

2015

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This article was originally published as:

Hine, G. S. (2015). Self-perceptions of pre-service mathematics teachers completing a Graduate Diploma of Secondary Education. *Issues in Educational Research*, 25 (4), 480-500.

Original article available here:

<http://www.iier.org.au/iier25/hine.pdf>

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Self-perceptions of pre-service mathematics teachers completing a Graduate Diploma of Secondary Education

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This qualitative research project explored the self-perceptions of pre-service secondary mathematics teachers completing a Graduate Diploma of Secondary Education. Specifically, the researcher investigated the extent to which teachers perceived their readiness to commence a secondary mathematics teaching position. The project relied principally on the use of a single, 10-item, qualitative research instrument that was used repeatedly and flexibly over time. Participants were asked to complete two questionnaires; one was administered before and after their Teaching Internship Practicum. Responses from all participants indicated varying degrees of readiness to teach secondary mathematics. An analysis of participant responses suggests three key findings: pre-service teachers require further training in mathematical content, particularly in upper school content; pre-service teachers require additional training in mathematical pedagogy; and the practicum experience confirmed initial participant perceptions of teaching readiness.

Introduction

The coursework required of pre-service secondary mathematics teachers has been discussed extensively within the mathematics education community (Cox et al., 2013). Typically, secondary mathematics teacher education programs require pre-service teachers to complete a mathematics major, or the equivalent (Artzt et al., 2011; Conference Board of the Mathematical Sciences (CBMS), 2001). Such training allows pre-service teachers to engage deeply with mathematical content, which is considered essential for mathematics teaching (Miller & Davidson, 2006; Masters, 2009; Norton, 2010). Also discussed widely is the quality of pedagogical coursework offered within teacher education programs (Cox et al.), where pre-service teachers learn a variety of ways to represent mathematical content and to assist students in deepening their understanding (Ma, 1999; Shulman, 1987, 1999; Silvernam & Thomson, 2008). In addition, the teaching internship (or practicum experience) is an integral aspect of teacher education programs where pre-service teachers undertake the activity of learning to teach (Cox et al.; Putnam & Borko, 2000). Although there is a lack of understanding of how to best prepare pre-service teachers (Boyd et al., 2009), an analysis of Graduate Diploma of Secondary Education (Mathematics) students' self-perceptions may be insightful for future efforts in mathematics teacher formation. For this paper, two aims comprising the purpose of the research will be outlined initially. Then, current literature published on the preparation of pre-service, secondary mathematics teachers will explore three themes undergirding this research: mathematics content, pedagogical content, and practicum experience. The methodology section delineates the central components of context, participants, sample, instrumentation, and data analysis as they pertain to the research. After the key findings have been presented, the discussion section provides interpretive and analytical insight into those findings.

Finally, the conclusion reviews and interprets the findings of the research project in relation to the originally stated purpose of the inquiry.

Purpose of the research

There are two specific aims of this research project. The first is to investigate the self-perceptions of pre-service teachers enrolled in a Graduate Diploma of Secondary Education program as they prepare to teach secondary mathematics for the first time. The second aim is to explore how these pre-service teachers understand and perceive their 'readiness' to undertake such a task, based on their recent tertiary training. Both aims will be examined at all stages of the research project. The significance of this research lies in the belief that the Graduate Diploma of Secondary Education course adequately prepares students for the teaching profession, and that research into this area can strengthen future efforts in preparing pre-service teachers. Specifically, the unit ED SM04/ED SS04: Secondary Teaching Method (Mathematics) has the potential to influence the way pre-service secondary mathematics teachers are professionally and pedagogically prepared for the classroom. This study seeks to address a current gap in the literature by describing the self-perceptions of pre-service teachers preparing to teach secondary mathematics for the first time.

Review of literature

The tertiary training of pre-service teachers is pivotal in their professional preparation and formation as qualified mathematics educators. As some authors have pointed out, there is a lack of understanding of how best to prepare pre-service teachers (Boyd et al., 2009). Within the literature, various commentators have reported that pre-service mathematics teachers require training in mathematical content, mathematics pedagogy, and adequate practicum experiences (Cox et al., 2013). These themes are now considered.

Mathematical content

There is almost uniform agreement among researchers that knowledge of mathematical content is central to its teaching (Norton, 2010). Miller and Davidson (2006) asserted that prospective teachers require coursework that focuses on the foundations of the disciplines rather than on studying them to greater depths. Also, ongoing debate questions the most appropriate models of teacher education including the importance of content knowledge and how it might be best developed in teacher education programs (Cavanagh, 2009; Osana et al., 2006). Norton (2010) pointed out that there has been little research conducted on the "level of mathematics understanding that graduates typically bring to teacher preparation and the effect of teacher education courses upon that knowledge base" (2010, p. 66). The importance of teachers' content knowledge has been articulated by the U.S. Department of Education (2008, p. 36): "Teachers must know in detail the mathematical content they are responsible for teaching and its connections to other important mathematics, both prior and beyond the level they are assigned to teach." Masters (2009), in his report on the 2008 Queensland NAPLAN performance (Ministerial

Council on Education, Employment, Training and Youth Affairs [MCEETYA], 2008) similarly noted:

Highly effective teachers have a deep understanding of the subjects they teach. These teachers have studied the content they teach in considerably greater depth than the level at which they currently teach and they have high levels of confidence in the subjects they teach. Their deep content knowledge allows them to focus on teaching underlying methods, concepts, principles and big ideas in a subject, rather than on factual and procedural knowledge alone (p. 4).

