Shifting pre-service teachers' views of teaching secondary mathematics

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Teacher education programs are pivotal in the professional preparation and formation of pre-service secondary mathematics teachers (PSMTs), but there appears to be a lack of understanding of how best to prepare PSMTs for the profession. The purpose of this study was to examine and monitor changes over time in PSMTs' views about approaches to teaching mathematics in secondary schools, before and after undertaking mathematics teaching methods courses (including practicum teaching). These views included their perceived readiness to teach secondary mathematics, as well as an indication of their likelihood to use particular teaching approaches for mathematics. PSMTs at two Australian universities were surveyed before and after they undertook their respective teaching methods courses, and interviewed upon course completion. Overall, survey data did not indicate a significant change in PSMTs' views of readiness to teach mathematics from either university (N = 61 pre-survey, N = 34 post-survey). An analysis of interview data revealed that PSMTs were not ready to teach secondary mathematics, with their emphasis focused on their mathematical content knowledge and mathematical pedagogical knowledge as areas of requiring improvement. Nearly half of the interviewees reported feeling confident to teach mathematics to lower secondary classes (Years 7-10). Despite these concessions, all interviewed PSMTs outlined at least one area where they had experienced professional growth since commencing a teacher education degree.

Introduction

Focused programs of teacher education for pre-service teachers intending to teach mathematics (PSMTs) are provided by many tertiary institutions. These programs combine both practicum experience and exposure to a range of pedagogical content issues, such as effective teaching approaches. The quality of these programs is influential for PSMTs as they move into employment as beginning teachers (Hine, 2015; Vale & Herbert, 2021). However, recent international studies indicate that much needs to be done to improve Australian students' success in mathematics (Thompson et al., 2020). Unfortunately, there is little agreement about optimum approaches in preparing PSMTs to meet this challenge (Boyd et al., 2009; Cavanagh, 2009; Osana et al., 2006). This conundrum has become a growing field of interest for researchers in education (Hine, 2015). Some researchers have focused on PSMTs' mathematical content knowledge (MCK) (Ball et al., 2008), whilst others have explored their mathematical pedagogical knowledge (MPK) (Harris & Jensz, 2006; Norton, 2010). Less research has focused on the role played by actual teaching experience and PSMTs' teacher mentors in influencing changes in PSMTs' identities as teachers (Hine, 2018; Hine & Thai, 2019; Livy et al., 2016).

The aim of this study was to examine and monitor changes over time in PSMTs' views about employing various teaching approaches and their perceived readiness to teach mathematics in secondary schools before and after undertaking mathematics teaching methods courses (including practicum teaching). To do this, PSMTs at two different Australian universities were surveyed before and after undertaking their respective teaching methods courses, and interviewed upon course completion. This study was guided by the following research questions:

1. What are PSMTs' views about their readiness to employ various approaches to teach mathematics?
2. In what ways, if any, do PSMTs' views about their readiness to teach mathematics change over time through engagement in mathematics methods courses including practicum?
3. What changes, if any, to PSMTs' views about the way mathematics should be taught occur after undertaking methods courses about the teaching of mathematics including practicum?

Literature review

The tertiary provision of teacher education for PSMTs is pivotal in their professional preparation and formation as qualified educators. Despite this acknowledged importance, some authors have pointed to a lack of understanding of how best to prepare teacher education students (Boyd et al., 2009). Also, ongoing debate questions the most appropriate models of teacher education to enhance content knowledge (CK) and pedagogical content knowledge (PCK). Further insight is required regarding how CK and PCK might be best developed in teacher education programs (Cavanagh, 2009; Osana et al., 2006). Over the past two decades the literature base concerning the preparation of PSMTs has been growing steadily (Hine, 2015). Researchers have examined how PSMTs are prepared with specific regard to mathematical content knowledge (MCK) (Ball et al., 2008), MPK (Harris & Jensz, 2006; Norton, 2010) and, to a lesser degree, the impact of the teaching practicum (or professional experience) on professional formation (Hine, 2018; Hine & Thai, 2019; Livy et al., 2016; Norton, 2010). The following review of literature explores PSMTs' views on their readiness to teach mathematics, teaching approaches and the role of teaching practicum.

PSMTs' readiness to teach

One commonly-espoused assumption within teacher education is that PSMTs who successfully complete tertiary mathematics courses, pedagogical (or teaching methods) courses, and practicum experiences should have a high level of MCK, confidence in doing mathematics themselves, as well as sufficient self-efficacy, confidence and skill to teach it (Hine & Thai, 2019; Livy & Herbert, 2013; Norton, 2019). Despite this assumption, some scholars have pointed out that course achievement or performance during a teacher education program may not directly correlate with a readiness to teach (Burghes & Geach, 2011; Tatto et al., 2008). In response to this assertion, various studies have reported on PSMTs' self-perceptions of readiness to undertake a secondary or middle school

mathematics teaching role (Hine, 2015; Hine, 2018; Hine & Thai, 2019; Norton, 2019). Overall, these studies indicate that a majority of participants feel prepared to successfully perform the secondary mathematics they are teaching and possess strategies to teach it.

