Enhancing a mathematics leader's knowledge for teaching through a co-teaching situation

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This paper reports on a mathematics leader who participated as a co-teacher alongside a teacher educator in a university classroom. The collaboration was designed to bring the profession into the university. Case study research design and qualitative methods were used to analyse written self-reflections, transcripts of interviews and the co-teachers' post-lesson discussion notes. Along with identifying the benefits of the co-teaching for pre-service teachers, it became evident that the mathematics leader also benefitted from this experience. The findings suggest that such collaborative co-teaching experiences may be a legitimate professional learning experience for school mathematics leaders.

Introduction

A middle school leader, such as a mathematics leader can help teachers in their school to identify how and what to teach as well as shape students' learning experiences. Mathematics leaders are pivotal for helping teachers to improve their content knowledge and pedagogical knowledge (Sexton & Lamb, 2017). Australian research suggests that the role of the middle leader is under researched (Willis, Chuchward, Beutel, Spooner-Lane, et al., 2018), and Sexton and Lamb (2017) agree further research will help identify what motivates middle leaders' learning for their role as mathematics leaders.

This paper reports on part of a collaboration and university initiative that was designed to improve the quality of teacher education and assist pre-service teachers (PSTs) to develop their knowledge for teaching mathematics. A teacher educator and mathematics leader co-taught weekly tutorials during two semesters in 2018, and reflected on their experiences after teaching. The case study in this paper reports on how a co-teaching experience supported the mathematics leader in her role at a primary school. To identify how the co-teaching provided professional learning for the leader the category of *foundation knowledge*, one of the four categories from the Knowledge Quartet (Rowland, Turner, Thwaites & Huckstep, 2009) was used to code and discuss the leader's reflections related to the yearlong collaboration.

Background

Over the past decade, within Victorian primary schools there have been initiatives introduced to help improve students' performance in mathematics. This has included training of mathematics coaches and primary mathematics specialists. Mathematics coaches (or leaders) are often classroom teachers who complete a professional development program before taking on their role. They work collaboratively with teachers to improve teacher instruction and student learning outcomes (e.g. Anstey & Clarke, 2010). Primary mathematics specialists are classroom teachers that are upskilled to become mathematics specialists (Department of Education and Early Childhood Development [DEECD], 2014).

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These roles may be full time or part time depending on funding, size and needs of the school. In addition to a leadership role, these teachers may also have a classroom teaching role.

Coaches may be the most important source of professional learning for teachers when developing quality practice (Millet & Johnson, 2004). As reported by Beswick, Anderson and Hurst (2016) there have been a number of ways that teachers acquire knowledge for effective teaching of mathematics. For example, co-teaching provides both educators with rich opportunities to grow and reflective on their practice (Gaziano & Navarrete, 2012). Within a recent review of Australasian research on the education and development of practicing teachers none reported teacher professional learning as a co-teacher in a university classroom, where a MTE and classroom teacher planned and co-taught PSTs (Beswick et al., 2016).

Bridging the gap between practice and research is fundamental in supporting teachers. A Teacher Education Ministerial Advisory Group (TEMAG, 2014) report advocated a need for professional learning for teachers that is research based. Like teachers, leaders require professional learning if they are to make differences to the quality of teaching and learning in their schools and improve student performances. Leaders have reported that informal mentoring is important for their professional learning (Sexton & Downton, 2014). Programs designed to support leaders to extend their own pedagogical content knowledge also impact positively on teacher and student learning (Gaffney & Faragher, 2010).

Quality professional learning supports teacher change and sustained practices (Beswick et al., 2016), but there is no single model for professional learning programs when training coaches (Campbell & Malkus, 2014), and classroom teachers are often selected or apply for the role of leader/coach (e.g. DEECD, 2014). These leaders must demonstrate mathematical content knowledge and pedagogical knowledge; enact the school's vision; support teachers in their planning to cater for students' diverse learning needs; as well as provide teachers with critical advice when planning and teaching (Jorgensen, 2016). They might see themselves as facilitators of professional learning for their staff, facilitators of change and facilitators of teachers' planning (Sexton & Downton, 2014). Other roles include mentoring beginning teachers and co-ordinating whole school programs (Willis et al., 2018). The role as a mathematics school leader is also important for bridging the gap between what happens in the classroom and the school leadership team (Jorgensen, 2016).

Theoretical framework

As teachers we are always learning, our experiences are relived, remembered and re-experienced through discussion, critique and critical thinking (Fitzgerald, 2018). The co-teaching situation provided an opportunity for discussion and critical thinking to occur as the co-teachers regularly reflected upon the weekly lessons. The Knowledge Quartet framework (Rowland, Turner, Thwaites & Huckstep, 2009) was chosen as a tool to analyse these discussions and identify how co-teaching supported the leader's knowledge for teaching.

