Secondary Preservice Teachers' Anticipated Objectives and Practices for Teaching Mathematics

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Australian students' attitudes to mathematics are in decline relative to other countries. Their participation in senior secondary mathematics that provide pathways to further study is also falling. Pedagogical approaches that improve students' attitudes to mathematics and knowledge of mathematics are required. This paper reports on preservice secondary mathematics teachers' objectives for their students' learning and their anticipated teaching and learning activities. The study was conducted over one year using quantitative analysis of paired responses to items in pre and post questionnaires. At the end of the year, the preservice teachers emphasised objectives for understanding and positive disposition but anticipated using fluency activities almost daily. Investigations involving problem solving and reasoning were anticipated to occur at least weekly. However, a significant decline in their anticipated use of activities that link mathematics to other disciplines or applying mathematics to real world problems occurred. Other data suggest a lowering of emphasis on developing students' disposition and interest in mathematics. The findings suggest that more attention needs to be given to raising preservice teachers' awareness of the importance of students' disposition. Further research on the impact of teaching experience and opportunities to develop all proficiencies and to link mathematics to other disciplines and real-world problems during preservice teacher education is recommended.

Keywords · preservice secondary mathematics teachers · teaching practices · learning objectives · positive disposition · interest; reasoning · problem solving · understanding

Introduction

There is an urgent need to improve students' attitudes to, and knowledge of mathematics and encourage students' participation in mathematics in senior secondary years (Chubb, 2013). Currently, few Australian students undertake mathematics at senior levels of secondary school and even fewer enrol for mathematics at university (Wienke, 2017). Mathematics achievement and attitudes in Australia have declined relative to other countries (Mullis et al., 2016; Thomson et al., 2013). Teachers' attitudes and beliefs are known to impact on students' attitudes, engagement, and achievement in mathematics (Attard, 2013; Beswick, 2007; Carmichael et al., 2017; Forgasz & Leder, 2008; Teacher Policy Research, 2006). Without serious attention and innovation longstanding patterns of negative attitudes and underperformance will not change (Brown et al.,2008). "However, there is virtually no systematic, methodologically sound research that indicates the attributes of preparation programs … that lead to improved student outcomes" (Teacher Policy Research, 2006, p. 1).

The aim of this study is to explore prevailing opinions held by preservice mathematics teachers about mathematics and its pedagogy. The challenge for preservice mathematics teacher education is to provide experiences of student-centred teaching approaches that foster student engagement and participation and promote improved attitudes and achievement of all the mathematical proficiencies (Frykhom, 1999; Little & Anderson, 2015; Peressini et al., 2004; Prescott & Cavanagh, 2008; Ng, Nicholas & Williams, 2010). This study explores secondary mathematics preservice teachers' (PSTs') goals for students' mathematics learning and anticipated teaching practices:

- What are preservice teachers' objectives for students' mathematics learning?
- What teaching and learning activities do preservice teachers anticipate using to achieve their learning goals?
- How do their objectives and anticipated practices change over their teacher education experience?

Background

In recent years there has been a shift away from traditional mathematics teaching approaches focusing on knowledge of mathematical processes and algorithms with an emphasis on correct answers (Cady et al., 2006). Reflecting this shift, the Australian Curriculum: Mathematics (AC:M) defines four mathematical proficiencies that teachers are required to support their students to develop:

- understanding, "a robust knowledge of adaptable and transferable mathematical concepts",
- fluency, "skills in choosing appropriate procedures; carrying out procedures flexibly, accurately, efficiently and appropriately; and recalling factual knowledge and concepts readily",
- problem solving, "make choices, interpret, formulate, model and investigate problem situations, and communicate solutions effectively", and
- reasoning "an increasingly sophisticated capacity for logical thought and actions, such as analysing, proving, evaluating, explaining, inferring, justifying and generalising" (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2017a).

Building on the model of mathematical proficiencies developed by Kilpatrick et al. (2001) other nations around the world have developed similar goals for mathematics learning in their curriculum (for example, United States of America: Common Core State Standards Initiative, 2010; United Kingdom: Department for Employment and Education (DfEE), 2014). Kilpatrick et al. included a fifth proficiency, *productive disposition*, which they defined as "habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy" (2001, p. 5). Goos et al. (2014) defined positive disposition as involving confidence, flexibility, initiative and risk-taking behaviours and included this attribute as an under-pinning quality in a model of numeracy. In addition, a positive or productive disposition enhances the likelihood of pursuing studies in senior secondary mathematics and onto university, with the potential to result in higher numbers of graduates with qualifications and knowledge for emerging and developing professions (Forgasz & Leder, 2008; Pampaka et al., 2012).

The Australian Curriculum: Mathematics (AC:M) directs that students:

> Respond to familiar and unfamiliar situations by employing mathematical strategies to make informed decisions and solve problems efficiently and … [mathematics education should also] ensure all students benefit from access to the power of mathematical reasoning and learn to apply their mathematical understanding creatively and efficiently (ACARA, 2017b).

Attaining the ACARA mathematical learning goals involves recognising and valuing these proficiencies in secondary school mathematics; developing understanding of these proficiencies and how they are learned; and enacting pedagogical approaches that are student-centred and relate to the learning context and students' needs.

In addition, numeracy is included as a general capability in the Australian Curriculum (ACARA, 2017b) so numeracy is a learning objective for all disciplines. The Australian Curriculum states:

> Students become numerate as they develop the knowledge and skills to use mathematics confidently across other learning areas at school and in their lives more broadly. Numeracy encompasses the knowledge, skills, behaviours and dispositions that students need to use mathematics in a wide range of situations. It involves students recognising and understanding the role of mathematics in the world and having the dispositions and capacities to use mathematical knowledge and skills purposefully (ACARA, 2017b).

Statements such as these excerpts from the Australian Curriculum open up possibilities for mathematics education to move beyond isolated rote learnt procedures, providing opportunities for student-centred approaches including open questions and investigations to feature more strongly in secondary mathematics. Student-centred approaches provide avenues for engaging students who historically have shown a low interest in mathematics and/or patterns of underperformance (Brown et al., 2008) and address affective issues, such as emotions and disposition towards mathematics (Bieg et al., 2017; Carmichael et al., 2017; Kaur et al., 2019; Maxwell, 2001). Teacher education programs therefore need to provide opportunities for preservice teachers to develop knowledge and productive or positive dispositions towards teaching mathematics.

