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Readiness to Teach Secondary Mathematics: A Study of Pre-Service Mathematics Teachers' Self-Perceptions

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This study evaluated pre-service teachers' (PSMTs) perceptions of their own readiness to teach secondary mathematics. The study was conducted at an Australian university across two campuses, in different states. Specifically, PSMTs' perceptions of their preparedness were explored in terms of mathematical content knowledge, pedagogical content knowledge, and mathematical knowledge for teaching. Findings indicate that while the majority of participants feel that they have the requisite content knowledge to confidently teach Lower School secondary mathematics, further training is required to develop their content and pedagogical knowledge, especially for upper secondary mathematics.

Scholars have argued that the pre-service, secondary mathematics teachers (PSMTs) must possess a substantial level of both mathematical content and pedagogical knowledge (Ball, 2008; Schoenfeld & Kilpatrick, 2008; Norton, 2010). Similarly, the professional experience (or practicum) is also considered essential for pre-service teachers' training, and instrumental in developing their overall teaching craft, perspective and philosophy (Cox et al., 2013). This study builds on a previous study, which explored pre-service teachers who were completing a Graduate Diploma of Secondary Education (GDE) and their self-perceptions of readiness to teach secondary mathematics (Hine, 2015). In this study, we extended the scope of this previous work by evaluating students enrolled in a GDE, Master of Secondary Teaching (MTeach), and Bachelor of Secondary Education (BEde) programs across two university campuses, situated in different states in Australia. This study used semi-structured qualitative interviews to support survey-generated data.

Research Aims and Significance

This research project has two specific aims. The first aim is to investigate the self-perceptions of PSMTs as they prepare to teach mathematics for the first time. The second aim is to explore how these PSMTs understand and perceive their 'readiness' to undertake this role, by analysing their self-perceptions against key themes presented in the theoretical framework. The significance of this research lies in the assumption that current tertiary education courses adequately prepare students for a secondary mathematics teaching role, and that research into this area can strengthen future efforts in preparing PSMTs.

Theoretical Framework

Three interrelated themes form the theoretical framework for this research, namely: Mathematical Content Knowledge (MCK), Mathematical Pedagogical Knowledge (MPK), and the domains of Mathematical Knowledge for Teaching (MKT). These themes are now explored within the context of preparing PSMTs for the teaching profession.

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Mathematical Content Knowledge (MCK)

There is a substantive literature base to support the claim that knowledge of mathematical content is central to its teaching (Norton, 2010). Ma (1999) contended that such knowledge is concerned with the depth, breadth, connectedness, and thoroughness of mathematical concepts and theory. Additionally, Schoenfeld and Kilpatrick (2008) asserted that proficient mathematics teachers possess a broad and deep knowledge of the mathematics taught at school level, as well as knowing multiple methods of representation and how ideas develop from conceptual understanding. Empirical studies have suggested strongly that the knowledge of mathematics teachers positively affects student achievement (Baumert et al., 2010; Campbell et al., 2014). In this paper, MCK is defined as knowledge related to or underlying the secondary school mathematics content assessed at Years 7-12.

Pedagogical Content Knowledge (PCK)

Following extensive research on the relationship between teachers' mathematical content knowledge and their ability to teach, there is clear and growing evidence to support a positive association on this relationship (Ball et al., 2005; Ma, 1999). Scholars have suggested that teachers require a development of PCK, which has been described as an intersection of subject knowledge and pedagogical knowledge (Delaney et al., 2008). For this study, PCK can be understood as knowing a variety of ways to present mathematical content and assisting students in deepening their understanding of mathematics (Ma). More recently, the profound knowledge of mathematics and methods of representing it to students has been described as MKT (Delaney et al.).

Domains of Mathematical Knowledge for Teaching (MKT)

In light of Shulman's proposal that teaching knowledge is a complex, multi-dimensional construct (1999), Ball et al. (2008) analysed extensively the work of mathematics teachers and hypothesised a conceptual framework for MKT. As represented in Table 1, this framework comprises two overarching domains, Subject Matter Knowledge and PCK, each of which are comprised of three sub-domains. Subject Matter Knowledge comprises the sub-domains: Common Content Knowledge (CCK), Specialised Content Knowledge (SCK), and Horizon Content Knowledge (HCK). PCK consists of the sub-domains Knowledge of Content and Students (KCS), Knowledge of Content and Teaching (KCT), and Knowledge of Content and Curriculum (KCC).

