perspectives and explore a range of participant views (Bogdan & Biklen, 2006). The focus group interview and the partner teacher interview were semi-structured and designed to probe more deeply the participants' perceptions of the learning community. The questionnaire and focus group interview questions are listed in the appendix.

Ethics approval to conduct the study was obtained and a research assistant who was not part of the learning community obtained informed consent from the participants prior to the data collection. Data collection procedures aimed to minimise the chance that student teachers might overrate their experiences for the benefit of the methods lecturer. Hence the questionnaires were completed anonymously and administered by the research assistant who also conducted the focus group interview. On each occasion that he collected data from the student teachers, the research assistant reminded them that the researchers would not have access to their responses until after the university had released their final results for the Graduate Diploma.

The aim of this research study was to understand and describe the learning community from the perspective of the participants so a phenomenological case study design was used. Phenomenological research "seeks the individual's perception and meaning of a phenomenon or experience" (Mertens, 2005, p. 240). The qualitative data analysis procedures employed in the study garnered information about the participants' perceptions of the learning community and how it compared to their other professional experience activities. Data analysis commenced at the conclusion of the academic year after the methods lecturer first accessed the completed questionnaires and the recording of the focus group interview. These data and the recording of the partner teacher interview were analysed independently by the methods lecturer and a research assistant. They each read the questionnaires multiple times and made detailed notes as they listened to the interview recordings. They used an emergent analysis approach by open coding (Strauss & Corbin, 1990) to closely examine the data and categorise them so that some common themes could be identified. Later on, the

methods lecturer and the research assistant met to compare their initial codes to contrast and refine them. The research assistant then continued the data analysis by a process of axial coding (Strauss & Corbin, 1990) to establish connections between the refined categories and to develop the major themes reported in this paper.

Results

The results are reported in terms of three major themes relating to the research questions which arose from the data analysis procedures described above. The quotations from the questionnaire and interview data referred to in reporting the results are indicative of the general responses obtained from the participants.

Learning to link theory and practice

The pre-service teachers were unanimously positive in their evaluation of the learning community, with many regarding it as the most important and worthwhile feature of their entire teacher education program. They commented frequently on the ways that the combination of regular classroom visits and follow-up activities at university encouraged them to think more deeply about the connections between their experiences at the school and what they were learning at university.

> These activities are thought provoking and add a different dimension to teaching mathematics.
> [Questionnaire response from the end of Semester 1]

The learning community encouraged pre-service teachers to make links between the reform-oriented teaching theories they learned at university and the classroom practice at the school. Connections arose because the teaching observed in the learning community classroom was unlike their other professional experiences. The learning community lessons were "radically different", "unconventional" and "very different from other teachers observed". Because they had not seen problem-solving lessons like these in their other school placements, the pre-service teachers viewed the learning community lessons as "non-traditional" and incorporating a "new style of teaching". In acknowledging these differences, pre-service teachers began to consider how the teaching methods of the learning community classroom closely mirrored the pedagogical approaches they studied at university.

The extended period of the learning community program allowed these connections to be made explicit over and over again in the discussions which took place during the methods workshops. There the pre-service teachers reflected on their classroom observations and recognised how the classroom practices they observed at the school "closely reflected theories taught at uni". They began to "realise [that the] teaching theories we learn at uni have real applications".

When it came time for the pre-service teachers to co-teach some problem-solving lessons of their own, they had a chance to further explore the links between theory and practice by "testing a different teaching strategy that otherwise couldn't have been done during normal prac".

> Most teaching I have seen in schools has been of the 'direct instruction' variety—this experience has been quite different and beneficial.
> [Questionnaire response from the end of Semester 1]

Since the problem-solving lessons were "successful", and the pre-service teachers could "see that it can be done" the lessons demonstrated that constructivist learning theories could be productively implemented in realistic classroom settings.

> I have been able to see a style of teaching different from what I have experienced and one that works.
> [Questionnaire response from the end of Semester 1]

As one student teacher remarked, "it gives me hope that there is another way to teach maths". Observing how well the problem-solving lessons assisted student learning in mathematics also encouraged the pre-service teacher to implement some of the activities and teaching strategies in their other school placements.

