Beginning Teachers' Perspectives on Attributes for Teaching Secondary Mathematics: Reflections on Teacher Education

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The aim of this collaborative study was to understand what factors beginning secondary mathematics teachers attribute their success to in the classroom, regardless of their preparation program. Further description of how and when beginning teachers reported acquiring important teaching attributes provides a perspective on how they make the transition to teaching. A large-grain analysis of critical developmental moments, pre-, during, or post-program, contributes to the conversation about teacher education, highlighting valuable aspects of the preparation process for beginning teachers. The results have implications for informing the types of students mathematics education programs should try to attract or recruit, and defining areas on which teacher education programs should focus and where practicum or internship components might be incorporated into the preparation process.

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Striving for High Teaching Standards

Education plays a vital role in any society; so much so, that countries strive to have not only adequate, but excellent educators in their classrooms. Obtaining such teachers involves a number of confounding factors, ranging from societal factors to recruitment and training in teacher education.

Some countries have high standards for entering the profession of teaching and have structures in place to recruit highly qualified and highly skilled educators. For example, both Finland and the Singapore Ministries of Education recruit prospective teachers from the top third of a university cohort; where in some cases, as few as 10% are accepted into teacher training programs (Darling-Hammond & Rothman, 2011). The United States, on the other hand, by and large has not been in a position to decline interested applicants in the recent past due to concerns about teacher shortages, particularly in certain types of schools and in certain content areas, such as mathematics (NASBE, 1998). Yet obtaining high-quality teachers, particularly for secondary mathematics and science, has been described as a national priority; the impetus to reform education continues to look toward improving the teachers sent into the classroom.

The practical goal of filling mathematics classrooms with great educators needs to be informed by research on how best to recruit highly qualified candidates in this field, how best to facilitate the teacher preparation process, and how best to ease their transition into the profession of teaching. In this study, we argue that the perceptions of beginning

teachers are particularly pertinent to, though frequently left of out, this conversation. Using the perspectives of beginning secondary mathematics teachers in the United States, this manuscript presents what two groups of novice teachers (some participants completed a traditional undergraduate program and others experienced an alternative certification program) articulated as being most valuable for their transition to classroom teaching and when these attributes were reportedly developed. This approach complements other work in the field that obtains teachers' views of important mathematics teaching attributes, by including beginning teachers (e.g., Wilson, Cooney, & Stinson, 2005).

The purposes of the research were: 1) to ascertain beginning mathematics teachers' views of which attributes were most important during the transition to teaching; and 2) to identify any patterns in how teachers reported their development of these attributes.

Attending to beginning teachers' reflections provides a lens for understanding possibilities for recruitment as well as considering the influence of various aspects of teacher education.

Background

As incentives to attract strong candidates to the profession of teaching increase, the ability to identify and develop characteristics of beginning candidates that will determine a successful transition into secondary mathematics teaching accurately is critical. Unfortunately, the research regarding what types of knowledge, skills, or peoples will translate into effective secondary teaching and teachers lacks sufficient clarity (Allen, 2003). Economists insist that a larger pool of applicants will increase competitiveness, and in turn, create the opportunity to hire more-qualified candidates. However, precisely how to identify these highly qualified candidates is still unknown, so one purpose of this research is to address some aspects of this issue.

While researchers and practitioners often use experienced educators as the source of information, we chose to study the views of beginning teachers for their proximity to the teacher education process and transition into the classroom, which is notoriously challenging (e.g. Marso & Pigge, 1992). We contend that those who have recently dealt with the shift from teacher education to teaching are perhaps best equipped to contribute perspectives on the identification and development of important attributes that were useful for transitioning into the classroom.

The second purpose of the research was to find out when important teaching attributes were developed, providing further information for recruitment and teacher education. It is important to determine whether program components were the real source of teaching competence. Perhaps deep content knowledge did not come during required mathematics courses; perhaps completing written assignments and videotape analyses had little to do with learning personal reflection; and perhaps four years of learning theories and methods had little to do with graduates' ability to implement them. Perspectives on, and reports about, when important attributes were learned (pre-, during, and post-teacher education) presented in this research yield an important component to understanding the processes of recruitment and development in teacher education; the answers from beginning teachers give a unique perspective on which factors were particularly important for coping with the inherent challenges of classroom teaching.

Literature Review

Literature about secondary mathematics teaching and the types of knowledge and skills that are important for proficient teaching informed the framework for analysing data from interviews, particularly regarding the first research objective. While effective mathematics teachers certainly have unique traits (i.e., different ways of relating to students, of gaining students' attention, of communicating, etc.), we focused on common features that may unite them. Proficient teachers have: strong mathematics content knowledge and pedagogical content knowledge (Ball & Bass, 2000; Hill, Rowan & Ball, 2005; Ma, 1999; Shulman, 1986); certain beliefs about the nature of mathematics (Thompson, 1992) and about mathematics learning (Davis & Brown, 2009); an optimistic attitude toward education, a positive disposition, and self-efficacy (Borko & Whitcomb, 2008); and aptitudes for reflection (Lerman, 2001; Schön, 1987) and for clearly communicating and relating to students (Schoenfeld & Kilpatrick, 2008). According to Zaslavsky (2008), "the 'content' related to [teachers'] learning involves beliefs, knowledge, and practice as well as some meta-cognitive skills, such as … reflection" (p. 105). These important attributes—mathematical knowledge, pedagogical knowledge, and personal traits such as beliefs, experiences, and characteristics—comprise a common curriculum ("content"), of sorts, that mathematics teachers should develop. We briefly characterise each of these further before discussing the analytic lens used for the second research objective.

Mathematics Knowledge

Strong content knowledge, at many points, has been the sole factor in determining qualifications to teach secondary and college level mathematics. Research supports the notion that strong mathematics knowledge is important for good teaching, since teachers strong in content need less time to understand material, have more time that can be geared towards instructional strategies, tend to be more flexible and confident, and have better substance to their teaching (Brown & Borko, 1992). However, Askew, Brown, Rhodes, Wiliam, and Johnson, (1997) and others (Carroll, 2005; Nickson, 1988) maintain that it is not simply the formal qualifications in mathematics that determine this confidence but rather the nature of the subject knowledge that has been acquired. Shulman (1986) describes this necessary deep content knowledge as the ability to understand how the subject matter is structured, conceptualised, and organised, as well as the principles of inquiry and establishing truth. A significant amount of work has been done on further characterising the types of mathematical content knowledge needed for teaching (e.g., Ball, Thames & Phelps, 2008; Rowland & Ruthven, 2011).

Pedagogical Content Knowledge

While deep content knowledge is useful, it is easy to find exceptions to this rule—strong teachers who lack formal content instruction, or those strong in content who are ineffective teachers (Davis & Brown, 2009). Therefore, much research in the last 25 years has been focused on understanding and developing the notion of pedagogical content knowledge (PCK)—knowledge of particularly useful ways of teaching, investigating, and presenting mathematics.