Recently the Teacher Education Ministerial Advisory Group (TEMAG) (2014) unanimously agreed that the Australian Professional Standards for Teachers (Professional Standards) are not being effectively applied by teacher education providers. Consequently the TEMAG (2014) suggested providers will be required to select carefully entrants possessing requisite academic skills. Furthermore, pre-service teachers must collect evidence that they demonstrate skills and capabilities for both graduation and employment, in particular a thorough knowledge of content they will go on to teach.

Despite a strong emphasis placed on pre-service teachers' acquisition of mathematical content knowledge, the link between teachers' background knowledge and their students' achievement is at best only mildly positive (Miller & Davison, 2006). To amplify, Ball (1990) found that prospective secondary mathematics teachers had only a cursory understanding of the concepts underlying elementary mathematics. In general, there appears to be no association between the number of advanced mathematics courses a teacher takes and how well his/her students achieve in mathematics (Monk, 1994). Ma (1999) discovered that Chinese teachers, even though they had less formal instruction in mathematics than American teachers, had more profound knowledge of basic mathematics and worked harder at developing effective ways to teach. Several decades ago, Begle (1979) asserted:

It is widely believed that the more a teacher knows about his subject matter, the more effective he will be as a teacher. The empirical literature suggests that this belief needs drastic modification and in fact suggests that once a teacher reaches a certain level of understanding of the subject matter, then further understanding contributes nothing to student achievement. (p. 51).

The Conference Board of the Mathematical Sciences (CBMS) (2001) recommended that pre-service secondary mathematics teachers complete "a 6-hour capstone course connecting their college mathematics courses with high school mathematics" (p. 8). For the purposes of the CBMS survey, a capstone course was defined as a course taken at the conclusion of a program of study for pre-service secondary mathematics teachers that places a primary focus on providing at least one of the following: (1) bridges between upper-level mathematics courses, (2) connections to high school mathematics, (3) additional exposure to mathematics content in which students may be deficient, and/or (4) experiences communicating with and about mathematics (Loe & Rezak, 2006). Banner and Cannon (1997) summarised the critical importance of teacher content knowledge as

follows: “In order to teach they must know what they teach and know how to teach it; and in order to teach effectively, they must know deeply and well” (p. 7).

Mathematical pedagogy

The relationship between teachers’ mathematical content knowledge and their ability to teach has been well researched and there is clear evidence on the positive relationship between them (Ball et al., 2005; Darling-Hammond, 1997; Harris & Jenz, 2006; Ma, 1999; Norton, 2010; Shulman, 1987, 1999). Multiple authors have asserted that teachers require a development of pedagogical content knowledge (PCK), which has been described as an intersection of subject knowledge and pedagogical knowledge (Chick, 2012; Shulman, 1987). In other words, pedagogical content knowledge can be understood as knowing a variety of ways to present mathematical content and to assist students in deepening their understanding (Ma, 1999; Shulman, 1987). The profound knowledge of mathematics and methods of representing it to students has more recently been described as mathematical knowledge for teaching (MKT) (Silverman & Thomson, 2008). Building upon previous work, Shulman (1999) asserted that teaching knowledge is not a simple, uni-dimensional variable. Instead, and at the very least, teacher knowledge ought to include: content knowledge, pedagogical content knowledge, general content knowledge, curriculum knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, purposes and values (Shulman, 1999).

Various commentators herald the importance of reinforcing theory and practice within teacher-education programs (Emerick et al., 2003; Miller & Davidson, 2006; TEMAG, 2014). For instance, the TEMAG (2014, p. xiii) asserted that pre-service teachers must develop a “solid understanding of teaching practices that are proven to make a difference to student learning”. Furthermore, Emerick et al. (2003) argued that high quality teachers must possess both appropriate content knowledge and an ability to communicate effectively to students. Miller and Davidson articulated this claim, stating that “teacher dispositions like collegiality, self-reflection, collaborative and interactive skills, and the ability to adjust personal and professional practice based on reflection are important characteristics of good teachers” (2006, p. 58). Pre-service teachers often begin teacher education programs with strongly held beliefs about teaching and learning (Cavanagh & Garvey, 2012). Their own school experiences exert a powerful influence on their conceptions about the curriculum and how best to teach it, and they invariably want to teach as they were taught (Sherrf & Singer, 2012). This is a critical issue in secondary mathematics because most pre-service teachers have themselves learned mathematics in a traditional manner (Ebby, 2000). Consequently, pre-service teachers are unfamiliar with alternative pedagogical approaches and tend to want to teach very teacher-centred lessons. The situation is exacerbated because rather than challenge pre-service teachers’ prior understandings, some teacher education courses and field experiences have been found to reinforce them (Zeichner, 2010).