However, PSMTs' self-reported claims of feeling ready, prepared or confident to teach or do mathematics are offset with various disclosures of not feeling ready, prepared or confident in certain aspects of these central tasks. For instance, Hine (2018) found that as many as half of the PSMT participants sampled disclosed they needed further training in the MCK and MPK required to teach even lower secondary mathematics and a much higher proportion of these participants considered they required additional training in upper secondary mathematics. Norton (2019) investigated the MCK, mathematics confidence and self-efficacy of 99 pre-service middle school mathematics teachers enrolled in a teacher education program, finding that even though the participants' MCK was not strong, they tended to overestimate their mathematical ability when expressing levels of confidence and self-efficacy. Collectively, these key findings suggest that assumptions of readiness to teach during teacher training or following graduation should be treated with caution.

PSMTs' teaching approaches and beliefs

PSMTs often commence teacher education programs with strongly-held beliefs about learning and teaching of mathematics (Cavanagh & Garvey, 2013). However, Leaman and Flanagan (2013) claimed that teacher education programs do not challenge PSMTs' to re-examine their beliefs. These beliefs may typically be influenced by an *apprenticeship of observation* (Lortie, 1975), which describes the conceptions PSMTs develop about teaching as they observe and evaluate the work of teachers during their own time as students. However, as pointed out by Jao (2017), during this apprenticeship PSMTs do not reflect critically upon mathematics teachers' work, nor classroom events. Consequently, teacher education programs need to bridge the gap between pedagogical theory and practice, and to help PSMTs re-examine their beliefs about education through critical reflection (Feiman-Nemser & Norman, 2000; Leaman & Flanagan, 2013).

In addition to beliefs held about teaching, many PSMTs start their teacher education programs having been taught mathematics through traditional teaching approaches (Ebby, 2000; Jao, 2017). Such approaches have been described by Miller (2010, p. 15) to be where teachers "transmit facts, skills, and values to students" following a step-by-step, procedural format and using a textbook to support student learning. As a result of learning mathematics this way, PSMTs can be unfamiliar with alternative pedagogical approaches and tend to prefer to teach mathematics using teacher-centred lessons (Ebby, 2000). Some alternative approaches can include problem-based learning (e.g. Lambros, 2002; Savery, 2006) and inquiry-based learning (e.g. Hine et al., 2021; Li et al., 2010; Towers, 2010).

Swan (2005) investigated the beliefs and practices of secondary mathematics teachers in England, in order to develop and implement innovative professional development approaches. He found that while there were "... a number of teachers with widely differing

beliefs in further education, the predominant practices in GCSE [General Certificate for Secondary Education] classrooms are almost entirely teacher-centred" (p. 69). Additionally, Swan noted that most of the participant teachers reported for various reasons they were constrained to teach mathematics in ways they did not believe. The reasons preventing teachers from implementing student-centred learning approaches included "...a perceived need for syllabus coverage, a lack of suitable resources, the social pressures of the F[urther] E[education] culture and a low expectation of GSCE students to take advantages of these approaches" (Swan, 2005, p. 65). While Ball (1988) maintained that mathematics teachers tend to teach in the way they were taught, other scholars have suggested that teachers' practices also directly influence the beliefs students in their classes hold about mathematics (McLeod, 1992; Mosvold & Fauskanger, 2014).

Practicum

Scholars and educational advisors have noted that the physical and social settings in which pre-service teachers (PSTs) undertake the activity of learning to teach are an integral part of the learning that takes place within them (Le Cornu, 2012; Putnam & Borko, 2000; TEMAG, 2014). Many PSTs consider the professional experience (or practicum) to be a major influence in their teacher education and training (Allen & Wright, 2014; Goos, 2006; Smith & Lev-Ari, 2005). Indeed, practicum can help PSMTs influence the extent to which they feel prepared to teach secondary mathematics, and following critical self-reflection, to establish areas of strength and growth (Hine, 2018; Hine & Thai, 2019). Moreover, Hine (2018) noted that despite PSMTs' claims of feeling ready to teach (and, at the same time, claiming needs of further training in MCK and MPK), their participation in a practicum appears to have positively influenced their self-perceptions of readiness.

However, commentators have highlighted various concerns voiced by PSTs as they simultaneously straddle university pre-service programs and practicum experiences. For instance, PSTs have bemoaned inadequate training for challenges of the classroom (Goos, 2006), and perceived a mismatch between tertiary training and PSTs' classroom experiences (Shane, 2002). In particular, a number of scholars have underscored how PSTs have experienced difficulties when their university content and methods courses are not matched by the approaches found in their practicum school (Cavanagh & Garvey, 2012; Eames & Coll, 2010). As such, while PSTs are regularly exposed to progressive pedagogical approaches at university, they may not observe these approaches on practicum (Oleson & Hora, 2014), and may inadvertently have undesirable teaching practices reinforced (Maynard, 2001). Furthermore, the influence of the mentor teacher cannot be under-estimated (Livy et al., 2016, p. 169), wherein:

> All mentor teachers should facilitate learning by guiding pre-service teachers when they are planning lessons; observing pre-service teachers teaching; providing feedback after the lesson; as well as modelling good practice when teaching primary mathematics lessons.