Ma's (1999) book was significant in developing the notion of PCK in elementary mathematics and in differentiating this knowledge from content

knowledge. Ball, Thames, and Phelps (2008) further delineate PCK into: 1) knowledge of content and students; 2) knowledge of content and teaching; and 3) knowledge of content and curriculum. Others have debated the merits of PCK—claiming that a more developed understanding of PCK is necessary for it to be a useful and not elusive concept, particularly for beginning teachers (Tirosh & Graeber, 2008).

More recently, Neubrand and Seago (2009) have summarised research that examines how these two types of knowledge—mathematical and pedagogical—relate to one another. They cite research that demonstrates a high correlation between them: people who possess strong content knowledge are also highly likely to possess strong pedagogical content knowledge. However, they also indicate that these two types of knowledge exist independently of one another and maintain that the two types of knowledge are fundamentally distinct. The many studies examined by Neubrand and Seago also contend that PCK is primarily learned in and from practice, which has implications for developing attributes of good mathematics teachers.

Personal Traits

Characteristics of good mathematics teachers also encompass certain beliefs, experiences, attitudes, personality, etc. These types of characteristics will be referred to as "personal traits" (in contrast to knowledge components).

In one summary of research findings—about work done primarily in the 1980s and 1990s—from the University of Texas' Instructional Assessment Resources (n.d.), characteristics or personality traits of effective teachers are described. The ultimate conclusion is that effective teachers are both personable and considerate of students. Personable includes being flexible, enthusiastic, clear, well organised, caring, humorous, confident, approachable and respectful; being considerate of students includes the ability to adapt to individual differences, provide specific feedback, promote active learning, motivate students, encourage questions, and gauge student comprehension levels. Attitudes toward education, a positive disposition, and critical reflection also tend to be identified as significant attributes of quality teachers (InTASC, 2010; Oliveira & Hannula, 2008; Zaslavsky, 2008). These types of abilities allow teachers to build relationships that support learning and to organise, craft, and manage learning environments.

When should attributes develop?

As a reflection on teacher education, the framework for analysis of the second research objective regarding when important teaching attributes were reportedly developed includes: pre-, during, and post-teacher education. It is well documented that teachers often learn from on the job training (Brown & Borko, 1992; Cobb, Wood & Yackel, 1990; Shulman, 1986) and that facets of personality are important in effective teaching (Davis & Brown, 2009; Hamachek, 1971): thus the inclusion of the time periods pre- and post-teacher education is relevant.

However, developing a framework for when learning happens is complicated, since knowledge cannot often be packaged neatly into "when" it was acquired. Ideas evolve and people continue learning in years to come. Developmental progressions articulate learning into stages of development, where subsequent stages represent increasingly mature understanding. While this is certainly the case, frequently there are significant experiences or critical moments that people can identify as crucial to learning particularly useful ideas (Giordano, 2003). Simon (2006) describes such

particularly useful ideas as *key developmental understandings* in mathematics—important knowledge that acts as a springboard for learning. Therefore, the discussion regarding development of important teaching attributes as reported by beginning teachers will remain at a broad grain-size. (Future work, at a finer grain-size, would include more complete stages of developmental progression.) This study intentionally includes overlap, allowing participants to describe critical moments for developing attributes that span various time periods.

Splitting beginning teachers' development of attributes into three stages, pre-, during, and post-program, may yield further insight into what a teacher education program not only should focus on but also how to improve. To find some common personality trait or knowledge developed pre-program that helped with success gives an idea as to what types of students programs should try to attract or recruit. Finding components that graduates are doing well helps to distinguish particularly successful aspects of teacher education programs, and identifying knowledge learned in post-program helps define areas of programs where practicum or internship components might be better utilised.

Methodology

Independent samples of beginning mathematics teachers (less than two years of teaching experience) were attained from two teacher preparation programs in the states of Texas (sample size = 8) and California (sample size = 7) for this qualitative study. The two programs represent both an undergraduate and an alternative certification program respectively. Two researchers collaborated throughout the process but independently implemented the research, each working with one population. Some basic differences between the two populations are described in Table 1. While the table does not document every difference that may exist between the programs, it does provide some relevant contextual information about the structure of each program.

Table 1
Differences Between Populations

Population	Length of program	Program Field experience	Typical Age	Maths Major required	Working environment
California Alternative	4 weeks, plus meetings during 1st year teaching	~15 days	Graduates and Career changers	No	Title I Schools[1]
Texas Undergraduate	4 years	~115 days	Recent Graduates	Yes	Various

[1]Title I schools receive additional federal funding for serving a high percentage of students from low-income families.

The samples of beginning mathematics teachers used in the study were not random selections from all of the possible beginning mathematics teachers of each program, which were 49 from Texas and 35 from California. The

researchers used a purposeful sampling of those beginning teachers who could be identified as strong beginning mathematics teachers. The reason for doing so was to explore particularly when high-quality beginning teachers—as opposed to all novice teachers—learned characteristics of good mathematics teaching. Essentially, the goal was to identify the top graduates from each program, providing information-rich cases whose insights into teaching were largely of interest to the questions being studied. To identify such candidates, both studies employed three criteria that incorporate the ideas previously discussed in literature: strong pedagogical content knowledge, strong content knowledge, and specific personal traits:

1. Nominations from a consortium of knowledgeable teacher educators as the top of his/her graduating class
2. A minimum 3.0 GPA in college Mathematics courses (The alternative certification program study incorporated other avenues to justify strong content knowledge since participants did not necessarily take a significant number of college mathematics courses.)
3. Previous leadership experience prior to teaching

While the three selection criteria are not sufficient to demonstrate the depth of these traits described in the literature, they do help identify candidates as being high calibre. In particular, the "community nominations" (Ladson-Billings, 1994) significantly support their use, since strong nomination from a consortium of knowledgeable teacher educators (primarily as an indicator of strong pedagogical content knowledge) also would be likely to include some demonstration of content knowledge and desirable teaching traits.

Notably, the use of selection criteria does not identify *all* teachers who may have achieved some success in teaching; rather the criteria were used to justify those included as being high-quality candidates.

Procedure

Using the selected samples of beginning teachers, both researchers (who were not instructors in either program) implemented a qualitative research methodology to collect data with individual interviews.

The interview protocol was developed collaboratively between the two researchers and was modified as a result of interactions with other knowledgeable mathematics educators and pilot study participants (N=4). The literature reviewed helped form the theoretical framework for the questions posed, as well as an organizational structure for interview coding. (See Appendix for final categories and descriptions used.)

Each participant had one 60-minute semi-structured interview composed of two parts that corresponded to the two research objectives. A semi-structured interview allowed the researchers flexibility to uncover reasons behind certain responses and to explore these reasons in depth, inserting questions based on participants' responses (Gibson & Brown, 2009; Newman & McNeil, 1998). The researchers created a recording template in order to write and organise information discussed during the interview sessions in a similar manner.

