A Professional Experience Model for Primary Pre-service Teachers Specialising in Mathematics

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Many primary pre-service teachers (PSTs) who are enthused by tertiary courses that espouse and model a socio-constructivist approach to teaching mathematics, revert to a traditional approach when they encounter mathematics teaching during professional experience. An intervention was designed to translate the initial pedagogical intent of four mathematically competent primary PSTs into classroom practice. Soon after completion of their first unit in mathematics teaching, they took part in a professional experience learning community focussed on teaching mathematical problem solving. We report their reflections and the impact of the program on their future professional experiences of mathematics teaching. Results suggest that the program could serve as a model for the provision of professional experience to primary teacher education students specialising in mathematics.

The Teacher Education Ministerial Advisory Group (TEMAG) recently reported on "how teacher education programs could be improved to better prepare new teachers with the practical skills needed for the classroom" (TEMAG, 2014). TEMAG recommended that in future, all primary teachers should graduate with at least one subject specialisation, prioritising science, mathematics or a language (TEMAG, 2014). The government's response (Australian Government Department of Education and Training, 2015) supported the recommendation. The report also stressed the importance of PSTs connecting what they learn in their university studies with real world practice through school-based professional learning experience (commonly known as the practicum). The Australian Government Department of Education and Training (2015) believes that this should be achieved through close partnerships between universities and schools and recommends that it be provided to PSTs as early as possible in every teacher education course. In this paper we follow four mathematically competent primary PSTs who were given such an experience as their initial exposure to classroom teaching. Based on their observations and reflections, we canvass a model of professional experience for primary PSTs specialising in mathematics and consider the role of a professional learning community involving PSTs learning to teach mathematics in a way that validates their theoretical learning.

Literature Review

Professional experience is considered fundamental to effective teacher preparation (White, Bloomfield, & Le Cornu, 2010). The traditional model has been a supervisory model—an experienced teacher supervising a PST. In the 1990s the term 'mentor' came to replace the term 'supervisor' in teacher education, the idea being that the experienced teacher was there to help the PSTs reflect upon their efforts rather than tell them what they should be doing (Le Cornu & Ewing, 2008). Le Cornu & Ewing (2008) argue that professional experience should be framed around the notion of learning communities in which PSTs work with their mentors and peers in more collegial and reciprocal ways.

Although an experienced teacher mentor is more knowledgeable in areas such as

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classroom management and school procedures, a peer may know more about innovative, new teaching strategies (Hargreaves & Fullan, 2000). Peers in a comfortable collegial relationship, may also be in a better position than a supervising teacher to give much needed emotional support (Hargreaves, 1998). Due to the absence of positional power, peers can offer personal support to each other in a reciprocal relationship, thereby reducing the PSTs's feelings of isolation during their school-based professional learning experience. They are able to give each other greater confidence to teach (Harlow & Cobb, 2014).

Reflective practice is also considered essential in teacher education (Husu, Toom, & Patrikainen, 2008; Lane et al., 2014). If PSTs have the opportunity to observe and reflect upon the results of an expert teacher modelling what they have learnt in their coursework, they might be more convinced of its value and its practicability. In recent years, a renewed emphasis has been placed on the importance of shared reflection and critique. Rodgers (2002) states that "when one is accountable to a group, one feels a responsibility toward others that is more compelling than the responsibility we feel only to ourselves" (p. 857).

It has been argued that a powerful impetus for PSTs to reflect on their teaching is discourse with others, and that those best able to facilitate such verbal interaction are peers who can trust each other and understand each other's analyses of the outcomes of their teaching in relation to their intentions (Hatton & Smith, 1995). For this reason, Le Cornu & Ewing (2008) believe paired PST placements should be incorporated early in Teacher Education Programs. Another important reason given for paired placements and shared reflection is that a PST feels less vulnerable to sole blame for any real or perceived weaknesses that reflection might uncover (Hatton & Smith, 1995). Reflective practice among peers is particularly suited to their teaching of a problem-solving lesson because most PSTs, having little or no prior experience of such a lesson, are likely to be less confident than they would be in a traditional mathematics lesson. Their lack of familiarity with this type of lesson is also likely to stimulate deeper reflection.

