Sticking together in a world full of sharks: Pre-service teachers' perspectives of mathematics content courses

Secondary mathematics pre-service teachers (PSTs) are required to take university-level mathematics content courses to develop their mathematical content knowledge. Although PSTs' experiences as students play a major role in the types of teachers they become, there is limited research investigating the experiences of PSTs engaging in these courses. Thus, our study used a series of semi-structured interviews to provide first-hand accounts of PSTs' experiences. Findings suggest that PSTs experienced a range of challenges, including difficulties connecting with and understanding course content, and being ignored and dismissed by mathematics instructors. To cope with these challenges, PSTs became reflective practitioners and considered how their experiences in these courses applied to their learning as future teachers. PSTs also developed a community with each other that grew out of needing support with mathematical content, but evolved into collegial friendships. While PSTs were able to find positive features within negative experiences, this study highlights the need to understand PSTs' experiences in these courses so that effective improvements can be made.

Keywords: mathematics content courses, student experience, pre-service teachers, pre-service teacher education, secondary mathematics, university mathematics

Introduction

An important component of being a mathematics teacher is possessing a strong knowledge of mathematics. Specifically, research has demonstrated that teachers' mathematical knowledge has a large impact on their self-efficacy (Gonzalez & Maxwell, 2018) and facility with different instructional methods in the classroom (Ball et al., 2005). Furthermore, mathematical knowledge is critical for teachers to be able to provide depth to their teaching, adapt to different contexts, and make connections within and across disciplines (Ball et al., 2009; Lam et al., 2013; Menon, 2009). As such, many teacher education programs around the world, including those from

jurisdictions with high-performing students, emphasize the development of mathematical knowledge for pre-service teachers (PSTs) (e.g., Cheng, 2011; Ingavarson et al., 2014).

For secondary mathematics PSTs, mathematical knowledge is typically developed through university-level mathematics content courses either taken prior to or concurrently with their teacher education program (Artzt et al., 2011; Speer et al., 2015). Yet, many PSTs encounter major challenges in these courses, and struggle to grasp the material and its relevance to teaching secondary mathematics (Goulding et al., 2003). Further, the experiences that PSTs have in these courses can have an influence on PSTs' career trajectories. Indeed, students' experiences in mathematics content courses have a major impact on how they perceive mathematics teaching and learning and how they relate it to their future work (Hayes, 2002; Hong & Shull, 2010). In other words, for secondary mathematics PSTs, their experiences as students in these courses can play a major role in the types of teachers they become (Goulding et al., 2003).

Though some studies do exist (e.g., Laursen et al., 2016; Nadeau & Proulx, 2013), research exploring secondary mathematics PSTs' experiences in mathematics content courses remains relatively limited. This focus on mathematics content courses is especially significant given the importance of mathematical knowledge. Through first-hand accounts, our study offers a window into the perspectives of PSTs themselves as they experience these courses, to better inform how teacher educators and mathematics instructors[1] can best support PSTs' positive development as mathematics teachers. As such, drawing from a larger study on Canadian secondary mathematics PSTs' experiences in their teacher education program, we explore the question: What are the experiences of these PSTs in their university-level mathematics content

[1] We use the term 'instructor' to refer to the person responsible for teaching the course regardless of their title (e.g., lecturer, professor).

courses? We realize that students' experiences includes how they interact with academic, social, and cultural factors both within and beyond the classroom (Arambewela & Maringe, 2012; Shah & Richardson, 2016). However, to truly prioritize the *students'* experiences, our study attends to the components of this definition that PSTs felt most encompassed their experience in their mathematics content courses.

Literature review: Mathematics content courses

In many countries around the world, teacher education programs require secondary mathematics PSTs to take a certain number of university-level mathematics content courses, as determined by their institutions (e.g., Kim et al., 2011; Liljedahl et al., 2009; National Center on Education and the Economy, 2021; Strutchens et al., 2017). Typically, these courses range across different domains of mathematics including calculus, analysis, statistics, and geometry. In addition, PSTs often have the option to take complementary courses in related areas such as computer science, and the history and philosophy of mathematics. In this section, we present details about mathematics content courses, as they relate to our research context of North America. Specifically, we discuss their rationale and logistics, and background about the instructors who typically teach these courses.

Rationale and logistics

Mathematics content courses are intended for secondary mathematics PSTs to learn how to communicate mathematically by mastering definitions and terminology, explore and make connections across a breadth of mathematics domains, understand what mathematicians do, develop a "big picture" of mathematics, and develop self-confidence in their own mathematical abilities (Hodge et al., 2010; Williams, 2001). The content of these university-level mathematics content courses typically extends beyond the required secondary-level curriculum. Yet, these

courses are still important in providing PSTs with advanced and robust mathematical knowledge - a crucial component of becoming an effective mathematics teacher (Plotz et al., 2013).

Despite their importance, many PSTs experience major issues with respect to mathematics content courses (Ebby, 2000; Ferrini-Mundy & Findell, 2010). Goulding et al. (2003) found that secondary mathematics PSTs often indicate that the first time in their educational careers that they struggled with mathematics was when taking university-level mathematics courses. Generally, PSTs find the content of these courses difficult to grasp (Goulding et al., 2003). Further, PSTs often question the value of these courses in large part due to the perceived irrelevance of the advanced material to their future careers as secondary mathematics teachers (Plotz et al., 2013).