The first portion of the interview focused on identifying attributes that beginning teachers reported were helpful to them for doing the work of teaching. The researchers collaborated to create an interview protocol that allowed participants to state their opinion on which factors they would report as being instrumental to their success in teaching. Successive questions then incorporated the framework of mathematical knowledge,

pedagogical knowledge, and personal traits, to extend the range of possibilities for individuals' responses. Finally, they were asked to reflect on and identify those factors, out of all the possibilities discussed, they viewed as *most important* for helping them achieve success. While this aspect limited the results to only those they viewed as most important (and not all things they might consider important), it also provided additional focus in their responses.

The coupling of open-ended responses and responses to specific ideas from the literature assured that participants considered a full spectrum of possible factors that aided their success in teaching. After narrowing down these attributes to those they reported were most important, the second part of the interview consisted of a discussion that elaborated on understanding to what degree a particular attribute was learned pre-, during, or post-teacher education program. Participants were asked to report critical moments for learning those "most important" teaching attributes, using the framework of pre-, during, and post-teacher education as reference periods. Elaboration on these critical events followed during the interview process.

Analysis

Once interviews were completed and transcribed, the researchers developed more specific codes using the constant comparative method (Strauss & Corbin, 1990), going through iterations of coding descriptions until common vocabulary was being used consistently to describe the attributes beginning teachers discussed as most important to their development in both analyses. While the coding framework was organised around strands from reviewed literature, the specific codes were developed from participants' responses during the interviews. (See Appendix.)

Rather than independently coding the transcripts and using a numerical reliability rating, the researchers adopted collaborative strategies to establish validity and reliability (Harry, Sturges & Klingner, 2005; Truxaw & DeFranco, 2008). The goal became consensus, not simply comparable independent coding, with each point being debated and clarified until both agreed on appropriate usage of the coding framework. When further clarification was needed, member checks were conducted to confirm with participants the interpretation of the interview data, adding another level of transparency in the analysis (Charmaz, 2006). The coding framework helped identify and classify the factors that participants claimed were most important to their success in teaching and helped broadly characterise when these were learned or experienced by participants specific to their teaching.

After independently analysing the data from each population, the researchers compared their qualitative results to identify similarities and differences. Based on the analyses, the researchers were able to specify a number of attributes that were common between the independent samples and also identified similar themes regarding when particular attributes were reportedly developed.

Findings

The reports from this research indicate specifically which attributes were considered most important during beginning teachers' transition to the classroom. While these contain elements identified in literature by researchers and other experts, the list of factors below represents the unique perspective of beginning teachers in thinking about important teaching attributes. In particular, these include the types of knowledge, pedagogy,

and personal traits that, we argue, can be considered particularly helpful in successfully dealing with the often-difficult transition to teaching and offer a unique reflection on teacher education and development.

Overall, from the interview categories of factors that were singled out as most important, the common themes between the two samples included: Mathematics knowledge, Experimenting and practical tools, Inquiry engaging pedagogy, Contextualising, Differentiation, Flexible, Classroom Management, Hard-working, Caring, Optimistic, Confident, Entertaining, Extrovert, Collaboration, and Colleagues. Further description of each of these attributes is included below, while also incorporating the beginning teachers' ideas about critical moments for developing them. While some results regarding when important attributes were developed are expected—even predictable—others need further explanation.

We use the three time periods to organise the responses and provide excerpts from the interviews to help clarify some of these relationships for when attributes were primarily learned. Only those factors that contribute significantly to discussion of the two research objectives, which includes elaboration and specification of some of the two population's similarities and differences, are included.

Pre-teacher Education Program

Many characteristics that teachers bring to the classroom are inherent parts of who they are. Teachers have different ways of relating to students, of gaining students' attention, of deciding what is fair and just, of communicating, etc. But great teachers, like great artists, while unique, also have commonalities with others in their profession. In reporting the attributes that beginning secondary mathematics teachers frequently learned Pre-program, the research aims not to discuss the unique personal traits that inevitably distinguish teachers but rather to emphasise those more common features that potentially unite them.

"Hard working" and "Believing in all students". "Hard working" and "Believing in all students" were important attributes commonly proposed as being most important for good teaching. They were usually frequently cited as being learned while growing up, Pre-program.

The teachers' experiences growing up influenced their approach to teaching, and were the dominant reason they reported bringing Hard work and a Belief in all students to the classroom. Although these might appear obvious—good teachers definitely work hard and believe students can learn—the findings are not necessarily trivial. The realities and hardships of teaching, particularly during the transition to the profession, frequently can whittle away at the drive to work hard as well as at the belief that all students can learn. Continuing to be optimistic about each student, to believe in the possibility and to work tirelessly for every student in spite of setbacks and failures, are what set these teachers apart and were reported as vital to their success, helping them combat some of the challenges faced by novice teachers.

While one can imagine the influence that parents' attitudes and expectations can have on developing a mentality of working hard, there were, however, comments on the roles played by preparation programs and the weight of responsibility in teaching as motivation for exerting extra effort. But more often than not, strong work ethic was reportedly developed Pre-program.

> … cause I'm kind of driven by the pressure. You know, myself, to be better as a teacher. [Julia, undergraduate program]

> My mom just taught me just hard-working aspects … I take pride in the ability to try to outwork other people. [Chris, undergraduate program]

> ... it's just unrealistic that you could ever get to a point where you're done. Like oh, I'm a good teacher, whew … whenever I started noticing teachers who I thought were bad teachers, that that is where they had gotten to. So maybe out of fear that that is what would happen to me …. [Ali, undergraduate program]

> Well, [the Texas program] was kind of like the scaffolding into the classroom. It helped paint the picture as to what needed to be done. So I knew how to work hard ... it taught me how to work hard in the classroom. I think that you can have any hard-working individual and you can come into a classroom, and you can say you worked hard, but you have to know how and what to focus your energy on in order to achieve it. I think that really is what [the Texas program] has done. [Chris, undergraduate program]

> … wanting to do a good job as a teacher, I had to put the time and effort in. I mean, you're in charge of kids' lives. [David, alternative program]

From the interviews, the notion of Believing in all students—that all students are capable of learning—was frequently expressed as caring and putting in the effort to get to know every student. Both populations most frequently credited this driving belief to parents and influential role models. Some other quotations show the potential for developing a caring attitude through realisations about the professional world.