Secondary Pre-service Teacher Education Studies

Previous studies of the impact of preservice teacher education have focused on PSTs' mathematical and pedagogical content knowledge, beliefs and affect, and socio-cultural processes of learning and have typically used qualitative methods with small samples of participants (Adler et al., 2005; Goos et al., 2008). These and other studies have reported on the influence of context for teachers' learning and practices (for example, Anthony et al., 2015). Hence, we have used situated learning theory (Peressini et al., 2004) as the theoretical framework for the current study. In situated learning theory, learning is influenced and shaped by the social context, experiences, and events. For PSTs of secondary mathematics this includes their own experience of learning mathematics which have shaped their beliefs about teaching (Conner et al., 2011; Ertl & Kremer, 2010; Ng et al., 2010) as well as PST education coursework and teaching practice experiences. Of significance for PSTs is the way in which their learning in one situation is transferred and built upon in other situations, for example from coursework to teaching practice experiences or across different schools, a process referred to as "recontextualising" (Ensor, 2001).

In the current study, evidence was sought of changes in preservice teachers' learning objectives and teaching practices arising from their experiences.

Studies of preservice primary or elementary teachers dominate the literature on knowledge and beliefs of preservice teachers (e.g., Charalambos, 2015; Charalambous et al., 2008; Grootenboer, 2008; Jao, 2017; Langford & Huntley, 1999). These studies have reported on the impact of elements of preservice primary mathematics education such as the methods course or practical experience or ways in which PSTs' beliefs are related to teaching practice. In general, they report findings that beliefs about mathematics teaching and learning were more reform-based following participation in preservice education programs including teaching and other practical experiences. Participants' mathematical content knowledge have influenced PSTs' initial beliefs and their opportunities to implement reform-based teaching have influenced changes in beliefs.

There are fewer studies involving secondary mathematics PSTs about the influence of coursework or teaching experience on their teaching objectives for teaching mathematics. These studies typically use mixed methods with small samples to explore changes in beliefs about mathematics and teaching mathematics (e.g., Barkatsas & Malone, 2005; Conner et al., 2011; Dede & Karakus, 2014; Jao, 2017) or the relationship between beliefs, knowledge of curriculum and teaching practice (e.g., Frykholm, 1999; Little & Anderson, 2015; Prescott & Cavanagh, 2006, 2008; White-Clark et al., 2008).

Prescott and Cavanagh (2006) interviewed 16 secondary PSTs at the beginning of the course about their perceptions of good teachers and good teaching. Their findings provide evidence of the influence of PSTs' own learning experience on their perceptions of good teaching. Prescott and Cavanagh reported that the PSTs' perceptions concerned traditional exposition methods such as providing clear explanations and practicing skills, along with making mathematics relevant using real-life examples. In a follow up study with four beginning teachers, Prescott and Cavanagh (2008) reported that these beginning teachers saw a need to balance traditional textbook teaching and working mathematically approaches. They also reported that they were often constrained by a lack of resources and support from the school to implement inquiry approaches. Some teachers reported feeling pressure to keep up with other classes and teachers who were following a more traditional textbook approach. However, one teacher who felt constrained to traditional methods during practicum experiences was enjoying being able to explore their ideas for teaching mathematics, as they felt supported by the senior staff at their school.

Jao (2017) used pre- and post-questionnaires that included twenty Likert belief items as well as analysis of assessment tasks to explore the impact of a reform-based teacher education program which emphasised student-centred and exploratory learning and problem-solving on middle years teachers' beliefs. They reported that PSTs' initial beliefs were based on their experiences as learners of mathematics and were able to identify tasks from their teacher education program that had encouraged them to shift their beliefs to more student-centred beliefs. However, the preservice teachers reported difficulty in implementing these beliefs and practices when completing practical experiences as part of the course.

An earlier study of secondary preservice teachers, whose course focussed on National Council of Teachers of Mathematics (NCTM) *Standards* and included an internship for one semester, used mixed methods including questionnaires, lesson observations and interviews to explore beliefs and pedagogies of three cohorts of secondary PSTs (N=63) in the final stage of the mathematics teacher education program (Frykholm, 1999). Fryholm described the reform-based pedagogical focus of the *Standards* as providing opportunities for students "to reason, communicate, make connections, and problem solve" (p. 83) and reported that PSTs developed understanding and beliefs consistent with the content of the *Standards* but struggled to implement reform-based pedagogies in the classroom. Such approaches enable students to investigate and discover mathematics ideas for themselves and involve cooperative learning and the use of materials and/or digital technology. Fryholm coded the data on teaching practices that the PSTs observed and enacted during teaching experience as direct instruction, enhanced direct instruction or reform-based. However, enhanced direct instruction and reform-based pedagogy were not clearly defined or described in this study.

Similarly, White-Clark et al. (2008) investigated teaching approaches. They surveyed 49 preservice secondary mathematics teachers at the end of their teacher education program and found that the PSTs continued to use teacher-directed, didactic approaches and were mastery-orientated rather than more constructivist and reform-based. The PSTs in their study also reported that the teacher educator predominantly used lectures and did not model or provide hands-on experiences of constructivist and reform-based pedagogies in their mathematics courses. Little and Anderson (2015) also found that secondary preservice teachers experienced limited opportunities to develop reform-based teaching practices for mathematical problem solving during their teaching practicum. They investigated the factors that inhibited use of problem-solving approaches using mixed methods, involving a questionnaire and semi-structured interviews. These modes of data collection occurred at the end of the mathematics curriculum course following their practical experience with participants completing a Master or undergraduate teacher education program. One factor they identified was the PSTs' beliefs. Little and Anderson (2015) used Beswick's (2005) framework of beliefs to select the eleven Likert items from TEDS-M study (Tatto et al., 2008) for their questionnaire. The items concerned *instrumentalist* beliefs (Ernest, 1989) that is, being content-focused with an emphasis on performance when teaching (Van Zoest et al., 1994); or *problem solving* beliefs (Ernest, 1989) that is, enabling learners to construct their understanding of mathematics (Van Zoest al., 1994). None of their items specifically concerned *Platonist* beliefs (Ernest, 1989) that is, being content-focused with an emphasis on understanding in teaching approaches (Van Zoest al., 1994). Other items in their questionnaire invited PSTs to state the frequency of completing various practices. Little and Anderson (2015) reported that most of the PSTs held problem solving beliefs, whilst the other PSTs held instrumentalist beliefs. More than half their participants described using problem solving tasks, but not all students with problem solving beliefs had implemented problem-solving lessons.