Table 1
Domains of MKT. Adapted from Ball et al. (2008, p. 403)

Subject Matter Knowledge	Pedagogical Content Knowledge
Common Content Knowledge (CCK)	Knowledge of Content and Students (KCS)
Specialised Content Knowledge (SCK)	Knowledge of Content and Teaching (KCT)
Horizon Content Knowledge (HCK)	Knowledge of Content and Curriculum (KCC)

Methodology

Methods

This study was interpretive in nature and used qualitative research methods to collect and analyse data about how PSMTs perceived their readiness to teach secondary mathematics. For this investigation, the researchers developed and used two online, qualitative surveys and semi-structured qualitative interviews to collect data from participants. Participants were asked to respond to a ten-item survey prior to commencing a teaching practicum experience. Immediately following the teaching practicum experience, the participants were asked to respond once more to the same survey. Then, both researchers invited all participants to participate in a semi-structured interview. In this manner, the researcher was able to determine the extent to which any of the participants' self-perceptions of readiness had changed following their experience in the classroom. The survey items and interview questions are included within this section.

Research Participants

The entire student cohort enrolled in courses for secondary mathematics pedagogy at the one Australian university was invited to participate in the research. Specifically, of the 53 students enrolled in these courses across both campuses, 20 elected to participate in the pre-practicum survey, 14 in the post-practicum survey, and six participated in the interview. The demographic details of the survey and interview participants are included in Table 2. PSMTs in the GDE and MTeach completed a two-week practicum. Across the four-year degree, BEd students complete eight mathematics content courses and a mathematics pedagogy course, or six mathematics content courses and two mathematics pedagogy courses, and undertake four practicum experiences totalling 32 weeks in schools.

Table 2

Summary of Participants' Demographic Data

Pre-Practicum Survey Participants [n=20]	Gender	Age	Degree	Major	Specialisation
	13 Female	17-25 = 14	GDE = 8	Math = 11	Math = 9
	7 Male	26-35 = 4	MTeach = 2	Science = 5	Science = 7
		36-45 = 2	BEd = 10	Other = 4	Other = 4
Post-Practicum Survey Participants [n=14]	Gender	Age	Degree	Major	Specialisation
	7 Female	17-25 = 9	GDE = 7	Math = 7	Math = 7
	7 Male	26-35 = 5	MTeach = 1	Science = 3	Science = 5
			BEd = 6	Other = 4	Other = 2
Interview Participants [n=6]	Gender	Age	Degree	Major	Specialisation
	5 Female	17-25 = 6	GDE = 3	Math = 5	Other = 5
	1 Male		BEd = 3	Science = 1	Math = 1

Survey and Interview Items

Nine items comprised the pre-practicum and post-practicum surveys of this research. Survey items 1-4 were for participants to indicate specific background information regarding their age, gender, and prior tertiary studies. Survey items 5-9 directly assisted the

researchers in pursuing the specific aims of the research. These items required participants to adopt a critically reflective stance towards their perceived readiness (before & after the practicum) in teaching secondary mathematics. The interview schedule was comprised of survey items 5-9. The research participants had been furnished with the terms *MCK* and *MPK* in their mathematics pedagogy courses.

5. Describe your readiness to teach secondary mathematics students in terms of the mathematical content knowledge and skills you currently possess.
6. In what area(s) of mathematical content knowledge do you feel you require further training?
7. Describe your readiness to teach secondary mathematics students in terms of the mathematical pedagogical knowledge and skills you currently possess.
8. In what area(s) of mathematical pedagogical knowledge do you feel you require further training?
9. Overall, describe your readiness to teach mathematics to secondary students.

Data Analysis Process

The researchers analysed qualitative data collected from the pre-practicum and post-practicum surveys (items 5 - 10) and interviews according to a framework offered by Miles and Huberman (1994) which comprises the three components: data reduction, data display, and drawing and verifying conclusions. Within each of these components the researchers executed the following operations: coding, memoing, and developing propositions. Codes developed by the researchers were attached to gathered data via pre-practicum surveys, post-practicum surveys, and interviews, and were selected from those data based on their meaning. In particular, the codes were developed according to the domains of MKT (Ball et al., 2008) which are delineated in Table 1.

Findings

The key findings of this research have been generated exclusively by participant responses from the surveys and interviews. Overall, PSMTs responses suggested a self-perceived degree of readiness within the themes of MCK and MPK. These findings have been summarised in tabulated and discursive formats, and in alignment with the six domains of MKT. Findings from post-practicum interviews are also included.

Mathematical Content Knowledge - Readiness

Nearly all of the PSMTs stated they felt ready to teach mathematics before the practicum experience (17 of 20). One participant (who had CCK, SCK and HCK) stated

I feel confident to teach the content of secondary mathematics. I have recently completed mathematics content units which I did not find difficult. I feel I have a good conceptual understanding of the different mathematical concepts I will be required to teach and feel confident that I will easily be able to 'brush up' on any topics (if need be) before I am required to teach them.