> I taught Year 9 one of the [problem-solving] activities. They liked it, they loved it, and the supervising teacher liked it too.
> [Focus group response from the end of Semester 2]

The pre-service teachers also theorised their classroom practices in three main ways. First, by observing the variety of pedagogical approaches adopted by the partner teacher, the pre-service teachers understood that "there are several ways of teaching mathematics" and "having many approaches brings out great ideas from the students". Second, by reflecting on the successful elements of these lessons they recognised the legitimacy of problem solving as a productive mathematical learning experience because "problem solving skills are important" and "a sense of challenge and purpose to solve a problem increases engagement". Third, by adopting some of the partner teacher's strategies in their co-taught lessons they became more closely attuned to the notion of teachers as facilitators of learning. Their teaching was "not only standing at the board and explain[ing]" and "I learnt that it is not always necessary to explain everything fully" because "allow[ing] the students to comment on their learning provides teachers with an understanding on the students' learning".

The learning community activities allowed pre-service teachers to discuss learning and teaching episodes from a theoretical perspective in university workshops, and to observe constructivist learning theories implemented successfully in the classroom. The additional requirement that pre-service teachers complete a personal reflection after each school visit impelled them to think more deeply about what they had experienced. Consequently, they made stronger connections between theory and practice as a means of making sense of their professional experience. For example,

> [The teacher] introduces algebra while using examples. This corresponds to what [the lecturer] talks about in our workshops: that lessons should involve lots of examples at the start, followed by student-centred generalisations of features common to these examples, and finally introduction of mathematics to make this generalisation (which the students have already discovered) formal.
> [Focus group response from the end of Semester 2]

Collaborative learning within the learning community

Members of the learning community assisted each other in learning about the elements of effective mathematics teaching. Through observing, co-teaching, discussing and reflecting on each other's lessons, all participants had many opportunities to share their experiences and collaborate in constructing pedagogical knowledge.

The pre-service teachers learnt "many different ways" and "more options" to "enrich the teaching of mathematics" from watching the lessons of the partner teacher. Regular school visits reinforced the importance of these approaches and proved to be a powerful influence on pre-service teachers. Observing the successful implementation of reform-oriented practices each fortnight promoted experimentation by pre-service teachers in their other school placements. They reported incorporating problem-solving tasks as a small part of their lessons, becoming more aware of the need to make lessons relevant to students, and minimising the use of direct instruction techniques in favour of a more constructivist style. Even if some of their initial attempts were unsuccessful, they were encouraged to persevere by repeated exposure to the positive outcomes they observed in the learning community classroom.

The partner teacher also "learnt a great deal" from observing the lessons co-taught by pre-service teachers in the second semester. He explained that he was inspired by their innovative and creative lesson introductions and the ways they used technology to motivate and engage students. He added that he intended to adapt his teaching of some of the problem-solving activities in the following year in light of what he had seen. The teacher also commented that "comparing how they teach the same lesson with the way I taught it gives me a lot to think about".

> What is really good, the best part is when they've been teaching. What's great is that they're coming up with beautiful things and that's teaching me something. They bring a new aspect to it and it's fun to watch, it's a bit different.
> [Teacher interview response from the end of Semester 2]

The partner teacher also found the post-lesson discussions useful because the pre-service teachers "have a perception of things that's really worthwhile [and] it's interesting to hear their ideas about my lessons". He said the group discussions were "very different" to those he was accustomed to from his previous experiences supervising pre-service teachers.

> What's great is how much they are focusing on [the lessons]. Usually discussing a lesson is just a sideline, an occasional thing and then you move straight on to the next class, the next urgent thing that has to be done. There's no time to stop and think about the lessons they have taught or observed. But here it's different.
> [Teacher interview response from the end of Semester 2]

The opportunities for co-teaching were unique to the learning community program because pre-service teachers completed their other professional experience activities individually. Pre-service teachers were unanimously positive in their comments about co-teaching. The experience of co-teaching was "empowering" and highlighted how much they could "learn off their peers" about lesson planning and classroom teaching. In lesson preparation, co-teaching "brings more ideas and approaches to the table" and "encouraged experimentation" because the process of designing the lesson was "less isolated". In delivering the lesson, co-teaching was "less scary with someone for support" and provided a unique opportunity for pre-service teachers to "learn how to collaborate with another colleague to produce a lesson". For example,

> I really enjoyed the lesson, and the way that I learnt from my classmate. It really made me think about my presentation and my

> voice in the class. … You can be open and talk about the lesson for improving your way of teaching.
> [Focus group response from the end of Semester 2]

Another distinguishing characteristic of the learning community was that the participants could observe their peers teach a lesson. This allowed them to "see different ways of teaching" and because their peers were "at the same level" it was easier to imagine how they could "put into practice things you liked or thought were effective in others' lessons". Being observed by their peers allowed pre-service teachers to receive "quality feedback from different perspectives" and to hear "different aspects of myself from others' point of view". An interesting element of the discussions frequently commented on by the participants was their richness and variety: "One thing that really comes out clear is that some people have different views on the same thing". The diversity of the views expressed in the groups was helpful because it allowed "alternate perspectives that may not have been previously considered" to emerge and opened up "many different alternative courses of action".