In most cases, mathematics content courses are not only taken by PSTs; other students in the courses, typically comprising the majority of the class population, are usually in Science, Technology, Engineering, or Mathematics (STEM) programs (Dreher et al., 2016; Hodge et al., 2010). For STEM students, many of these courses are "service courses" where the purpose is to equip students with technical skills, and foundational concepts and ideas pertinent to their field of study (e.g., engineering, biology) (Alsina, 2001; Hochmuth, 2020). Yet, given their general nature, students (whether in education or various STEM programs) struggle to find meaning in these courses (Hayes, 2002). Alsina (2001) argues that while there is a myth that mathematics is a context-free discipline, it is incumbent upon instructors to adjust their pedagogical approaches and content to better support student needs and interests. This can be critically important as, in the context of our study, mathematics instructors can play an important role in PSTs' experiences, because they "act as teacher educators de facto" (Leikin et al., 2018, p. 452).

Mathematics instructors

Generally speaking, mathematics content courses are taught by pure and/or applied mathematicians with advanced degrees. These individuals do not often have required formal training in education or pedagogy (Leikin et al., 2018; Oleson & Hora, 2014; Walczyk et al., 2007). While teaching may be a priority for some, the norms and expectations of research-intensive institutions lead many mathematics instructors to focus more on their mathematical scholarship (Bucheit et al., 2001; Chen et al., 2006). Indeed, studies have found that students in university-level mathematics courses have expressed that their instructors appear to be disinterested in teaching their courses (Hong & Shull, 2010; Sierpinska et al., 2008).

Mathematics instructors have traditionally taught in teacher-centred ways that focus primarily on lecture and passive intake of information (Handelsman et al., 2004; Stains et al., 2018). For many instructors, limited educational training and time spent considering their teaching practice results in replicating teaching approaches that mirror how they were taught as students, themselves (Mazur, 2009). While there is a growing number of researchers and practitioners investigating ways to enhance the pedagogy and teaching occurring in these courses (e.g., Dagley et al., 2018; Kogan & Laursen, 2014; Reinholz, 2018), some mathematics instructors are resistant and/or unequipped to engage in the student-centred approaches to teaching that have been shown to have a positive impact on students' learning (Braun et al., 2017; Miller et al., 2020).

Research also indicates that student-instructor relationships have an impact on students' learning (Komarraju et al., 2010; Kuh & Hu, 2001), motivation, perseverance, and self-efficacy (Lynch & Trujillo, 2010; Winberg & Hedman, 2008), and ultimately students' success (Self-Brown & Matthews, 2003). For example, in a study by Hong and Shull (2010), undergraduate engineering students described the relationship with their instructors to be negative. To support

their beliefs, students recounted instances of being "humiliated" when they approached their instructors for help, leaving the students to feel ostracized and unable to rely on their mathematics instructors for support (Hong & Shull, 2010, p. 275). Furthermore, despite continued perceived antagonistic behaviour by the instructors, the students developed a "self-determination" (p. 276) to make it through their courses. There are limited studies that expand on this idea, however, these findings suggest that in some cases, students are able to leverage their negative experiences into motivation to succeed. Nevertheless, because of the dearth of research in this area, it is unclear if a majority of students are, indeed, able to do this.

Ferrini-Mundy and Findell (2010) have called for more research on the learning environment in mathematics content courses, particularly for those who are mathematics majors. Though students who seek to become secondary mathematics teachers are not always mathematics majors in name, we suggest that their experiences, too, deserve exploration. Hence, we sought to investigate secondary mathematics PSTs' experiences in the mathematics content courses component of their program. While there is a small but growing body of literature focused on secondary mathematics PSTs' experiences in mathematics content courses after they have taken them (e.g., Nadeau & Proulx, 2013; Zazkis & Leikin, 2010), there is limited research investigating the experiences of PSTs engaging in these courses during their teacher education program. Further, because the majority of students who participate in university-level mathematics courses are from STEM programs, we suggest that the experiences of PSTs in these courses are unique (Hill et al., 2008) and aim to explore their perspectives further.

Theoretical framework: Situated learning

The learning environment that PSTs engage with during their teacher education programs and their experiences within them can have a profound impact on PSTs' development. For this study,

we use the theoretical lens of situated learning theory which posits that learning takes place in (i.e., is situated in) a particular context (Bell et al., 2013). More specifically, Lave and Wenger (1991) emphasize the social and dynamic nature of learning, suggesting that given a context that is authentic to the learner in question, deeper learning can take place. As it relates to teacher education, Korthagen (2010) suggests that in addition to theoretical learning, PSTs should learn in spaces that approximate, if not authentically reflect, the contexts that they will teach in. This is of particular importance as jurisdictions push towards reform-based pedagogies (e.g., Liu & Li, 2010; National Council of Teachers of Mathematics, 2000; Ontario Ministry of Education, 2020) that PSTs might not have experienced as learners in their K-12 education. Consequently, being able to both observe through instructor modelling and attempt these pedagogies is critical for PSTs' learning (Borko et al., 2008). Indeed, learning for PSTs can take place in the context of field experiences where they, themselves, are teaching (Anderson et al., 1996), but it can also take place during the coursework of their teacher education programs that they experience as both students and prospective teachers.