Practicum experience

The physical and social settings in which pre-service teachers undertake the activity of learning to teach are an integral part of the learning that takes place within them (Putnam & Borko, 2000; TEMAG, 2014). Goos (2006) shared that an Australian Secondary Principals' Association (ASPA) survey found that "many beginning teachers felt their university pre-service program had not prepared them adequately for the challenges of the classroom, and that their in-school training was far more effective than anything they learned in university classes" (p. 6). In addition, many authors remained critical about the perceived 'mismatch' between the professional training teachers receive and their pre-service classroom experiences. For instance, Shane (2002) highlighted the importance of the learning environment when the reform approach to mathematics teaching taken in the university methods course was not matched by a similarly progressive stance in the practicum school. Others outlined that difficulties with traditional approaches to professional experience programs may relate to the fragmentation of coursework and classroom practice (Eames & Coll, 2010). Consequently, many pre-service teachers encounter difficulty integrating what they are learning at university with what they are experiencing at the school. So, even though pre-service teachers are regularly exposed to progressive pedagogical approaches at university, they nevertheless often shift to more traditional teaching practices as they move into the practicum and begin their teaching career (Cavanagh & Prescott, 2007).

From their own research, Cavanagh and Prescott (2007) reported that the student-teachers' own secondary school experiences bore close resemblances to their practicum observations. As such, these practicum observations served to reinforce this style of teaching as an acceptable and workable model of pedagogy (Cavanagh & Prescott). Wubbels et al. (1997) referred to a didactic teaching-learning-teaching cycle in which teacher education programs did not provide pre-service teachers with opportunities to critically analyse their own schooling. In a similar vein, Chamoso et al. (2012) posited that one crucial element in helping prospective teachers identify some of the shortcomings in traditional teaching practices, and encouraging them to broaden their range of pedagogical approaches, is by engaging in critical reflection on the lessons they observe and teach. In addition, professional experience placements may not provide pre-service teachers with opportunities to observe or teach using student-centred approaches (Cavanagh & Garvey, 2012). Consequently, pre-service teachers may simply replicate the kinds of teaching they received in their own schooling without carefully considering alternative approaches (Eames & Coll, 2010). Eames and Coll (2010) exhorted teacher educators to devise new kinds of professional experience programs that help pre-service teachers integrate theory and practice. These authors suggested that pre-service teachers be given multiple opportunities to experiment with novel teaching approaches different from those they experienced when they were students themselves. In doing so, pre-service teachers may be better able to appreciate the importance of a variety of mathematics pedagogies and reframe their ideas about what constitutes quality learning and teaching (Star & Strickland, 2008).

Methodology

Methods

This study was interpretive in nature, and used qualitative research methods to collect and analyse data about how pre-service, secondary teachers perceived their readiness to teach mathematics. Drawing upon the theoretical perspective of symbolic interactionism, the researcher was able to place himself in the setting of the other, and to consider situations from the point of view of 'the actor'. Procedurally, symbolic interactionism directs investigators to take, to the best of their ability, the standpoint of those being studied (Crotty, 1998). The researcher used two online, qualitative surveys to collect data from research participants. Participants were asked to respond to a ten-item survey (see below) prior to commencing a twelve-week teaching practicum experience. Immediately following the teaching practicum experience, the participants were asked to respond once more to the same survey.

Research context

At The University of Notre Dame Australia pre-service teachers wishing to complete a teaching qualification with a major (8 tertiary mathematics content units needed) or a specialisation (4 tertiary mathematics units needed) in secondary mathematics education must complete the unit EDSM04/EDSS04: Secondary Teaching Method (Mathematics). Typically, students who enrol into this unit are undertaking a Bachelor of Education (Secondary) degree, a Master of Teaching (Secondary) degree, or a Graduate Diploma of Secondary Education. The 20-credit point unit is the only secondary mathematics pedagogy unit offered at the university, and it is run over seven weeks for a total of 21 hours contact time. The unit meets the requirements of the Australian Qualifications Framework (AQF) for secondary teachers, is nationally accredited for initial teacher education programs, and addresses a variety of Australian Institute for Teaching and School Leadership (AITSL) standards (AITSL, 2011).

Within the unit, students complete two assessments: A Forward Planning Document (FPD) and a Practicum Reflective Workbook (PRW). The FPD is comprised of twelve sequential, well-detailed lessons of a particular theme or unit of work in mathematics. Additionally, one lesson from the FPD must be written up in considerable detail and using a Lesson Plan template. The PRW requires pre-service teachers to record observations and reflect upon pedagogical experiences while on a two-week Classroom Immersion Period. Following the annotation of these observations and experiences, pre-service teachers respond to a series of reflective questions regarding mathematical content, mathematical pedagogy, technology, resources, and classroom management. These assessments meet the program standards for initial teacher education programs in Australia. During contact hours, pre-service teachers engage with secondary mathematical pedagogy (both for lower school and upper school students), examine key curriculum and policy documents, and investigate best practice approaches regarding planning, assessment, technology, and resources.

Sample

From the entire student population enrolled in the tertiary unit EDSSM04/EDSS04 Teaching Method: Mathematics, only those enrolled in the Graduate Diploma of Secondary Education were invited to participate in the research. Specifically, of the 20 students enrolled in this unit, 15 were purposively sampled. Of those 15 students, 10 elected to participate in the pre-practicum survey and the post-practicum survey. From the 10 participants, six were male and four were female. The participants' gender and ages, undergraduate majors, and undergraduate minors are displayed in Figures 1, 2 and 3 respectively.