Following the practicum, all PSMTs (14 of 14) declared they were ready to teach in terms of their MCK. Specifically, all participants stated that they had CCK, and many of these expressed feeling confident in teaching Lower School classes (i.e. Years 7-10) only. Herein one participant (who had CCK) described

[I feel] Good overall although there were some topics in Year 11 and Year 12 classes that I had not seen for a long time. I think that I'll need to take the time to learn this content properly and master it.

Things like matrices, some parts of vectors, proofs and pieces of calculus. I'm ready overall, and really ready for Lower School classes.

The reported self-perceptions of PSMTs' readiness in MCK are displayed in Table 3.

Table 3

Mathematical Content Knowledge – Perceived Readiness

Pre-Practicum	Relative Frequency	Post-Practicum	Relative Frequency
I Feel Prepared	17 of 20	I Feel Prepared	14 of 14
I Have CCK	19 of 20	I Have CCK	14 of 14
I Have SCK	7 of 20	I Have SCK	3 of 14
I Have HCK	1 of 20	I Have HCK	0 of 14

Mathematical Content Knowledge – Further Training Needed

Before the practicum, all PSMTs were able to identify an aspect of their MCK that they required further training (see Table 4). In particular, most PSMTs identified these aspects as HCK (20) and SCK (17). One participant (who needed SCK & HCK) reflected

I need to consolidate my content knowledge especially for the advanced classes. Year 8 content knowledge I'm fine, it's probably everything for Year 9 and Year 10 advanced classes that I need to practise. Things like algebra, probability trig[onometry], indices and especially the harder examples.

Similar to pre-practicum responses, the PSMTs continued to focus on HCK and SCK as areas for further training post-practicum. For example, one PSMT (who needs HCK) stated “I feel as though I only need further training with Extension content as I have never taught an Extension class, and only had the opportunity to observe one”. Another PSMT (who needed SCK & HCK) listed various curriculum topics: “I will need to refresh the higher skills of calculus, trig[onometric] relationships, geometry, matrices, and linear algebra”.

Table 4

Mathematical Content Knowledge – Further Training Needed

Pre-Practicum	Relative Frequency	Post-Practicum	Relative Frequency
I Need HCK	20 of 20	I Need HCK	13 of 14
I Need SCK	17 of 20	I Need SCK	11 of 14
I Need CCK	1 of 20	I Need CCK	5 of 14
I Need None	0 of 20	I Need None	1 of 14

Mathematical Pedagogical Knowledge - Readiness

A majority of PSMTs (17 of 20) claimed they felt ready to teach in terms of their MPK, particularly with regards to KCS. From those who expressed that they felt prepared, one participant (who has KCS) stated

Coming from a high school education where it was...based off the 'chalk and talk' style of teaching, I felt I did not have as much knowledge on different pedagogical skills and knowledge that can be used to engage students in mathematics. Coming to university...taught me there are many different ways mathematics should be taught to students...I feel much more ready after doing some units.

After the practicum experience, 13 of 14 PSMTs expressed feeling ready, and particularly in terms of their KCS. One participant (who had KCS) stated

I'm pretty happy with my teaching so far. I felt I was learning new things each week with my classes, like how to break down concepts so that the younger school students can understand better. My mentor was really helpful in showing me how to make a lesson engaging for younger students, like splitting up the activities, getting students involved, and checking work.

A summary of PSMTs' self-perceptions of readiness in MPK is presented in Table 5.

Table 5

Mathematical Pedagogical Knowledge – Perceived Readiness

Pre-Practicum	Relative Frequency	Post-Practicum	Relative Frequency
I Feel Prepared	17 of 20	I Feel Prepared	13 of 14
I Have KCS	17 of 20	I Have KCS	13 of 14
I Have KCT	2 of 20	I Have KCT	1 of 14
I Have KCC	0 of 20	I Have KCC	0 of 14

Mathematical Pedagogical Knowledge - Further Training Needed

Prior to the practicum experience, 17 PSMTs identified a need for further MPK training. Moreover, a majority of these expressed they required KCS, KCT or KCC (or any combination of these domains). One PSMT (who needs KCS, KCT & KCC) wished to become more proficient in “Diversifying the teaching of the content. If it is explained one way and students do not understand, how do you change your thought process to adapt and meet their requirements?” Following the practicum, all participants nominated something to work on, pedagogically speaking. One PSMT (who needs KCC & KCT) stated

I think that learning how to be more creative with lessons so it's not the same kind of lesson each time. I did try to avoid this so the students wouldn't get too bored but planning huge and exciting lessons takes so much time! Finding new or different ways to help students connect their knowledge to new ideas would also be helpful.