Yet, for situated learning in teacher education to be fruitful, it is not enough for PSTs to simply experience learning opportunities in authentic contexts for learning to occur. PSTs must also be able to critically reflect on their experiences and relate them to their practice (Cavanagh & McMaster, 2015; Osterman & Kottkamp, 2004). Indeed, researchers have suggested that to bring meaning to the learning that occurs in settings that centre situated learning, critical reflection is vital (Eick et al., 2003; Herrington & Oliver, 1995). Critical reflection is a process where PSTs are "actively engaged in the study of one's practice and the intersection of belief, action, and outcome so that in the future wiser decisions can be made while teaching" (Bullough & Gitlin, 2001, p. 14). By engaging in this work, PSTs are pushed to consider their attitudes and

biases as they make pedagogical decisions (mathematical strategies they use, how they interact with students, etc.), and make connections about themselves as educators, in an effort to continuously improve their practices (Osterman & Kottkamp, 2004). In doing so, particularly in spaces that are authentic to or approximate settings that PSTs will eventually teach in, critical reflection is one means of supporting transformative learning (Liu, 2015). Hence, PSTs must reflect on their own practice when teaching, as well as the learning they are experiencing in context, as in the focus of this study – mathematics content courses.

Methodology

The study took place within the context of a four-year undergraduate concurrent teacher education program (Bachelor of Education) at a large Canadian, research-intensive university. Graduates of the program are certified to teach at the secondary school level and choose one subject as an area of expertise – in the case of our participants, mathematics. The teacher education program is comprised of coursework and school-based field experiences. Courses include subject-specific content courses, subject-specific teaching methods courses, and general education courses taken by all PSTs (e.g., educational psychology, technology in the classroom). Specifically, secondary mathematics PSTs take mathematics content courses with students in other programs of study (e.g., mathematics, sciences). This includes a set of required mathematics content courses (e.g., calculus, geometry, statistics) and choosing elective courses to further contribute to their breadth and depth of content knowledge (e.g., mathematical logic, number theory). Participants for the study were all of the secondary mathematics PSTs in one cohort of the program[2] (N=6).

[2] Mathematics is typically the smallest of the subject areas of specialization in the teacher education program. Other subject areas (e.g., English Language Arts, social studies) may have cohorts upwards of 30 students.

Using an exploratory case methodology (Yin, 2009), qualitative data was collected to explore secondary mathematics PSTs' experiences in their mathematics content courses. This methodology was chosen to allow for the development of a thick description of a complex phenomenon embedded in its real-life context. Specifically, this methodological approach allowed us the opportunity to gain deeper and more nuanced understandings of a particular group's experiences situated in the context of the mathematics content courses, and to follow up with them when necessary. Hence, the data used in this case study came from a series of semi-structured interviews (Gubrium & Holstein, 2001) conducted with the PSTs at the end of each of the fall and winter semesters of their program. These interviews ranged from 60-90 minutes in length based on the availability and interest of the participant. We opted to conduct semi-structured interviews, rather than closed or open-ended, because they allowed for flexibility of questioning within a set framework (Merriam & Tisdell, 2015), and thus, gave us and our participants the opportunity to delve deeper into constant and emerging themes as necessary (Creswell & Guetterman, 2019). In doing so, the integrity of the scope of the research could be maintained while allowing for researcher and participant latitude to explore different ideas in greater depth. During interviews, PSTs were asked to reflect on their experiences from that past semester (e.g., Tell me about the courses that you took this past semester. How did the courses contribute to your development as a secondary mathematics teacher? What was challenging about the courses?). For our study, PSTs were also asked to speak specifically to these experiences within their learning contexts (i.e., mathematics content courses). Interviews were transcribed verbatim, and pseudonyms are used for all participants.

Data analysis of all transcripts were conducted through an iterative process of coding that drew on the constant comparative method (Kolb, 2012; Maykut & Morehouse, 2002). *A priori*

codes were developed based on major ideas from interview questions. These codes were used to analyze transcripts for existing and emerging codes. In this paper, we focus broadly on the idea of "student experience" as defined by the participants, and as it existed within their learning environments. Hence, we looked for converging ideas within the transcripts that related to these students' experiences while leaving room for divergent and/or surprising findings. The initial cycle of coding was done with a word processor where codes were identified within a transcript using features such as highlighting text with different colours and inserting comments. After the first cycle of coding was completed, we discussed findings with the aim of resolving differences before completing a second cycle of coding, now with the assistance of *NVivo 12*. The utility of this program was such that, after coding, we could elucidate common and unique themes within and across the interviews and begin to consolidate into major themes. Because this paper shares data from a larger study, codes that were specific to the focus of this study (i.e., related to mathematics content courses) were consolidated and further analyzed. This consolidation was later solidified through the organization of codes into a table that could be viewed and annotated to ascertain the major themes. Throughout the analysis process, findings were frequently shared and dissected to ensure that, as much as possible, analyses were consistent and rationalized, and themes (discussed in the Findings) were reasonable.

Findings

In this section, we present secondary mathematics PSTs' experiences of mathematics content courses in two parts. First, we describe the challenges faced by PSTs, specifically in relation to the course material, their mathematics instructors, and how these experiences made them feel. Second, we explore the ways PSTs responded to these challenges as reflective practitioners (through observation of their negative and positive experiences with mathematics instructors)

and through the development of a community with their peers.