Individual learning within the learning community

Many of the learning community activities focussed on developing the individual participants' professional practice by providing opportunities for in-depth discussion and reflection. Pre-service teachers wrote a personal critique of the lessons and posted them to the online forum within a day or two of their visit to the school. There they could read the postings from their peers. They noted how the emphasis on self-reflection was very different to their other field experiences.

> It brings in more self-reflection than other professional experience activities. This is done through different perspectives (i.e. students' reflection, peer postings, my own, the teacher's and the lecturer) giving great feedback and helping me develop.
> [Questionnaire response from the end of Semester 2]

The pre-service teachers recognised the important role played by the written reflection tasks in helping to "increase awareness" about learning and teaching by "making me focus on specifics of the lesson" and "making me think through what I have observed". They found the writing task more challenging but also more rewarding than the group sharing. Individual written reflections were more personal and "provided the opportunity to pause and deeply reflect on the observed lesson". The deliberate act of writing "forces pre-service teachers to pause and think" and served as a means of evaluating the learning and teaching which took place. This assisted each of the pre-service teachers to focus more acutely on their individual strengths and weaknesses.

Identifying the positive elements of each other's lessons was affirming for the learning community members, while constructively critiquing the less successful aspects was beneficial because "reflection, particularly writing it down, allows one to identify areas for improvement". Writing down their reflective comments also helped to ensure that the student teachers could process the outcomes of the group discussions in a more considered way. Their reflective practice developed through not only hearing the views of others, but also in thinking more deeply about the ideas. As one pre-service teacher wrote, "Digesting others' point of view opens up my thinking". In fact, the reflections often raised many more questions for the pre-service teachers to consider about the lessons they observed and or taught, such as: "What went wrong? How could things be done better?"

These deliberations had an impact on the individual pre-service teachers' practice beyond the learning community classroom. As one remarked, "I can take at least one piece of advice and use it in normal prac". Another pre-service teacher summarised her own

developing reflective practice in terms of a three-stage process: "Try, Reflect, Re-model" indicating that the key to making the most of the opportunities for reflection lay in the participants' ability to think deeply about what they had noticed and enact changes in their classroom practice.

> Reflection allowed the pedagogy and lessons to be broken down.
> These manageable parts can be more readily applied to other prac.
> [Questionnaire response from the end of Semester 2]

Improving the program

In responding to the questionnaires and participating in the interviews, the participants also provided feedback on how the learning community program might be strengthened and improved. Some pre-service teachers indicated that they would have preferred to know about the lesson topics in advance of visiting the school to observe the class. They believed they would have gained more from the lesson observations if they had known about the lesson aims and topic prior to the visit. Arriving in the classroom without this preparation meant that there was no opportunity for the pre-service teachers to imagine how they might have approached teaching the problem-solving task before they observed the lesson.

> If we had the lessons beforehand we could have read them and that
> would make it easier to think about what happened.
> [Focus group response from the end of Semester 2]

The pre-service teachers and the partner teacher all recognised the value of co-teaching. There was general agreement therefore that this aspect of the program could have been started earlier than it was. The somewhat artificial arrangement of observing for an entire semester before commencing the co-teaching phase was questioned and it was felt that greater opportunities for co-teaching would have significantly improved the benefits gained by participating in the program.

> Start co-teaching earlier. I don't think you have to wait until the
> second half of the year to do this.
> [Questionnaire response from the end of Semester 2]

Some of the pre-service teachers commented that while they found the lesson observations very interesting and useful, they sometimes found it difficult not to concentrate more on trying to solve the problem along with the students rather than focus on what the teacher was doing. It was therefore suggested that a lesson observation pro forma could be developed to help pre-service teachers focus on some important aspects of the learning and teaching which took place.

There were also concerns raised about the quality of the reflective postings. Some of the pre-service teachers reported that the postings became "rather repetitive" and they indicated that they wanted more direct involvement in this aspect of the program from the methods lecturer. There was a feeling that the reflections could have been made more meaningful if the methods lecturer had posed some focus questions or highlighted some points raised by pre-service teachers and encouraged others to comment upon or further

develop these ideas in their own reflections.