A summary of PSMTs' response for further MPK training is presented in Table 6.

Table 6

Mathematical Pedagogical Knowledge – Further Training Needed

Pre-Practicum	Relative Frequency	Post-Practicum	Relative Frequency
I Need KCC	17 of 20	I Need KCC	14 of 14
I Need KCT	17 of 20	I Need KCT	14 of 14
I Need KCS	11 of 20	I Need KCS	1 of 14

Overall Readiness to Teach Secondary Mathematics

Nearly all PSMTs stated that they felt ready to teach secondary mathematics prior to the practicum experience (18 of 20). Such assertions of readiness were conditional, however; over half of those PSMTs stated they needed to develop elements of their MCK, MPK or both of these knowledge domains. For instance, one PSMT (needing SCK & HCK) qualified her self-perception of readiness with “Lower secondary I feel 90% confident. Upper secondary I do not feel confident at all, maybe 40% at that. I could learn the content the night before the lesson. I am aware that this is not good going into prac[ticum]”. Following the practicum, an overwhelming proportion averred feeling prepared to teach (13 of 14). Again, all of these responses were qualified with an expressed need for PSMTs to develop professionally in MCK and MPK domains. While one participant expressed how he was “Itching to get started”, another (who needed SCK & HCK) stated “Overall, I feel as though I am quite ready to teach in secondary schools. There are definitely a few gaps [in my content knowledge] but nothing that I don't think won't be sorted out after a year or two of teaching in my own classroom”. Approximately half of the pre- and post-practicum cohorts reported feeling ready to teach Lower School classes but conceded that elements of their MCK and MPK for Upper School courses required improvement (see Table 7 for a summary of participant responses).

Table 7

Overall Readiness to Teach Secondary Mathematics

Pre-Practicum	Relative Frequency	Post-Practicum	Relative Frequency
I Feel Prepared	18 of 20	I Feel Prepared	13 of 14
I Need KCT	14 of 20	I Need SCK	7 of 14
I Need KCC	13 of 20	I Need HCK	7 of 14
I Need HCK	12 of 20	I Need KCC	3 of 14
I Need SCK	11 of 20	I Need KCS	2 of 14

Discussion and Conclusion

Findings in this study supports previous findings and revealed that PSMTs are generally confident in their ability to teach lower secondary school mathematics (Years 7-10). However, many are still working towards developing the SCK and HCK required to teach upper secondary mathematics, especially Specialist/Extension courses (Tables 3 & 4). While the majority claimed to be ready to teach secondary mathematics to varying degrees prior to the practicum (17 of 20), all 14 participants in the post-practicum survey indicated that they possess the requisite MCK to teach lower secondary mathematics. Therefore, these claims suggest that participation in the pedagogical unit of study or the practicum positively influenced PSMTs self-perception of readiness with regards to having the necessary content knowledge, at least for teaching Years 7-10. There was also a shift in students' self-perceptions regarding the level of content knowledge that they possess post-

practicum. Before the practicum 7 of 20 students indicated they had sufficient SCK and 1 of 20 had HCK. Following the practicum only 3 of 14 students indicated that they have SCK and none for HCK (Table 3). This change is surprising, as many participants have completed up to second-year tertiary or higher levels of mathematics, which surpass even the highest level of secondary mathematics. A potential explanation for this self-perceived lack of SCK and HCK post-practicum could be that PSMTs have not yet mastered these mathematical skills and content knowledge, and therefore do not feel confident teaching it.

It is also possible that PSMTs' lack of confidence to teach upper secondary mathematics is compounded by their self-perceived MPK. Indeed, 17 of 20 students claimed to possess the requisite MPK to teach Years 7-10 prior to the practicum, which increased to 13 of 14 in the post-practicum survey (Table 5). All 14 participants in the post-practicum survey indicated that they lack the MPK to effectively teach Years 11 and 12, especially the Specialist/Extension courses (Table 6). Some common explanations offered by interviewees for this self-perceived deficiency included limited exposure to upper secondary classes during their practicum, an expressed need to develop MCK, or not seeing a direct link between university level mathematics and what is covered in the upper secondary mathematics syllabus. Overall, this study revealed that PSMTs perceive themselves to be ready to teach Years 7-10; however, more support is required for the development of their MPK and mastery of MCK to teach upper secondary mathematics.

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