Challenges faced by PSTs in mathematics content courses

Participants described the mathematics content courses to be difficult for a variety of reasons. Specifically, PSTs shared that they found it challenging to learn course material, experienced difficulties with their mathematics instructors, and felt like outsiders within the discipline.

Difficulties with course material

All PSTs had experienced success in mathematics prior to beginning their teacher education program. However, in the university-level mathematics content courses, many PSTs struggled to grasp the material at the required pace. For example, Ruby said of this challenge, "I was confused. I was genuinely confused because that had never happened to me before. Like, I was always good in math, like why was this hard for me?" The feeling of being confused by the mathematical material coupled with the newness of this feeling was an experience shared by many of the PSTs.

The consequences of these unfamiliar experiences were profound for the PSTs. In addition to making it more difficult to successfully complete individual courses, the PSTs' challenges with mathematical learning also became significant barriers for them when it came to completing their teacher education program. Some PSTs shared that the academic repercussions of struggling to master course material had them reconsider whether they wanted to continue, or if they could ever be successful, in the program. As she continued to speak of her struggles with the mathematics content courses, Ruby shared:

> I failed a course and I remember being like, this is not for me. Like, I remember I told my boyfriend, like, "If I fail one more course, I'm out of this program. I'm out. I'm leaving." Like, that's good-bye. Like, I'm not good enough for this.

Indeed, when PSTs reflected on their teacher education program as a whole, the majority shared that they were just trying to "get through" the mathematics content courses. Domino explained, "I had no motivation, apart from the fact that I really just had to pass it." Most of the PSTs agreed that they simply wanted to "pass" the courses. As Paula said, "That's my goal. Like, that's my number one goal." The PSTs shared that most of them had failed at least one mathematics content course, resulting in them retaking courses in later semesters, which in turn, had consequences on other components of their program (e.g., delaying field experiences). In some instances, PSTs extended their program to complete the required coursework. For example, Paula described how her struggle to successfully complete mathematics content courses derailed her ability to graduate with her peers. She explained,

> I wish I graduated when I was supposed to. I'm also 25, so realistically, if I did everything on time, I could've graduated three years ago. I think about this, but I can't go back in time. This, like, the fact that it's taking me six instead of four years is bothering me more because this is recent, I could've made this not happen but, as of right now, I have like, the plan. I can't change it, so it's the best I can do. In the end, I'll have the degree I wanted to have.

In fact, Paula's challenges with the mathematics content courses led her to switch teachable subjects (i.e., change her specialization from secondary mathematics to another subject area) in order to complete her program. While Paula was willing to explore a new subject area to graduate, the PSTs also spoke of other students who had been part of their cohort but dropped out of the program entirely in their first year in large part due to major struggles they had in their mathematics content courses. As Magda lamented, "the courses being difficult kind of discourages you a bit. I think that's why a lot of people drop out of the program." Indeed, the content courses seemed to be a gatekeeper in the secondary mathematics option of the teacher education program.

In addition to the challenges they faced in trying to understand the mathematical concepts in their coursework, many PSTs felt there was limited value to these courses for them because the mathematics content felt so disconnected from what they would be expected to teach at the secondary level. Regarding the mathematics content courses, Domino noted that, "there's very little that I get that I can apply to high school math", and later added that there was "literally nothing" she felt she could incorporate into her teaching from the courses she had taken up to that point. This sentiment was shared by many of the PSTs throughout the interviews. Although many PSTs shared that the university-level mathematics content could be used to enhance and enrich their secondary students' knowledge, generally speaking, it was clear that the course material was, as Zorra said, "not really part of the [secondary] curriculum". PSTs' struggles with learning the material in addition to not seeing the relevance of the material compounded their negative feelings towards the mathematics content courses. These feelings of frustration were evident in both the PSTs' words and tone throughout the interviews.

Difficulties with mathematics instructors

PSTs described largely negative experiences with their mathematics instructors, with a few exceptions (further elaborated on in a later section). Specifically, PSTs felt that their mathematics instructors exhibited poor teaching practices and more broadly, did not seem to care about teaching.

Throughout the interviews, PSTs critiqued the pedagogical choices of the instructors of their mathematics content courses. For example, PSTs felt that the mathematics instructors simply did not seem to know how (nor did they seem interested in learning how) to teach their courses in effective ways. The PSTs spoke of mathematics instructors not being able to make the content "accessible to the majority of the students" (James) and their inability to "diversify"

(Domino) their lecture-based instruction. Specifically, the PSTs indicated that it seemed as though the mathematics instructors were teaching to a specific subset of the student population. Ruby described how she felt that one of her instructors tailored their course to "two [STEM] students...like geniuses, they were just so intelligent." While some instructors seemed focused on academic prowess, others targeted specific programs of study. For example, Magda shared that it seemed that the instructor "was catering more towards people in physics when it was just supposed to be a general advanced class."

In addition to feeling that mathematics instructors were catering the courses to a subset of students in the class, the PSTs also felt that instructors were more interested in discussing their own research or mathematics content that was more advanced than what was described in the course description. The PSTs felt that in doing so, the mathematics instructors further indicated their lack of sound pedagogical judgment. Ruby shared one example of this saying:

> This [instructor] would just be like, "I'm just going to talk about my research, but it's obviously way beyond your scope." So, he just didn't seem to like, want us to even – it was like, you know how people think when mathematicians talk about math, they think they're so smart? They're like "Look at the conversation I'm having, you can't keep up, look at all this language I'm using that you don't know." That's what it felt like in his class, he was like, "Look at all these terms, you don't know what I'm saying, isn't that funny?" And you're like "Oh my God."