The Knowledge Quartet framework includes four categories (*foundation knowledge, transformation, making connections* and *contingencies*) designed to support focused reflection and development of mathematics teaching (Rowland, et al., 2009). The category of the Knowledge Quartet most relevant to this study was *foundation knowledge* including:

- Knowledge and understanding of mathematics itself;
- Knowledge of mathematics pedagogy;
- Beliefs about mathematics, including beliefs about why and how mathematics is taught (Rowland et al., 2009 p.30).

Knowledge and understanding of mathematics includes common content knowledge, learnt at school as well as the specialised mathematical content knowledge needed and used by teachers (Ball, Thames, & Phelps, 2008). Teachers also rely on procedural knowledge, procedural fluency and conceptual knowledge (Ball & Bass, 2002) and is evidence of their content knowledge. In contrast, specialised content knowledge is unique to teachers (Ball et al., 2008) and is used by teachers when planning lessons, listening to, or observing students' mathematical solutions.

Knowledge of mathematics pedagogy is how teachers transform their knowledge so their students learn (Rowland et al., 2009). This might include how a teacher breaks down mathematical concepts during teaching. A teacher might consider approaches for leading mathematical discussion such as talk moves (Kazemi & Hintz, 2014), or practices for encouraging discussion of students' solutions (Smith & Stein, 2011). See Livy, Downton, and Muir (2017) for examples of how to use student work samples with PSTs.

Beliefs about mathematics includes an awareness of the purpose of mathematics education (Thwaites, Huckstep & Rowland, 2005). Teachers may believe that mathematics is difficult or all about one answer (Liljedahl, 2005), or that all children can learn mathematics and that this can be achieved by helping them to develop a positive growth mind set (Boaler, 2015).

In the past, the Knowledge Quartet has been used with teachers and PSTs (Rowland et al., 2009). It would be expected that MTEs would assist PSTs to develop *foundation knowledge* by reflecting on what they know and need to know for teaching mathematics. Similarly, mathematics leaders can help teachers to extend their *foundation knowledge* by focusing on the key components. Contrastingly, if leaders can also extend their own *foundation knowledge,* this should improve teaching and learning within their school.

In order to document the experiences of a primary school mathematics leader co-teaching in a university setting and to examine the impact on her mathematics knowledge, this study sought to answer the following research question:

How did a co-teacher partnership in teaching mathematics education provide professional learning experiences for a primary school mathematics leader?

Methods

The participant, Mary (pseudonym) was a mathematics leader in her school and also taught a Year 4 class three days per week in a large government primary school. In addition, she held a co-teaching role at a university one day per week during the university semester. Mary was invited by a MTE to participate in a university initiative to improve the quality of teacher education, in response to TEMAG, and as part of the university's initiative of extending relationships with the profession.

Mary and the MTE co-taught a two-hour tutorial once a week to primary PSTs throughout 2017. Following the tutorial, they both wrote individual reflections in a diary, and then met to reflect on their experiences, which were recorded and later transcribed. A weekly reflection question included what Mary had learnt today from the PSTs and the MTE. The third and fourth authors also interviewed Mary twice each semester after observing the co-teaching, collecting additional data as part of the larger project (e.g. Downton, Muir & Livy, 2018). Prior to teaching, the MTE and Mary planned the following week's tutorial. Mary often contributed to the planning and teaching by bringing artefacts such as planning documents or student work samples to share with the PSTs.

Written reflections and transcripts of interviews were coded. The codes of *foundation knowledge* (Rowland et al., 2009) were used to identify evidence of when Mary's personal growth as a teacher and leader enhanced her professional learning (Table 1).

Table 1.
Categories of foundation knowledge related to professional learning.

Codes of foundation knowledge	Example of evidence when reflecting on
Knowledge and understanding of mathematics	Set readings, talking with MTE
Knowledge of mathematics pedagogy	Set readings, trialling lessons with children, listening to and observing the MTE, new resources including websites, questioning skills
Beliefs, why and how mathematics is taught	Participating in discussion with PSTs, planning tutorials, conversations with the MTE

Results and Discussion

Before attending the weekly tutorials, Mary would complete set readings, thereby revising her *theoretical knowledge.* She provided input when co-planning the teaching experiences and like all of us, acknowledged that as teachers we are always learning. When thinking about her reading she stated,

> I read the chapter on ratio, proportion and percentages and it helped me to understand the similarities and difference of ratio and proportion. It also helped me to identify the big ideas and then assist my teachers back at school with their planning giving me ideas for learning activities and student experiences. [Semester 1, week 6, joint reflection with MTE]

The tutorials focused on different topics related to primary mathematics, including number, algebra, measurement, geometry, statistics and probability. Different resources were shared with the PSTs as well as pedagogical approaches.

