Engaging teachers to engage students with mathematics:

Building teacher capacity through sustained professional development

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1 Background to Study

Springvale Public School (a pseudonym), in the outer western suburbs of Sydney, has a history of poor results in the National Assessment Program – Literacy and Numeracy (NAPLAN). The school’s new principal indicated that the staff had experienced little to no professional development (PD) opportunities in mathematics resulting in a lack of teacher and student engagement and leading to poor academic results. He expressed a desire to build the capacity of the teachers by engaging one or two specialists in numeracy to provide theory and practice for numeracy learning specifically targeted at the Grades 3 to 6 teachers.

The role of the University of Western Sydney (UWS) in this project was twofold. First, it provided two mathematics and numeracy experts (one of whom was also the researcher) to assist with the PD of the teaching staff in grades 4 to 6 (eight class groups in total). This assisted the school by providing:

- support in their endeavours based on a sound theoretical framework; and
- assistance in identifying the critical factors that may positively influence the teaching and learning of numeracy.

The UWS academics provided a series of PD sessions and assisted the participating teachers in their programming and planning for numeracy by acting as ‘critical friends’, participating in demonstration lessons and observing mathematics lessons.

The second role of UWS in this project was to research the effectiveness of the teacher PD in improving teacher and student engagement and eventually student achievement in mathematics. The research is timely in light of the impending implementation of the new K-10 Mathematics Syllabus incorporating the Australian Curriculum, Mathematics, in 2015, requiring teachers, in some cases, to ‘up-skill’ in relation to their content knowledge in particular areas of the mathematics curriculum where content has been moved from Stage
4 into the primary curriculum. It is also timely in that legislation in the NSW government has been introduced mandating that by the end 2017 all teachers in New South Wales will be required to maintain accreditation with the Board of Studies, Teaching and Educational Standards (BOSTES). Part of this requirement is that teachers must participate in 100 hours of professional learning over a five-year period. A study on the effectiveness of sustained PD may be useful in the design of future PD opportunities.

This project incorporated the implementation of sustained, in situ PD uniquely tailored to meet the PD needs of the teachers at the school. This report will focus on the influence of the PD on teachers and their students and will conclude with some recommendations for the school and for future research. The report will now turn to the literature underpinning the project.

2 Literature Review

In setting the context for this study, this literature review will explore the following questions:

- How do we define engagement in the context of mathematics, and why is engagement an issue in mathematics education?
- How is professional development defined for the purpose of this research?
- What are the elements of effective professional development?
- What are identified issues in regard to professional development and mathematics?

2.1 Engagement and mathematics

The term engagement is used often by educators to describe students’ levels of involvement with teaching and learning. There are many definitions of engagement in the literature, however for the purpose of this report, engagement is defined as multi-dimensional, operating at cognitive, emotional and behavioural levels (Fredricks, Blumenfeld, & Paris, 2004). Viewed this way, engagement occurs with, and can be defined as the coming together of all three dimensions; cognitive, affective, and operative (Fair Go Team NSW Department of Education and Training, 2006; Munns & Martin, 2005), (in line with Fredricks,
et al.’s cognitive, behavioural and emotional engagement) that leads to students valuing and enjoying school mathematics and seeing connections between school mathematics and their own lives beyond the classroom.

The Framework for Engagement with Mathematics (FEM) introduced by Attard (2014) (Figure 1) was devised to assist teachers in planning engaging learning experiences in mathematics. It was used as a foundation for the PD provided to the teachers and is also used in this research to assist in analysing the data and helping to understand whether the project was effective in achieving its goals.
FRAMEWORK FOR ENGAGEMENT WITH MATHEMATICS

In an engaging mathematics classroom, positive pedagogical relationships exist where:

- students’ backgrounds and pre-existing knowledge are acknowledged and contribute to the learning of others
- the teacher is aware of each student’s mathematical abilities and learning needs
- interaction amongst students and between teacher and students is continuous
- the teacher models enthusiasm and an enjoyment of mathematics and has a strong pedagogical content knowledge
- feedback to students is constructive, purposeful and timely

In an engaging mathematics classroom, engaging pedagogical repertoires mean:

- there is substantive conversation about mathematical concepts and their applications to life
- tasks are positive, provide opportunity for all students to achieve a level of success and are challenging for all
- students are provided an element of choice
- technology is embedded and used to enhance mathematical understanding through a student-centred approach to learning
- the relevance of the mathematics curriculum is explicitly linked to students’ lives outside the classroom and empowers students with the capacity to transform and reform their lives
- mathematics lessons regularly include a variety of tasks that cater to the diverse needs of learners

Students are engaged with mathematics when:

- mathematics is a subject they enjoy learning
- they value mathematics learning and see its relevance in their current and future lives
- They see connections between the mathematics learnt at school and the mathematics used beyond the classroom

Figure 1: Framework for Engagement with Mathematics (Attard, 2014)

The low levels of student engagement with mathematics have been of some concern to Australian mathematics educators and stakeholders for several decades. The National
Numeracy Review (Commonwealth of Australia, 2008) found many students fail to enjoy or recognise the personal relevance of mathematics and few voluntarily continue to study it. The reasons students make the decision not to participate or engage in mathematics are varied. However, recent research on student engagement with mathematics (Attard, 2011, 2012) indicates that during the primary and middle years, teachers have the most influence on the engagement of students.

Given that teachers have so much influence on the engagement of students, it makes sense to assume that when teachers themselves are disengaged with the teaching of mathematics, the likelihood of students becoming and remaining engaged is significantly decreased. Hence, the PD program’s priority was to improve the teachers’ levels of engagement with mathematics.

2.2 Defining Professional Development

In recent times the term ‘professional learning’ has come to be used interchangeably with the term ‘professional development’. For the purpose of this report it is important to explore the two terms and provide a definition of the term professional development as it pertains to this study.

Although used interchangeably, professional learning and PD have been differentiated in recent literature (Mayer & Lloyd, 2011), with a noticeable shift away from ‘development’ towards ‘learning’. Knapp (2003, as cited in Mayer & Lloyd, 2011, pp. 3-4) defines PD as “the full range of activities, formal and informal, that engage teachers or administrators in new learning about their professional practice” (p.112), while professional learning refers to “changes in thinking, knowledge, skills, and approaches to instruction that form practicing teachers or administrators repertoire” (pp.112-113).