A mentor teacher who models only traditional approaches may be extremely influential in shifting PSMTs' views about the effectiveness of teaching approaches encouraged at

university, shifting to more traditional teaching practices during practicum and as beginning teachers (Cavanagh & Prescott, 2007). Consequently, PSMTs may simply replicate the kinds of teaching approaches they received in their own schooling without carefully considering alternative approaches (Eames & Coll, 2010; Little & Anderson, 2016; Oleson & Hora, 2014).

Research design and method

The participants in this study were PSMTs from two Australian universities, who were invited to complete two online surveys, and to participate in a single, semi-structured interview. According to Saleh and Bista (2017), online surveys in educational research have become a popular method of data collection because they enable quick responses and are more likely to have a better response rate than paper-based surveys. Interviews were selected as a method of data collection as they strive "to understand the world from the subjects' points of view, to unfold the meaning of people's experiences, to uncover their lived world prior to scientific explanations" (Kvale, 1996, p.1). Using the *Qualtrics* platform, pre- and post- surveys were constructed to identify changes in PSMTs' views about their readiness to teach mathematics as a result of their engagement in teacher education programs in mathematics teaching. Horizon Research (Weiss, Banilower, McMahon & Smith, 2001) had conducted similar research with in-service teachers, so their survey instruments were considered and adapted in the design of the online surveys for this study. The pre-survey consisted of five questions, with four of these directly matched in the post-survey. These four matching questions captured PSMTs' attitudes to mathematics; their readiness to teach it; approaches for teaching mathematics; and priorities for planning and teaching mathematics.

Participants were invited to take part in the survey before (N=61) and after (N=34) one course (i.e. 13-week semester) focused on mathematics teaching methods, and 14 agreed to be interviewed. These teacher education courses included many common features (see Appendix 2), but noteworthy differences in the number of practicum days. Participants from both universities were enrolled in either a Bachelor of Education or Master of Teaching program. At University A all participants attended 27 hours of face-to-face instruction (9 three-hour classes), whereas at University B some participants engaged in 33 hours of face-to-face sessions and others studied online. Appendix 2 shows a comparison of the curriculum content and assessment items for mathematics methods courses offered at each university. Before the data collection process commenced, the project was approved by a Human Research Ethics Committee at the university of each researcher.

This paper reports on a subset of the data from the surveys, focussing on Likert scale survey items related to PSMTs' views of teaching approaches (Question 4) and readiness to teach mathematics (Question 2) (see Appendices 3 and 4). Altogether 61 PSMTs completed the survey at the beginning of a mathematics method course – 31 from University A from a cohort of 36; and 30 from University B out of 54. For the post-survey 15 PSMTs from University A and 19 PSMTs from University B completed the survey. 19 PSMTs completed both the pre-survey and the post-survey. Interviewees responded to the interview questions given in Appendix 1.

Data analysis

Survey data were analysed using a statistical software package (Microsoft *Excel*). Pre- and post- data analysis allowed a comparison of PSMTs' responses to Question 2 and Question 4 before and after engagement in a mathematics methods course and a cross-university comparison of participants' intended use of classroom activities and their views about their readiness to teach secondary mathematics. Descriptive statistics, including means and standard deviations, were calculated for responses to each item from Question 2 (readiness to teach) and Question 4 (teaching approaches) from both the pre- and post-surveys. In addition, t-tests were conducted for each item with a significant p-value less than 0.05 ($p<0.05$). These tests indicated when the item comparison is significantly different, thus providing insights into any differences between the universities' approaches to pre-service secondary mathematics teacher education.

Interview data were first transcribed by the researchers and then responses for each question were analysed for common themes. The researchers followed an analytical framework and guidelines offered by Miles and Huberman (1994), comprising three main components: data reduction, data display, and drawing and verifying conclusions. Each of these components, in turn, involved three main operations: coding, memoing, and developing propositions. After reading through the interview transcriptions, the researchers developed an *a posteriori* coding system and met virtually to discuss codes which could be applied to responses for each question. The researchers coded the transcripts and then met virtually to discuss similarities in their coding. Based on this discussion, consensus was reached and the inter-rater reliability was calculated as 91%. Memoing assisted the researchers to synthesise coded data so that recognisable clusters were generated around one general concept, e.g. *Growth in mathematical knowledge for teaching* (MKT). Based on the coding and memoing processes, the researchers were able to generate propositions about connected sets of statements, reflect on the findings, and draw conclusions about the study.

Findings

An analysis of the items related to readiness to teach in Question 2 and teaching approaches in Question 4 of the pre- and post-surveys, enabled comparison of the responses from each university at the commencement of their course and after their course (see Appendices 3 and 4). This analysis reveals any differences between students' responses according to location. The following results are interpreted to investigate this comparison and explore any differences. Since there were only 19 matched pairs of PSMTs, 10 from University A and 9 from University B, who completed both pre-survey and post-survey, results of a comparison have not been included.