The process of problem solving is at the centre of mathematical thinking and learning (Stacey, 2002). Teaching mathematics through problem solving requires particular pedagogical skills on the part of the teacher. The teacher needs to be able to choose a suitable non-routine problem for the class, understand the range of strategies that students have at their disposal, plan questions that elicit these strategies, follow up on students' responses in ways that encourage deeper thinking, and structure class discussion so that students are given time to reflect (Nelson, 2001). Teachers' own knowledge and confidence in mathematics is an important factor determining whether they adopt a problem-solving approach (Anderson, 2003). A problem-solving approach requires a culture in which students expect to be able to learn from their peers, have a willingness to persist, and are given opportunities to reason (Sullivan & Davidson, 2014). Liljedahl (2016) found that in a classroom culture of individual work and direct instruction, the majority of the class is unable to persist with problem solving. PSTs placed in such a culture may be quickly de-motivated by classroom management problems that can arise (Cavanagh & Prescott, 2010). If, on the other hand, PSTs can observe a problem-solving lesson conducted by a skilled teacher, they may notice positive results in terms of student engagement and learning, and continue to aspire to this way of teaching (Grootenboer, 2006).

The study

In this study, PSTs were mentored by their university lecturer (the second author) and an experienced teacher who taught a mathematics enrichment program for high-achieving students in a combined Year 5/6 group (aged 10-11) that met weekly for one hour. The PSTs

observed the teacher's lessons, prepared and co-taught problem-solving lessons with a peer, gave and received feedback, and wrote a reflective journal. We investigated how the intervention impacted their confidence to teach problem-solving lessons. We also investigated whether their intentions to implement a problem-solving approach in their teaching were realised during subsequent professional experience placements.

Context and Participants

Our research, which took place in the first half of the 2013 academic year, focuses on a group of four PSTs as they first learned how to teach problem-solving lessons in the primary mathematics classroom. In 2012, the PSTs completed an introductory numeracy unit, EDUC258 (Mathematics in Schools). Tutorial activities in EDUC258 provide regular opportunities for the PSTs to work collaboratively in small groups as they solve rich tasks, reflect on their own mathematical learning, and discuss how the tasks could be used in the classroom. At the time of the study, the PST participants were enrolled in the third full-time year of their four-year double degree programs to become primary school teachers. They were all competent mathematicians, having successfully completed a calculus-based mathematics course in high school and they all achieved a merit grade in EDUC258.

Method

The participants were recruited via an advertisement on the university Moodle site calling for PSTs who were competent mathematicians and who wished to build on the knowledge and skills they had learned in EDUC258. The four PSTs (all female) and the second author made six fortnightly visits to the school during Term 2 of 2013. For the first two visits, the PSTs observed the teacher teach a problem-solving lesson. As they observed the lesson, the PSTs completed a Lesson Observation Schedule which incorporated the dimensions of the Quality Teaching Framework (NSW Department of Education and Training, 2008). During the phases of the lesson when students were working in small groups, the PSTs moved around the room to engage with the students and begin to introduce themselves to the class. Immediately following the lesson, the teacher led a discussion with the PSTs about her aims for the lesson, the ways that she had structured the activities, and the student learning which had taken place. The PSTs contributed to this discussion by asking questions and sharing their observations. The second author observed the discussion and made notes but did not contribute.

Subsequently, the PSTs each chose a partner and the pairs alternated between co-teaching the lesson one visit and observing their peers the next. As before, the observers used an observation schedule and were able to move among the students while they worked on the problem-solving tasks. Immediately following the class, the teacher led a short discussion about the PSTs' co-taught lesson and encouraged all of the PSTs to contribute their ideas while the first author took field notes. After each lesson, The PSTs wrote an individual reflection on their experiences. Reflective prompts provided to the PSTs asked them to consider the learning outcomes for the lesson, the extent to which these were achieved and the nature of the lesson activities. The PSTs also reflected on what they had learned about effective mathematics learning and teaching and considered which aspects of the lesson they might want to incorporate into their classroom practice beyond the project.

After the final visit to the school, the PSTs individually completed a short questionnaire about their experiences. The questionnaire focused on what they had learned during the project and invited them to discuss the impact of the various aspects of the program

(observing the class teacher, co-teaching, peer observation and reflective writing). Three of the four PSTs agreed to a semi-structured interview 18 months later, by which time they had completed their teacher education course. In the final interview, they reflected on how their participation in the project impacted on their teaching and learning experiences during their professional experiences that followed, and they looked ahead to their future teaching careers.

We employed a phenomenological case study design which "seeks the individual's perception and meaning of a phenomenon or experience" (Mertens, 2005, p. 240). The data included the initial email correspondence from the four PSTs, their lesson plans and peer lesson observation reports, their reflective journal entries which they wrote up after each school visit, their questionnaire responses, and the field notes made by the first author during the school visits. Interviews were also conducted individually with three of the PSTs at the end of their undergraduate studies in November of 2014. All interviews were audio-recorded and transcribed and they typically lasted for approximately 15 minutes each.