> I enjoy seeing the Maths300 games in action with the teachers. I take these ideas and her [MTE] questioning techniques into the classroom back at school. By doing this, I am learning new ways of doing things. [Semester 1, week 7, research interview]

During the tutorials Mary had the opportunity to reflect on her own teaching and learning and would often apply the same tutorial ideas and experiences used in the tutorial with her Year 4 students. Tutorial experiences were also capitalised on by teaching and modelling lessons with teachers at her school.

Often before teaching at the university Mary would trial a planned activity with her Year 4 class and bring student work samples to the tutorial, in order to share the experience with the PSTs. For example, in the week prior to the fractions and decimals tutorial, Mary played a colour in decimat game with fraction dice (Roche, 2010) with her students.

At school, Mary met with her staff once a month. She would commence these meetings with an activity she had learnt from participating in the co-teaching. Mary remembered sharing lots of games like the decimat game and other dice games with her teachers, and also introduced the teachers to the talk moves (Kazemi & Hintz, 2014).

Many of Mary's weekly comments and reflections related to her development of knowledge of mathematics pedagogy and beliefs related to why and how mathematics should be taught.

> I'm learning new content as well – [talk moves] I've called them different things in the past revoicing and I called it paraphrasing, those type of things … I made a poster for all my teachers to have in their classroom like we gave the PSTs. [Semester 1, week 8, research interview]

The use of the talk moves impacted on Mary's leadership skills and helped her to consider strategies when conducting her meetings.

> The talk moves are really good for encouraging meaningful conversations and active listening by all participants. I have utilised these talk moves strategies with my classroom and during staff meetings and professional development opportunities such as asking the teachers to turn and talk and share their thinking. This model has taught the teachers at school to vary the ways talk is incorporated in the lesson and strengthened the notion that talk enhances the learning experiences of students. [Semester 1, Week 12, joint reflection with MTE]

Mary also noticed how the teachers were using talk moves in the classrooms, which was evidence of the impact of her learning on the teachers.

> I have noticed on travels observing teaching at school that teachers are using the sentences stems for the talk moves and are attaining great information from the students of their learning. This data could be used for future planning and assessment. [Semester 2, Week 12, individual reflection]

As part of her role and leader of professional learning, Mary spoke about the importance of self-reflection on teacher practice as central to self-improvement. Mary was using an improvement cycle to evaluate, diagnose, prioritise, set goals, develop, plan, implement and monitor better outcomes for students at her school (DET, 2018). She was also able to make connections with the stages of the improvement cycle and what she was learning with the PSTs by applying new pedagogical approaches with her teachers such as talk moves.

> Encouraging talk about maths at school has kept our focus on numeracy, which is a focus for the strategic plan and subsequent annual implementation plan and the self-improvement plan for mathematics. [Semester 2, Week 12, research interview]

Mary also introduced the Knowledge Quartet (Rowland et al., 2009) framework to the teachers at her school.

> The Knowledge Quartet improved the way I focused on my teaching. It was a great model to emphasise the dimensions of teaching – foundation, transformation, connections and contingency. It was a concise model that articulated what I believed was important for teachers to understand. This has been shared with a team of teachers who are new to the profession and one experienced teacher. [Semester 2, Week 12, research interview]

Hands on materials were regularly used during tutorials to model pedagogical approaches for teaching mathematics that would support children's' conceptual understanding. Other experiences related to the lesson structure of teaching with challenging tasks (e.g., Livy, Muir & Sullivan, 2018) and planning lessons.

> Helping PSTs to unpack learning with the aim to develop deep conceptual understanding for the students was a crucial aspect of the weekly tutorials. On reflection when helping my teachers to plan I stress the importance of helping students to develop conceptual understanding. [Semester 1, week 8, joint reflection with MTE]

When considering her own beliefs about how children learn mathematics, Mary was passionate about considering the child as the centre of learning. She often stated this to the PSTs. As a co-teacher, she would typically and quietly observe the PSTs when they were working in groups. She would listen to their discussion, rather than joining their conversations. Then when addressing the whole class, Mary would often refer to what she had heard, acknowledging the PSTs' ideas. When reflecting on this with the MTE she said:

> … I really do feel it's important for the PST or the student to be allowed to work it out on their own because I don't want them to think I've got all the answers. I don't have all the answers, like you I'm learning as well. [Semester 1, week 8, joint reflection with MTE]

Mary expressed surprise at the level of some of the PSTs' mathematical content knowledge. She reflected on their misconceptions when learning measurement:

> I learnt that there was a large variance in their understanding about perimeter, area and volume. I think the way they were taught these concepts – memorisation of a formula played a part in this. [Semester 1, week 8, research interview]

Through noticing and reflecting on the PSTs' mathematical errors and misconceptions, Mary would also consider whether her teachers might have the same misunderstandings, and how she could use this knowledge when working with them. Mary regularly made connections with her co-teaching experiences and leadership role.