As Ruby explained, the content that the mathematics instructor chose to include and the ways in which he communicated with the class seemed to both exclude and make the course inaccessible for students. Furthermore, Ruby described how the mathematics instructors would teach in ways that conflicted with what she was learning in her education classes. Indeed, this discrepancy contributed to why many of the PSTs had such emotional reactions to their mathematics instructors' teaching.

Although frustrating, some PSTs felt that perhaps it was understandable that not all mathematics instructors would be interested in teaching and good teaching practice. For example, James said, “There are some teachers [who] shouldn’t be in the service classes. And, I mean, no matter how much feedback you give...it’s not in them to be dealing with an auditorium of 300 students.” Indeed, the PSTs indicated that many of the larger service courses that they were required to take would be particularly challenging for reluctant instructors to teach. Further, the PSTs attributed their mathematics instructors’ lack of interest in teaching to the priorities at a research-intensive university, in that teaching simply did not take precedence for their instructors. While all PSTs remarked on the pedagogical issues they observed, Ruby was particularly descriptive about this. She further reflected on what she believed would be required to change the experiences of PSTs and other students in mathematics courses stating,

> Having teachers that want to be teachers, I think, is the first step [towards improving these courses] because a lot of the people there, you can tell are there for research reasons and they absolutely do not care about the students’ success…it’s just so obvious that they really don’t care.

Ruby’s comments are particularly interesting given her earlier comments regarding the content that instructors chose to include in their teaching. For Ruby, mathematics instructors who spoke about their research in courses both demonstrated the instructors’ true priorities as well as their poor pedagogical judgment.

The perception that their mathematics instructors did not care about teaching or about their students as individuals, let alone students’ success, was felt by many of the PSTs. While all PSTs could identify mathematics instructors’ actions that supported this belief, Ruby identified one instance that stood out to her as being particularly hurtful. She shared that a mathematics instructor had told the entire class of students, “The class average last year was below a 50, so I

hope you're not as stupid as my last class". Ruby elaborated on this point by expressing the frustration she and her peers felt, recalling that,

> I was kind of like wow, that's really mean to say about students that you just had, but also like not even say like, "We're going to work together and make sure that never happens again." He looks at us and questions our intelligence.

For the PSTs, remarks such as this one, were evidence of the disdain that mathematics instructors had for their students.

Further contributing to their negative beliefs about mathematics instructors, the PSTs spoke of their (attempted) interactions with instructors outside of class time. For example, PSTs shared that they often had difficulties setting up meetings with mathematics instructors to ask for clarification about course material or review marks received on course assignments. Again, Ruby provided a detailed recollection, saying:

> I emailed him several times with no response which I thought was really not cool, but it was very – he didn't seem interested in his students' success in the least. I had friends that would try to meet him for office hours and he would say... "I'm very busy." And he would have one hour of office hours a week and he would cancel them very frequently. So, that was kind of not cool and it was very discouraging as a student to know that you had no support.

PSTs as outsiders

The PSTs' experiences in the mathematics content courses made them feel like outsiders in these spaces. This impression was developed in part due to feeling inferior to other students in the courses who were in STEM programs. Although they acknowledged that these classmates were not necessarily condescending, PSTs felt that it was challenging to keep up with these students. Hence, as students from many programs often do, the PSTs in the mathematics content courses formed study groups or worked on course assignments together. Even though they shared these

courses with students from a variety of programs, the PSTs indicated that they inevitably ended up only working with other PSTs. Magda described the reasons for this as:

> With someone in education, we are able to go at the same speed and we understand it at the same speed. Whereas if I am placed with someone in math, I have a lot more difficulty keeping up with them. So it doesn't – not that they are, I mean, they are nice people, but it's just I tend to feel like I am behind, like way behind, and I am never going to attain where they are.

Even though non-education students did not necessarily create an unwelcoming environment in an explicit way, PSTs often felt that their starting place in mathematics content courses was different than STEM students', and this feeling prevented them from establishing relationships with others.

This outsider status was exacerbated by mathematics instructors who were either inattentive to the PSTs' needs as education students or seemed to be deliberately demeaning to them. For example, Magda recalled an instance where an instructor told their class, "The class average is usually [high], but what brings people down is the education students because, you know." These experiences reinforced the PSTs' perspectives that they were not wanted and did not belong in the mathematics content courses. It is therefore unsurprising that the PSTs often felt hesitant to seek help from their mathematics instructors. Zorra explained, "There's that little insecurity with your instructor […] you want them to think that you're, I guess smart, but you worry about the questions you might ask, [and that] you might appear kind of superficial or dumb." Zorra's words indicate that her hesitation in reaching out to mathematics instructors was rooted in a fear or belief that she was academically inferior, a message that was both explicitly expressed by mathematics instructors and implicitly felt based on the challenges that PSTs faced learning the course material. Feeling and appearing "unintelligent" was discussed a few times, and the PSTs seemed to have internalized their "place" by describing themselves as "not…math

expert[s] by any means" (Ruby), even though they "do the same classes [as students in] the math program" (Magda). As such, it appeared that both through their direct experiences in mathematics classes and their own internalized beliefs, PSTs felt like outsiders within the mathematics community.