Aside from studies with an interest in the problem-solving proficiency and the use of problem-solving approaches for teaching, the very small mixed methods study by Conner et al. (2011) concerned mathematical reasoning and PSTs. Their study explored six (6) preservice secondary teachers' beliefs about mathematics, proof and teaching mathematics by using a questionnaire that included items related to beliefs about proof, and teaching mathematics, and interviews after a four-semester program that included practical experiences. Items in their questionnaire also related to Ernest's (1989) three categories of beliefs: instrumentalist, Platonist and problem solving. They found that the PSTs' beliefs about mathematics and proof were either Platonist or instrumentalist and did not change whereas, PSTs' beliefs about teaching shifted from teacher-directed to being more open to student-centred approaches and developing student understanding. Some PSTs viewed proof as important for developing understanding of mathematics.

Studies of preservice teachers have not tended to focus on developing students' positive disposition for mathematics or interest in mathematics. Carmichael et al. (2017) described the two sources of interest as emotional and cognitive, whereby the first derives from enjoyment, and the second from accepting and completing a challenge. Interest for primary students is more likely derived from enjoyment, whereas cognitive challenge is more likely to stimulate interest for secondary students. Disposition, on the other hand, is associated with self-efficacy and a willingness and confidence to investigate and apply mathematics. Carmichael et al. (2017) surveyed more than 400 primary and secondary students and their teachers to identify factors that influenced students' interest in mathematics. They found that teachers' enthusiasm for teaching mathematics rather than their enthusiasm for mathematics influenced students' interest in mathematics. In addition, teachers' practices that created a learning environment that focussed on developing students' understanding was more likely to generate students' interest in mathematics than practices that created environments that were performance focused.

Australian studies of secondary mathematics PSTs have focussed on beliefs (Beswick 2005, 2007, 2012), problem solving (Little & Anderson, 2015) and using problem solving approaches (Prescott & Cavanagh 2006, 2008). The aim of this study is to investigate secondary mathematics PSTs' perceptions of teaching mathematics by focussing on PSTs' goals for student learning and their anticipated teaching approaches as these goals relate to mathematical proficiencies: fluency, understanding, problem solving, reasoning and disposition.

Methodology

This exploratory evaluation study used survey methods to collect data using online and hardcopy pre- and post-questionnaires to investigate changes in mathematics learning objectives and anticipated teaching approaches or strategies of preservice secondary mathematics teachers during one year of their teacher education program. Exploratory research is used to formulate problems and generate hypotheses and when using survey methods typically use convenience rather than random samples (Bryman, 2016). As 102 PSTs were enrolled in the junior secondary mathematics course, we expected a response rate sufficient for pre- and post- comparative analysis of PSTs' learning goals and anticipated teaching approaches used in quantitative evaluation research. Critical realism that is, interpreting findings with respect to program, in this case course, as well as the contexts in which it occurs is central to evaluation research (Pawson & Tilley, 1997). As the aims of this study were to identify PSTs' learning objectives and teaching approaches and any changes to those over time, explaining changes in PSTs' goals reported in this paper will require a follow-up study using other methods. The participants were drawn from several secondary teacher education programs at one Australian university, but all experienced the same mathematics education course content.

Participants and Course Context

All participants of the study were enrolled in one of several secondary teacher education programs at the same university and each participant was enrolled in the two secondary mathematics curriculum courses and participated in the study in accordance with the approval from the Human Research Ethics Committee of the university. These programs included three different combined four-year undergraduate secondary teacher education programs that required study of two years of tertiary mathematics and two mathematics curriculum courses within the programs, and two post-graduate Master of Teaching programs for secondary teacher education for students who had completed two years of tertiary mathematics study for entry to the program. There were 52 PSTs enrolled in the undergraduate course for the pre-survey and 45 for the post-survey with 51 enrolled in the Masters course for the pre-survey and 44 for the post-survey.

Participants from the undergraduate programs, usually undertaking their third year of the program, were completing a combined education and science, arts or health and physical education undergraduate degree. These preservice teachers completed 30 days teaching experience during the year of the study. Participants from the standard Master of Teaching (MT) program included full-time on campus students and part-time off-campus students. Preservice MT teachers normally completed 35 days teaching experience during the year. The other MT PSTs were employed as associate teachers with a 0.8 teaching load after completing four MT courses including the first mathematics education course.

All participants completed the same two courses of mathematics curriculum and teaching (see Table 1). The first author taught the junior secondary mathematics course for the Undergraduate and MT on campus PSTs and the second author taught both courses for online undergraduate and MT PSTs. A third teacher educator taught the senior secondary mathematics unit for on campus students. In both courses the teacher educators modelled inquiry approaches to mathematics learning that engage students in problem solving and mathematical reasoning. The first focussed on junior secondary years from Year 7-10 including transition from the primary years; the second concerned teaching mathematics at the upper secondary level.

The first course introduced preservice teachers to the content and proficiencies of the *Australian Curriculum: Mathematics* and student-centred teaching approaches. Each weekly seminar for on-campus and off-campus focussed on one proficiency and one of the content domains, this meant that more than one week was devoted to developing understanding, problem solving and reasoning proficiencies. Student-centred approaches that included approaches consistent with learner-focused beliefs and socially and culturally responsive approaches was a focus for at least two weeks. Seminars, online activities, and assessment tasks were designed to develop preservice teachers' capacity to reflect on their teaching. In the first course these included a group task to plan, teach and reflect on teaching a mathematics lesson, and then research an issue in teaching mathematics that arose during their teaching experience.

The second course developed preservice teachers' knowledge of the content and assessment requirements of the various mathematics subjects provided in each state of Australia for students in upper secondary years. Assessment tasks consisted of a group presentation and an individual journal article-style written task based on the analysis of examiners' reports, engagement in online discussions and a detailed plan of novel sequencing of senior secondary mathematical concepts.