The teacher accreditation body in New South Wales (NSW Institute of Teachers, 2012), (renamed the Board of Studies, Teaching and Educational Standards in 2012) discuss professional learning as being “the growth of teacher expertise that leads to improved student learning.” They clarify PD as “the processes, activities and experiences that provide opportunities to extend teacher professional learning. Participation in continuing PD assists in the development of teacher professional learning” (p.3).
In acknowledging the integral relationship between professional learning and PD, Mayer and Lloyd (2011) cite a definition from Day and Sachs (2004, as cited in Mayer & Lloyd, 2011) that includes both development and learning: “all natural learning experiences and those conscious and planned activities which are intended to be of direct or indirect benefit to the individual, group or school and which contribute...to the quality of education in the classroom.” It is this definition that is adopted for this study, incorporating the idea that professional learning occurs as part of PD through a combination of planned and unplanned activities. Characteristics of effective PD will now be explored briefly.

2.3 Characteristics of effective professional development

Literature on PD describes two common models: the traditional type of activities that involve workshops, seminars and conferences, and reform type activities that incorporate study groups, networking, mentoring and meetings that occur in-situ during the process of classroom instruction or planning time (Lee, 2007). Although it is suggested that the reform types of PD are more likely to make connections to classroom teaching and may be easier to sustain over time, Lee (2007) argues there is a place for traditional PD or a combination of both, which may work well for teachers at various stages in their careers. An integrated approach to PD is supported by the NSW Institute of Teachers (2012) and this was the approach taken in this study, where teachers were provided with some opportunities to participate in external seminars and conferences as well as tailored and sustained in-situ PD opportunities.

The provision of on-site PD provides a contextually responsive approach, allowing the facilitator of the PD to contextualise to the teacher’s site of practice (Garet, Porter, Desimone, Birman, & Yoon, 2001). Extending this idea, Higgins and Parsons (2011) argue for “situated professional learning opportunities in the teachers’ classroom” enabling “facilitators to engage teachers in the PD core ideas and enact these in practice” (p.55).

Providing PD for all of the teachers at Springvale rather than a select few was also a feature of effective practice according to Garet et al., (2001), who claim that focusing on a group of teachers from the same school “may help sustain changes in practice over time” (p.47-48) due to teachers leaving the school or extended periods of leave.
The duration of PD has been identified as a significant characteristic of determining its effectiveness (Lee, 2005). The literature refers to duration in terms of providing time, space and support to develop teachers’ confidence, ability and skills (Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009; Desimone, 2009; Wayne, Yoon, Zhu, Cronen, & Garet, 2008). Some research suggests that PD programs offering substantial contact hours (ranging from 14 to 100 hours in total) with a duration spread over six to 12 months show a positive and significant effect on student achievement (Darling-Hammond & Richardson, 2009; Yoon, Duncan, Lee, Scarloss, & Shapley, 2007).

Furthering the influence of duration, Darling-Hammond et al. (2009a, 2009b) suggest changes in teacher practice and student learning responded to “intensive and sustained PD activities, especially when they include applications of knowledge to teachers’ planning and instruction, have a great chance of influencing teaching practices and, in turn, lead to gains in student learning” (2009b, p.44). The literature also supports the argument that well-designed PD is seen to provide classroom support over a sustained period of time (Desimone, 2009; Higgins & Parsons, 2011), recognising that change is progressive and requires time and effort (Guskey, 2002).

Effective PD caters to teachers’ knowledge of students, their learning and strategies for improving that learning (Hill & Ball, 2004). Effective PD also addresses both pedagogical skills and content knowledge. Garet et al., (2001) report PD that was coherent, focused on content knowledge, involved active learning and focused on student learning positively influenced teaching practices.

Another aspect of effective PD that was particularly relevant to Springvale Public School was provision of the opportunity for collective and collaborative participation to build a professional community within the school (Borko, 2004; King, 2014). This is supported by the NSW Institute of Teachers: “Teachers who contribute to their professional growth by participating in collegial professional practice. PD is most effective when undertaken in this manner”. Wenger (Unknown), defines communities of practice as “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly”. Furthermore, professional collaboration is articulated in the standards set by the current professional accreditation body, BOSTES. Other literature supports the
building of a professional community through PD as a new paradigm in effective PD, promoting sustained, job embedded and collaborative teacher learning strategies (Darling-Hammond & Richardson, 2009). However, Cwikla (2007) cautions that in order to inspire a community of practice, participants require a central and focused goal to work toward – simply providing space and time is not enough.

2.4 Professional Development and Mathematics

In Australia, mathematics teachers are encouraged to be active, lifelong learners. The Australian Association of Mathematics Teachers (AAMT) state: “all educators of mathematics must have the opportunity to access high quality professional learning that promotes a culture of inquiry into teaching practice” (Australian Association of Mathematics Teachers, 2013). In terms of the design of PD in mathematics, Elliot et al (2009) argue that PD leaders use “frameworks as tools for learning to lead mathematically rich discussions”, to attend to social norms (the general ways in which teachers engage with one another) and sociomathematical norms (the specific ways in which teachers engage in mathematical work) and to recognise the importance of “having purpose when facilitating mathematical tasks” (p. 367). They propose a set of content and process oriented design principles (p.368) to inform the design of seminar based PD, and these principles align with what was implemented at Springvale Public School during the group sessions:

1. Tasks should have mathematical coherence and important mathematical ideas across the seminars

2. Way of understanding sociomathematical norms is for leaders to explore the roles that questioning and responding to confusion or error play in negotiating what counts as adequate explanations and justifications in PD.

3. The importance of purpose is central in identifying the reason for engaging and sharing approaches to math tasks and is a central driver of facilitation as leaders engage in learning opportunities.

4. Leaders should have opportunities to engage in connecting the work in seminars to their own work of facilitating teacher learning. Tools can help leaders to make links between the analysis of sociomathematical norms and leadership of practice
5. A stance of inquiry should be cultivated during the seminars through which leaders consider the affordances and constraints of particular pedagogical moves and recognise that there are no prescriptions for the “right way to facilitate” mathematic PD.

There are several issues relating to PD and mathematics that are described in the literature. These include, but are not limited to, issues of accessibility, experience of teachers’ professional practice (e.g. teachers at various stages of their teaching careers, as was the case at Springvale Publics School), and the stance of the PD types.