Quantitative data

On Question 2, using a 5-point scale where the options ranged from 'Not at all prepared' (1) to 'Very well prepared' (5), the PSMTs were asked to respond to the question "How

well prepared do you currently feel to do each of the following in your mathematics teaching?" (see Appendix 3). For Question 4, also using a 5-point scale the options ranged from 'Never' (1) to 'Every lesson' (5), PSMTs indicated "How often do you think each of the following should be included in mathematics teaching/classes?" (see Appendix 4). Displayed in Appendices 3 and 4, are the items for each Question (Column 1), the means and standard deviations for the pre-survey instrument (Columns 2 and 3), the means and standard deviations for the post-survey instrument (Columns 4 and 5), and p-values of students' responses from both universities on the pre- and post-survey (Column 6).

The means of the responses to all items on the pre-survey for Question 2 and 4 are similar to the means for each item on the post-survey. The p-values for each item in Questions 2 and 4 all exceed 0.05, indicating that the comparison of the means of the pre-survey responses are not significantly different for these items on the post-survey. Consequently, there was no change in PSMTs' views about their readiness to teach mathematics (Q2), nor in their views about teaching approaches (Q4), before and after engagement in a mathematics education course.

Qualitative data

The interview findings have been arranged and summarised according to the questions asked of participants (Appendix 1).

Growth as mathematics teachers
All participants were able to outline at least one area they had experienced growth in since commencing a teaching degree. For the most part, participants' responses focussed on areas of mathematical knowledge (e.g. MKT, MCK), general pedagogy (Teaching using different approaches, Planning and preparation), and general education (Relationships with staff and students). The area of growth elicited most frequently by participants was that of MKT. To illustrate, one participant stated he had developed most in was:

> My understanding of the content, like I know the content, but knowing how to explain it from the very basics and then scaffolding it up for the students ... you've got to start from the very beginning and scaffold your way up to whatever you want to teach them.

In a similar vein, another participant highlighted how he had grown in MKT but also in curriculum content knowledge (CCK):

> I think [MKT and CCK is] the combination of having to know the content, having to know how to teach the content, having to know the curriculum, and not just for the years you teach. You've got to know how it flows ... from Year 6 right up to Year 12, and how students learn...

Other commonly expressed responses included teaching mathematical content using different instructional approaches (4 of 14), and learning how to plan and prepare lessons during practicum (4 of 14).

Table 1: Responses to Question 1 (Growth as a secondary mathematics teacher)

Code	Relative frequency
Mathematical knowledge for teaching	5 of 14
Teaching using different approaches Planning and preparation on practicum	4 of 14
Teaching for student understanding	3 of 14

Readiness to teach mathematics

A majority of participants expressed they did not feel ready to teach mathematics in terms of their MCK (9 of 14), their MPK (10 of 14), or both their MCK and MPK (8 of 14). To illustrate, one participant noted how he needed to develop both MCK and MPK:

> I know I need to get more content knowledge, particularly in the upper school topics, and it's not just the knowledge, it's more about the understanding and being fluent in it, so I can actually teach the students well, and not just be on their level - I've got to be a step ahead of them.

In addition to these statements about the types of knowledge needed to feel ready, eight participants stated they felt ready to teach lower secondary school (i.e. Years 7-10) classes only. For instance, one participant stated:

> I think I'm more ready to teach lower school; however, I want to develop my content knowledge more for upper school. It's not quite there yet for upper school I don't feel. For lower school, I feel confident - because it was such basic things, I knew the content and how to teach it really well. And [on practicum] when they asked questions I was able to quickly come up with the answer. So if I was [teaching Mathematics] Methods ATAR, maybe if they threw a question at me I wouldn't be as prepared.

Other areas where participants indicated they were not ready included: teaching lower level learners (3); providing a differentiated lesson to engage all learners (2); planning lessons (1); and CCK (1).

Table 2: Responses to Question 2 (Readiness to teach secondary mathematics)

Code	Relative frequency
Not ready - mathematical knowledge for teaching	10 of 14
Not ready - mathematical content knowledge	9 of 14
Ready to teach lower secondary only	6 of 14
Not ready - teaching lower level learners	3 of 14

Changing views

Table 3: Responses to Question 3 (Changing views of mathematics teaching)

Code	Relative frequency
Teaching approaches	9 of 14
Students' negative attitudes towards mathematics	5 of 14
Educational change; Assessment Streaming; Complexity of teaching	2 of 14
Real-world applications Efforts put forth by teachers	1 of 14

All participants were able to identify at least one aspect of their views about teaching and learning mathematics that had changed since commencing the course. Nine participants expressed how their views regarding teaching approaches had changed, supporting their statements with recent practicum experiences. To commence, one mature-aged participant noted how

> [when I was] at school 25-30 years ago, ... I had this mindset that that's how teaching is, very teacher-centric, ... so now it's changed, and I'm starting to question that approach and to see that I'm becoming more student centric.