> So one of the main things in my teaching philosophy was a quote my Mom used to always say: 'They won't care about your work until they know how much you care about them.' [Elisa, undergraduate program]

> I come from parents that are like that, that always believed in us ... That I always thought my friends, you can do it … try it again, or try to explain it a different way to them. But never thought that anybody just couldn't, just can't do math. [Abby, undergraduate program]

> I think some of the process is just what our [Texas program] professors used, I mean they got to know us individually … I would say that they promoted that kind of atmosphere of believing in all students …. [Abby, undergraduate program]

> I was really mean because all teachers said you have to be super-strict so I was kind of a [jerk] and I didn't build any kind of relationships with the kids and it showed after a few weeks … They [could] see that I wasn't very interested in them at all and they felt if I didn't care, then why should they care about the class. A lot of it was because I was just not being me and I wasn't trying to get to know them. I never knew about that. Nobody ever told me, get to know your students. All they told me was to be strict and have them in fear and you'll be all right ... After I found that out, I started getting to know the kids and the dynamic started to change so much. It's so true how important the relationships were. [Charles, alternative program]

> I do feel like I'm a lot more empathetic and caring than I was to begin with. In the beginning I was like, any person can get an A ... But then you come here, you write CPS reports for kids, and … they definitely have home-life situations that are preventing them from learning ... If they're coming to school with bruises, that's a bigger influence than hard work. [Julia, undergraduate program]

"Mathematics knowledge" and "Previous experiences". Participants from both populations also mentioned learning some of the Mathematics knowledge necessary for teaching during this time period and having Previous Experiences that helped them feel comfortable as a teacher; both were factors they identified as important. Strong Mathematics knowledge,

an attribute that merits closer inspection in this study, was reported by all of the alternative certification participants as being formed predominantly Pre-program. The undergraduate program participants were split fairly evenly between mathematics knowledge learned growing up and knowledge acquired during the program. A foundation in mathematics, learned during teachers' own schooling experiences, was reported as an important factor for these participants' teaching.

> Honestly, I think I could teach this class if I hadn't gotten my math major … I guess it gives me confidence with the material. [Elisa, undergraduate program]

> Going into math teaching, I thought 'Geez I don't have that much math knowledge. Am I really qualified for this?' I was able to pass the CSET exams. But I still felt [unqualified]. And I realised fast it didn't matter too much for teaching Algebra 1 or Geometry. I knew way more than the students. I knew the Algebra I material thoroughly, but not as well as I know it now. Now I know it backwards and forwards that I've taught it four times. [David, Alternative Program]

> ... I think what [the Texas program] did, and what I'm doing now fine-tuned my abilities [in mathematics]. Growing up provided that basis. [Rebecca, undergraduate program]

Some participants seemed to change their minds slightly:

> I really don't think that any of those higher level math classes did anything for me as an Algebra teacher. I don't think it's necessarily the fact that I had a math degree that makes me feel confident in my math knowledge…[but] the [higher level courses] helped me personally, to think abstractly and to problem solve. [Rebecca, undergraduate program]

The other factor was having Previous experiences that were relevant to teaching. Experience in a Leadership position prior to teaching was used as part of the selection criteria in this study partially based on the idea that these experiences and developing certain characteristics are important. Some participants found the comfort afforded by such Previous experience meaningful to their beginning success as teachers.

> I did a year of military training … I went through the ROTC program where I received a lot of leadership skills so having had those leadership qualities and skills evolved from a student cadet to all of a sudden into the service. I still have that; I know how to lead. That mentality. [Robert, alternative program]

> I think that having a similar background to the students that I teach, in that I am also Latino and from the community, gives me a different perspective and helps me sympathise with my students and what they have to deal with in their day to day life. As a result, I can relate to them very well and I have an excellent rapport with them. [Gerry, alternative program]

Evident in the last statement, one of the distinct differences between the two populations was teaching placement. For many of those in the alternative certification program, they were coming back home to teach—returning to teach in the cities and neighbourhoods where they grew up, even their own high schools. Familiarity with the location and the population of students, and having the ability to relate to people and place was seen as an advantage. Those graduating from an undergraduate program, at a university that is not necessarily close to home, did not inevitably teach in schools close to, or even similar to, those they grew up in.

During and Post-teacher Education Program

At this point, due to differences between the teacher preparation programs (mostly the length of the program) and the results from the study, aspects learned both during and post-program will be addressed simultaneously, extracting similarities and differences between the populations as needed. The different programs and teacher-training experiences support the notion that teacher education programs of all varieties can be experiences of great value and worth for preparing beginning teachers; each able to contribute, somewhat distinctly, to useful preparation.

"Engaging pedagogy". While a number of important ideas were discussed as related to the teacher education program, participants in both populations reported learning various instructional strategies during their programs that were instructive. Participants from both populations mentioned that their experiences during their respective programs were formative for developing their pedagogy about how mathematics education should look in practice. While this is not always the case, and many teachers simply "teach how they were taught", the high-quality beginning mathematics teachers from this study agreed that this aspect was essential to their teaching. They specifically mentioned that students should be active participants in their learning and engaged. Active participation and engagement were viewed as the most effective way to have *all* students learn, though some beginning teachers mentioned that some students were capable of learning without this type of class environment. Graduates from the undergraduate program expressed the depth of impact teacher education programs can have on developing this pedagogy.

> I came with the conception of, 'this is the way I learned it so its got to be the best way to teach it so that's probably the way I'll teach it'. And then [the Texas program] changed my views completely, took a 180 … I think the [Texas program] structure completely changed my vision of what its like to be a teacher. [Chris, undergraduate program]

> Well the idea of inquiry anything was brand new from [the Texas program]. [Erin, undergraduate program]

> Definitely, engaging lessons … and maybe that's just … engrained in my mind, that they've got to be engaged to be to maximise their learning … [Julia, undergraduate program]

For those in the alternative certification program, however, application of the theoretical ideas presented during the program to practices in teaching was attributed more frequently to time spent in the classroom. Due to time constraints, much of the learning about pedagogical ideas for the alternative certification program was through readings as opposed to experience; and while literature can be helpful, teachers reported that it took more time to process the theoretical ideas and know how to put them into practice. The difference in length between the two programs was substantial here.

> It's kind of frustrating. I do get a lot of [the material] sinking in, but at the same time I'm not receiving everything. It's the pace. I'm getting things through the program, but I want a lot more time. Time to comprehend. … I always say it's too fast, I need to understand … I need the time to process it. [Robert, alternative program]

This disadvantage for the alternative certification program, a lack of time, was one advantage in the undergraduate model. Teachers in the undergraduate program not only had time to process and practice implementation but they also had more time to see such theory modelled by professors. While this was not always done effectively, the participants in

this study recalled how influential professors were in modelling a different type of instruction:

> … it wasn't just a 'Here is a bunch of methods'. The more, the further I went into the [Texas] program, I realised that they were using the methods on us. That we were learning in the ways that they were teaching us to learn. And so I appreciated that and got to see the real impact of inquiry-based learning and the power it can have because I had been taught by so many lecture styles [before]. [Abby, undergraduate program]

> [It was] not so much…[professors'] classes, but more witnessing them teach their classes that made a huge difference. [Elisa, undergraduate program]

"Practical tools". During the interviews, participants made a distinction between beliefs guiding their classroom teaching and practical tools drawn on during instruction. Pedagogical beliefs about instruction may include ideas such as: students need to be actively engaged, students need to discover concepts on their own, and students need differentiated instruction. Different from these, practical tools might be things like: using technology, warm-up problems, the 5E lesson model (the five E's standing for: Engage, Explore, Explain, Extend/Elaborate, and Evaluate), exit slips, questioning strategies, using heuristic hints, and adapting problems to students.