> I want to support others and that's been part of my leadership role. I'm supporting other teachers in their journey but to do it in a different context is really, really good for me and I think it develops a richer educator because you're allowing yourself to explore different ways of learning … it's been really, really good because I'm expanding my learning about things that are happening. [Semester 2, Week 12, research interview]

The professional conversation and informal mentoring related to mathematics teaching and learning with the MTE and PSTs were a highlight of Mary's learning and experiences.

> So, it's really nice because, when [the MTE] discusses something, I go and explore even further but then I'm able to converse with her on a similar level, where I can say, "Okay, now I understand how that works," and then, "This is how we could use it here," and she's [the MTE] very open to that as well which is really good, and she allows me to learn in the tutorial as well. [Semester 1, week 8, research interview]

Mary also valued the co-teaching experience because of the new knowledge she could share with her teaching colleagues at school, and the rich learning she gained from the MTE. Although not gathered as data collection, the interactions between Mary and her staff may have been more significant than in the past. This could be a recommendation for further research. Knowing more would have also increased Mary's confidence as a leader in the school. The teachers may have taken more notice of the ideas and activities that Mary shared because they related to current research and came with authority, because they had been used with the PSTs at university. In other words, they were perceived as important and current. Similarly, after sharing these resources at the university Mary would have developed and extended her understanding of why they were important and how they might help improve practice and teaching at her school.

As a next step and recommendation Mary might consider how she could extend her teachers' use of the Knowledge Quartet as a tool to support their teaching. Many teachers at her school only had five to ten years of teaching experience and five were graduate teachers. The Knowledge Quartet would assist them, like the PSTs to focus on what they know and do when teaching.

Mary's concluding reflection, at the end of the year, shows evidence of her beliefs and impact of the experience as a mathematics leader.

> I think I have maybe grown in confidence. I think often people might say I have a very gentle nature and I do agree. I do have a gentle nature. I don't want to raise my voice and things like that, even in the classroom with the kids, so I've grown in confidence but I feel that this opportunity has allowed me to really show my organisation of things and manage two roles essentially, with my role at school and then my role over here. So, I think it's strengthened me in a number of ways, so that confidence, it helped me which is really good because I think that I do believe that I've got a lot to offer and to have this opportunity is just wonderful for me. I thought wow, that's great that someone thinks that I could do this and allow me the opportunity, it's supported by my school and my leadership team thinks this is a good opportunity for me. So, I think it's been great being here. [Semester 2, Week 12, research interview]

Mary has chosen to continue her co-teaching position in 2019 and is keen to extend her leadership capacity drawing on these and other professional learning opportunities.

Conclusion and Implications for teaching

The co-teaching experience provided the mathematics leader with learning opportunities and professional learning related to her theoretical foundation knowledge. As evident in

Mary's reflections she described how her beliefs and pedagogical knowledge impacted on her learning and how this knowledge was applied in her school. It could be assumed that Mary already had strong mathematical content knowledge, but some experiences may have refreshed what she knew and used when teaching. Mary acknowledged her gentle manner and how this experience assisted her to increase her confidence to share new and existing *foundation knowledge* with greater confidence as a leader in her school. Future studies could extend data collection at a school level by conducting interviews with the leadership team and Mary's teaching colleagues to measure further impact of this collaboration.

The respect, collaboration and partnership between the co-teacher and MTE were also fundamental in the success of Mary's growth in shaping her leadership capacity. Similarly, middle leaders in other studies value informal mentoring (Sexton & Downton, 2014). Although only reporting on one case, which could be considered a limitation of the study, these findings support Fitzgerald's claim that:

> Learning does not typically happen in a vacuum. Experiences are relived, remembered and re-experienced through discussion, critique and critical thinking. Often these acts happen in collaboration with another, who is knowledgeable of the context and the situation (Fitzgerald, 2018, p. 200).

The research outcomes from this small study have shown possible ways that could be adopted by schools and universities to support the professional development of mathematics leaders. When compared to other professional learning, the major benefits of this collaboration were the sustained (weekly) learning over one year that made connections to research based teaching. Given the need for schools to upskill teachers' mathematical knowledge for teaching, finding purposeful learning opportunities for middle leaders is also fundamental for supporting all teachers and improving student outcomes. Similar experiences would also benefit leaders and teachers across other disciplines including primary and secondary teaching. Finally, this experience also provided an opportunity for a mathematics school leader to experience teaching at University level, which may encourage her to consider further study and/or explore this as a career option in the future, thereby extending her learning even further.

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