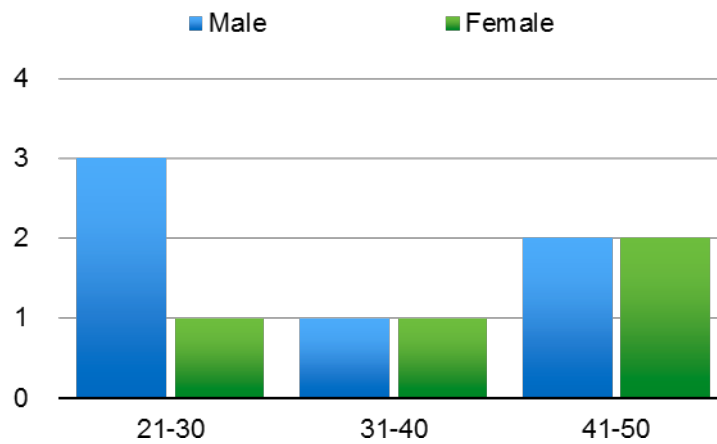


Figure 1: Age of participants

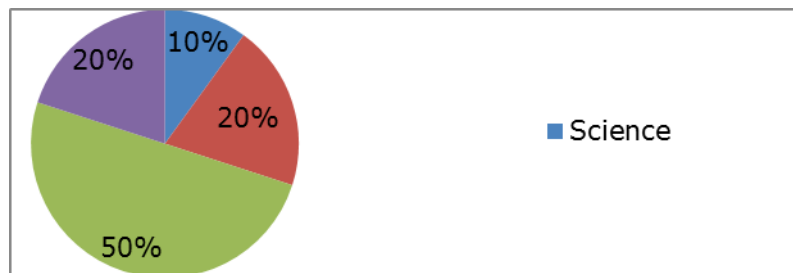


Figure 2: Undergraduate major of participants



Figure 3: Undergraduate minor of participants

Survey items

The pre-practicum and post-practicum surveys comprised 10 items. Items 1 - 4 were included for participants to indicate specific background information regarding their age, gender, and prior tertiary studies. Survey items 5 - 10 directly assisted the researcher in pursuing the specific aims of the research. These items required participants to adopt a critically reflective stance towards their perceived readiness (before and after the practicum) in teaching secondary mathematics. For instance, survey items 5, 7 and 10 required participants to describe the extent to which they felt ready to teach secondary mathematics in terms of their mathematical content knowledge (MCK), PCK and overall. Survey items 6, 8 and 9 asked participants to outline specifically which areas of their mathematical competency (PCK, MCK and overall) could be improved. Although there are well-known frameworks that could have been used in this research, for example self-efficacy (Moriarty, 2014), PCK and TPACK, the researcher elected to devise the following survey items independently. The survey items comprise:

1. What is your gender?
2. What is your major teaching area?
3. What is your specialisation teaching area?
4. Which category below includes your age?
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. As a pre-service, secondary mathematics educator, are there any other areas you would like to receive professional training and development in?
10. Overall, describe your readiness to teach mathematics to secondary students.

Data analysis process

Qualitative data from the ten pre-practicum surveys and ten post-practicum surveys were analysed and explored for common themes. When analysing the data collected from survey items 5 - 10, this project adhered to the framework and guidelines offered by Miles and Huberman (1994). This framework assisted the researcher in identifying relationships among participants' self-perceptions and reflective insights, based on the similarities and differences that connected these proffered statements. The framework itself is comprised of three main components: data reduction, data display, and drawing and verifying conclusions. In turn, these components involve three main operations: coding, memoing, and developing propositions. Within each of the components, the researcher employed a continual process of coding, memoing, and developing propositions. Codes, as Miles and Huberman (1994) explain, "are tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study" (p. 56). These codes were

attached to the data gathered through pre-practicum and post-practicum surveys, and were selected from those data based on their meaning. The researcher then used memoing to synthesise coded data together so that they formed a recognisable cluster grounded within one general concept, e.g. Mathematical Content Knowledge. The memoing process also captured the ongoing thoughts of the researcher as the coding process took place. Finally, the researcher generated propositions about connected sets of statements, reflected on the findings, and drew conclusions about the study.

Findings

Mathematical content knowledge - readiness

All of the participants (10 of 10) indicated that they were prepared to teach secondary school mathematics (to varying degrees) before the 12-week practicum experience commenced. In their responses, participants expressed their preparedness chiefly in terms of mathematics courses and year levels. To illustrate, a number of participants (4 of 10) felt they were ready to teach mathematics only to lower school students. One pre-service teacher expressed her readiness as “I feel as I am ready to teach secondary maths in terms of the mathematical content knowledge and skills, however [I] would feel more confident in the initial years of teaching in Years 7, 8, and 9.” Other participants spoke of certain ‘gaps’ in content knowledge (4 of 10) that would restrict them in teaching upper school mathematics courses. One pre-service teacher disclosed:

I am only now studying the highest level of mathematics that is taught in secondary schools. There are many gaps in my content knowledge, especially in topics that were covered when I was in Year 10-11 and not a very serious student, and also in topics which are not continuously emphasised throughout the school curriculum (such as project networks and some topics in statistics). However I was able to re-learn much of this in detail so that I could teach it during prac[ticum].