PSTs' responses to experiences in mathematics content courses

In response to the many challenges they faced, PSTs developed a combination of coping strategies and ways of finding meaning in their struggle, by becoming observers in their classes and being reflective practitioners, and by developing a learning community.

PSTs becoming reflective practitioners

Through their experiences in the mathematics content courses, PSTs developed into reflective practitioners, as they frequently considered what their mathematics instructors were doing as mathematics educators and the impact these actions had on them as mathematics learners. As mentioned previously, while PSTs mostly pointed to negative experiences with mathematics instructors, several of them highlighted two instructors (Evy and Matt, pseudonyms) with whom they had positive experiences. The PSTs shared that these mathematics instructors showcased strong pedagogical skills and made the PSTs feel that they were acknowledged and cared for.

With both Evy and Matt, PSTs noted that pedagogical strategies and principles that they were learning in their education classes were actually being put into action. For example, in their mathematics teaching methods courses, the PSTs had learned about high-leverage practices (HLPs) (e.g., Grossman et al., 2009; Hatch & Grossman, 2009). HLPs are teacher actions that have been shown to increase students' learning (Ball et al., 2009; Hatch & Grossman, 2009) and include broad aspects of teaching including planning instruction and the interactional work of teaching (Thompson et al., 2013). Throughout the interviews, PSTs described how they observed

Evy and Matt using HLPs. The PSTs saw both mathematics instructors using a variety of HLPs, including strategies such as wait time, positioning students competently, and checking in with students through questioning. PSTs shared that in the mathematics teaching methods courses, the HLPs were primarily discussed in relation to their use in secondary mathematics classrooms. While the PSTs acknowledged that their education instructors modeled HLPs throughout the mathematics teaching methods courses, the PSTs shared that this occurred most often during activities with mathematics tasks appropriate for the secondary mathematics classroom. Although they were university students engaging in these activities, the PSTs described how these experiences allowed them to see how HLPs could be enacted with secondary mathematics students. Now, through Evy and Matt, the PSTs observed an additional application of HLPs, this time in a university-level mathematics classroom. As Domino said, "It was good to see [the HLPs] applied to a group of, like, a hundred 21-year-old students. That was interesting." Indeed, in reflecting on the ways that these two mathematics instructors taught, the PSTs described the value of seeing teaching approaches in a different context. The PSTs shared that they developed a deeper understanding of the HLPs through their enactment in university-level mathematics courses.

Importantly, PSTs also felt welcome in Evy and Matt's classrooms because these mathematics instructors, through the way that they taught, demonstrated care for their students. For example, PSTs mentioned that Matt not only acknowledged their presence ("He actually addressed us" (Ruby)), but included them in his teaching by making connections between the course material and secondary mathematics. These mathematics instructors made a point of recognizing and incorporating the realities of the different groups of students (including the PSTs) into their teaching. As Zorra explained, "The way [Matt] approaches [teaching], whether

you're a [mathematics] major, half major, or you're a [Bachelor of Education] student, you'll be able to connect to it." In this reflection, Zorra recognized that Matt differentiated his instruction based on the different groups of students in the classroom. PSTs indicated that Evy similarly did this in her classes. As a result, the PSTs felt more included and engaged in the learning.

In spite of the positive models of teaching the PSTs saw in Matt and Evy, PSTs largely observed what they felt was evidence of poor teaching. Virtually all of the PSTs reflected that, in seeing these negative examples, they learned, as Domino said, what they "don't want to do…as a teacher." PSTs expressed that as education students, they observed their mathematics instructors frequently employing specific teaching practices that were not conducive to their learning. For example, many indicated that the mathematics instructors primarily lectured without taking time to engage in questions or activities. Further, and as described earlier, the PSTs saw mathematics instructors moving through course material at such a fast pace that it seemed as though the courses were designed for the elite few (i.e., those who were academically advanced), rather than differentiated for a diverse group of learners.

In addition to their pedagogical concerns, PSTs reflected that the negative ways that the mathematics instructors frequently made them feel had a large impact on their learning and how they viewed the mathematics instructors as educators. When thinking about particularly discouraging experiences in her mathematics content courses, Ruby reflected,

> [If you] observe the instructors...and watch how what they do makes you feel as a student, like, just going back on my thoughts, some empathy, just to be attentive to how it is you feel in the class and when you feel discouraged. What was it that made you feel discouraged, and then kind of take note of that and don't do that. Like, fix it. Make sure you don't have your students feel that way, right? Because now, at least, you know how it was to feel that way and you wouldn't want anyone else to go through that, right?

Notably, Ruby was able to translate the way she was made to feel as a student in the mathematics content courses into a directive on what she would *not* want to do as a teacher. For Ruby, this was especially important so that her future students would not have to experience the same negative consequences that she had personally encountered if she taught the way her mathematics instructors did. Again, the idea of what PSTs did not want to do once they become teachers, as a result of what they observed their mathematics instructors doing and how it impacted them, continued to be a common sentiment throughout the interviews. Magda corroborated this, explaining that in her mathematics content courses, "I feel confused and I feel frustrated, and then I was like...some of my students must be feeling this".