The time frame difference between the two programs, particularly the number of teaching opportunities afforded throughout the program, allowed teachers from the undergraduate preparation program to acquire practical tools during the program more easily. These teachers unanimously expressed that their experiences during the program were the most influential for developing an array of practical tools to use in the classroom. For those in the alternative certification program, acquiring a repertoire of practical tools for classroom instruction was more frequently discussed as being learned post-program. This was noticeable particularly with regard to technology, as graduates from the alternative certification program went to work in "Title I" schools, which receive additional federal funding for serving a high percentage of students from low-income families and often have the resources to provide more technology in the classrooms. However, these teachers felt inadequately prepared to effectively utilise technology in their classrooms.

> I do feel the bag of tricks was huge. They had so much; I still use popsicle sticks, the red cards, and green cards. I mean I use so many—the think-pair-share … so many of the tools that came from [the Texas program] are used still in my classroom. [Abby, undergraduate program]

> I really think the top one is [the Texas program], for sure. Because that's where I was presented with the idea that people learn in different ways, even though I hadn't experienced it, I was presented with it and so that made me start thinking that way. That there are different ways to present it. [Erin, undergraduate program]

> … experience is more important than theory. Don't get me wrong; I think theory is important but as a beginning teacher I think the immediate focus should be on short term goals rather than the bigger picture that theory brings. [Gerry, alternative program]

> We had a lot of other teachers just telling us about [education] theory, but it doesn't always really work in a classroom. There was a huge disconnect between the theory and practice; especially in an urban classroom. [Mark, alternative program]

> I mean I had no idea how to … use certain technology or any of that before [the Texas program]. Today we did this *Who wants to be a millionaire?* with circle vocabulary. And I was like, 'Oh, I wish I had one of those TI-

> Navigators like we did [during the Texas program]'. [Elisa, undergraduate program]

> And then our math coach at the time said, 'If you ever need anything with technology go talk to Mr. Sans.' He [a teacher co-worker] has all of this technology and knows how to use it and will gladly teach you. [Charles, alternative program]

"Contextualisation". Another difference between the programs had an impact on how the two populations responded to learning how to contextualise their teaching. It related to the types of schools in which the educators were going to teach. In the alternative certification program, all graduates were placed in low-performing Title I schools. Knowledge of the type of school they would be working in and the type of student they would be working with allowed the alternative program to deal with relevant cultural and contextual issues. On the other hand, participants from the undergraduate model in this study ended up teaching in a large variety of contexts, from urban to rural, high performing to low performing.

Teachers from both populations reiterated that becoming skilled at adapting class activities for the particular set of students required contextual experience in a particular setting. The short duration of the teaching experiences, even in the undergraduate model where students had opportunities more frequently, was limiting for developing a sense of how to adapt to context. As Rebecca describes, "I came in, taught a lesson, then left. It's very hard to tailor to their knowledge if you don't know what they know". In response to a question about learning how to relate to a particular population of students, Rebecca quickly replied, "After [the Texas program]". The alternative certification program, on the other hand, was able to address culture and context in a more meaningful way. As Charles states, "… we just took a cultural diversity class and that kind of made me realise … it's a worthwhile investment, because culture is very important ... they'll be even more interested in what you're going to say". So while both populations made similar reports as to the importance of being able to contextualise teaching to the particular students in the classroom, the lessons for learning how to do so effectively were described as being during different time periods for the two populations.

"Mathematics knowledge". Participants from both programs also relayed that a teacher's knowledge of higher-level mathematics is important and necessary for good secondary mathematics teaching. Those in the undergraduate program ascribed the university experience as an influential period for learning this Mathematics knowledge: they were required to major in mathematics.

Some mentioned that the rigorous mathematics courses required during the program were the primary reason for their strong Mathematics knowledge; others were adamantly opposed—classes like Real Analysis were debated in terms of being relevant for teaching.

> … taking the rigor that you take at [the Texas program] … At some points I asked questions as to why I was doing things while I was at [the Texas program]. I don't ask those questions anymore. [Chris, undergraduate program]

> I would definitely recommend that they do upper division math classes in college. Because those, even if the content doesn't directly relate, the thought process and being able to prove those things mathematically definitely relate. [Julia, undergraduate program]

> I think that really understanding the content is important, but what is more important is knowing what concepts will follow students later in their

> mathematics education. I think having that knowledge of how math is structured and how students are going to learn it will be useful. [Natasha, alternative program]

Supplemental to the mathematics learned before and during the teacher education program, participants from both populations insisted that a significant amount of mathematics was acquired Post-program. Participants from both populations indicated that the experience actually teaching the material was important for developing the necessary content knowledge.

> But to be completely honest, after teaching from August until now, I've learned more about math having to teach it in those however months than I did actually taking math classes … I learned it inside and out. [Chris, undergraduate program]

> And I would say after college, in some ways, has been the time that I've learned the most in certain aspects, just because I've started to put math together as a whole. [Julia, undergraduate program]

In particular, mathematics knowledge was learned to some degree during all three time periods by teachers from both populations. Not everyone had strong mathematics backgrounds, and not everyone thought upper-division mathematics courses were helpful. Many from the undergraduate program felt that the rigor demanded from mathematics majors was useful for building confidence and for establishing helpful habits of mathematical thinking. Others felt that teaching high school mathematics did not require knowing the theoretical, upper-division mathematics content. Still others claimed that the content knowledge learned from actually teaching in the classroom was significant, particularly for making connections between materials and gaining an understanding of the curriculum at large.

The types of mathematical knowledge gained during each period, however, were somewhat different (Wasserman, in preparation). Some wove all three together:

> I think you need all three [Pre-, During, Post-] to be an effective, a good teacher. That learning process just continues. All three pieces are necessary. [Abby, undergraduate program]

Counter-intuitively, some participants felt that their own difficulties—not strengths—in learning the material growing up helped them become effective teachers.

> When I was in those upper level math classes, they were really hard for me. I'm the type of person that had to study really hard to get it. It [helps me identify and understand my students' problems], it does a little bit. [Larry, alternative program]

Regardless, all three periods were reported to have some influence on gaining a strong content knowledge. Learning and continuing to learn mathematics during all periods seemed to serve these beginning secondary mathematics teachers well.

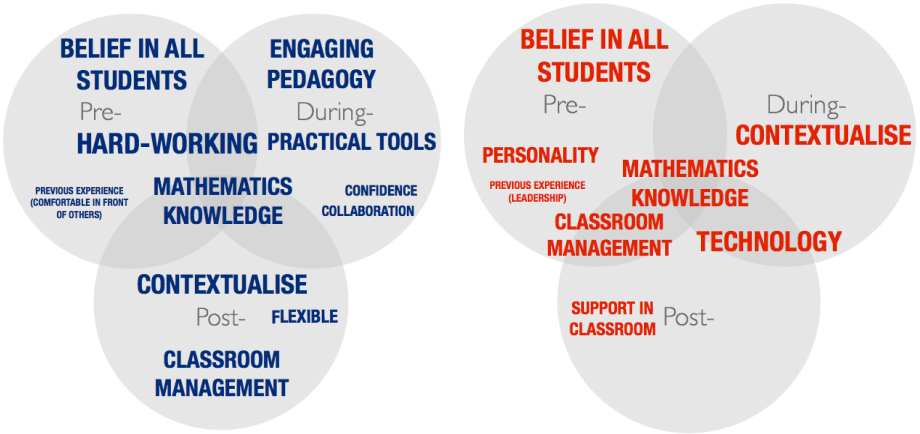
Discussion

From this coordinated study, two populations of secondary mathematics teachers with different teacher education experiences provided their perspectives about which attributes were most important during their transition to teaching. Notably, both groups reported very similar ideas regarding which attributes were "most important". These attributes, in particular, we argue may be considered particularly potent factors in

helping beginning teachers overcome the difficulties of transitioning to the profession of teaching.