Similarly, some participants admitted that there were particular ‘gaps’ in content knowledge (4 of 10) that would restrict them in teaching specialist mathematics courses.

Immediately following the 12-week practicum experience, all of the participants (10 of 10) averred their preparedness to teach secondary school mathematics. This time, three of ten participants intimated a readiness to teach mathematics only to lower school students. Another three of ten participants voiced that ‘gaps’ in content knowledge would restrict them in teaching upper school mathematics courses. For example, one pre-service teacher stated “I have appropriate content knowledge for lower secondary and basic classes in upper secondary. More work is needed to prepare for the likelihood of teaching advanced class in upper secondary.” Additionally, a number of participants (3 of 10) stated that ‘gaps’ in content knowledge that would restrict them in teaching specialist mathematics courses. One pre-service teacher commented “Lower school [content] is good. Some upper school skills require refresh[ing], but overall I am very ready to teach maths to

secondary students up to 3C-3D.” The most commonly reported self-perceptions of mathematical teachers’ content knowledge are shown in Table 1.

Table 1: Mathematical content knowledge: Readiness

Pre-practicum	Relative frequency	Post-practicum	Relative frequency
Prepared	10 of 10	Prepared	10 of 10
Prepared (lower school)	4 of 10	Prepared (lower school)	3 of 10
Prepared (upper school gaps)	4 of 10	Prepared (upper school gaps)	3 of 10
Prepared (specialist gaps)	4 of 10	Prepared (specialist gaps)	3 of 10

Mathematical content knowledge: Further training needed

Prior to the practicum experience, a majority of participants (8 of 10) stated that there were areas of their mathematical content knowledge that required further training. In particular, a number of participants expressed that they required further training in upper school content (5), specialist content (4), and general content (4). One comment echoed by all participants was offered as:

It would be good if there were one of two units earlier in my course which cover upper school mathematics in such a way that I could fill in any gaps in my knowledge about the maths that I now need to teach. I can learn this [content] as I teach but I would feel more prepared if I had some more training beforehand.

Furthermore, most participants (6 out of 10) specified the mathematical topics needed for professional learning. These topics included: calculus, probability, matrices, proofs, and networks. Two participants who had recently completed undergraduate degrees with a major in mathematics asserted that they required no further mathematical content training.

After the practicum experience, a majority of participants (6 out of 10) maintained that there were areas of their mathematical content knowledge that required further training. Specifically, participants avowed that they required further training in upper school content (4), specialist content (4), and general content (2). Again, participants expressed particular mathematical topics required for their own professional learning such as: geometry, differential and integral calculus, trigonometry, probability, quadratics, matrices. After observing upper school lessons on practicum, one participant stressed that she needed support in the content taught in WACE Courses of Study 3A-3D. Four participants stated that they did not need any further training in mathematical content.

The most commonly proffered responses for further mathematical training needed by pre-service teachers are displayed in Table 2.

Table 2: Mathematical content knowledge: Further training needed

Pre-practicum	Relative frequency	Post-practicum	Relative frequency
Upper school content	5 of 10	Upper school content	4 of 10
Specialist content	4 of 10	Specialist content	4 of 10
General content	4 of 10	None	4 of 10
None	2 of 10	General content	2 of 10

Mathematical pedagogical knowledge: Readiness

All participants (10 of 10) claimed that they were prepared to teach secondary mathematics with regard to pedagogical knowledge. To illustrate, one pre-service teacher described her readiness:

I feel I have all the skills (from a pedagogical perspective) because the pedagogical knowledge was dealt with so comprehensively. I particularly valued the shift to teaching mathematics in the context of real life examples (e.g. exploratory) and using student centred [lessons] rather than teacher [centred lessons].

A majority of participants (6 of 10) described how they felt their postgraduate training in general pedagogy had helped them prepare to teach secondary mathematics. For instance, one pre-service teacher asserted

I know a lot of pedagogical theories that I will take into account when planning lessons and teaching, but in practice I can only integrate a few of them into my lessons. I do feel well prepared in terms of general pedagogical knowledge, and I'm looking forward to developing my pedagogical knowledge that is specific to teaching mathematics.

Other commonly proffered responses included feeling confident to apply pedagogical knowledge only to lower school classes (3 of 10) or only to upper school classes (2 of 10). Furthermore, two participants stated that they were ready to teach mathematics but did not feel confident because of a lack of experience.

Following the practicum experience, all participants (10 of 10) reaffirmed they possessed sufficient pedagogical knowledge to teach secondary mathematics. One pre-service

teacher explained how the practicum experience had helped him consolidate his pedagogical knowledge, in that “My skills are relatively strong, [and I] need more repetitiveness so that they become habits. I have picked up many different things to engage with the students and motivate their learning.” A majority of the participants (7 of 10) acknowledged that despite acquiring sufficient pedagogical knowledge to teach secondary mathematics, they wished to develop their pedagogical skills further. For example, one pre-service teacher stated “I am very ready to successfully apply what I have already learned, and my pedagogical skills are constantly growing and evolving. I will need to find a range of ways to develop my skills and to learn more about how to better teach mathematics.” A number of participants offered that they felt confident to apply general pedagogy within secondary mathematics classes (5 of 10), while others disclosed that they required further professional training in using inclusive pedagogical approaches (2 of 10). In contrast to pre-practicum comments, no participants acknowledged a lack of confidence due to teaching inexperience. Participants’ responses regarding mathematical pedagogical knowledge are shown in Table 3.