Table 1
Mathematics education courses

	Junior Secondary Mathematics Curriculum	Senior Secondary Mathematics Curriculum
Course Delivery	Undergrad: 1 hr lecture and 2 hr seminar for 9 weeks Masters: 1 hr lecture and 2 hr seminar for 9 weeks or online forums or 2-day intensive	Undergraduate: 3 hr seminar for 8 weeks Masters: 3 hr seminar for 6 weeks TFA: Online forums for 6 weeks
Content	Student engagement through problem solving; Student-centred pedagogies in the middle years; Assessment for and as learning; Shallow and deep algebraic thinking; Lesson planning; Socially and Culturally Response-able Tasks; Learning from teaching; Inquiry-based pedagogies and technology enhanced mathematical inquiry; Mathematical modelling; The complexities of teaching mathematics.	Engagement in mathematics learning and deep mathematical understanding; Assessing mathematical learning and understanding; Connecting mathematical ideas; Strategies for promoting deep mathematical understanding; Building characteristics that incline students to explore; Focus on mathematical topics, such as calculus.
Assessment tasks	• Individual essay – research teaching and learning of a mathematics topic • Group – Plan, teach and reflect on teaching a lesson for the mathematics topic • Individual research essay – reflection on teaching practice	• Group Rehearsal: Evidence of an Absence of Understanding on Senior Secondary Mathematics Assessment • Individual Journal Article: Changing the Nature of Senior Mathematics Teaching to Address Understanding • Learning through online discussions • Sequencing the Curriculum to Elicit Deep Level Understandings
Field experience	Undergraduate & Masters: Observing two lessons, team teaching one lesson	
Concurrent school practicum/teaching	Undergraduate: 15 days Masters: 10 days	Undergraduate: 10 days Masters: 25 days or 0.8 teaching for 3 school terms

Data Collection

A pre- and post-questionnaire were used for the study. In accordance with ethics approval, the responses to the online versions of the pre and post surveys were anonymous, and a research assistant administered hard copy versions of the instruments in the absence of the teacher educator. Data from the pre- and post-questionnaires were not analysed until after the completion of both units of study. Items from questionnaires designed by Horizon Research (2000) and Teacher Policy Research (2006) were selected as these instruments were designed to collect data relating to similar issues as the current study. As explained by Horizon Research the instruments included items to collect both demographic data as well as teachers' pedagogical practices:

> The 2000 National Survey of Science and Mathematics Education was designed to provide up-to-date information and to identify trends in the areas of teacher background and experience, curriculum and instruction, and the availability and use of instructional resources" (Horizon Research, p. 1).

These instruments had also been tested and found to be valid and reliable. Design-based research was used to develop and field test the survey instrument used in the National Survey, which involved 5,728 American science and mathematics teachers. The Horizon Project aimed to find out the extent to which teachers support reform notions in the National Research Council's National Science Education Standards and the National Research Council's National Mathematics Education Standards by analysing teachers' objectives and the activities that teachers use to meet these objectives. Selected items from this survey were considered appropriate for our study even though our participants were preservice and associate teachers rather than teachers. The pre- and post-questionnaires for our study generated data on the participants' attitudes to mathematics; readiness to teach mathematics; learning objectives for planning and teaching mathematics; opinions of the nature of mathematics; and approaches for teaching mathematics. After trialling the questionnaire with a similar cohort, changes were made to improve the internal reliability of items for the current study context and ensure that the items addressed the research questions.

The pre-questionnaire consisted of five questions. One question gathered information regarding the mathematics courses that they had completed, and two questions concerned their readiness for teaching and self-efficacy. The other two questions gathered information about their student learning objectives for mathematics teaching[1] (Question 3, see Figure 1) and anticipated frequency of teaching and learning activities (Question 4, see Table 3). The post-questionnaire mirrored these four questions and also collected data regarding their teaching experience: the year levels taught and observed; demographic information about the school's location and socio-economic status; and self-reported data on activities included in a recent mathematics lesson that they taught.

[1] Objectives rather than goals is used in this study as the item concerning student learning objectives was taken from a validated survey instrument (Teacher Policy Research Project, 2006).

3. When planning to teach a topic/ unit of work in mathematics please rank in order of priority (by writing numbers in the boxes) each of the following 11 student objectives.
3.1 ______ Increase students' interest in mathematics
3.2 ______ Understand mathematical concepts
3.3 ______ Recall of mathematics facts, rules and algorithms
3.4 ______ Form and test mathematical conjectures
3.5 ______ Explain mathematical concepts and procedures for solving problems
3.6 ______ Justify mathematical thinking and solutions
3.7 ______ Learn how mathematics ideas connect with one another
3.8 ______ Prepare for further study in mathematics
3.9 ______ Learn how to apply mathematics to the workplace, business and industry
3.10 _____ Prepare for standardised tests
3.11______Develop positive disposition towards mathematics

Figure 1. Question 3 pre- and post-questionnaires

In this article, we report on the paired responses for Question 3 and Question 4 of the pre- and post-questionnaire about preservice teachers' learning objectives for planning and teaching mathematics and the anticipated frequency of conducting specified teaching and learning activities. Question 3 listed eleven possible learning objectives (Teacher Policy Research Project, 2006) and participants were asked to rank them in order of priority. Eight of these learning objectives align with mathematical proficiencies included in the *Australian Curriculum: Mathematics* (ACARA, 2017): Understanding (Items 3.2, 3.5 and 3.7), Fluency (Items 3.3 and 3.10), Problem solving (Items 3.5 and 3.9) and Reasoning (Items 3.4 and 3.6). A further three possible learning objectives are related to student attitudes to mathematics as defined by productive disposition, a learning objective included in the NCTM curriculum, (Kilpatrick et al., 2001) and models of numeracy as a general capability in the Australian Curriculum (Items 3.1, 3.8 and 3.11). Each of the items are worthy student learning objectives and as shown above, relate to the learning objectives expected by the *Australian Curriculum: Mathematics* and so we expected that participants would be likely to agree or strongly agree with using each learning objective if we opted for Likert items as used in the Teacher Policy Research (2006) instrument. By ranking these possible learning objectives in order of priority, we aimed to expose their perceptions about the learning and teaching of mathematics.

Question 4 consisted of Likert items and participants responded to the question: About how often do you think each of the following should be included in mathematics teaching/classes? The possible responses were: never (1), a few times per term (2), every week (3), almost every lesson (4), or every lesson (5). Twenty items were included (see Tables 4 and 5) and sourced from Horizon Research (2001). Five items concerned teacher practices or actions, four that were constructivist or student-centred teaching practices (Ernest, 1989; Van Zoest et al., 1994) (Items 4.1, 4.2, 4.3 and 4.5) for example, Item 4.5: Allow students to work at their own pace and one item related to traditional practice (Item 4.6). The other fifteen (15) items concerned student activities that a teacher would plan and enact (Items 4.4 and 4.7–4.20). Nine of these items concerned student-centred activities or constructivist pedagogies (Van Zoest et al., 1994) such as, Item 4.15: Complete reflections on learning, and Item 4.4: Investigations where students form and prove conjectures.