Regarding the large-grain analysis of reported critical moments for developing these attributes, many similarities existed. While discerning the time period(s) for when specific attributes developed was difficult at times because it was based only on participants' responses, some broad themes were evident across the responses from these beginning teachers. The differences between the populations were mostly related to the differences in program length, as those in the alternative certification program did not have as much time to process ideas and practice teaching during their program. However, the contextual nature of the alternative certification program did allow for additional preparation for teaching particular types of students, and that was regarded as helpful.

Responses from both populations shed some ideas about what is possible—and particularly meaningful—for preparation programs to accomplish in preparing beginning teachers. Figure 1 gives a visual summary of the results for both populations, underscoring the degree to which participants articulated agreement about learning specific factors during particular time periods.



Undergraduate Program (TX) Alternative Program (CA)

Figure 1: Visual summary of results between both studies.

Pre-program

Being *Hard-working*, having a *Belief in all students*, and having *Previous Experiences* that prepare future teachers to be comfortable in front of others were all described as "most important" factors for success learned or experienced primarily Pre-program.

That these three significant attributes were learned before a teacher preparation program, reportedly, offers insight into the types of students a mathematics teacher education program should try to attract and recruit. Regarding personal traits, it is likely not novel that good teachers work hard and believe that students can learn. Moreover, that these are traits that have not been taught during formal education but have been instilled throughout

a lifetime of interactions with parents, teachers, peers, etc., may seem obvious.

However, there are at least two aspects from this report that are significant. The first is that *these* two traits—not organisation skills, sense of humor, being relatable, enthusiastic, approachable, respectful, etc.—were more universally common personal traits reported by high-quality beginning teachers. While some teachers might be organised, others humorous, others easily relatable, the traits that were common among these beginning mathematics teachers and identified as extremely relevant to success in the secondary classroom, were hard-work and believing in all students. The second is that these two personal traits are pertinent for sustaining the desire and motivation to be a teacher, particularly during the transition to teaching. This is not trivial.

During a transition year that has been described as a shock, constituted by a large gap between expectations and reality for first year teachers (Marso & Pigge, 1992), these beginning teachers had the ability to maintain their hard-work and belief in all students. They held onto the belief that, although it might take hard work for both student and teacher, everyone is ultimately capable of learning the mathematics being taught. Since teaching places a large amount of responsibility on the individual teacher, who is often solely in charge of the quality of classroom instruction with little influence from outside sources, the personal motivation to work hard and the desire to get to know individual students, while demanding, is important to strive for in order to have success as a classroom educator, and is particularly poignant for beginning teachers.

During and Post-Program

Differences between the two programs evoked slightly different responses regarding when some attributes were learned. Both populations indicated that learning theories about how teaching and learning mathematics were important and advantageous to beginning teachers; however, the additional duration of the undergraduate program allowed more time to process theoretical notions, as well as to practice and witness effective implementation.

The extra time in the undergraduate program, as opposed to the alternative certification program, also afforded those teachers the opportunity to learn practical tools to experiment with in the classroom, including appropriate use of technology. Aspects of the particular undergraduate program in this study also increased graduates' confidence in and passion for education, which made a significant impact on their teaching. Those from the alternative certification program felt they had to learn these things post-program. However, the added focus—due to knowing the types of schools the graduate would be teaching in and the population the graduates would be teaching to—that the alternative certification program was able to incorporate was useful. The ability to address culture and specific contexts in a meaningful way during the program better prepared these graduates for adapting mathematics teaching to particular groups of students.

Those in the undergraduate program said they felt that although the opportunities to teach throughout the program were particularly helpful, the short duration of each experience did not help them develop a great sense of context or the ability to successfully adapt lessons to varied students and situations. Interestingly, despite the fact that these two populations differed somewhat on when these attributes were learned, the important attributes themselves were common to both groups.

From this research, it is evident that effective pedagogy, practical tools, technology, and the ability to contextualise teaching are incredibly important for and can be taught successfully during a teacher education program. The beginning teachers reported the importance of these particular attributes for overcoming the challenges to teaching and discussed these as meaningful contributions to their teaching practices learned during the teacher education process. Such insight from beginning teachers should help inform the aim and scope of teacher preparation, so that graduates are prepared to overcome the transition to teaching.

Given the relatively short duration of teacher preparation, a teacher education program cannot, and should not, attempt to teach everything a teacher needs to know before entering the profession. With this in mind, one other result from this study, not fully described in this manuscript, was that Classroom management and being Flexible were perceived as beneficial by both populations of beginning teachers but had been learned largely Post-program. This knowledge helps define two areas where specific practicum or internship components might benefit future teachers. Both factors, being competent managing the classroom and being flexible during instruction, were gained distinctly through experience teaching. Acquiring these abilities evidently required more long-term experiences teaching, where teachers were able to realise the potential to manage a classroom and were afforded time to think about contextualising and being sensitive to the particular students being taught. Identifying if there are meaningful ways to incorporate these two ideas into teacher education programs could help foster these most-necessary attributes for beginning success in teaching.

This study provides evidence that beginning secondary mathematics teachers, across two different teacher education programs, identified similar attributes that were helpful for their successful transition to teaching. In addition, the two populations' responses informed some similarities and differences regarding when these attributes were reportedly developed that provide a reflection on teacher education. However, the relatively small (national) samples in this study limit the generalizability of their reports; and while the comparison from two populations of beginning mathematics teachers provides some evidence of the findings' more general nature, they are nonetheless limited.

The use of two programs, which helped identify similarities, at times also made specific comparisons more difficult. In addition, the use of high-quality beginning teachers, based on the selection criteria, in this study also provides some limitations with respect to the findings reported. In particular, by using nominations from teacher educators, the beginning teachers selected for this study may be biased toward graduates who closely aligned their beliefs, goals, and philosophies with those of the preparation program. Future work could incorporate other indicators, such as additional independent observers or standardized test scores, to improve the nomination process; alternatively, a more random cross-section of beginning teachers could be incorporated. In addition, longitudinal data from these same teachers may provide information about if and how their reports about influential attributes may change or modify after additional time in the profession and for reflection. Whether some of these issues are specific to beginning teachers, as opposed to mid-career and late-career educators, could further inform the overall transition to teaching.

Conclusion

From this study, reports from the purposeful sampling of high-quality beginning secondary mathematics teachers that Hard-work and a Belief in all students are described as some of the most important characteristics, and are often instilled in people before a teacher education program, gives educators something valuable to look for when recruiting candidates for teacher education programs. Similar to the way that *Teach for America* or the Singapore Ministry of Education are highly competitive and selective in determining who is admitted to their program, mathematics teacher education programs might seek such qualities as a good starting point for training highly-qualified secondary mathematics teachers.