Table 3: Mathematical pedagogical knowledge: Readiness

Pre-practicum	Relative frequency	Post-practicum	Relative frequency
Prepared	10 of 10	Prepared	10 of 10
General pedagogy	6 of 10	Prepared and developing	7 of 10
Lower school pedagogy	3 of 10	General pedagogy	5 of 10
Upper school pedagogy	2 of 10	Inclusive pedagogy needed	2 of 10

Mathematical pedagogical knowledge: Further training needed

Before the practicum experience, half of the participants (5 of 10) mentioned that they required further training in general pedagogy. Of these five participants, three voiced that further training in mathematical pedagogy was required. For instance, one pre-service teacher acknowledged:

I have learned a lot about Bloom’s *Taxonomy*, constructivism and other broad theories but very little about specific ways of teaching maths. Being creative and observing other teachers’ own techniques are both important but I would feel better prepared to teach mathematics if I could learn more about specific strategies that have been found to be effective when used properly. This sort of information helps me to better evaluate my own ideas and the teaching strategies that I observe.

Another pre-service teacher remarked “I think I require more training on how to formulate a more interesting lesson. I think if we were provided with more examples of interactive lessons across a variety of mathematical areas it would be easier to develop our own variations of interactive lessons.” In addition to statements made about general and mathematical pedagogy, two participants expressed they needed supplementary training in lower school pedagogy. Another two participants stated that they did not need any further training regarding mathematical pedagogical knowledge.

After the practicum experience, a majority of participants (6 of 10) indicated that they required further training in general pedagogy. Five participants mentioned that they needed additional preparation in mathematical pedagogy. A range of statements regarding general pedagogy included a need to “create a learning environment in which every student is engaged”, “learn a few different teaching style ideas, but nothing too major”, and “watch other teachers teach maths and sharing notes with them.” Four participants reported that they did not require any further training concerning mathematical pedagogical knowledge. A number of participants (4 of 10) reflected that they needed supplementary training in lower school pedagogy. One pre-service teacher delineated her professional development needs by stating:

I want to learn how to break down the simple stuff. I am finding when teaching Year 7/8 I assume too much. Many [students] do not know their times tables and so simplifying fractions becomes difficult. Techniques for scaffolding these gaps would be great.

Others stated that they needed professional development to learn ‘techniques’ and ‘ideas’ for teaching lower school students. Participants’ responses regarding further training in mathematical pedagogical knowledge are presented in Table 4.

Table 4: Mathematical pedagogical knowledge: Further training needed

Pre-practicum	Relative frequency	Post-practicum	Relative frequency
General pedagogy	5 of 10	General pedagogy	6 of 10
Mathematical pedagogy	3 of 10	Mathematical pedagogy	5 of 10
No training needed	2 of 10	No training needed	4 of 10
Lower school pedagogy	2 of 10	Lower school pedagogy	4 of 10

Further professional development

All ten participants were able to identify at least one area of professional development that they needed further training in before commencing the practicum experience. The most commonly offered responses included the integration of graphics calculators into lessons (3 of 10), engaging in mathematical content ‘refresher’ courses prior to teaching (3 of 10), learning how to develop original and appropriate resources to facilitate learning (2 of 10), and creating assessments for lower and upper school classes (2 of 10). Immediately following the practicum experience, all participants were again able to identify at least one area of professional development that they needed further training in before assuming a full-time teaching position. The participants reported a variety of responses consisting of the integration of graphics calculators into lessons (5 of 10), undertaking ‘refresher’ courses in mathematical content prior to teaching (4 of 10), learning additional classroom management techniques (2 of 10), and receiving guidance on how to adapt lessons for all students – especially special needs students (2 of 10). The responses for further professional development are displayed in Table 5.

Table 5: Further professional development

Pre-practicum	Relative frequency	Post-practicum	Relative frequency
Graphics calculators	3 of 10	Graphics calculators	5 of 10
General content	3 of 10	General content	4 of 10
Resources	2 of 10	Classroom management	2 of 10
Assessments	2 of 10	Special needs education	2 of 10

Overall readiness to teach mathematics

All participants (10 of 10) reported that they felt prepared to teach secondary mathematics prior to the practicum experience. In a similar vein to responses presented earlier, participants voiced their perceived degree of readiness to teach according to year level and the mathematical content. Specifically, a number of participants shared that they felt prepared to teach lower school classes only (5 of 10), and others (4 of 10) disclosed that they were ready to teach all content from Years 7-12 (but not specialist mathematics). These same 4 participants also shared that they felt comfortable with lower school mathematical pedagogy. To illustrate, one pre-service teacher stated “I would say I am competent in teaching mathematics to Years 7-10 but I think I need a lot of work on teaching strategies.” In addition, 3 of 10 participants described their readiness to teach all content from Years 7-12 (including specialist mathematics).