Issues of accessibility often arise as a result of the way teacher typically function and practice, in an isolated and insulated environment. Higgins and Parsons (2011) describe this as the ‘difficult to reach dimension’ of accessing teachers’ actual practice in light of these isolated norms which “conceal the practices of both the strong and the weak teachers from public observation and exchange” (Cwikla, 2007, p.555). Ball (1996) views this through the lens of the ‘challenge of incomplete teacher knowledge’ where teachers’ pedagogical content knowledge is unable to effectively anticipate, interpret and respond to students’ actual mathematical discourse, understanding and outcome achievements. Herein, Ball raises issues around teachers’ capacity to implement mathematical problems ‘in a deeper way’ as a means of engaging students with core mathematical concepts, which has been linked to levels of student achievement (Hiebert, et al., 20013, as cited in Santagata, Kersting, Givvin, & Stigler, 2010). Likewise, Santagata et al., (2011) suggest that commonplace teaching of middle school mathematics in the USA, “tended to reduce all problems to sets of procedures that required students only to execute routine steps” (p.2), in contrast to what is understood to be best practice, engaging students in effective and meta-cognitive mathematical discourse and understanding.

A second issue the literature recognises is a variation in teacher needs and preferred forms of PD in light of their teaching experience and longevity of professional practice. Cwikla (2003) focused on the response and reflections of less experienced teachers finding that the less experienced teacher “might welcome meaningful peer interaction maintaining the collegial attitudes similar to the university atmosphere they have just
left” (p.183) as compared to more senior teachers who have grown accustomed to the individualistic and isolated teaching environment and defer to the ‘politeness norm’ that “dominates most current teacher discourse” (p.184). As a result, Cwickla recommends PD programs in mathematics structured around peer groups for less experienced teachers, including “content and pedagogy focus sessions, study groups, ‘expert’ presentations, journal reflections, small group lesson preparation mentoring, classroom observations and reflection records” (p.184).

Thirdly, the stance taken by types of PD is viewed as limiting to professional mathematical discourse. Traditional PD (in-service workshops, seminars, meetings) assume a stance toward practice that concentrates on answers: conveying information, providing ideas, training in skills, offering participants a wide range of resources, however, their “potential is restricted by the lack of critical discussion...seeking to make participants comfortable...leaders rarely challenge the teachers’ assumptions or provoke disequilibrium” (Ball, 1996. p.505). As teachers politely “refrain from critique and challenge, they have no forum for debating and improving these understandings” (p.505), impeding their capacity to grow. Reform PD should foster a stance of critique and inquiry, hence, the leaders and facilitators of PD are influential in instigating a community of learners where inquiry is valued (Borko, 2004).

2.5 Research Questions

The research aimed to address the following questions:

1. Can sustained and tailored professional development re-engage teachers with mathematics?
2. Did the professional learning program influence and change teachers’ practices?
3. Did the professional learning program result in increased student engagement with mathematics?
4. What were the teachers’ overall perceptions of the professional development program?
3 Methodology

3.1.1 Communities of practices as a conceptual framework

The project methodology is framed within the concept of communities of practice. Wenger (Wenger, Unknown) defines communities of practice as “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” (p.1). Participation within a community of practice is an encompassing process of “being active participants in the practices of social communities and constructing identities in relation to these communities...such participation shapes not only what we do, but also who we are and how we interpret what we do.” (Wenger, 1998, p. 4). Lave and Wenger (1991) acknowledge that learning involves increasing participation within a community of practice that is composed of novices and experts. This social theory of learning aligns well the goal of the school principal in relation to building the capacity of the teachers, and the intention of the PD program. This is the lens through which the data was investigated, alongside the Framework for Engagement with Mathematics (Attard, 2014).

The research aspect of this study utilised case study methodology. The study was located within a social constructivist approach in order to gain insight into the perspectives of the participating teachers in relation to their experiences with sustained PD. A total of eleven teachers participated in the PD program and data was collected in the following ways:

- Teacher interviews (mid-way and on completion of the project)
- Student focus groups (on completion of the project)
- Field notes

Interviews and focus group discussions were transcribed verbatim. Data was examined manually for emerging themes or patterns and categorised, and this occurred each time data was collected during the course of the study.
3.2 Methods

3.2.1 Ethical procedures

The research methods employed in this project were approved by the University’s Human Research Ethics Committee (approval number: H10208) and by the NSW Government’s Department of Education and Communities (approval number: SERAP-2013182).

3.2.2 Research site

Springvale Public School is situated in a low socio-economic area of Sydney’s Western suburbs. Twenty-nine per cent of the school’s population has a language background other than English and 12% of the school’s population is Indigenous. The total school population in 2013 was 472 with a total of 28 teaching staff. As stated in the introduction to this report, the school academic results were situated in the lowest quartile of NAPLAN performance in literacy and numeracy. The school’s principal had been appointed one year prior to the commencement of the PD program.

3.2.3 Participants

Although all teachers from grades four to six were involved in the PD program, participation in the research aspect of the project was voluntary. All of the teachers accepted the invitation to participate. The teachers ranged in experience from newly graduated up to 30 years experience. There was one male teacher in the group and he was the only male staff member apart from the school principal. To protect their identity, all participants’ names have been removed from the data and the teachers will be identified by codes detailed in the table below (Figure 2). Students will simply be identified by their grade. The following table is the list of teachers and their coding:
It was intended that the teacher be interviewed on commencement of the PD program. However, due to delays in gaining ethics approval, the initial interviews were held mid-way through the project. Two teachers took part in only one interview (T11 took part in the initial interview, and T6 took part in the final interview) due to personal leave.

The initial teacher interviews were semi-structured and consisted of the following prompts:

1. Can you tell me about your teaching experiences prior to this professional development project?
2. How do you see yourself as a teacher of mathematics?
3. Tell me about the professional development opportunities you experienced prior to this project.
4. What do you hope to gain from the opportunity to engage with the current professional development project at your school?
5. How do you think the current project will affect your students in relation to their mathematics learning and their engagement with mathematics?

The final teacher interviews were based on a new set of prompts:

1. Can you tell me about your teaching experiences during the course of the project?
2. Have you changed how you see yourself as a teacher of mathematics as a result of the project?
3. What have you gained from the opportunity to engage with the current professional development project at your school?

4. Tell me if/how your practices have been influenced as a result of the project?

5. How do you think the current project has affected your students in relation to their mathematics learning and their engagement with mathematics?