The data were analysed by reading the responses multiple times and keeping detailed notes to closely examine the data and categorise them so that some common themes could be identified. Throughout this process, examples of participants' responses were recorded in tabular form to establish the properties for each code. We then identified relationships and established connections between the refined categories to develop the major themes.

Results and Discussion

This section is organised into four key themes that emerged from the analysis of the data: learning from an experienced teacher; peer learning; the value of reflection; and the development of their PCK for teaching mathematical problem-solving lessons. The individual PSTs are referred to by numbers: PST1, PST2, PST3 and PST4.

Learning from an Experienced Teacher

All PSTs reported that their experience of mathematics at school was traditional with a focus on rote learning and none could recall the kinds of rich tasks they saw as part of this project. Although all had studied constructivist learning theories and teaching approaches as part of EDUC258, it was not until they saw the teacher's problem-solving lessons that the PSTs began to appreciate how these theoretical approaches could be translated into practice. As PST1 noted in her first interview, "It was a truly enriching experience to be able to see everything I have learnt about mathematics instruction being used in a classroom setting." Similarly, PST4 commented in her first interview that observing the lessons gave her "the opportunity to see the theoretical content of mathematics education in action" and PST3 noted that the teacher "demonstrated the ways in which problem solving can be integrated into a maths lesson in an engaging and meaningful manner." In keeping with Zeichner's (1990) notion that the practicum is closely aligned with discipline-specific understandings, the theoretical study PSTs had previously undertaken helped them to make sense of their classroom observations. In turn, this enhanced their PCK and validated the theory they had been taught. However, consistent with our previous research (Cavanagh & McMaster, 2015), the PSTs observed and commented on the teacher's classroom management techniques in much greater depth and frequency than any other aspect of her lessons.

Peer Learning

While the PSTs reported that they gained a great deal from observing an experienced

teacher, they also recognised how much they could learn with and from each other. PST1 commented about observing the lessons taught by her peers in her first interview: "it was a lot easier to relate to my own teaching skills and ideas since we were all in the same stage of our teaching experience." PST3 said that when she observed her peers "it highlighted to me things I sometimes did when teaching, and how this may not be the most appropriate strategy to adopt" and PST4 noted that peer observation, "helped me see strengths and weaknesses more objectively".

Co-planning and co-teaching was another feature of the learning community PSTs found very beneficial. PST4 noted that this shared approach to lessons "helped us ease into the teaching experience … [and] made the task less daunting." Specifically, in terms of lesson planning, PST1 commented that it "allowed us to bounce ideas off each other" and PST2 reported that "we could often pull each other up on what would work and what wouldn't". There was considerable peer support when it came to teach the lesson. PST2 commented that it was "good to have that extra support to help you if we forgot the lesson structure … [and] during the lesson, if one of us lost our place, it was handy to have the other to fall back on if required." and PST1 commented that co-teaching helped her "monitor the students' understanding and concentration since whoever was talking would be more focused on delivering the material correctly rather than monitoring everything else at the same time." Co-planning helped them be more creative and co-teaching helped to make the first experience in front of a class more enjoyable and more productive.

When looking back after completing the Teacher Education program, PST4 reflected on the value of co-teaching because "being able to team teach with a partner … was a really good introduction to the prac experience because if I went into prac on my own then I think I would have been much more anxious and it would have been more daunting." She also recognised how much she had learned from working with her peers "because their ideas were quite unconventional and it was different to what I would have done and so that opens the floor up for more innovative ideas".

The Value of Reflection

The PSTs had many opportunities for reflection when giving and receiving peer feedback and when critically analysing their own lessons. Shared reflection through receiving feedback from peers made the PSTs accountable to the group (Rodgers, 2002) and enabled them to notice more than they would have through self-reflection. As PST3 noted in her journal, "[feedback from peers] gave me ideas about what worked and what didn't, especially when I had missed these myself" and PST1 commented in her first interview that "It was truly wonderful to receive feedback from my fellow pre-service teachers because often they picked up on things that I never would have thought of." PST4 commented in her first interview that the feedback she got from her peers was "much better support and feedback than I would have received in a unit-run practicum" and PST2 regarded the peer feedback she received as a crucial aspect of the program, stating in her first interview "my classroom practice in the future will be different because of it."