Discussion

This study investigated a learning community for a group of nine pre-service secondary mathematics teachers and their supervisor to identify the kinds of knowledge about practice the pre-service teachers developed through their participation in this professional experience learning community and the features of the learning community that facilitated the development of this knowledge. The learning community included sustained opportunities for pre-service teachers to observe, co-teach, discuss and reflect on their own and others' teaching (to facilitate reciprocity among learning community members). It focused on *teaching* rather than *teachers* (to promote an educative rather than an evaluative field experience) in a reform-oriented classroom context (to showcase mathematical investigations and problem-solving activities). The program also included the on-going engagement of the methods lecturer (to link the methods workshops and school visits).

Much of the literature on improving the quality of teacher education programs argues for a closer alignment between university studies and field experiences (e.g., Darling-Hammond, 2006). Similar to the findings of Eames and Coll (2010), the close collaboration between the partner teacher and the university lecturer in designing and sustaining the learning community helped pre-service teachers forge stronger links between their university and classroom experiences.

The school visits were primarily envisioned as an opportunity for pre-service teachers to learn from watching an experienced teacher as he delivered a series of problem-solving lessons. Interestingly, the pre-service teachers also reported that much fruitful learning came in the second half of the program when they co-taught, observed and discuss each other's lessons. As in the study of pre-service primary teachers by Bobis (2007), the co-teaching provided to the pre-service secondary teachers in the present study proved to be an extremely valuable learning experience for them. In addition, the present study also highlights the importance of peer observation during the co-taught lessons because the pre-service teachers were at a similar level of professional development so they could contribute significantly to the learning of their peers and they learned so much from observing each other teach.

Previous research has identified some of the difficulties that pre-service teachers face in reflecting on their teaching (e.g., Chamoso, Cáceres, & Azcárate, 2012). As Sim (2006) observed, the key to becoming more reflective lies in exploring and discussing fundamental aspects of practice. The present study confirms this finding and demonstrates two other important features of reflective activities for pre-service teachers: their quality and synchrony. High quality reflection was achieved through a combination of individual and group tasks, both oral and written, which encouraged pre-service teachers to think more deeply about their experiences. Synchrony of reflection occurred by interweaving the school visits with follow-up activities in methods workshops to mirror the classroom experiences and reinforce the practice of reflection. These two elements were particularly beneficial in drawing pre-service teachers' attention to the importance of reflection and in sustaining them as they developed their own reflective practice.

The learning community included many features designed to make the experience more educative in nature. These included the on-going presence of the university supervisor during the school visits, and the strong links he established between the classroom and the methods workshops. The school visits were separate from other school placements (so there was no prescribed evaluation of the co-teaching) and the reflective writing tasks did not contribute to the final grade for the methodology unit (so there was no formal assessment of the reflective comments).

The explicit focus on reform-oriented teaching practices in the context of mathematical problem solving was another important educative element of the learning community. The problem-solving lessons not only provided the stimulus for the reflective

tasks, but also demonstrated that student-centred teaching approaches could be successfully implemented in a secondary mathematics classroom. The experience of observing and co-teaching these lessons encouraged the pre-service teachers to further develop their professional knowledge of mathematics teaching.

The nature of the supervisory roles adopted by the partner teacher and the university lecturer were also significant. Previous research has shown that reflection can be difficult during field experiences. Often this is due to inadequate forms of supervision such as irregular supervisory visits (Wilson, 2006) and giving too much attention to classroom management and organisation (Goos, 2008). In contrast, the learning community supervisors maintained an on-going presence at the school and maintained the focus of the post-lesson discussions on the problem-solving activities and the student learning which took place.

The supervisors deliberately positioned themselves as equal partners in the design and development of the learning community. They conceived the program together and developed a supervisory partnership as the learning community progressed. The partner teacher shared his experience in teaching problem-solving lessons and the university lecturer provided a theoretical lens through which to view and discuss the classroom episodes.

The supervisors participated in the learning community activities as co-constructors of knowledge with the pre-service teachers. They demonstrated their commitment to collaborative learning in the ways they each conducted the various post-lesson discussions and reflections. At the school, the partner teacher led the discussions but he did so in a way that did not dominate them. He allowed the student teachers to share their observations and react to each other's ideas. He posed questions to facilitate the dialogue and used the ideas proposed by the pre-service teachers to make the points he wished to make. The university lecturer adopted a similar role in the methodology workshop discussions as well. Thus their roles might be better described as advisory rather than supervisory in nature.