Six of these Question 4 items provide opportunities to develop students' fluency, for example, Item 4.12: Practice routine computations/algorithms. Three items provide opportunities to develop understanding, for example, Item 4.2: Engage the whole class in discussions; three items would more likely promote mathematical reasoning such as, Item 4.3: Require students to explain their reasoning; three items would promote problem solving proficiency, for example, Item 4.9: Interpret and solve non-routine problems. The other seven items are more aligned with student-centred approaches to teaching mathematics rather than a particular proficiency (Van Zoest et al., 1994), for example, Item 4.5: 'Allow students to work at their own pace'. No items specifically concern promoting positive dispositions. It is, however, possible that the items concerning student-centred teaching approaches align with an objective to promote positive dispositions and interest in mathematics.

The pre-questionnaire was completed at the commencement of the first junior secondary mathematics curriculum course and the post-questionnaire after the completion of the second senior mathematics curriculum course completed in the second half of the year by all participants. The pre-questionnaire was administered online at the end of face-to-face sessions for on campus participants. At the time of the post-questionnaire all participants had completed mathematics teaching experience. The post-questionnaire was administered online for all participants. Whilst 85 PSTs completed the pre-questionnaire and 37 the post-questionnaire only 20 participants completed both the pre- and post-questionnaires and provided identifiers to enable pairing of responses for pre- and post-questionnaire items.

Table 2 provides information gathered from the post-questionnaire about the nature of their teaching experience during the year for participants who completed both questionnaires. It reveals that about a quarter of respondents had only taught senior mathematics lessons and a quarter had only taught streamed mathematics classes. About two-thirds of respondents taught in metropolitan schools; the other third taught in regional, rural, or remote schools. Two-thirds also taught in high socio-economic schools.

Table 2
School experience (n=19)

Year level taught	*n* (%)	Class type taught	*n* (%)	School location	*n* (%)	School SES	*n* (%)
Junior	8 (42%)	Mixed ability	9 (47%)	Metro	12 (63%)	Low SES	2(11%)
Senior	5 (26%)	Streamed	5 (26%)	Regional	4 (21%)	Middle SES	4 (21%)
Junior & Senior	6 (32%)	Mixed & streamed	5 (26%)	Rural/remote	3 (16%)	High SES	13 (68%)

Data Analysis

Pre- and post- paired data analysis allowed tracking of changes in participants' objectives when teaching mathematics and indicated whether their approaches to teaching mathematics may have shifted. Descriptive statistics including medians, means and standard deviations were calculated for each item in Question 3 and Question 4 for pre-questionnaire and post-questionnaire responses. For Question 3 median scores were used to order these learning objectives according to median ranking. Quartiles for each item and pre-post questionnaires were calculated and graphed using box and whisker diagrams. Given the small sample size and the possibility of skewed responses, non-parametric analysis employed the post hoc Wilcoxon matched-pair signed rank tests (MacFarland & yates, 2016). A Wilcoxon rank test with a p <0.05 indicates that the median post-questionnaire rank is significantly different from the median pre-questionnaire rank. Since there were multiple comparisons Bonferroni corrections were applied with the significant difference set at p = 0.045 for the number of items (Weisstein, n.d.). Following the Horizon Research (2000) report for Question 4 the frequency that actions were anticipated every day and at least weekly are reported. The non-parametric Wilcoxon matched-pair test was used to test for changes in practice over time. Significant differences after Bonferroni corrections were set at p = 0.0025. These data analyses provided insights into participants' objectives for learning of mathematics. The findings from quantitative data analysis and interpretations of these findings are reported and discussed below.

Results

Learning Objectives

Results of the analyses of participants' responses to Question 3 are recorded in Table 3 for paired-data from the pre- and post-questionnaires. The items have been clustered by related proficiency. Descriptive statistics including the pre- and post- medians and probabilities from the Wilcoxon rank test are reported. Columns 3 and 4 report the median score for the ranking of importance of each of the possible objectives in the pre- and post- responses. The lower the median score the higher the ranking of importance. The sixth and seventh columns in Table 3 show the rank for each item in Question 3 from the pre-questionnaire and post-questionnaire as established by the median for each item. These rankings indicate the preservice teachers' perceptions of the importance of each item.

Item 3.1: Increasing student interest in mathematics was the highest ranked item. Item 3.2: Understanding mathematical concepts and Item 3.11: Develop positive disposition to mathematics were ranked equal second in importance using the median scores at the beginning of the course. These objectives for student learning suggest that the preservice teachers were focussed on developing positive attitudes and dispositions as well as understanding for their students. By the end of the course Item 3.2: Understanding mathematical concepts ranked as the most important. Item 3.1: Increasing student interest in mathematics dropped to being outside the top four. Items 3.11: Develop positive disposition to mathematics also showed a higher median score that is, a lower ranking, at the end of the year but remained one of the top four goals for emphasis.

Table 3
Wilcoxon test for ranking of student mathematics learning objectives (n=20)

	Q3: Learning objectives	Median		Wilcoxon rank	Rank by Median	
		Pre	Post	*p*	Pre	Post
UNDERSTANDING	3.2 Understand mathematical concepts	3.0	2.0	.364	2	1
	3.5 Explain mathematical concepts and procedures for solving problems	5.0	4.0	.347	6	2
	3.7 Learn how mathematics ideas connect with one another	4.5	4.0	.646	4	2
FLUENCY	3.3 Recall facts, procedures, rules and algorithms	9.0	9.0	.441	9	8
	3.10 Prepare for standardised tests	11.0	10.0	.647	11	11
PROBLEM SOLVING	3.5 Explain mathematical concepts and procedures for solving problems	5.0	4.0	.347	6	2
	3.9 Learn how to apply to the workplace, business and industry	4.5	7.0	.068	4	7
REASONING	3.4 Form and test mathematical conjectures	8.0	9.0	.756	8	8
	3.6 Justify mathematical thinking and solutions	6.0	5.0	.756	7	5
DISPOSITION	3.1 Increase students' interest in mathematics	2.5	5.0	.021*	1	5
	3.8 Prepare for further study in mathematics	9.5	9.0	.156	10	8
	3.11 Develop positive disposition towards mathematics	3.0	4.5	.015*	2	4

* Significant difference Wilcoxon rankings test, $p < 0.05$; ** Bonferroni correction, significant difference $p < 0.0025$

In the boxplot (see Figure 2) comparing the pre- and post-questionnaire responses for Item 3.1: Increase interest in mathematics, there is a difference in the medians (pre, 2.5 and post, 5) and interquartile ranges (pre, 4; and post, 5) indicating a shift away from prioritising students' interest in mathematics in their teaching. These differences suggest that the participants did not perceive student disposition or interest in mathematics as among the most important priorities for learning objectives in their teaching following their teaching experience.