This developed empathy for future students was frequently cited by the PSTs. Recall that the mathematics content courses were the first instance where the PSTs struggled to learn mathematics. So, although the mathematics content courses were difficult and enduring poor mathematics teaching was frustrating, for many PSTs, these experiences also provided a new lens through which they could understand their future students. For instance, Domino noted that:

> [The mathematics content courses] helped me realize what it is to sort of struggle in math because I think before this, I had never really struggled. Like, it was smooth sailing. So, that was...a positive sort of thing that I can relate to now...what it's like to struggle, what it's like to work really, really hard and then still not understand it.

This lived experience as struggling mathematics learners gave the PSTs a more direct and meaningful connection to the realities of some of their future students. In the end, while PSTs did have some positive experiences in their mathematics content courses, most of their experiences were negative. However, as future secondary mathematics teachers, they were able to engage in reflective inquiry that allowed them to consider their experiences in ways that resulted in valuable professional learning.

Community development for survival

Early on in their teacher education program, the PSTs noticed that their course schedules were generally aligned because they were all taking similar mathematics content and education courses. The convenience of this as well as the sincere need for community allowed them to become a close-knit group that could work together. James explained that while "you do get to know some [other] students…you don't see them as often. Whereas those in math, you see them in [mathematics] content courses, in your [mathematics teaching] methods courses, and in some of your other education courses." Hence, the PSTs found and leaned on each other for mathematical and emotional support throughout their time in the mathematics content courses.

As described earlier, the PSTs organized study groups in response to the academic challenges they faced with the mathematics content courses. The PSTs shared that the initial impetus of these study groups was to support the learning of course material and that these sessions together were critical towards their mathematical learning. Magda recounted, "I would [have] drown[ed]…especially if I didn't have someone else that I knew inside the class to work through [the mathematics problems]," emphasizing the need she had to work with others to understand the material. Given the feelings of exclusion that the PSTs otherwise felt, working with other PSTs who understood their feelings and context was crucial and as Magda further elaborated, these study group sessions provided her with "motivation outside of [my] own motivation" to get through these academically challenging courses.

Further, these study groups had additional, non-academic benefits. PSTs described these group sessions to be "more like...therapy" (James) and by working together, PSTs felt validation in their struggles. James further explained,

> You develop…a sort of relationship [with other PSTs] and it's easier to get a sense of "you're not alone in the thing" …but having people you could sort of ask and turn to and at some point, you realize, okay, okay, they're struggling, too, and it's…it's definitely okay. It's not just me.

These study groups evolved into friendships and emotional support structures for the PSTs. Specifically, the PSTs described how their group evolved from simply working through course material to having meaningful relationships with one another. As Zorra said, "We were always there to help each other and got to know each other well throughout the three years, and it was those friendships and relationships that were formed." These friendships were critical for the PSTs who found solace in not just working together, but commiserating together about their difficult experiences. Notably, it appeared that this community was borne out of necessity, and in particular, a need to survive their program. To emphasize this, Domino shared advice given to her by another secondary mathematics PST from an earlier cohort: "Us education fish have to stick together in a world full of sharks." Or, as Ruby put it, "If we're going to survive, we need to work together."

Discussion and Conclusion

In this paper, we highlight the experiences of secondary mathematics PSTs in a Canadian concurrent teacher education program. Specifically, we present these PSTs' experiences in mathematics content courses and provide insight into the ways they experienced and reflected upon these courses as prospective teachers. While the PSTs in our study described experiences and negative perceptions of mathematics content courses that mirror similar studies with STEM students (e.g., Hong & Shull, 2010), their concurrent training as future teachers gave them a "teacher lens" through which to unpack these experiences. More specifically, these PSTs leveraged their negative experiences into opportunities to be reflective practitioners by reflecting on their feelings as students and making observations of their educators (i.e., the mathematics

instructors). For example, the PSTs' first-time encounters with conceptual difficulties in mathematics (Goulding et al., 2003) helped them develop empathy for the way that some of their future students might feel in secondary mathematics. Beyond their challenges with the mathematics content, PSTs' experiences in the courses allowed them to consider the impact of the classroom environment on students' experiences in meaningful ways, as their instructors were essentially modelling (good and bad) teaching for them (Borko et al., 2008). Feeling dismissed and not cared for reinforced to them the value of student-educator relationships and how influential educators' attitudes towards students are on students' learning (Kuh & Hu, 2001). In mathematics, student-educator relationships are particularly important because to meaningful engagement in the discipline requires participation and discussion, both from peers as well as with educators (or in our case, mathematics instructors) (National Council of Teachers of Mathematics, 2014; Ontario Ministry of Education, 2020). The PSTs also had a reflective stance regarding their mathematics instructors, analysing their behaviour (including pedagogical approaches, words, and actions) both inside and outside of the classroom. As the PSTs compared their mathematics instructors' behaviour to what they were learning in their education courses, they also considered the implications of the instructors' actions on them as students in the courses. For example, PSTs' struggles with the mathematics content were exacerbated by their feelings of dismissal and exclusion as a result of the mathematics instructors not meeting with them outside of class time and/or dismissive comments made by the instructors. In line with previous studies in university contexts (e.g., Komarraju et al., 2010; Micari & Pazos, 2012) and more specifically in STEM disciplines (e.g., Hong & Shull, 2010), the negative relationship with mathematics instructors impacted the PSTs' confidence in their courses, their self-efficacy, and often, their academic success. Indeed, PSTs often felt excluded and thought they did not belong

(Sahmbi & Jao, in preparation) and reflected on the impact of this feeling on them as learners. Experiencing this themselves, PSTs came to understand more fully the significance of the student-educator relationship in the mathematics classroom.