All teachers participating in the study sent invitations to parents and caregivers of their students an invitation for their child to participate in a focus group discussion. Three focus groups were then formed based on the signed consent forms returned to the school. These groups were made up of the following:

1. Year 3: six students, mixed gender from two different class groups
2. Year 4: six students, mixed gender from one Year 4 class
3. Years 4/5: six students, mixed gender, from a blend of Year 4 and Year 5.

The focus group discussion used the following prompts to initiate the discussions:

1. Can you tell me about your experiences of mathematics teaching and learning this year?
2. Talk about some of the typical things you do in mathematics lessons.
3. How do you see yourself as a learner of mathematics?
4. What do you think a ‘good’ mathematics lesson looks like?
5. What do you think a ‘bad’ mathematics lesson looks like?
6. Do you think your mathematics lessons have changed this year, and if so, how?
7. If you had to give your teacher some advice about how to teach mathematics, what would you say?

3.3 The Professional Learning Program

The following (figure 2) is a list of the PD program activities that were implemented at Springvale over the course of the project. Apart from the initial whole school PD session on
iPads, the activities were developed over the course of the project in response to the teachers’ requests and needs.

<table>
<thead>
<tr>
<th>Year</th>
<th>Date</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>November</td>
<td>Provided advice and assistance to school principal in relation to the ordering of mathematics resources and materials</td>
</tr>
<tr>
<td></td>
<td>December 20</td>
<td>Whole school PD session presented by Catherine Attard on using iPads to teach primary mathematics</td>
</tr>
<tr>
<td>2013</td>
<td>February 15</td>
<td>Half day sessions with Stage 2 and Stage 3 teachers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Content covered:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Student engagement (introduction of FEM)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Best practice in the teaching of mathematics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Using concrete materials to improve engagement</td>
</tr>
<tr>
<td></td>
<td>March 22</td>
<td>Half day sessions with Stage 2 and Stage 3 teachers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Content covered:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Needs analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Activities linked to best practice were introduced</td>
</tr>
<tr>
<td></td>
<td>March 29</td>
<td>Mathematical Association of NSW one day primary conference attended by several staff</td>
</tr>
<tr>
<td></td>
<td>May 30</td>
<td>Demonstration lessons in Year 5 and 6 classrooms</td>
</tr>
<tr>
<td></td>
<td>June 6,</td>
<td>Demonstration lessons in Year 5 and 6 classrooms</td>
</tr>
<tr>
<td></td>
<td>July 15</td>
<td>Demonstration lessons in Year 3 and 6 classrooms</td>
</tr>
<tr>
<td></td>
<td>August 19</td>
<td>Half day sessions with Stage 2 and 3 teachers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Content covered:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Mathematical Investigations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Introduction of Maths 300 program</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Linking investigations to the Australian and NSW Curricula.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Programming approaches were discussed</td>
</tr>
<tr>
<td></td>
<td>August 29</td>
<td>Demonstration lesson, Year 6</td>
</tr>
<tr>
<td></td>
<td>September 5</td>
<td>Demonstration lesson, Year 3</td>
</tr>
</tbody>
</table>
## 4 Research Results

At the start of the PD program, there was little evidence of a functional community of practice operating at the school. Each of the teachers programmed and planned their mathematics lessons independently, with little or no knowledge of what was occurring in other classrooms. As stated earlier in this report, the staff at the school had received minimal or no PD in the area of mathematics prior to the appointment of their current principal in 2012. When asked about their previous experiences of PD, some teachers had experienced one-off, ad-hoc events, however there was a sense that this had not been
effective. One teacher made the following comment that aligns with Cwilka’s (2003) belief that PD imposed from outside schools and classrooms may not match with the agendas or needs of individual teachers:

Well the one off event only affects that one person and then they can then choose or not choose whether to share it or whether they’ve been requested to share it, or whether it just gets put and filed away, or whatever it may be. So I don’t think that method works very well at all (T11).

There are also issues of control relating to the provision of PD that is limited to select teachers rather than a whole staff. Staff selected to attend PD may not necessarily feel they can benefit from the ideas or agendas of others. If the learning from such PD is not shared amongst teachers who do not attend, this could lead to feelings of exclusion. When discussing prior PD opportunities, other teachers claimed there was little encouragement to participate from the previous school executive or when PD was made available, the range of ideas created confusion and conflicted with teachers’ personal beliefs about pedagogy and best practice: “They tell you all different ways, I think it becomes very confusing…intuitively I think I was doing the right thing anyway” (T2).

During the first interview, the teachers spoke about how they viewed themselves as teachers of mathematics. Several of the early career teachers (ECTs) reported a lack of confidence and felt challenged in engaging their students with mathematics. One teacher made this comment: “So maths is not my forte; it’s not my favourite subject but I feel as though I’m learning with the kids. You know when we get things to do I find that if I can quickly work out how to do it I’m of course a much better teacher, but sometimes I don’t” (T1). Another ECT stated: “I’m slowly starting to get more confident with it. Some areas I feel like I have a lot more trouble trying to engage the students than others…I can’t work out ways to make them as interesting as I can with other aspects” (T10).

Given that the development of pedagogical content knowledge occurs over time and with experience and continuing PD, these ECTs required support from colleagues and at that point in time, were working in isolation from other teachers. Other, more experienced teachers, were more confident with their overall teaching skills and mathematical ability,
but did not enjoy teaching it or felt restricted by a lack of teaching ideas and resources, as this teacher, T8, expressed:

I’ve been teaching for about 30 years but maths has always been something I tend to shy away from. I found that early on I’d rely on things like textbooks and worksheets where literacy was always my area, I could expand on literacy and ideas would come to me, where maths never did.

Of some concern, was the following comment by a Year 3 teacher, T2, with 10 years of experience: “Lately I've actually felt that when I first came out of uni I was better at teaching mathematics than I am now. In terms of, I was willing to try new things, I was differentiating more.” This teacher appeared to be disengaged with the teaching of mathematics due to the mixed messages she received from those teaching around her and the PD that she did experience. It also appears that the pressure to conform to existing school cultures may influence ECTs to adapt their practices in order to fit in. There was also the perception of a lack of supportive supervision at the school and an assumption that experienced teachers did not need continuing PD, as evidenced in this comment from a Year 5 teacher, T8, with over 20 years of experience: “I think the supervisor has a lot to do with it as well and the supervisor I had last year it was “you’re experienced, you know what you’re doing, do what you want.””