The finding that effective pedagogy, practical tools, technology, collaboration, and the ability to contextualise teaching can be successfully taught during a teacher education program communicates that practice, practical tips, theory, and contextualization are important for teacher education programs to communicate and model in their instruction. Counter to the notion that teachers only want to know practical teaching skills, and some subsequent development of programs focused only on these, strong beginning mathematics teachers voiced benefitting from learning both theory and practice. From their reports, we cannot simply focus teacher education programs around practices and strategies, but instead need to intertwine these two components as two strands of the same cord that reinforce and enhance one another.

Similarly, the focus on planning lessons during teacher preparation would benefit from additional discussion about the *context* of whom the lesson is taught, which should inform and impact instruction, and which beginning teachers will need during their transition to teaching various groups of students.

Finally, Classroom management and being Flexible were qualities seen to be most frequently learned Post-program. These factors establish the need to consider incorporating practicum or internship experiences that prepare students to learn—or at least to begin the process of developing these qualities during the course of a teacher education program. Both feeling comfortable managing a classroom and learning to be flexible are factors gained distinctly through longer-term experiences of teaching. Affording future teachers the chance to create, or role-play, various disciplinary situations and non-routine events and student questions may benefit future graduates. In addition, other continuing professional development opportunities could also focus on some of these aspects of teaching.

The described list of factors, deemed most important for beginning success in mathematics teaching, highlight specific areas that we argue should be a focus for teacher education programs. Listening to those attributes reported by beginning teachers as serving them particularly well is an important lens through which to look in analysing the process of teacher education. While many of these factors are not novel, they represent an important *subset* of the attributes in the literature that merit further inspection and additional description of how best to incorporate them throughout various teacher education programs, based on their importance reported from beginning teachers.

By focusing on the reports from beginning teachers, we gained unique insight. Preparing confident and informed teachers for success in the classroom, from the beginning, is important work and has the potential to inform the practices of both recruiting and training highly qualified teachers.

References

Allen, M.B. (2003). *Eight questions on teacher preparation: What does the research say?* Denver, CO: Education Commission of the States.

Askew, M., Brown, M., Rhodes, V., Wiliam D., & Johnson, D. (1997). Effective teachers of numeracy in UK primary schools: Teachers' beliefs, practices and pupils' learning. In E. Pehkonen (Ed.), *Proceedings of the 21st conference of the international group for the Psychology of Mathematics Education* (Vol. 2, pp. 25–32). Lahti, Finland: IGPME.

Ball, D. L., & Bass, H. (2000). Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics. In J. Boaler (Ed.), *Multiple perspectives on mathematics teaching and learning* (pp. 83–104). Westport, CT: Ablex Publishing.

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*(5), 389–407.

Borko, H., & Whitcomb, J. (2008). Teachers, teaching, and teacher education: Comments on the National Mathematics Advisory Panel's report. *Educational Researcher, 37*(9), 565–572.

Brown, C., & Borko, H. (1992). Becoming a mathematics teacher. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 209–239). New York: Macmillan.

Carroll, J. (2005). Developing effective teachers of mathematics: Factors contributing to development in mathematics education for primary school teachers. In P. Clarkson, A. Downton, D. Gronn, M. Horne, A. McDonough, R. Pierce, & A. Roche (Eds.), *Building connections: Research theory and practice. Proceedings of the 28th Conference of the Mathematics Education Research Group of Australasia* (pp. 201-208). Melbourne, Australia: MERGA.

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. Thousand Oaks, CA: Sage.

Cobb, P., Wood, T., & Yackel, E. (1990). Classrooms as learning environments for teachers and researcher. In R. B. Davis, C. Maher, & N. Noddings (Eds.), Constructive views on the teaching and learning of mathematics. *Journal for Research in Mathematics Education Monograph Series, No. 4* (pp. 125–146; 195–210). Reston, VA: National Council for Teachers of Mathematics.

Darling-Hammond, L., & Rothman, R. (Eds.) (2011). *Teacher and leader effectiveness in high-performing education systems*. Washington, DC: Alliance for Excellent Education, and Stanford, CA: Stanford Centre for Opportunity Policy in Education.

Davis, B. & Brown, L. (2009). Development of teaching in and from practice. In R. Even & D. L. Ball (Eds.), *The professional education and development of teachers of mathematics. The 15th ICMI Study: New ICMI Study Series,* (Vol. pp. 149–166). New York: Springer.

Gibson, W. J. & Brown, A. (2009). *Working with qualitative data*. Thousand Oaks, California: Sage.

Giordano, P. J. (2003). *Critical moments in learning: Do we know when we are teaching?* W. Harold Moon Invited Address presented at the 15th annual South-eastern Conference on the Teaching of Psychology, Marietta, GA.

Hamachek, D. (1971). What makes a good teacher? In D. Aichele & R. Reys (Eds.), *Readings in Secondary School Mathematics* (pp. 338–346). Boston, MA: Prindle, Weber & Schmidt.

Harry, B., Sturges, K., & Klingner, J. K. (2005). Mapping the process: An exemplar of process and challenge in grounded theory analysis. *Educational Researcher, 34*(2), 3-13.

Hill, H., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(5), 371–406.

Instructional Assessment Resources (n.d.). *Instructional Best Practices*. Retrieved 17 March, 2013, from http://www.utexas.edu/academic/diia/assessment/iar/teaching/plan/why-practices.pdf

InTASC (2010). Model core teaching standards: A resource for state dialogue. (Draft) Washington, DC: Council of Chief State School Officers.

Ladson-Billings, G. (1994). The dreamkeepers: Successful teachers for African-American children. San Francisco, CA: Jossey-Bass.

Lerman, S. (2001). A review of research perspectives on mathematics teacher education. In F. L. Lin & T. J. Cooney (Eds.), *Making sense of mathematics education* (pp. 33–52). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Lawrence Erlbaum Associates.

Marso, R., & Pigge, F. (October, 1992). *Teachers rating of job entry expectations prior to and following the first year of teaching: Evidence of idealistic expectations and transition shock.* Paper presented at the Annual Meeting of the Midwestern Educational Research Association, Chicago, October 14–17.

National Association of State Boards of Education (NASBE) (1998). *The numbers game: Ensuring quantity and quality in the teaching workforce*. Alexandria, VA: NASBE.

Neubrand, M., & Seago, N. (2009). The balance of teacher knowledge: Mathematics and pedagogy. In R. Even and D. L. Ball (Eds.), The professional education and development of teachers of mathematics. The 15th ICMI Study: New ICMI Study Series (Vol. 11, pp. 211–225). New York: Springer.

Newman, I., & McNeil, K. (1998). *Conducting survey research in the social sciences*. Lanham, MD: University Press of America.

