Fear, loathing and ambivalence toward learning and teaching mathematics: Preservice teachers' perspectives

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Preservice teachers graduate from an education system that shapes their mathematical understandings, beliefs and attitudes, and then re-enter that system to shape their own students' mathematical understandings, beliefs, and attitudes. Unfortunately, many of our future teachers have developed negative attitudes symptomatic of a self-perpetuating cycle of inter-generational fear, loathing, and ambivalence to mathematics. We investigated the mathematical attitudes of 152 third year preservice teachers (PST) using their written reflections about their categorisation of, and catalysts for, their attitudes towards mathematics. To understand better the genesis and consequences of negative mathematical attitudes and beliefs, we focus on the responses of 111 preservice teachers (nearly three-quarters of our sample) who acknowledged their negative or neutral attitudes towards mathematics. Our findings confirm the complex relationship between attitudes, beliefs, and emotions that impact on learners' motivation, engagement, and learning approaches, and, for our sample of preservice teachers, that will shape how they teach.

Keywords · preservice teachers · mathematics teacher education · mathematical attitudes and beliefs

Introduction

Mathematics teachers' pedagogical practice is influenced by the attitudes and beliefs they formed as students (Cooney & Wiegel, 2003). Many preservice teachers (PST) harbour negative attitudes towards mathematics, narrow beliefs about the discipline, and limiting self-beliefs about their capacity to do, learn, and teach mathematics (Beswick & Dole, 2008; Boyd, Foster, Smith, & Boyd, 2014; Di Martino & Zan, 2011; Swan, 2004; Tobias, Serow, & Schmude, 2010; Uusimaki & Nason, 2004). It is concerning that many of our future teachers remain unenthused about mathematics given the influential role they play as purveyors of mathematics for our current and future generations.

Learning mathematics elicits affective responses from students. Attitudes towards mathematics develop from repeated emotive responses to an event or situation and can be either positive or negative (Grootenboer & Marshman, 2016). Attitudes are distinguished from emotions or feelings by their more permanent nature. Mathematical beliefs develop from direct experiences or are learned indirectly from others. Beliefs have been defined as assumptions (Rokeach, 1968) or understandings (Phillipp, 2007) thought to be true. Mathematical beliefs and attitudes are considered inter-related and "over-lapping constructs" (Grootenboer & Marshman, 2016, p.15) because beliefs become lenses that affect perceptions and dispositions (Phillipp, 2007) and consequently influence the development of attitudes.

Learners who have developed positive mathematical attitudes perceive the discipline as an eloquent language that describes and explains the universe. Successful learners appreciate the logic, beauty, and power of mathematics because their experiences have taught them that mathematics is usable, worthwhile, interesting, and doable. Successful mathematics learners believe their learning investment pays dividends (Kilpatrick, Swafford, & Findell, 2001) and they believe in their efficacy as learners of mathematics (Lewis, Fischman, & Riggs, 2015). Being 'good' at mathematics creates self-perpetuating, affirming beliefs about capacities to learn and apply mathematics to solve problems (Ma, 1997). In turn, positive self-reinforcement (Marsh, 2007) enhances learners' engagement, persistence, confidence, and resilience with mathematics (Kilpatrick et al., 2001; Marsh, Walker & Debus, 1991), which produces beliefs that predispose learners to careers with science and mathematical foundations (Grootenboer & Marshman, 2016; Parker, Marsh, Ciarrochi, Marshall, & Abduljabbar, 2014). Consequently, positive mathematical beliefs and attitudes can and do shape learners' destinies.

Learners who develop negative attitudes believe mathematics is impenetrable, unknowable, and undoable. Repeated failure produces in learners a belief that they lack the aptitude to learn. Perceptions that mathematics is an alien body of knowledge without practical application impact learners' engagement and motivation. Axiomatically, students holding negative views believe that mathematics is difficult, boring, and useless (Brown, Brown & Bibby, 2008; Kyriacou & Goulding, 2006; Nardi & Steward, 2003; Swan, 2004). Serial underachievement in mathematics produces self-fulfilling spirals of discontent, disempowerment, and disengagement. When faced with seemingly intractable problems for which learners believe they possess too few tools to resolve, they capitulate and rarely sustain the effort needed to complete tasks (Schunk & Pajares, 2002). Apathy towards mathematics develops and stronger negative emotions may manifest. "I'd rather die" (Brown et al., 2008) than study mathematics reflects a repeated symptom of 'dis-ease'. Unfortunately, many learners develop negative attitudes towards mathematics and limiting beliefs about mathematics and their capacity to learn (Grootenboer & Marshman, 2016; Larkin & Jorgensen, 2015). Indeed, Furner (2000) estimates that two-thirds of Americans either loathe or hate mathematics. It is clear that addressing negative mathematical beliefs and attitudes is a particular challenge for mathematics education.

A complex and cyclic relationship exists between beliefs, attitudes, and success in learning mathematics (Grootenboer & Hemmings, 2007, Ma, 1997). Grootenboer and Marshman (2016) note that much research into mathematical attitudes focuses on measuring attitudes. Less research has focused on factors that shape mathematical attitudes. Goodykoontz (2008) identified that pedagogical approaches and teacher characteristics influenced learners' attitudes toward mathematics. Pedagogical approaches and learning environments also determine learners' mathematical beliefs; whether students see mathematics as useful or useless, relevant or irrelevant, exciting or boring, and knowable or impenetrable (Beswick, 2008). The learning environment also influences students' mathematical self-efficacy, self-concept, and self-regulation (Carter & Norwood, 1997; Fast et al., 2010; Tuan, Chin, Tsai, & Cheng, 2005), and ultimately, student learning and aspirations (Perels, Dignath, & Schmitz, 2009; Polly et al., 2013). These factors play a significant role in the way in which students engage with the subject, and how they view mathematics and their mathematical futures. The learning environment and teachers' pedagogical practices also shape students' perceptions of mathematics teaching and learning.