At the final interviews, teachers were asked if they had changed the way the viewed themselves as teachers since experiencing the PD program. The majority of the teachers reported that they felt more confident in engaging their students with mathematics, however one Year 3 teacher, T1, who claimed that ‘maths was not her forte’, still lacked confidence, stating: “A lot of the kids in the class are much smarter than me at maths, I know they are”. The same teacher also appeared to be struggling with behavior management, which could have interfered with the development of her mathematics pedagogical content knowledge: “I think finding the time with trying to teach my kids manners and not to interrupt and that’s hard, because if you're talking to someone who doesn’t understand it you’ve got everyone saying “Miss, miss, miss” that’s hard”.

Another teacher, T4, made this comment:
I was still trying to find myself as a maths teacher because I’m – had just – well I finished uni about four or five years ago and I was doing support so it was my first year on class. So it was really helpful to have you come in and sort of show me some things that I should be doing because I was still trying to work out what was the right way of doing things. So it really helped me develop sort of what I wanted to sort of do in maths. And having all of the interactive stuff because sometimes you just get thrown all these are worksheets, these are things you have to do and you don’t know the different activities out there that you can do that are more engaging for the kids so that sort of helped me sort of develop what I wanted to teach the kids (T4).

Other issues some teachers faced during the course of the PD included the challenge of sharing their practices with other teachers during the sessions. To some, this was intimidating: “I mean, because different people always bring in different ideas and with another teacher talking about all her hot houses or whatever she was doing. It sort of makes you feel inadequate to some degree” (T9). The same teacher also found it a challenge to try new things and to adapt and use other teachers’ ideas within her own classroom:

We’ve always been very much like programming and stuff by ourselves so I mean just personally speaking I find it difficult to integrate other people’s ideas I guess not that theirs is wrong – often times they are better whereas I’ve been teaching longer than some and shorter than some.

Although the levels of confidence amongst the teachers were improving, at the conclusion of the program there was still much room for improvement.

4.1.1 Expectations of the PD program

When asked in their initial interview what they expected from the PD program, it was clear that the teachers felt a lack of professionalism and sense of community. The following are some of the comments made by the teachers in this regard:

I think it was the idea of being able just to have that professional discussion and try and work out different ways to go about things. And so, straight out of uni a lot of it had already been there, but there’s always more, and it was being able to explore that because when its taught to you at uni it is very broad from K–6 because you don’t know where you’re going to end up, and whereas now its this is very stage focused (T10).

“The focus – I’ve never seen the school so focused as it is at the moment, which is lovely. So we all know where we’re going, and we’re all going in the same direction, but it tended to not be that way prior to your involvement” (T11)
I guess I was hoping it would get us more as a school get more professional direction perhaps selfishly in the way I felt maths should be taught because I didn’t think I was that far away from where it should have been going (T5)

Other comments from the teachers related to the benefit of having an outsider from the University as a critical friend and advisor:

I thought oh that’s good, there’s some people that obviously know new developments and have their research behind them, whereas sometimes in schools you’ll just listen to your supervisor and people like that, which is good but they’re not in touch with what’s the ideal way of teaching maths (T2)

Other expectations were based on pedagogy and building up teaching ideas and resources. Interestingly, most teachers answered this question from a teaching perspective, and only two teachers responded from a learning perspective:

New strategies, new ideas, new ways of approaching teaching so that the kids not only get taught but they like maths. I don’t want them to see maths as maths. No, I don’t want to be doing maths, maths is boring (T3)

I hope to get sort of just ideas of how to make sort of I guess maths more interesting and how to sort of make it easier for kids to sort of grasp concepts and things like that (T10)

4.1.2 Changes to pedagogical practices

During their final interview, the teacher spoke about how the PD program influenced their practices. Although several of the teachers were still establishing their pedagogies, all of the teachers claimed their practices had changed to some degree. Many spoke about their changed approach to teaching mathematics and how it is now more student-centred:

It’s more the focus, getting them (the students) to think about why is that the answer, how did they get the answer, could they get a different answer? So I think saying before, the onus is back on them a little bit to challenge themselves and it’s not the teacher said to do this and that’s the answer (T3).

Last year was my first year for a long time on Stage 3 that was scary because I suddenly have to – had to look for ways of teaching to a rather difficult - and difficult class as well. And then when you guys came along I saw all these great problem solving ideas and they were the things that really engaged the students and I pretty much last year turned my whole maths teaching around... I think it’s changed more in the last 12 months than it did in the 28 years (T8).
Another common theme that emerged was the use of more operatively engaging, hands-on tasks that resulted in the new resources purchase by the school and the way they were demonstrated during the PD sessions:

I'm trying to make them more hands on, more, not, staying away from worksheets and just trying to use the cards, trying to use concrete materials that we have in our classroom, ... that we've got everywhere in our classroom and the kids love that and they learn better... I think you’ve showed me how to use the resources, the concrete materials which I thinks better, because otherwise I would have just done worksheets. (T1).

Sometimes you do something and they take it in a different direction. So I’ve sort of felt that that’s okay now to go in that direction but yeah or when (other teacher) said yes that’s fine. So you’ve sort of going with where the kids are going. And sort of sometimes even back planning and putting in what you’ve done and things like that (T4).

A significant aspect of teaching influenced by the PD program was the integrating of mathematics across the mathematics curriculum and across other key learning areas. Prior to the program mathematics had been taught in an isolated manner, with no links to other curriculum areas, limiting the students’ abilities to understand the relevance of mathematics and its real-world applications. This is an important element of engaging mathematics lessons as identified within the FEM (Attard, 2014): “the relevance of the mathematics curriculum is explicitly linked to students’ lives outside the classroom and empowers students with the capacity to transform and reform their lives.” The following quotes exemplify the new practices and beliefs of the teachers:

I was teaching just all the strands separately and all the KLA’s separately but now I’ve started to bring them in because you find there’s not enough time to do them all separately. But it sort of works better to bring them all in because the kids are getting more out of it. They’re picking up on the different things a bit easier because it’s not just stand-alone (T4).

They don’t realise that maths in everywhere and I think that open learning is helping to reinforce that whatever they do maths or English is involved and I don’t think they’ve seen it before, I just think okay, it’s HSIE time, English time, it’s maths time and they forget that they all correlate (T7).