Following the practicum experience, all participants (10 of 10) affirmed that they were prepared to teach secondary mathematics. Again, participant responses concerning their self-perceived degree of readiness were geared towards year level and the mathematical content. The most commonly offered responses comprised participants asserting their readiness to teach all content from Years 7-12 (but not specialist mathematics) (6 of 10), and asserting their readiness to engage with mathematics pedagogy from Years 7-12 (but not specialist mathematics) (6 of 10). Four participants also expressed confidence to teach all content from Years 7-12 (including specialist mathematics). Additionally, four participants shared that they felt prepared to teach lower school classes only. Participants' responses regarding their overall readiness to teach secondary mathematics are displayed in Table 6.

Table 6: Overall readiness to teach mathematics

Pre-practicum	Relative frequency	Post-practicum	Relative frequency
Prepared (lower school)	5 of 10	Prepared (general content)	6 of 10
Prepared (general content)	4 of 10	Prepared (general pedagogy)	6 of 10
Prepared (specialist content)	3 of 10	Prepared (specialist content)	4 of 10
Prepared (general pedagogy)	3 of 10	Prepared (lower school)	4 of 10

Discussion

Responses from all ten pre-service teachers indicated varying degrees of readiness to teach secondary school mathematics. Specifically, the pre-practicum and post-practicum surveys suggested three key findings: Pre-service teachers require further training in mathematical content, particularly in upper school content; Pre-service teachers require additional training in mathematical pedagogy; and the practicum experience confirmed initial perceptions of teaching readiness. These findings are now discussed.

All pre-service teachers (10 of 10) avowed their readiness to teach secondary mathematics in terms of content knowledge and skills to varying degrees. However, and before the practicum experience, only 4 of 10 pre-service teachers stated a readiness to teach only lower school (Years 7-10) mathematics courses. Following the practicum this number was reduced to 3 of 10. Similar numbers represented participants' self-perceptions that 'gaps' in upper school content (4 of 10 before; 3 of 10 after) and specialist content (4 of 10 before; 3 of 10 after) would restrict their ability to teach those respective courses of study. When pre-service teachers were asked to identify areas of content requiring further

training, the most popular responses included upper school content (5 of 10 before; 4 of 10 after) and specialist content (4 of 10 before; 4 of 10 after). Concerning further professional development, pre-service teachers expressed a need to engage in mathematical content 'refresher' courses prior to teaching (3 of 10 before; 4 of 10 after). When describing their overall readiness, 4 of 10 pre-service teachers expressed confidence teaching all content from Years 7-12 (but not specialist mathematics) before the practicum experience; following the practicum this number grew to 6 of 10. Additionally, fewer than half pre-service teachers (3 of 10 before; 4 of 10 after) described their readiness to teach all content from Years 7-12 (including specialist mathematics).

All pre-service teachers (10 of 10) asserted their readiness to teach secondary mathematics in terms of pedagogical knowledge and skills to varying degrees. For instance, a number of pre-service teachers mentioned they required further training in general pedagogy (6 of 10 before practicum; 5 of 10 after practicum). Following the practicum experience, 7 of 10 participants acknowledged that despite acquiring sufficient pedagogical knowledge to teach secondary mathematics, they wished to further develop their pedagogical acumen. When asked to identify pedagogical training opportunities, pre-service teachers mentioned they required more training in general pedagogy (5 of 10 before; 6 of 10 after) and in mathematical pedagogy (3 of 10 before; 5 of 10 after). A need to engage in further professional development concerning graphics calculators was strongly voiced by pre-service teachers (3 of 10 before; 5 of 10 after). Furthermore, in describing their overall readiness pre-service teachers (3 of 10 before; 6 of 10 after) stated they felt prepared to engage with mathematical pedagogy needed in Years 7-12 (but not specialist mathematics).

To a large extent, the practicum experience confirmed participants' initial perceptions of teaching readiness regarding mathematical content and pedagogy. To illustrate, there was very little change in participants' pre-practicum responses and post-practicum responses (see Tables 1-6). While an examination of the practicum experience was not an explicit focus of the research *per se*, participants offered various comments to suggest that the ten-week internship was valuable in their preparation as secondary mathematics teachers. For instance, the practicum experience was an opportunity for pre-service teachers to learn mathematics content and mathematics pedagogy from mentor teachers. It served as a period where mentors' teaching styles and methods of creating a mathematical learning environment could be discerned. The experience enabled pre-service teachers both to implement teaching strategies learnt in the Graduate Diploma of Secondary Education, and to experiment with methods dissimilar to those from their own mathematical education. Finally, the practicum experience assisted pre-service teachers with the identification and confirmation of mathematical content and pedagogy required for personal, professional development.