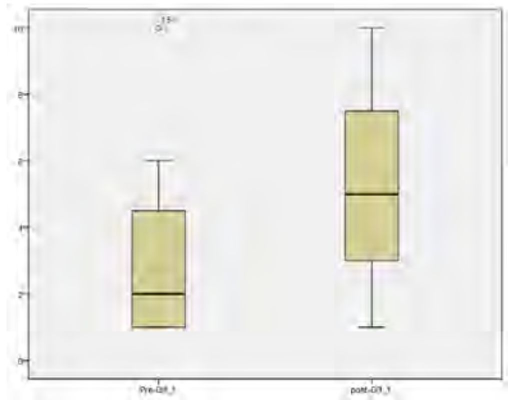

Figure 2. Boxplot comparing Item 3.1- Increase students' interest in mathematics[2]

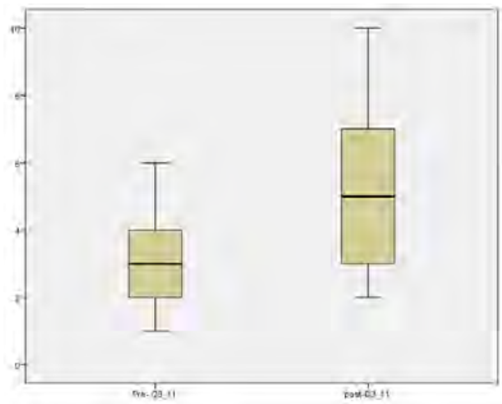

Figure 3. Boxplot comparing Item 3.11 – Develop positive disposition towards mathematics

Regarding Item 3.11: Developing positive disposition, the difference in pre and post median scores can be seen in the box plot (see Figure 3) comparing the distribution of pre- and post- medians and interquartile ranges. It shows a decline regarding the importance that participants placed on this learning objective. The interquartile range is wider (pre- 2 and post-4) and range is wider (pre-5 and post- 10) in the data from the post-questionnaire indicating more variation in the participants' prioritising of developing a positive disposition at the end of the year. The post hoc Wilcoxon test for these two items recorded low probabilities of the two scores in the same population and hence a difference in the pre- and post-ranking of these items (Item 3.1: z = -2.308, p = 0.021 and Item 3.11: z = -2.424, p = 0.015). However, when applying the Bonferroni correction for significant difference for these two items they were not found to be statistically significant. It is of note that the two items are from the same category of learning objectives (or proficiencies).

At the beginning of the year the top five learning objectives were spread across three proficiencies: *understanding*, *problem solving* and *student disposition*. At the end of the year, all three of the items concerning the *understanding* proficiency were ranked within the top four objectives. Regarding the *problem-solving* proficiency, Item 3.5: Explaining concepts and procedures for solving problems was highly ranked in both the pre- and post- questionnaire responses. Item 3.9: Applying mathematics to the workplace, business and industry was ranked

[2] NB. An increase in the median score means a decrease in importance.

in the top four learning objectives but seventh at the end of the course. The two *reasoning* learning objectives (Item 3.4 and Item 3.6) were rated lower than *understanding* and *problem solving* according to the median in the pre-questionnaires. Participants valued justifying (Item 3.6), which rose in the ranking (from 7th to 5th) over the year over. Generalising (Item 3.4), which was ranked eighth at the beginning of the year and in the post-questionnaire. Learning objectives concerning *fluency* (Item 3.3 and Item 3.10) are amongst the lowest ranked learning objectives in the pre-questionnaire and continued to be the lowest priority for learning objectives at the end of the year.

Teaching Practices

Analyses of Question 4 reveal participants' anticipated pedagogical approaches and provides further information upon which to interpret their objectives for teaching mathematics. Results concerning items regarding anticipated teacher actions from Question 4 are reported in Table 4 and those related to student activities are reported in Table 5. The items in each table are clustered as either constructivist and student-centred or traditional (Van Zoest et al., 1994) and ordered according to frequency for daily implementation. Results (z-scores and probability) for Wilcoxon test are also recorded in each table. The sample size is recorded for each item as participants chose not to answer some items in either the pre- or post-questionnaire.

The results in Table 4 show that the participants anticipated using constructivist and student-centred teaching practices daily or at least weekly. More than a majority anticipated requiring students daily to explain their reasoning when giving an answer (Item 4.3) at the beginning and end of the course. This teaching practice is consistent with two of their highest-ranking learning objectives priorities (Item 3.2 and Item 3.5) that align with the understanding proficiency. There was also little change in their expectation to conduct whole class discussions (Item 4.2) with about one-third of participants expecting to do this daily and almost all participants expecting to conduct these discussions at least weekly in both the pre- and post-questionnaire. This teaching strategy would also support student development of understanding, but it is not known whether these discussions would use socio-constructivist questioning strategies to make connections between students' solutions and reasoning or traditional triadic discussion focussing on correct solutions and procedures. Item 4.5: Allow students to work at their own pace suggests a student-centred belief about teaching mathematics however it is not clear whether this practice aligns with problem solving and autonomous student learning approaches to teaching or differentiating tasks to practice routine skills. There were no significant differences in the anticipated use of these teacher actions from beginning to the end of the course. The participants did not anticipate using a traditional practice of introducing content through formal presentations daily (Item 4.6) either at the beginning, or at the end of the course. Fewer participants anticipated using this practice at least weekly at the end of the course, but this difference was not significant.