In a similar vein, another participant expressed a growing awareness of the complexity of teaching mathematics, stating:

> I believe that you come into this degree or profession expecting it to be like sitting in a classroom and writing down equations and giving the answer and stepping through your working ... you don't think about the progression of lessons, the marking side of things, the actual teaching - the way you teach a student who doesn't understand it in the way you understand it. I think it's a lot more deep and broad that you ever expect it to be when you first start.

Approximately one-third of the interviewed participants (5 of 14) mentioned that their views had changed about how to deal with students who held a negative view of mathematics. For example:

> Students who have a dislike of mathematics, and they're coming in with a pre-conceived idea that 'My mum and dad didn't like maths, my sister didn't like maths, I'm not going to like maths ... so changing that for them is probably the hardest part.

Another participant suggested:

> Making sure you give good feedback, positive feedback, and creating that classroom where you inspire students to want to learn mathematics. Because you get a lot of them who - 'I'm not good at maths' - they've been told from a young age they're not good at maths, you don't have a 'maths brain', which we know is silly. So, building that classroom environment where you can include all the students and make them motivated to learn maths.

Additional testimony about participants' changing views focused on assessment (2); the complexity of teaching (2); ability streaming (2); and educational change (2). The use of real-world applications within lessons (1) and acknowledging the effort put forth by teachers (1) were also stated.

Improvements

All participants identified at least one area of their professional teaching which could be improved, with most acknowledging that some or various aspects of their teaching approaches required improvement (Table 4). For the most part, participant testimony focused on finding additional or better ways to explain concepts to students. To illustrate, one participant outlined how his greatest change was:

> Definitely not teaching to the book, [but] teaching to the judging standards in your program instead, was a big thing my mentor teacher told me. They're handy for questions and stuff, but don't follow the book. Follow the judging standards and the program you've created for your semester or for your term.

This quote also demonstrates the influence of the mentor teacher in directing change.

Another participant spoke of how he needed to adjust his lessons to accommodate for students working well below their year level. He noted that for these students, he needed:

> More experience … [in] engaging students in Year 7 and Year 8 who are still at a primary school level of mathematics, and being able to teach those fundamental skills as well as link it to the current concepts so that they're not left behind.

A third participant recalled how his explanations could be improved, especially with regards to helping students make mathematical connections across the domains of number, algebra and geometry:

> Showing kids in all those aspects, rather than 'This is how I learn it, this is the way that makes sense to me, this is how I'm going to teach it'. So, bringing it back to all of them, so having that fluency and understanding of that concept to be able to understand it in the three of them [domains], and being able to portray that to students ... I'm a very visual learner, so geometry works for me and I'll fall back to that rather than showing kids with numbers and algebra.

Five participants mentioned specifically they wished to improve or consolidate aspects of their MCK, in particular that content knowledge required to teach upper school courses well (e.g. methods, specialist).

Table 4: Responses to Question 4 (Areas for improvement)

Code	Relative frequency
Teaching approaches	8 of 14
Mathematical content knowledge - upper school	5 of 14
General pedagogy Behavioural management	4 of 14
Curiculum content knowledge	2 of 14

PSMTs' views about the best methods to teach mathematics

Participants offered a variety of opinions on what they felt are the best methods to teach secondary mathematics (Table 5). To commence, four participants shared that didactic approaches were the best method to be used with lower secondary school and upper secondary school classes. One participant outlined such an approach as

> So with chalk and talk and the 'I do, you do, we do' where you're ... walking through with the students how to approach a problem, you get to do it together with a bit of class discussion ... you give them the opportunity to do it themselves and bring it back...it's more worthwhile than doing individual questions in a chapter rather than the stereotypical lessons ... write down the notes from the chapter ... spend the rest of the lesson doing questions in the chapter, and (a) it burns out the kids … (b) it's just very repetitive.

Table 5: Responses to Question 5 (Best methods to teach mathematics)

Code	Relative frequency
Didactic teaching approaches Collaborative learning approaches Adapt methods to the class	4 of 14
Pedagogy - lower secondary methods Inquiry-based learning	3 of 14
Individual differences catered for	2 of 14

Three participants suggested specific pedagogical methods for teaching lower school students for mathematical learning. As an example, one participant described a typical lower school lesson in her day:

> I found for my classes ... to set four lessons in one. So, you do a routine thing ... they'll come in, they'll sit down, they'll do their mental maths, they've got their revision questions on the board they have to finish. That's the first 15 minutes. The next 15 minutes is where you'll explain something or you do an activity with them. Not necessarily revising, but adding on to what they know now. And then the third activity would be a game that they would do, and then the final activity would be bookwork or a worksheet or something. But that's to keep them engaged ... they knew they couldn't go and do something else, because they knew there was something else next, there was always something that they had to do.

As tabulated in Table 5, a number of participants mentioned that other best methods of teaching mathematics included collaborative learning approaches (4); adapting teaching methods to the class (4); inquiry-based learning (3); and catering for individual differences (2).