The PSTs were also able to identify "meta-mathematical" aspects of their courses and consider incorporation into their teaching (Zazkis & Leikin, 2010). Thus, the PSTs' experiences as students informed their understandings as teachers. Their dual positions as students studying mathematics, and students studying to become teachers, made for ripe learning conditions that afforded the PSTs the ability to contextualize all their learning as future teachers. Indeed, we argue that because of the situated learning opportunities that PSTs had, they were able to critically reflect on their experiences as students and teachers (Osterman & Kottkamp, 2004). Although they had this same role (i.e., students) in all of their mathematics content and education courses, experiences in the former provided PSTs a particular opportunity to refine their understandings as future mathematics teachers. To be clear, as students in education courses, the PSTs experienced approaches to teaching and learning such as high-leverage practices (HLPs) as *education* learners (and in the case of the mathematics teaching methods courses while engaging in mathematics-specific activities also as (*secondary) mathematics* learners). In all education courses, while PSTs acted as learners in that they were observing their education instructors using HLPs with education content, in mathematics teaching methods courses, the PSTs were also able to see HLPs being used with mathematics they already understood (secondary mathematics). By contrast, in the mathematics content courses, the PSTs were solely experiencing the courses as *(university) mathematics* learners. So, while the PSTs experienced the HLPs as *mathematics* learners in both mathematics content and mathematics teaching methods courses, in the latter, they did so in relation to mathematics material which they felt

comfortable and confident in (i.e., secondary-level mathematics), as compared to university-level material in the mathematics content courses which was both new and challenging. Being able to experience both of these contexts that approximated their own future teaching environments was crucial for their development (Korthagen, 2010). Further, being able to reflect upon these experiences in the context of their future teaching practices (e.g., considering what they would *not* want to do) not only made their learning more meaningful (Eick et al., 2003), but also potentially planted the seeds for transformation in their teaching (Liu, 2015).

Findings also highlight the ways that the *de facto* community that the PSTs developed supported them through the mathematics content courses. Govender and Dhunpath (2011) describe how the positive experience of being a part of a community provides the support and encouragement university students need to get through heavy workloads and complete their programs. Furthermore, being part of a community helped to alleviate feelings of isolation during their program (Grossman et al., 2001). Importantly, this community was created by the PSTs themselves and was driven by their shared circumstances. Thus, we suggest that teacher education programs intentionally facilitate ways of promoting community development for education students as they navigate challenging programs. One possibility is a cohort model. Cohort models have been used for many years in teacher education programs (e.g., Beck & Kosnik, 2001; Radencich et al., 1998) and have been shown to facilitate community development, improve academic performance, increase retention, and support professional growth (Dinsmore & Wenger, 2006; Mandzuk et al., 2005). We suggest that this cohort model might be extended to specialized groups of students (e.g., secondary mathematics PSTs), as well.

In addition, we encourage the mathematics departments that typically offer the mathematics content courses taken by PSTs to develop an awareness of their student population

and reckon with the influence that specific coursework and instructors have on the success or failure of their students. We recognize that historically, students across many disciplines experience challenges in mathematics (e.g., Rasmussen & Ellis, 2013; Sithole et al., 2017; Zietara, 2016), and are not suggesting that departments (or their instructors) "dilute" course material. Rather, recognizing that students in their classes have different goals, making intentional efforts to connect course material to students' realities, and improving teaching methods will serve to support students from all programs. We are encouraged by recent efforts by mathematics instructors to engage in active learning and other innovative teaching methods (e.g., Dagley et al., 2018; Kogan & Laursen, 2014; Roop et al., 2018) to promote deeper mathematics learning at the university-level. In the context of working with PSTs (as in our study), mathematics instructors are both educators and teacher educators (Leikin et al., 2018), however implicitly. Consequently, mathematics instructors must understand that good pedagogy and positive student-educator relationships work in tandem to promote mathematical learning. Thus, we hope that in acknowledging this reality, mathematics departments are further motivated to support their instructors in pursuing not just good teaching practices, but also cultivating positive student-educator relationships. Doing so will certainly benefit future PSTs in their classrooms, as well as students across all programs.

This study represents the perspectives of secondary mathematics PSTs through a case that takes place within the context of one teacher education program in Canada. Thus, we recognize the limitations of our study size and context. Yet, we contend that the findings provide critical insights into the ways that PSTs use experiences of struggle to grow as professionals. We acknowledge that the subjectivity of the PSTs' perspectives is, definitionally, subjective, and may potentially change over time with the benefit of distance and space. Given this, we intend to

continue to engage in dialogue and reflective inquiry with these now in-service teachers. Even so, we offer this paper as a snapshot into the ways that some secondary mathematics PSTs experience a fundamental part of their mathematics teaching journey in an effort to illuminate a voice not-often heard in teacher education programs. Though the development of PSTs' mathematical knowledge is crucial, this cannot and does not happen in a passive vacuum. So, we hope that these findings show that while the PSTs in this study were able to find some positive features of largely negative experiences, it is important to consider what adjustments need to be made to provide PSTs with the positive learning environment that we hope they will provide to their own students in the future.

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