Nickson, M. (1988). Pervasive themes and some departure points for research into effective mathematics teaching. In D. A. Grouws & T. J. Cooney (Eds.), Perspectives on research on effective mathematics teaching (Vol. 1, pp. 245–252). Reston, VA: NCTM.

Oliveira, H. & Hannula, M. (2008). Individual prospective mathematics teachers. In K. Krainer & T. Wood (Eds.), *Participants in mathematics teacher education*, Vol. 3 of T. Wood (Series Ed.), *International Handbook of Mathematics Teacher Education* (pp. 13–34). Dordrecht, The Netherlands: Sense Publishers.

Rowland, T., & Ruthven, K. (Eds.). (2011). *Mathematical knowledge in teaching.* New York: Springer.

Schoenfeld, A., & Kilpatrick, J. (2008). Toward a theory of proficiency in teaching mathematics. In D. Tirosh & T. Wood (Eds.), *Tools and processes in mathematics teacher education*, Vol. 2 of T. Wood (Series Ed.), *International Handbook of Mathematics Teacher Education* (pp. 321–354). Dordrecht, The Netherlands: Sense Publishers.

Schön, D. (1987). *Educating the reflective practitioner*. San Francisco, CA: Jossey-Bass.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Simon, M. (2006). Key developmental understandings in mathematics: A direction for investigating and establishing learning goals. *Mathematical Thinking & Learning, 8*(4), 359–371.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park, CA: Sage.

Thompson, A. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 127–146). New York, NY: Macmillan.

Tirosh, D., & Graeber, A. (2008). Pedagogical content knowledge. In P. Sullivan & T. Wood (Eds.), *Knowledge and beliefs in mathematics teaching and teaching development,* Vol. 1 of T. Wood (Series Ed.), *International handbook of mathematics teacher education* (pp. 117–132). Dordrecht, The Netherlands: Sense Publishers.

Truxaw, M. P., & DeFranco, T. C. (2008). Mapping mathematics classroom discourse and its implications for models of teaching. *Journal for Research in Mathematics Education, 39*(5), 489–525.

Wilson, P., Cooney, T. J., & Stinson, D. (2005). What constitutes good mathematics teaching and how it develops: Nine high school teachers' perspectives. *Journal of Mathematics Teacher Education, 8*(2), pp. 83–111.

Zaslavsky, O. (2008). Meeting the challenges of mathematics teacher education through design and use of tasks that facilitate teacher learning. In B. Jaworski & T. Wood (Eds.), *The mathematics teacher educator as a developing professional,* Vol. 4 of T. Wood (Series Ed.), *International handbook of mathematics teacher education* (pp. 93–114). Dordrecht, The Netherlands: Sense Publishers.

Appendix: Interview Coding Framework

Strand	Code	Description
Knowledge for Mathematical Tasks	Strong General Content Knowledge	Strong mathematics background; solid content foundation both in scope and depth
	Strong Specific Content Knowledge	Strong mathematics knowledge specific to courses taught; confident when approaching curriculum and answering student questions
	Broad Knowledge of Curriculum	Strong grasp on all HS mathematics curriculum; for topics taught, understands implications for future mathematics study; mathematical knowledge at the horizon
	Communicating Mathematics	Ability to easily explain mathematical concepts to students in the classroom
	Problem-Solving	Ability in mathematical thinking and reasoning; comfortable approaching and solving novel mathematics problems
	Connection to State Standards	Able to relate curriculum to broader State standards; knowledge of standards
	Mathematical Struggles	History of personal struggles learning mathematics informs approach to teaching
Role in Discourse	Facilitate	Guiding discussion; involving all students in the learning process; answering teacher questions; groups or whole class
	Lecture	Directly explain concepts; passive learning and note-taking; memorization
	Practice Work	Assigns practice problems and checks for understanding; groups or individuals
	Flexible	Willing to change instruction based on student needs or other circumstances
Learning Environment	Classroom Management	Able to control discipline issues, routines, and structures to facilitate learning environment
	Engaging Lessons	Making content relevant to students; students are engaged in activities; mathematics presented in engaging way
	Inquiry Lessons	Students exploring concepts; discovering; making conjectures; collaborative group work
	Belief in all students	Evidence of expectation and belief that all students are capable of learning mathematics
	Ownership of Classroom	Students have input in classroom routines and curriculum; student work posted

Tools to Enhance Discourse	Experimenting with teaching	Importance placed on varying teaching styles; trying new approaches and methods
	Toolbox	Bag of tricks; toolbox; having a variety of resources to draw from when teaching
	Contextualise	Tailoring lessons to particular population taught; culturally relevant and interesting
	Differentiation	Tailoring lessons to individual learning differences; using different instructional approaches to reach all types of learners
	Technology	Evidence of using of technology to enhance classroom discourse
	Real World Application	Displaying connection between mathematics and real-world; mathematics is applicable and relevant
Analysis of Teaching and Learning	State Assessments	Using student test scores to guide curriculum; test scores reflective of student learning; teaching to the test
	Own Assessments	Using assessments to inform student progress; other types of informal assessment; reflective of student learning
	Reflection	Reflecting on teaching to improve practice; any modifications made to lessons based on experiences teaching
	Feedback	Verbal or written comments on teaching from administrators, teachers, colleagues, etc.
Personality	Confident	Confident in abilities as a teacher
	Hard-Working	Willingness to work hard; sacrifice; time and effort put into teaching
	Passionate	Excited about education; love of profession and teaching
	Entertaining	Entertaining; joking; puts on a show
	Extrovert	Outgoing; easy to talk and relate to
	Organised	Organised with teaching
	Caring	Caring about students; caring personality evident in interactions with students
	Tough but Fair	Hold students to standards; kind, yet maintains boundaries in discipline
	Leadership	Leadership skills; comfortable in front of large groups; authoritative
	Similar backgrounds	Having a similar background to students; naturally and culturally able to relate well
Beliefs	Survival	Make it through; survive first year
	Reasonable Expectations	Taking personal time; not over-working; not setting up for failure first year
	Grow Professionally	Desire to improve teaching; dedicated to becoming better teacher; not satisfied with status quo
	Efficacy	Belief that efforts put forth as teacher make a positive impact

Colleagues	Collaboration	Working together with others to create, improve, and assess lessons; emphasis on co-developing ideas
	Colleague Support	Getting advice, tips, etc. from colleagues for classroom managements, school policies, grading, lesson ideas; personal support; emphasis on receiving help
	Accountability	Collegiality; common assessments; whole-school curriculum and policies
	Professional Development	Time spent with colleagues in Professional Development environment to learn
	Role Models	Persons in past, or present, who represent models emulated in teaching
Rapport	Relationships	Importance placed on building student relationships; making specific efforts to get to know students; whole-person
	Trust	Establishing and building trust between students, class and teacher
	Student productivity	Espousing belief that better relationships lead to more student productivity
When	Pre-Program	Attributes were discussed in the context of being learned or experienced before the teacher education program
	During Program	Factors were discussed as being learned or experienced during activities, teaching experience, courses, etc. during the teacher education program
	Post-Program	Things learned or experienced after the program, on the job; while in the classroom

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