The final question gave participants an opportunity to share any final thoughts before the interview concluded. While four participants did not add anything further, others gave a variety of responses. The most commonly offered response was that participants required a better understanding of how to teach remedial learners in lower secondary classes (3 of 14). Building on his response from Question 4 (see above), one participant drew attention to how he would like to

> Have that Year 5, 6, 7 content understanding and content delivery to able to cater for those kids who are struggling is definitely something ... just because you're not always going to get a school where all the classes streamed, especially Year 7 classes.

The sentiments of this response were echoed by two other participants; the final thoughts of seven other participants are summarised in Table 6.

Table 6: Responses to Question 6 (Final comments)

Code	Relative frequency
Remedial learners - lower secondary	3 of 14
Non-traditional approaches Student engagement Calculator PD needed Assessment Mathematical pedagogical knowledge Teacher-student relationships General pedagogy	1 of 14

Discussion

Survey data analysis did not indicate a significant change in the way PSMTs from either university viewed their readiness to teach secondary mathematics. Consequently the conundrum we faced was to attempt to unpack the reasons why this was the case. Firstly, like Norton (2019) we found that at the commencement of their secondary mathematics education studies the PSMTs at both universities considered themselves to be 'somewhat prepared' to undertake the teaching activities listed in Survey Question 2. In the post-survey the PSMTs reported that they were still only 'somewhat prepared' to employ these activities in their teaching, so it appears that the strongly-held beliefs at the commencement of their study of secondary mathematics education had not been sufficiently examined or challenged (Leaman & Flanagan, 2013). It can be seen in Appendix 2 that the content of both courses is similar, with a reliance on published research in mathematics education in the design of the courses at both universities. These courses were designed and prepared independently from each other. The main difference

between the courses was the length of the time the PSMTs spent on practicum (a difference of 35-40 practicum days, depending on University and degree).

If practicum is considered to be fundamentally important in the preparation of PSTs (Le Cornu, 2012), it was surprising to find that the PSMTs at both universities held approximately the same views about readiness to undertake the teaching of mathematics after engagement in secondary mathematics education. The only statistically significant differences occurred on two items: 'Introduce content using open-ended problems or investigations' in accordance with the findings of Lambros (2002). PSMTs from University B were less likely than PSMTs from University A to introduce content in this way ($p=0.034$); and 'Complete reflections on learning' where PSMTs from University B were more likely to employ reflections on learning ($p=0.028$) as suggested by Feiman-Nemser and Norman (2000) and Leaman and Flanagan (2013). It might have been expected that there would be greater differences given University A's much longer practicum component.

Why then was there very little difference between the survey results for the universities? Perhaps the primary focus on practicum is on classroom management, and PSMTs became more aware of the challenges involved in this aspect of teaching over the content and approaches to teaching mathematics (Goos, 2006; Putman, 2009). Another consideration is the prevailing school culture about teaching mathematics (Cavanagh & Prescott, 2007). What approaches to teaching mathematics did they observe and attempt to emulate? Is the difference between the approaches espoused by the university courses in some way at odds with their practicum? The interview responses shed some light on these questions.

Table 2.28 from the *2000 National Survey of Science and Mathematics Education* report (Weiss et al., 2001) showed the percentage of mathematics teachers in eligible schools (Appendix 5) indicating whether they were either 'fairly well prepared' or 'very well prepared' for each task. Some of these items were included in the surveys completed by PSMTs. Together the tabulated data in Appendices 3 and 4 indicate that the PSMTs in this study were much less likely to engage in the activities listed in Appendices 5 and 6 than the teachers from the Horizon report (Weiss et al., 2001).

The aim of this study was to explore PSMTs' views about the best approaches to teach mathematics, and to discern any changes in these views before and after undertaking mathematics teaching methods courses (including practicum teaching). During their university studies, PSMTs at both universities were exposed to a range of innovative research-based practices for teaching mathematics. In our quantitative analysis we found little evidence of change in their views. Apparently university study has done little to challenge these views. The way PSMTs see mathematics taught on practicum and their own previous experience of learning mathematics reinforce their hard-to-shift views on the way mathematics should be taught (Ball, 1988; Cavanagh & Garvey, 2012; Ebby, 2000; Jao, 2017; Leaman & Flanagan, 2013). University courses need to do more than just expose PSMTs to alternative approaches to teaching mathematics.

Future improvements to university courses may include an intentional focus on shifting views of the teaching and learning of mathematics, rather than leaving it to the PSMTs to notice and question the difference between university study and practices they see during practicum. Further research is required into the design of university courses to embed strategies that challenge these strongly held pre-conceptions of mathematics teaching and better support PSMTs whilst on practicum. Perhaps partnerships with mentor teachers, PSMTs and university educators to co-plan some lessons may provide the necessary support, in the way that previous research has shown the effectiveness of teachers working in peer learning teams with the support of a university educator in building teachers' knowledge of mathematical reasoning (Herbert & Bragg, 2021).