Testimony from participants clearly indicated they required additional training in mathematical content before assuming a secondary teaching position (Cannon, 1997; Norton, 2010). Specifically, topics and concepts from upper school mathematics courses were frequently referred to as 'gaps' in mathematical knowledge. Although these participants recollected having learnt those particular topics and concepts in their

undergraduate degree, it was clearly acknowledged that learning the content at a deeper level was essential before confidently teaching it to students (Masters, 2009; Silvernam & Thomson, 2008; U.S. Department of Education, 2008). This is a particularly interesting finding, as students enrolling into the Graduate Diploma of Secondary Education must have completed eight tertiary mathematics units for a teaching major in mathematics, or four tertiary mathematics units for a mathematics specialisation. Two possible explanations are offered to account for these apparent knowledge ‘gaps’. First, 6 of 10 participants were older than 30 years of age, and would have completed their undergraduate degree approximately a decade ago. Second, topics and concepts in mathematical syllabi have changed several times over the last ten years; as such, participants would not have engaged with some content during their undergraduate studies. Participants also highlighted the need for further training in mathematical pedagogy. Together with additional opportunities to learn mathematical content, pre-service teachers saw the development of their own subject knowledge and pedagogical knowledge as critical for successful learning outcomes (Chick, 2012; Shulman, 1987, 1999). Comments from pre-service teachers also indicated a need to “try different things”, “use interesting lessons”, and “finding specific strategies that work” in clearly communicating mathematical concepts to students (Emerick et al., 2003; Miller & Davidson, 2006). Through observing their mentors’ teaching styles, implementing theoretical models learnt at university (Shane, 2002), and using a variety of lessons (Star & Strickland, 2008), pre-service teachers saw the practicum experience as valuable to their engagement with mathematical content and pedagogy (Eames & Coll, 2020; Putnam & Borko, 2000).

Limitations and implications for further research

There are several limitations associated with this research project. First, the project was undertaken at one university with a small number of research participants ($n = 10$). Consequently the researcher is not in a position to generalise the findings from this research to other universities or contexts of mathematics teacher education. The second limitation is that the research concentrated primarily on the self-perceptions and experiences of pre-service teachers. There was no attempt to solicit the viewpoints of other professionals (e.g. mentor teacher, supervising teacher) regarding these teachers’ perceived ‘readiness to teach mathematics’. Additionally, the researcher did not require participants to complete criterion-based, mathematical or pedagogical tasks to support statements regarding preparedness. A third limitation concerns the researcher’s principal reliance on using a single method of data collection. Use of other methods and instruments (e.g. an individual interview) may have assisted the researcher to examine more deeply particular issues *vis-à-vis* readiness to teach secondary mathematics. For instance, an interview could have been used to discern more carefully the inconsistency of participants’ perceptions of readiness to teach against their stated need to develop MCK and PCK.

This research may be replicated and developed further by other researchers interested in secondary mathematics teacher education. Considerations for further research could include developing a two-year, longitudinal study to assess the extent to which pre-service

secondary mathematics teachers feel their tertiary training was useful. Data gathered from such a project could offer insight as to the perceived value of teacher education programs both during tertiary training and the first year of professional appointment. A larger-scale project conducted across multiple tertiary institutions (at state and national levels) could provide valuable information outlining the efficacy of current efforts in preparing secondary mathematics teachers. It may also be practicable to relate participants' self-perceptions to their academic grades (including their Teaching Internship grade) achieved within the Graduate Diploma of Secondary Education

Conclusion and recommendations

This research project investigated the self-perceptions of pre-service teachers enrolled in a Graduate Diploma of Secondary Education program as they prepared to teach secondary mathematics for the first time. Concurrently, the researcher explored how these pre-service teachers understood and perceived their 'readiness' to undertake such a task, based on their recent tertiary training. Despite all participants (10 of 10) asserting feeling ready to teach mathematical content, a majority emphasised that they required additional training in mathematical content, particularly in upper school content. Similarly, all participants stated they felt ready to teach mathematics; however, a significant number articulated a need for further training in mathematical pedagogy. Although it was unclear from the research participants how such needs could be addressed, the author offers three recommendations. First, the author recommends that educational authorities (e.g. Department of Education, Catholic Education Office of Western Australia, Associated Independent Schools of Western Australia) and professional associations (e.g. The Mathematical Association of Western Australia) offer professional development opportunities for beginning secondary mathematics teachers. Such opportunities could be offered to beginning teachers wishing to develop their mathematical content knowledge and mathematical pedagogy knowledge. For instance, the offer of massive open online courses (MOOCs) – which may attract support from funding authorities – could enable flexibility in timing of participation, plus asynchronous group interactions with local peers.

Second, it is recommended that school leaders remain cognisant and supportive of the professional needs of beginning mathematics teachers. To illustrate, certain needs can be met through the exercise of mentorship and induction programs, as well as offering 'release time' for beginning teachers to engage in professional learning opportunities.

Third, the author will use the proffered insights of student participants to strengthen future offerings of the unit EDMS04/EDSS04: Secondary Teaching Method (Mathematics). Tangential to this third recommendation is an opportunity for teacher educators to consider the content of their own tertiary units against the needs of their pre-service mathematics teachers. In light of the findings of this research and building upon the existing literature associated with this genre, these recommendations are aimed at teachers developing a profound mathematical knowledge for teaching (Silvernam & Thomson, 2008).

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Please cite as: Hine, G. S. C. (2015). Self-perceptions of pre-service mathematics teachers completing a Graduate Diploma of Secondary Education. *Issues in Educational Research*, 25(4), 480-500. <http://www.iier.org.au/iier25/hine.pdf>