I’m finding that that’s really easy to make maths fit into everything else rather than sort of doing a worksheet with a picture of a tree on it. To say well we’ve covered HSIE and maths in one go, isn’t that terrific. And the kids are enthusiastic— its easy when you’re interested yourself and you’ve got that passion for what you’re teaching them. It comes out in them and all of a sudden you’re watching them go off into little groups and sometimes they’ll go off at a totally different tangent that you expected
them to. And they're doing something completely different to what you start with, but it's better (T8).

Another significant area of teaching influenced by the program and the resources was the integration of technology into mathematics teaching and learning. As mentioned earlier, the school purchased a number of iPads at the beginning of the program and the use of these devices as well as other technology-based tools was integrated heavily into the sessions. The teachers also had Interactive Whiteboards in their classrooms. Some simple robotics (ProBots) were also purchased and demonstrated during the PD program. One teacher who had previously refused to use her Interactive Whiteboard (IWB) made this statement: “I have gained the desire to actually use the interactive whiteboard in the classroom, which is (Laughing) so sad...it’s that I couldn’t see the purpose, now I can” (T9). Prior to project teacher didn’t see how technology could actually enhance teaching because she had seen poor examples of its use.

4.1.3 Building a community of practice

Wenger (1998) states some of the indicators that a community of practice has been formed, participants must have a “shared way of engaging in doing things together” (p. 125) and would include “knowing what others know, what they can do, and how they can contribute to an enterprise” (p. 125) and “a shared discourse reflecting a certain perspective on the world” (p.125). At the start of the PD program at Springvale there was little evidence of the existence of a community of practice, particularly at the level of classroom teaching and learning. This is evidenced in this comment from a Year 3 teacher (T3):

We haven’t had a lot of that sort of opportunity before it’s hard to then work with other people because we’re all in our own mindsets of how it needs to be done and how it needs to go ahead so I think those boundaries are sort of coming down a little bit but it’s tricky, but getting engagement together and getting people’s ideas is helping I think.

As a result of the PD program and the activities that provided the opportunity for the teachers to get to know each other on a professional level (they were already familiar on a social level), evidence of an emerging community of practice is seen. The following are some of the quotes that evidence this:

...it’s been really good that we’ve been to talk more with ..., we’ve been able to sort of interact and because we’re all in year 4, it’s good that we’ve sort of set up things
that we’re doing across the grade. So that’s really good and I’ve learnt a lot from it (T4).

...we used to often chat (during the PD program) after school and it was chats about maths actually and what was going on in the class and the activities they were involved in (T5).

I think being with the staff is the most that I’ve gained and having an insight to how they think and what they do. Just to see other people’s practises and along the way helping others...and I think all of us working together it’s amazing because you get so many other viewpoints that you oh, I didn’t even think of that, so that’s the most I’ve gained working with staff, I think the opportunities are great and when we work together it’s really good because last year there wasn’t so much of the collaboration, it was more you go off and do yours and you go off and do yours, so it’s insightful (T7).

I think we’re starting now to recognise each other’s strengths and to utilise them. I know if I come up with an idea I always run it by...and things like that (T8).

Although the community of practice was emerging, there were still some challenges for the teachers at the conclusion of the PD program, with the following quote indicating a sense of frustration:

I think that’s been one of the great benefits of the project because you sort of think you’ll try and get together to work with your stage and people say as a supervisor you need to meet with your stage and do this. But at the end of the day, there’s – teachers on my stage, they have children, there’s so many other demands, to sit down and do professional development, even just to discuss...you tend to be in your classroom and you go home and then you come back and you don’t really get that time to share ideas and to look at the potential of another idea (T5).

The teachers were experiencing and appreciating the benefits of the developing community of practice, however, outside influences such as family commitments placed some pressure on the teachers that limited their ability to take part in conversations outside of the school teaching hours. Perhaps over time, as teachers further develop their professional identities, and the whole school culture evolves, professional conversations with peers will become more of a priority. Support from the school executive members would assist with this.

One surprising benefit from the emergence of the community of practice appeared in one of the year 4 classrooms, where the students also appeared to be developing their own community of practice. The teacher of this group made several comments about how she had focused on increasing the levels of dialogue amongst her students and between herself and her students:
I think because of that communication it’s really good because now they’re starting to use it more in class as well and I try and make sure that we have time to reflect and talk about it more. Because last year when I first started teaching it was more about getting them to do the work rather than talking. So I’ve now been able to just stop – even if we don’t get through it all, we make sure we stop and reflect on what we’ve done (T4)

This practice aligns with the FEM in relation to supporting student engagement: “interaction amongst students and between teacher and students is continuous” and “there is substantive conversations about mathematical concepts and their applications to life “ (Attard, 2014). The increased dialogue amongst all the members of this class group resulted in more reflective learners and the development of a shared language in relation to the ways students began to see themselves as learners of mathematics.

As the ultimate goal of this PD program was to eventually improve student learning and engagement, the data discussion now turns to the students’ perceptions of their mathematics teaching and learning.

4.1.4 Students’ perceptions of mathematics learning and teaching

During their focus group discussions, the students were asked to talk about the sorts of things that happen in their mathematics lessons. At the time of the discussions the PD program had been running for almost 18 months, however, there seemed little evidence that the changes in the teachers’ practices had any influence on the students at that time. This finding is limited to the number of children participating in the focus group and the limited representation from the different class groups that was hindered by a lack of consent forms being returned to the school.

Many of the practices cited by the students appeared to reflect a traditional approach to teaching and learning mathematics. When asked if the students use worksheets as part of their lesson routines, this Year 3 student replied: “Yeah, heaps of them”. A Year 4 child described a typical lesson in his classroom as “So we first do it as a group and then after we get our worksheet and we work – work by ourselves”. This comment implies that there may be some hands-on or collaborative work in that particular classroom. It is interesting that many of the students didn’t emphasise the hands-on aspect of their lessons, indicating that perhaps their expectations of mathematics lessons incorporate a traditional, pen and paper
approach and they may not view hands-on and collaborative learning as an important aspect of their learning experience. Students’ expectations of what should happen in their mathematics lessons may also be influenced by their parents’ or caregivers’ expectations, and perhaps this could be addressed through parent workshops where more engaging practices are demonstrated and justified to the community.