Table 4

Frequencies, paired number and Wilcoxon z score and probability for anticipated mathematics teaching practices

Item	Frequencies (%) pre-questionnaire		Frequencies (%) post-questionnaire		Wilcoxon test		
	Daily	At least weekly	Daily	At least weekly	paired *N*	*z*	*p*
CONSTRUCTIVIST							
4.3 Require students to explain their reasoning when giving an answer	60	100	68	100	19	-0.632	.537
4.2 Engage the whole class in discussions	20	100	21	95	19	-0.632	.527
4.5 Allow students to work at their own pace	35	100	37	95	19	-0.250	.803
4.1 Introduce content using open-ended problems or investigations	0	50	6	73	18	-0.265	.791
TRADITIONAL							
4.6 Introduce content through formal presentations	0	90	0	79	19	-0.277	.782

* Significant difference Wilcoxon rankings test, $p < 0.05$; ** Bonferroni correction, significant difference $p < 0.0025$)

Table 5 records daily and at least weekly frequencies along with the Wilcoxon test results for student learning and assessment activities. In contrast with their anticipated teaching activities, and the low ranking for fluency as a learning objective, the participants anticipated using traditional mathematics learning activities daily or at least weekly both at the beginning of the course and at the end of the year. These activities included practising routine computations or algorithms (Item 4.12), using technology for practicing skills (Item 4.20) and completing textbook or worksheet exercises (Item 4.14).

Table 5

Frequencies, paired number and Wilcoxon z score and probability for anticipated mathematics student learning activities

Item	Frequencies (%) pre-questionnaire		Frequencies (%) post-questionnaire			Wilcoxon	
	Daily	At least weekly	Daily	At least weekly	paired *N*	*z*	*p*
CONSTRUCTIVIST							
4.15 Complete reflections on learning	10	70	11	79	19	-0.665	0.506
4.4 Investigations where students form and prove conjectures	10	56	0	46	19	0.000	1.000
4.7 Work on tasks that integrate mathematics with other disciplines	10	85	0	58	19	-3.07	0.002**
4.9 Interpret and solve non-routine real-world problems.	10	25	5	68	19	-1.147	0.251
4.10 Work in groups	10	10	10	91	19	-0.159	0.873
4.17 Complete formative assessment tasks	5	69	20	67	14	-2.214	0.34*
4.8 Use digital tools to investigate mathematical concepts	0	15	0	74	19	-0.333	0.739
4.16 Undertake self-assessment tasks	0	82	5	53	16	-0.367	0.714
4.13 Design and work on their own extended mathematics investigation or project	0	20	0	22	19	0.000	1.000
4.19 Make formal presentations to the rest of the class	0	13	0	21	14	-1.19	0.234

Table 5 Cont.

Frequencies, paired number and Wilcoxon z score and probability for anticipated mathematics student learning activities

TRADITIONAL							
4.12 Practice routine computations/algorithms	15	80	6	89	18	-1.190	0.676
4.20 Use technology for practicing skills	11	79	7	67	14	-0.418	0.238
4.14 Complete textbook or worksheet exercises	5	85	5	79	19	-1.179	0.377
4.11 Read/watch other (non-textbook) mathematics-related materials in class, such as online videos	0	15	0	57	19	-0.084 -1.795	0.073
4.18 Complete summative assessment tasks	0	48	0	0	14	-2.460	0.014*

* Significant difference Wilcoxon rank test, $p < 0.05$; ** Bonferroni correction, significant difference $p < 0.0025$)

The most frequent daily and weekly anticipated student-centred learning activity in both the pre- and post-questionnaire was completing reflections on learning (Item 4.15) and at the end of the year almost all participants expected that students would work in groups at least weekly (Item 4.10). More participants anticipated using formative assessment tasks (Item 4.17) daily at the end of the year than at the beginning (Wilcoxon z = -2.214, p = 0.034) but this was not statistically significant when applying the Bonferroni correction. By the end of the year, the majority of participants anticipated using investigations (Items 4.4, 4.7 & 4.8) and/or problem-solving learning activities (Item 4.9) at least once per week. However, there was a significant decrease in the proportion of students who anticipated that students would work on tasks to integrate mathematics with other disciplines (Item 4.7, Wilcoxon z = -3.071, p = .002). A boxplot comparing responses to Item 4.7 (Figure 4) shows that at the beginning of the year at least three-quarters of participants anticipated integrating mathematics with other disciplines at least once per week but at the end of the year three quarters of participants anticipated that this would occur once a term but not every week. These findings and the connections and relationship between objectives and teaching and learning activities are discussed below.

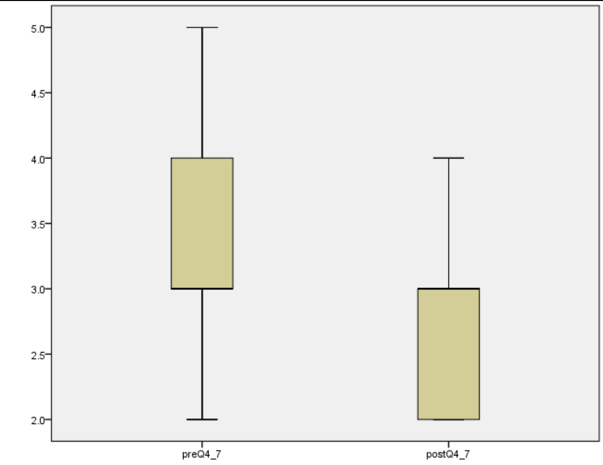

Figure 4. Boxplot comparing Item 4.7 Work on tasks that integrate mathematics and other disciplines

Discussion

When pairing the pre- and post-questionnaire responses of participants we found that we had a much smaller sample than expected. However, it is still of similar sample size to other studies of preservice secondary teachers' beliefs and practices (Conner et al., 2011; Frykholm, 1999; Jao, 2017; Little & Anderson, 2015). Over one year of the teacher education program that included two courses in mathematics education and teaching experience, there were no significant differences in their emphasis they would give to the various learning objectives.

We noticed though that their highest learning objectives concerned student attitudes, such as interest and disposition, and understanding at the beginning of the year, but by the end of the year all three objectives concerning understanding were in the top four learning objectives. We also noticed that *Understanding* mathematics (Items 3.2, 3.5 and 3.7) was given a higher ranking than items relating to *fluency* (Items 3.3 and 3.10). It is not clear though whether the meaning the preservice teachers have of mathematical understanding is instrumental, that is knowing and using facts, procedures, rules or algorithms, or relational and being able to make connections, explain and justify (Skemp, 1976). In accord with the findings by Conner et al. (2011), they ranked objectives for explaining and justifying highly but not generalising, that is discovering the rules for themselves. Participants were also anticipating using socio-constructivist teaching approaches, such as the use of whole class discussion that could potentially support development of relational understanding (Skemp, 1976). Nevertheless, more information about the sequencing and questioning strategies of these discussions and the nature of the tasks informing these discussions is needed to confirm a relational understanding objective.