A qualitative analysis revealed that for the most part, interviewed PSMTs indicated that they were not ready to teach secondary mathematics. According to their testimony, a majority of PSMTs expressed not feeling ready (or prepared, or confident) in their MPK and MCK (especially in teaching senior secondary content). Nearly half of those interviewed emphasised feeling ready to teach only lower secondary classes. These findings accord with those identified by researchers (Hine, 2018; Hine & Thai, 2019; Weiss et al., 2001; Norton, 2019). PSMTs from University A did not appear to consider themselves more ready to enact the teacher actions listed in the survey than students from University B, despite a substantially longer practicum experience. Such findings underscore past claims that course achievement or performance during a teacher education program may not directly correspond with a readiness to teach (Burghes & Geach, 2011; Tatto et al., 2008).

Despite these concessions of not feeling ready to teach mathematics, all interviewed PSMTs were able to outline at least one area where they had experienced professional growth since commencing their course. Commonly stated experiences of growth were grounded in the domains of teaching (e.g. MKT; Teaching using different approaches; Teaching for student understanding) and planning (Planning and preparation on practicum). Various authors have pointed to the centrality of teaching methods courses in improving PSMTs' self-efficacy, confidence and skills base in teaching mathematics (Hine & Thai, 2019; Livy & Herbert, 2013; Norton, 2019). At the same time, PSMTs' self-reported experiences of growth (and future areas of growth) during practicum is also well supported by scholars (Allen & Wright, 2014; Hine, 2018, Hine & Thai, 2019).

Findings from this research project have significance and benefits for the broader community, the participants themselves, people with whom the participants identify, and researchers. They contribute to a deeper understanding of beginning teachers' views about the nature and teaching of mathematics. Through this deeper understanding of the specific needs of teachers as they transition from university to schools, this study has provided insight into the comparative roles of initial teacher education and schools in fostering the development of the necessary skills, attitudes and knowledge needed for teaching mathematics.

Conclusion

These findings indicate that for PSMTs in two universities, engagement in one teaching methods course appears to have had little impact on their views regarding particular teaching approaches for mathematics in secondary schools (Norton, 2010). Perhaps one teaching methods course is insufficient to change PSMTs' strong, hard-to-shift views based on their own mathematics learning experiences at school (Cavanagh, 2009; Cavanagh & Prescott, 2007). PSMTs are required to have a proven background in mathematics, so they have been successful in learning mathematics from the traditional teaching approaches they had experienced. Perhaps they consider from their own successes in learning in this way, that the traditional approach is the best way to teach mathematics (Cavanagh & Garvey, 2012; Oleson & Hora, 2014). Also, interviewed participants identified various aspects of mathematics teaching they required further training in, including: learning more general pedagogical and behavioural management strategies, being exposed to different teaching approaches, and consolidating both their MCK (especially for upper school courses) and MKT.

Although both courses emphasise reflective practice and attention to State curricula, there are other differences to note. University A's description of content foregrounds lesson planning in preparation for practicum, whereas lesson planning is not mentioned in the description of the curriculum for University B. The differences between the universities on more progressive teaching approaches related to investigations and reflection may be explained by the great difference in the number of practicum days and mentor teacher influence whilst on practicum (Little & Anderson, 2016; Livy et al., 2016). The substantially greater number of practicum days may have influenced University A's PSMTs' perceptions on various teaching approaches and subsequently incorporated these perceptions into their views of how often innovative practices should be used (Eames & Coll, 2010). Further research is needed to explore the influence of practicum and mentor teachers on PSMTs' approaches to teaching mathematics.

There are some acknowledged limitations associated with this research. First, the pre- and post-survey items were not paired according to each participant, which limited the extent to which any changes in PSMTs' views could be tracked over time. Second, the survey instrument contained items focused solely on discerning PSMTs' teaching approaches in secondary mathematics. In this way, the instrument did not account for a variety of factors which could foreseeably influence PSMTs' views on teaching, including: the mentorship of a practicum teacher, the instructional guidance of a teacher educator, and the content contained within mathematics content courses.

To conclude, the researchers maintain that teacher education programs are important to the teaching profession. It is an essential part of PSMTs' educational experience that they reflect on their readiness to assume a full-time teaching position with particular regard to their professional training. Based on PSMTs' shared views about the teaching approach(es) they plan to use in a secondary mathematics classroom, university teaching staff are in a unique position to implement change within current educational programs offered.

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Appendix 1: Interview schedule

1. Since commencing your teaching degree, can you describe how you have experienced growth as a mathematics teacher?
2. Please comment on the extent to which you feel ready to teach secondary mathematics.
3. Since commencing your teaching degree, can you comment on the extent to which your beliefs about teaching and learning mathematics have changed? In what way(s)?
4. What areas do you feel you need to improve on before commencing a mathematics teaching position?
5. What do you feel are the best methods to teach secondary mathematics?
6. Is there anything else you would like to comment on?