It is interesting to speculate about the transferability of the learning community structure we have described here to other professional experience contexts. Clearly a strong level of cooperation between staff at the university and the school is required. It is advisable if university lecturers and teachers from the school come together to discuss how the learning community will operate and to collaborate in designing the main features of the program. Teachers and lecturers need to be explicit about the learning outcomes they want to achieve for pre-service teachers and they should clearly communicate these to participants. We also now believe that it is useful for pre-service teachers to have prior knowledge of the lesson topics and, if possible, to undertake the problem-solving activities themselves before they attend the school. Some form of post-lesson reflection is also crucial and the results of our study suggest that this reflection should be written down to maximise its benefits.

Our subsequent experience has shown that less constant supervision from the methods lecturer has not lessened the success of the program. Also, we have found that the cooperating teacher's role can be successfully adopted by other teachers who may not have the same level of expertise in teaching mathematical problem-solving lessons. In a subsequent implementation of the learning community we found that all six of the Year 8 teachers in the school have been able to take on the supervisory role at the school to the benefit of the pre-service teachers. These teachers have offered observation and team teaching opportunities to the pre-service teachers which were the equal of the supervising teacher described in this study. In fact, the program has been enhanced by these in-service teachers' joy at experiencing a reform-oriented secondary mathematics classroom curriculum.

Powerful learning opportunities have arisen for participants utilising a constructivist rather than supervisory approach in the learning opportunities for the pre-service teachers. We suggest that the number of pre-service teachers attending the classroom should be kept to about six but we see no reason why the program could not be up-scaled to a larger cohort of pre-service teachers if they can be spread across multiple classrooms and schools. The key

element is the desire of the mathematics staff at the school and the methods lecturer at the university to develop the relations in a way which furthers the collaboration between the school and the university. Whilst the supervisory personnel are not critical, it is our view that the overall structure of a stand-alone problem solving focus is necessary to the success of the program. Thus, in order for this structure to be transferred to other settings, a negotiation and commitment to use a problem solving approach would be required, together with the cooperation of the university and the cooperating school.

Conclusion

This study has shown how a group of nine pre-service teachers and their supervisors participated in a professional experience learning community for secondary mathematics. All of the participants valued the experience and were able to identify some benefits they gained as a result. The participants' responses to the questionnaires and in the interviews suggest that everyone developed a greater appreciation of the importance of mathematical problem solving as a practical way of implementing the reform agenda for secondary mathematics. The learning community activities assisted pre-service teachers in establishing strong links between theory and practice. In particular, the opportunities for co-teaching and peer observation allowed the participants to collaborate and support each other's learning. Finally, the individual writing tasks helped the pre-service teachers develop a more reflective stance on their personal classroom practice.

There are some changes which we have made to the way the program is framed since we completed our analysis of the data reported in this paper. The co-teaching activities, which proved so valuable in promoting reciprocity among the learning community members, have now been brought forward to increase opportunities for collaborative teaching and peer observation. Details of the problem-solving tasks for each lesson are now made available to pre-service teachers a few days before the school visits so they can arrive more fully prepared for observing the lesson. We have also broadened the program to involve all of the Year 8 teachers at the school so that they can participate in the learning community to share their knowledge, develop their classroom practice and offer their reflections on the lessons. We are also considering whether the university supervisor and the teachers could play a more active role in the online discussion forum to promote even richer individual reflections by posing questions for the other members of the learning community to consider.

Future research could further investigate the learning community model to see how it is implemented in other subject areas and with pre-service primary teachers. In fact, many current professional experience programs could readily implement some of the key elements of the program (co-teaching and peer observation) without the need for such extensive involvement by partner teachers or university supervisors. The first author has already begun investigating the outcomes of such a professional experience program with a new cohort of student teachers.

The learning community reported here enabled the pre-service teachers to expand their pedagogical horizons to encompass some key elements of the reform agenda for secondary mathematics. It promoted individual experimentation and reflection. Above all, it helped to position the pre-service teachers as collaborative partners who were able to recognise the value of learning with and from each other.

Authors' note

The opinions expressed in this paper are solely those of the authors and do not necessarily reflect those of the New South Wales Department of Education and Communities.

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Appendix: Questionnaire

1. What are your impressions of the learning community program? How have you found it?
2. How does the learning community program compare to your other professional experience activities?
3. Do you have any suggestions for improving the learning community program?
4. Do you have any further comments you would like to add?

Focus group interview schedule:

1. What are your thoughts on the various aspects of the program?
   Probe students' ideas in relation to the following:
   - co-teaching
   - lesson observations
   - post-lesson discussions
   - reflective comments posted to online discussion forum
   - discussions in methods workshop

2. How does this program compare to your other professional experience activities?
   Probe students' ideas in relation to the following:
   - observing problem-solving lessons
   - teaching problem-solving lessons
   - feedback they receive on their teaching
   - reflecting on teaching (their own and others)