Another interesting observation emerged from the focus group data in relation to the influence of NAPLAN testing on the practices of the teachers and the expectations of the students. This comment came from a Year 4 student:

Well when we do activities like a maths game – maths game we’re do some of them like we did last year and we revise them all. We do our times tables to remember because if you do a NAPLAN next year you might forget them.

Another comment implies that this students’ teacher is attempting to address misconceptions revealed in the school’s NAPLAN results: “It’s probably a bit harder but and then there’s stuff that we did in NAPLAN that she’s showing us.” This comment from a Year 4 student indicates the teachers at the school feel under some pressure to improve NAPLAN results: “sometimes whenever we’re talking, Miss says “Oh you must learn so you can get good results in NAPLAN.”” National testing does appear to drive some of the learning and teaching of mathematics and this does potentially hinder students’ engagement while giving the message that the purpose of learning mathematics is simply to pass a test.

4.1.5 Changes in teacher and student engagement

One of the research questions driving this study was: can sustained and tailored professional development engage teachers with mathematics? Evidence from the data collected suggests this PD program has engaged the teachers at Springvale. The program had the biggest impact on one of the most experienced teachers at the school, who made this comment:

I never considered myself a maths teacher in any way shape or form until this. I was always very good at literacy and I’ve done reading recovery. I’ve done all the things that I’ve done, have added to my literacy abilities but I’ve tended to avoid maths, whereas now I don’t. If I go home and I’m looking for activities and you know trolling the internet for ideas, it’s usually maths now rather than literacy. So I’m a lot more confident…it’s sort of made me feel a lot more rounded as a teacher…a lot more confidence in maths than I’ve ever had in thirty years of teaching. It’s not just the
teaching part of it that’s improved. I think it’s the whole outlook on maths. And passing that on to those kids particularly the ones that weren’t terribly enthusiastic (T8).

Comments from other teachers include: “it’s reaffirmed that I’m on the right track and that sometimes having evidence in a book isn’t always the evidence that we need to collect” (T5). Many of the teachers spoke about how their engagement with mathematics has improved the engagement of their students, often as a result of their increased use of hands-on resources leading to higher degrees of operative engagement:

We’ve been really sort of interactive with all the things that we’ve brought in so the white boards, the cards, the dice; the kids absolutely love sort of doing those things. I try and use those every lesson. We do still do work in our books and things like that but we try and – I try and give them that hands on experience with all of the equipment we have in the classroom (T4).

Another comment relating to the increased use of more interactive tasks as this:

I think they’re more engaged now because I think you have opened up the door for the activities to be more visible. Before it may have looked to some teachers that an activity was not learning and someone would come past and say they were playing games. And it’s like it’s not a game if it’s learning and thinking (T7).

Overall, the teachers were now implementing more student-centred tasks that were focused on mathematical processes such as problem solving, reasoning and communicating, rather than just mathematical content, which is a critical requirement of the current mathematics curriculum document. This then led to a deeper level of reflection on the part of the teachers as well as the students:

It’s more the focus, getting them to think about why is that the answer, how did they get the answer, could they get a different answer? So I think saying before, the onus is back on them a little bit to challenge themselves and it’s not the teacher said to do this and that’s the answer (T7).

The increased engagement amongst the students appeared to have given them a sense of voice and an increased confidence and awareness in their learning. This comment was typical of the reaction from other class groups:

...they didn't sort of have that exploration before and they wouldn’t speak up to say what about this, in case they were wrong. Now it’s like what about this one, this one? It’s like yes, yes. So they’re speaking up a bit more (T7).
In some classrooms there appeared to be a shift in focus from behaviour management and control to learning as a result of the engaged teaching and learning:

I think a great deal has changed with those students, they've been a difficult class, just the cohorts been difficult from very early on. And I find that, I think in the past they'd been given busy work because it kept them quiet and they were used to that (T8).

The same teacher also reported that her students had begun to extend their classroom work into their lives outside school, continuing their investigations at home, which had never happened prior to the PD program implementation.

While the students and teachers appeared to be more engaged in the teaching and learning of mathematics, there is no evidence yet to suggest that learning has improved. However, the teachers sensed that the students were more readily able to understand concepts now that they were being taught in more concrete ways and more integrated ways throughout the curriculum. The problem solving that was introduced through the PD program was also seen to have been of benefit to students: “I think the students are engaged. I think perhaps sometimes they’re not aware of how much maths we do. I’m finding that they’re starting to learn how to apply strategies” (T4).

As a result of the PD program, the teachers seemed to have gained a much stronger understanding of how to adapt their pedagogical practices to engage students. The resources provided and demonstrated through the sessions as well as the modelling of good practice provided a strong foundation for these teachers and enabled them to view mathematics teaching and learning in a very different way. The following quote exemplifies the general feeling of the teachers:

Engagement is no problem at all...there’s no reason for mediocrity to occur anywhere anymore. I’m sure it does, but there’s no need – there’s no room for it anymore. So the engagement is no issue – there’s enough stuff out there to engage them. Is the learning happening? That’s another thing all together, and that needs to be carefully monitored and looked at. I like to think it is happening, but I think just the passion for mathematics is starting to show in students like I’ve never seen before. So that’s from the engagement side of things (T11).
4.1.6 Teachers’ overall reaction to the PD program

During their final interview, the teachers discussed what they had gained from the PD program and spoke about their reactions to the program. The teachers appreciated the use of ‘outsiders’ to provide professional development as well as the credibility that came with the fact that the facilitators were from a University.

I think it’s really good having the expert people come in to help us out – being able to engage with other people at the school - definitely got good potential to do like changes within the school which have been missing for a long time (T3).

The ECTs at the school found the program particularly valuable, as it assisted them in developing positive habits early on in their careers and alleviated some of the stress involved in learning how to engage students who were historically disengaged:

I just think it was really good especially because I was a beginning teacher. It was really good to have that professional development as I was starting out so not going through a whole year or two and working out all these wrong things to do and then having to change. I think it’s sort of probably was easier for me because I was learning along the way. I didn’t have to change things I was doing (T10).