Appendix 2: Comparing methods courses offered at each university

	University A secondary mathematics curriculum	University B secondary mathematics curriculum
Curriculum	Key topics, strategies and ideas about teaching mathematics in secondary schools are presented and explored. The role of secondary mathematics teachers, effective instructional techniques, and the importance of reflective practice are examined. State and national school curriculum documents are unpacked and applied to lesson planning and forward planning documentation. Pedagogical approaches, assessment practices and the use of resources are considered from an age-appropriate perspective. Following the completion of the course students are expected to apply the knowledge and skills acquired during a formal 10-week practicum, where they will plan, teach, evaluate and reflect upon a program of work.	Informed by findings from research, and guided by the Australian Curriculum. Autonomous student thinking is a focus of attention. A diversity of tasks (from various mathematical domains) are examined. Tasks are then designed and implemented, and reflections upon the learning that occurred are a focus intended to develop the types of thinking of reflective teachers. Many complexities associated with classroom teaching are identified and discussed. Study of assessment techniques focuses on monitoring student progress to promote further learning, assessing students' mathematical performance, and providing opportunities for students to demonstrate they can work mathematically.
Assessment	Task 1 Each student prepares a forward planning document (FPD) comprising 12 consecutive lessons to be taught in a lower secondary mathematics class. The FPD is supplemented by a detailed lesson plan (chosen from the 12 lessons) and a rationale.	Task 1 Each group member individually explores an inquiry question and writes an essay to inform the collaborative design of their group's learning activity for the group's mathematics topic. Engage in the planning and implementation of the activity with subsequent reflection on it.
	Task 2 Each student completes a reflective practicum workbook following practicum.	Task 2 Individual research essay reflecting on teaching practice
Practicum	Undergraduate: 50 days Master of Teaching: 50 days	Undergraduate: 10 days Master of Teaching: 15 days

Appendix 3: Responses to Q 2 on the pre- and post-survey

How well prepared do you currently feel to do each of the following in your mathematics teaching? [5-point scale, range from 'Not at all prepared' = 1 to 'Very well prepared' = 5]	Pre-mean	Pre-SD	Post-mean	Post-SD	Pre-post p-value
Take students' prior understanding into account when planning lessons and teaching.	3.164	0.828	3.366	0.767	0.209
Have students work in cooperative learning groups.	3.433	0.874	3.439	0.867	0.971

Use a range of resources.	3.358	0.883	3.439	0.709	0.621
Teach classes that are mixed (heterogeneous) in terms of mathematics achievement.	3.090	0.900	3.341	0.728	0.133
Teach students who have limited English proficiency.	2.642	0.933	2.537	0.809	0.551
Engage females in mathematics.	3.821	0.851	3.756	0.860	0.703
Engage indigenous students in mathematics	3.075	1.020	2.805	0.928	0.171
Teach mathematics to students with learning disabilities.	2.439	1.025	2.659	0.990	0.279
Use the textbook.	3.761	0.872	3.902	0.970	0.436
Develop students' resilience and persistence in working with mathematical problems.	3.463e ndix	0.859	3.585	0.836	0.468

Appendix 4: Responses to Q 4 on the pre- and post-survey

How often do you think each of the following should be included in mathematics teaching/classes? [5-point scale, range from 'Never' = 1 to 'Every lesson' = 5]	Pre-mean	Pre-SD	Post-mean	Post-SD	Pre-post p-value
Introduce content using open-ended problems or investigations	3.049	0.845	3.118	0.686	0.687
Engage the whole class in discussions	3.951	0.884	4.059	0.776	0.553
Introduce content through formal presentations	3.180	0.885	3.029	0.797	0.412
Work in groups	3.557	0.786	3.588	0.701	0.849
Read/watch other (non-textbook) mathematics-related materials in class, such as online videos	3.000	0.837	2.912	0.668	0.599
Practice routine computations/algorithms	3.361	0.876	3.559	0.824	0.283
Design and work on their own extended mathematics investigation or project	2.525	0.788	2.394	0.747	0.437
Complete textbook or worksheet exercises	3.467	0.833	3.676	0.806	0.238
Complete reflections on learning	3.098	1.076	3.382	1.101	0.224
Undertake self-assessment tasks	2.932	0.868	3.118	0.844	0.319
Make formal presentations to the rest of the class	2.311	0.886	2.206	0.770	0.561

Appendix 5: Comparing Q 2 post-survey with the *Horizon Report*

Horizon Report: Weiss et al. (2001).

Survey item	% PSTs	% teachers Grades 5-8	% teachers Grades 9-12
Take students' prior understanding into account when planning lessons and teaching	49	86	85
Have students work in cooperative learning groups	54	85	76
Teach classes that are mixed (heterogeneous) in terms of mathematics achievement	39	81	73
Teach students who have limited English proficiency	12	26	18
Engage females in mathematics	63	96	94
Engage indigenous students in mathematics	24	88	86

Appendix 6: Comparing Q 4 post-survey with the *Horizon Report*

Horizon Report: Weiss et al. (2001).

Survey item	% PSTs	% teachers Grades 5-8	% teachers Grades 9-12
Introduce content using open-ended problems or investigations	31	67	61
Require students to explain their reasoning when giving an answer	89	95	92
Work on tasks that integrate mathematics with other disciplines	17	78	68
Use digital tools to investigate mathematical concepts	29	57	75

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