Giving feedback to peers also caused the PSTs to notice more about the lesson and think about how improvements could be made to their own lessons. In her journal, PST1 wrote, "It was while I was writing these [feedback comments] up that I could pick up on things." The fact that the feedback and personal reflections were written down was viewed by PSTs as especially significant "so I can refer back to them and base later lessons on them so to improve my preparation and deliverance of lessons" (PST1 journal).

In her final interview PST4 commented on the value that she now placed on self-

reflection. She noted how the reflective journal she had kept during the learning community program "made me realise the importance of reflection … it actually was really helpful in just sitting down and taking a moment to think about what just happened and what was effective and what wasn't effective. Even for myself." She went on to add how this experience had encouraged her, "so I was much more diligent with reflection on prac."

PCK for Problem Solving

As Anderson (2003) has noted, teachers' personal mathematical content knowledge and confidence levels are important factors in determining if they will implement the kind of 'thinking classroom' envisaged by Liljedahl (2016). Given the high calibre of the PSTs who participated in the present study, it is perhaps not surprising that when considering what they had learned from their experiences as part of the learning community, the PSTs focussed mainly on the value of problem-solving activities for learning and teaching mathematics. PST4 spoke about how she had come to see the importance of problem-solving tasks "because problem solving is a really big part of life … [and] if you incorporate maths with problem solving then it just makes it more real, more engaging for the students." PST2 spoke about how the project gave her "a whole different view of how to teach maths which was nothing like what I'd experienced in primary school." She also noted how her studies in EDUC258 had enlarged her view of teaching mathematics but that she still needed to see how they could be used in a lesson to integrate theory and practice: "I remember lots of people doing 258 were like, 'Oh it sounds so amazing, but how do we actually do it'. So having some of those ideas from 258 and then seeing what was done in this classroom was really useful."

PST1 noted how she learnt how to "find what worked" when structuring a problem-solving lesson, "how you should start it, what should be included, and how you'd finish it, and really being aware of the time as well." She also summarised how her approach to teaching mathematics had changed because she "recognised the importance of getting students physically modelling a problem … of getting every student involved and how you can make activities a bit more practical."

What is particularly interesting is how the PSTs reported the impact of the learning community program on their subsequent professional experience placements. PST1 said that while only one of her supervising teachers used a problem-solving approach, she was able to implement this style of teaching herself. She made her own modification of the structure she had observed and adapted it to suit her purposes, noting that this was due to participating in the learning community and she "would not have done it otherwise" because "if not for the project I would not have seen the value of it." In reflecting on her experiences, PST1 said she thought problem solving "worked well and I want to use this in my teaching in future." PST2 commented that "questioning students' thinking was something that I took into my pracs and giving them rich tasks that might have more than one answer or might get them to think about what they're doing." She also noted how one of her supervising teachers "was really impressed that I gave them [students] rich problems and didn't just work from the textbook."

Conclusion

In summary, the study found several advantages could be gained by PSTs who are mathematically competent, beginning their teaching of problem solving within a professional learning community. Through observing a teacher who is experienced in

teaching problem-solving lessons, they could appreciate how a teaching approach they knew about in theory, could be implemented in the classroom using practical techniques to manage the classroom and engage all children in problem-solving processes. The PSTs' creativity was enhanced through co-planning with a peer, and they could evaluate each other's ideas before enacting them. Co-teaching enabled them to support each other thereby enabling greater risk-taking, and through giving and receiving feedback and writing self-reflections they noticed and thought more deeply about their teaching in relation to student learning. It needs to be noted however that although the four PSTs in this study had never met each other before, they were fairly homogeneous in terms of their theoretical basis and teaching experience. Such mutual respect and support may not have been so forthcoming between peers with different mathematics backgrounds and years of teaching experience.

Although we only have the PSTs' self-reports on their later professional experience, for PSTs to confidently teach a problem-solving lesson, it appears that they may need more than just professional experience in which they are immersed into the general business of teaching. With a view to maximising the potential of these PSTs to transform mathematics learning and teaching in primary schools, we recommend their early induction into a professional learning community supportive of a problem-solving approach to teaching mathematics. Delaying this opportunity until they go into a generalist professional experience program in which mathematics is taught in a traditional manner could contribute to a loss of enthusiasm similar to that found by Cavanagh & Prescott (2010). Another difficulty we foresee in establishing a similar program in a primary mathematics specialisation is the need to upscale it. It could be challenging, at least in the first instance, to identify experienced teachers who have a passion for teaching mathematics and whose class is already familiar with problem-solving lessons. Collaboration between universities that draw PSTs from the same locations could help in this regard.

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