The findings with regard to the most frequent daily and weekly anticipated learning activities indicate that their view of understanding is more likely to be instrumental (Skemp, 1976) as routine exercises and practice of skills were highly represented. Even so, these participants anticipated using constructivist or socio-constructivist learning activities, such as investigations, problem solving tasks and working in groups at least weekly and for some participants even more often. These findings align to some extent with Little and Anderson (2015) and Prescott and Cavanagh (2006, 2008) whose preservice teachers shifted their support to being in favour of problem-solving approaches but found them difficult to implement. Perhaps as other studies have noted (Jao 2017; Little & Anderson 2015; Prescott & Cavanagh 2006, 2008), getting the opportunity to enact these lessons during teaching experience have stymied any possibility of developing problem solving approaches to teaching mathematics as described by Van Zoest et al. (1994).

A key finding from this study was the level of support for integrating mathematics with other subjects. Whereas at the beginning of the year the PSTs in our study anticipated that some of these weekly activities would be interdisciplinary, by the end of the year they were significantly less likely to anticipate learning activities that integrate mathematics with other disciplines. This finding has implications for implementing STEM (science, technology, engineering, and mathematics) integrated curriculum initiatives and for developing students’ numeracy skills through the application of mathematics to other subjects. It suggests that the schools in which they completed their teaching experience were not integrating mathematics with other subjects.

Support for student-centred teaching and learning activities was evident through their anticipated use of student reflections on learning daily or weekly reflections on learning along with their routine use of formative assessment either weekly or daily. Without further information about the nature and purpose of these activities it is not clear whether these activities are addressing objectives for instrumental or relational understanding (Skemp, 1976) or developing positive disposition towards mathematics (Goos, et al., 2014). Whilst developing a positive disposition remained in the top four learning priorities, increasing students’ interest was replaced in the top four goals by understanding goals at the end of the year. This finding suggests that as discipline specialists in mathematics, the secondary mathematics participants’ initial objectives of enhancing student disposition and interest in mathematics, relate to their passion for mathematics and goal to become teachers of secondary mathematics. It would be worth exploring the participants’ meanings of interest and disposition. Whether or not their experience of teaching lead them to learn that if students are to develop positive dispositions and interest in mathematics, they need to experience success, and that this comes through creating learning environments that enable students to develop understanding and being able to explain, justify and make connections (Brown et al., 2008; Carmichael et al., 2017).

We are reminded that previous studies have revealed that beliefs or objectives for teaching may not be consistent with practice and depend on context (Beswick, 2005, 2007, 2012; Cady, et. al., 2006; Conner et al., 2011; Cross, 2009; Little & Anderson, 2015). In this study the initial aim was to explore changes in PSTs’ objectives for teaching and learning mathematics. Further research is needed to explain the changes in their objectives (or goals) and the way in which different elements of context may have influenced changes in their objectives. In this study, the participants were completing secondary teacher education programs with differing opportunities and requirements for teaching practice (Table 2). Only one-third experienced teaching at both the junior and senior level, and a quarter of participants only taught streamed classes. So, depending on the year levels taught, and the way students were organised for mathematics, they may or may not have emphasised understanding objectives and fluency activities over attitude and reasoning or problem-solving objectives and activities. In addition, the school cultural context may have led some participants to prioritise some proficiencies over others by the end of the year. Most participants who completed both questionnaires experienced teaching in high socio-economic metropolitan schools. Without knowing more about their schooling background, it is not possible to state whether, or not, some participants were teaching in different socio-economic and cultural environments and how this influenced their learning objectives and teaching practices.

Further study is needed to explore the relationship between their learning and teaching experiences and their priorities for teaching mathematics. The sample size of the post-questionnaire data in the current study is likely to be too small to generate statistically significant findings for the range of context variables. As secondary mathematics teacher education courses in Australia typically have enrolments of less than one hundred students, a study would need to involve multiple teacher education sites to use quantitative methods to identify contextual factors that are related to PSTs changing learning. Since student disposition and attitudes are critical for student engagement and participation (Attard, 2013; Beswick, 2007; Brown et al., 2008; Carmichael et al., 2017; Forgasz & Leder, 2008; Teacher Policy Research, 2006) an explanatory qualitative or mixed methods study is needed to investigate reasons for changes in PSTs' objectives regarding student attitudes and student dispositions.

Conclusion

This study set out to identify PSTs objectives for student learning and their anticipated teaching and learning practices. We also sought to identify any changes to these objectives and practices over one year of teacher education study involving two mathematics teaching courses and mathematics teaching experience in schools. We found that PSTs preferenced objectives for teaching that focussed on the *understanding* proficiency and *disposition* but were more likely to use learning activities devoted to *fluency* that is, routine exercises. However, their preferences for learning activities did not exclude student-centred approaches or the *problem solving* and *reasoning* proficiencies as these were regarded as at least weekly activities for the vast majority of participants. With regard to changes in objectives and practices over the year, PSTs were significantly less likely to integrate mathematics with other disciplines.

Further investigation of participants' interpretation of understanding is needed to untangle instrumentalist and relational meanings of understanding and the role of context, especially their teaching experience. Mathematics education courses need to provide teaching experiences of investigating and generalising activities to develop their practice of student-centred socio-constructivist approaches (Van Zoest et al., 1994). Experience of applied mathematics tasks that make connections with other subjects and real-world contexts during course work and teaching experience are also needed if these activities are to be enacted. Whilst we placed a strong focus on student engagement and student-centred approaches within the mathematics curriculum courses, we clearly need to be more explicit and make connections between learning objectives concerning students' disposition and interest in mathematics and student-centred teaching approaches. This also means encouraging a shift away from, or resisting adoption of, traditional approaches to mathematics teaching that focus on processes and algorithms with a single correct answer. Whilst this may be emphasised during their program, PSTs teaching experience is influenced by the nature of the schools where teaching occurs and the culture for teaching mathematics at these schools. Collaborative, site-based teacher education programs (e.g., Anthony et al., 2015) for secondary mathematics teacher education might provide an avenue for providing these experiences for PSTs. Further research, involving a larger sample size and multiple providers of secondary mathematics teacher education, and/or the collection of qualitative data is needed to identify factors concerning learning and teaching experiences that influence beginning teachers' objectives for learning and teaching and learning practices.

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