There was a sense that the teachers felt they were now on the right track in terms of being engaged and engaging their students:

You have brought insight into the school of what works, what’s maybe not working, how we can challenge ourselves rather than just the children and putting us into that spot where you have to sort of get in there and investigate, I because you can’t teach it unless you do it yourself (T5)

4.1.7 Challenges in implementing the PD program

Although the PD program was a success, it was not without its challenges. Being asked to come into a school over a sustained period of time with permission to tailor the professional development to the needs of the teachers is not as simple as it may seem. Deciding where to begin was not easy, however the fact that the school had very few resources for the teachers to access provided a starting point and allowed the facilitators to begin the PD program by illustrating the FEM (Attard, 2014) through demonstrating the new resources
that had been purchased. The impending implementation of a new mathematics syllabus was also a foundation from which to base the PD sessions.

At the start of the program, it was important to develop a trust between the teachers and the facilitators. When the teachers requested that the facilitators conduct demonstration lessons within their classrooms, this assisted in developing that trust and also helped build a relationship of mutual respect. This also gave the facilitators a strong insight into the student needs and challenges within the school. As the program progressed, there were opportunities for the teachers to discuss issues that were of concern to them and their discussions informed future sessions.

Some of the practices put into place in the Early Stage 1 and Stage 1 classrooms did not align with the philosophies being promoted in the Stage 2 and 3 PD program and this was the cause of some tension for the teachers. In particular, there appeared to be two different and separate communities of practice developing within the school. The ES1 and S1 teachers were encouraged to use a particular language that had become quite popular in schools and the Stage 2 and 3 teachers felt excluded. They also felt that the lesson structure being promoting in the younger grades was too restrictive.

Although the teachers were reassured in relation to the tensions described and the PD program was successful, it is believed that it would have been more beneficial for all of the teachers to be receiving the same message to ensure the whole school developed a shared understanding of best practice in the teaching of mathematics to ensure long term success in building student achievement.

5 Recommendations and conclusion

The recommendations for any future professional development provided at Springvale Public School have been developed by analysing the research data gathered from the teachers involved in the sustained PD program and some of their students. Key themes have emerged as a result of the data analysis and these form the basis for the recommendations. These include:
5.1 Support continuing professional development in mathematics

The findings from this research align with recommendations from literature that teachers must have the opportunity to participate in professional development throughout their careers. This is particularly critical for early career teachers who are in the early stages of developing their mathematics pedagogical content knowledge. The teachers at Springvale Public School had already begun to adapt their practices as a result of the PD they had received through this project. However, further PD is important to maintain the momentum gained. It is also recommended that the teachers be provided with a range of PD opportunities that include self-nominated PD, and PD that is focused on individual needs as well as group needs.

5.2 Provide space (face-to-face and online) for teachers to engage in professional dialogue

One of the challenges faced by the teachers at Springvale Public School was a sense that there had been few opportunities to work collaboratively and engage in professional dialogue. Several of the teachers cited that the opportunity created by the PD program was one of its major benefits, and this was evidenced at the end of the program when the teachers were planning units of work together. As the teachers further develop their professional identities, and the whole school culture evolves, professional conversations with peers will become more of a priority. Support from the school executive members would assist with this.

It is recommended that some time be timetabled for teachers to work together. To ensure teachers work together during this time it is suggested that Stage Coordinators/Supervisors set agendas for these meetings. Agendas should include activities such as professional readings, sharing of ideas, and planning of teaching and learning activities.

In addition to having planned meeting times, the teachers should be encouraged, where possible, to observe each other teaching. This will address the issue of teacher isolation and support the continued development of the community of practice at the school. Finally, the provision of an online space that will allow teachers to collaborate and share resources would be of great benefit. One of the challenges when trying to collaborate is the pressure
felt by teachers from outside the school. Often teachers have other commitments that prevent them from spending time with colleagues outside formal school hours. An online, shared space would alleviate some of this pressure.

5.3 Continue professional relationship between school and outside experts

The teachers at Springvale valued the professional relationship that had developed with the facilitators from the University of Western Sydney and they felt the provision of critical friends from outside the school was of benefit. The teachers felt that the knowledge shared by the academics was contemporary and assisted them in the development of their mathematics pedagogical content knowledge. It is recommended that, where possible, this relationship be continued or other relationships between the school and outside experts be developed.

5.4 Expand the community of practice to other stakeholders

Students’ expectations of what should happen in their mathematics lessons is often influenced by their parents’ or caregivers’ expectations and as the teachers adapt their practices to be more hands-on and student-centred, it would be useful for the school to hold parent/carer workshops where more engaging practices are demonstrated and justified to the community. This will assist parents and caregivers in supporting their children, and will also assist the teachers in implementing new pedagogical practices. The development of a shared language around the teaching and learning of mathematics will develop a different, and broader community of practice, whose members are participating to enhance the mathematics learning outcomes of the students at Springvale Public School.

5.5 Develop a whole school philosophy of best practice in mathematics education

One of the challenges that arose during the PD program was the conflicting messages about pedagogy received from others in the school and the university academics. For a community of practice to function well, there needs to be a shared understanding of best practice in mathematics education across the school. This should be developed collaboratively by the entire school staff as a professional development activity to ensure teachers have a voice. This will ensure there is a commitment to best practice across the school and will be of
benefit to students as they progress through their school years in terms of building consistency with pedagogical practices.

5.6 Conclusion

The purpose of the sustained professional development program at Springvale Public School was to build the capacity of the teachers in Stages 2 and 3, in order to promote student engagement and eventually improve students’ learning outcomes in mathematics. This study illustrates that this type of sustained professional development can be successful, but needs to be continually maintained. Although the PD program ran for almost 18 months and there appeared to be significant changes in the teachers’ attitudes and practices, further PD would be of benefit, particularly with regard to the early career teachers.

It is not clear yet whether there has been any improvement in student learning – this will become more obvious over time if the teachers’ practices continue to evolve and if the community of practice that had begun to develop continues. Although this study is limited to one school and a small group of teachers, further research into sustained mathematics PD would be of benefit, particularly in light of new accreditation requirements and the increasing availability of online professional development opportunities. Other research comparing the effectiveness of off-site (online or face-to-face) PD and in situ professional development in mathematics education would also be of benefit.

The five key recommendations that evolved from the study are as follows:

Recommendation 1: Support continuing professional development in mathematics

Recommendation 2: Provide space (face-to-face and online) for teachers to engage in professional dialogue

Recommendation 3: Continue professional relationship between school and outside experts

Recommendation 4: Expand the community of practice to other stakeholders

Recommendation 5: Develop a whole school philosophy of best practice in mathematics education
6 References