PSTs' experiences as students in mathematics classrooms have shaped their mathematical beliefs and attitudes. Unfortunately, many PSTs hold negative mathematical attitudes and limiting beliefs (Beswick & Dole, 2008; Tobias et al, 2010). Graduating PSTs who hold negative mathematical beliefs and attitudes will return to the classroom as teachers who will unwittingly contribute to the cycle of inter-generational hatred of mathematics. We investigate PSTs' mathematical beliefs and attitudes to understand how these develop and to explore the potential impacts on their careers as future teachers of mathematics.

Method

We employed a case study design (Creswell, 2014) to determine how PSTs' negative mathematical attitudes and beliefs develop and to establish the impact that past mathematics teaching approaches have had on PSTs who will teach mathematics to this and future generations. Our sample consisted of a cohort of 152 preservice primary teachers who were commencing the third year of a four year primary teaching degree at a regional campus of an Australian university. Up to 40% of the student population are classified as low SES and more than two-thirds are students who are the first in their family to undertake tertiary study. Approximately three-quarters of our sample were female.

Our experiences working with PSTs had taught us that many harbour negative attitudes and beliefs about mathematics. Through this study, we aimed to give voice to learners who now hate, fear, dislike or remain ambivalent towards mathematics in order to understand the catalysts for these negative attitudes and beliefs. To this end, we identified PSTs' attitudes toward mathematics through administering a written reflection task that asked students to describe their attitude towards mathematics and self-identify causative factors that shaped their attitudes. As a prompt for the reflection, our participants read an article by Swan (2004), entitled *I Hate Maths*. Like Di Martino and Zan (2010), we chose to represent attitudes and beliefs using respondents' own descriptions of their attitudes towards mathematics and their narratives of their mathematical journeys. Our approach afforded a degree of resolution on the nature of attitudes and beliefs and the underpinning rationale for the PSTs' thinking. The narrative approach incorporated an exploration of PSTs' reflections of their lived experiences as mathematics learners and allowed us to bring PSTs' voices to the forefront (Creswell, 2014). We identified commonly reported factors that contributed to negative or neutral attitudes, and structured a collective and chronological narrative using PSTs' reflections. An initial analysis of the qualitative data determined criteria for categorising the PSTs' attitudes toward mathematics (Table 1). We categorised the 152 written responses using these criteria. To validate the categorisation, three researchers independently verified the choices made.

Table 1
Schema for classifying preservice teachers' reflections about their mathematical attitudes

Criteria	Descriptors
Positive	Passionate about mathematics. Appreciation and/or unconditional enjoyment of mathematics. Consistent positive experiences.
Somewhat Positive	Conditional enjoyment of mathematics. Positive attitude is qualified as "mostly" or "fairly". Mostly positive experiences.
Neutral	Neutral or mixed feelings about mathematics. Some positive and some negative experiences.
Somewhat Negative	Dislike of mathematics. Mostly negative experiences.
Negative	Strong dislike, fear or hatred of mathematics. Consistent negative experiences.

Table 2 provides examples of representative comments allocated according to schema in Table 1. We focus on the 111 PSTs' reflections that had been classified as negative, somewhat negative, or neutral, identifying common themes about causative influences on negative and neutral mathematical beliefs and attitudes.

Table 2

Representative comments allocated to Schema for Classifiying Preservice Teachers' mathematical attitudes

Positive	Somewhat Positive	Neutral/Mixed	Somewhat Negative	Negative
Over time Mathematics has developed into the most rewarding and enjoyable subject that I have come to study. My experiences of mathematics have always been positive. I did well in mathematics at school and it is a subject I have always enjoyed. I maintain a positive attitude towards mathematics.	I have in general had quite positive experiences with maths. While it may not be my favourite subject it is also not something that I can't stand. My maths experiences in school changed from year to year; however, for the most part it was a positive time. In general, I liked maths at school, and I still like maths in general today.	My attitude towards mathematics at this point in time is neutral. I neither like it nor hate it My attitudes toward mathematics is a neutral one, sometimes I really enjoy mathematics and other times I hate it Mathematics causes me to feel many mixed emotions, for I have had good experiences while I have also had bad experiences.	I enjoyed the subject during the early years of primary school, but as it began to get more difficult, I developed a dislike of maths that I am struggling to shake today. My overall attitude towards maths at this stage in my life is negative because the majority of my high school maths experiences were negative. I would say I am probably a little on the negative side of neutral.	The fear of maths throughout my school years has developed into a general loathing of the subject now. As I went through school I developed a hatred of maths. For as long as I can remember I have always had a negative outlook on maths, almost to the extent of saying I hate it. All through my primary and secondary education, I despised mathematics.

Findings

Our work identified a suite of challenges that contribute to the cycle of inter-generational hatred of mathematics. The analysis of the reflections of 152 third year preservice primary teachers revealed that nearly three-quarters described their attitude towards mathematics as negative (36 respondents), somewhat negative (26 respondents) or ambivalent (49 respondents), while the remaining quarter (41 respondents) described their attitude as positive or somewhat positive. Table 3 presents attitudinal data according to gender. A chi-square goodness of fit test confirmed that there is an association between gender and PST attitudes to mathematics. A significant difference emerged (χ^2 (4, n=152) = 8.18705, $p<0.1$), in the proportion of PSTs who identified as having positive, neutral, or negative mathematical attitudes and whether they were female or male.

Table 3

Preservice Primary Teachers' reflections about mathematics classified by attitude and gender (n=152)

	Male	Female	Total
Positive	9 (21%)	15 (14%)	24 (16 %)
Somewhat Positive	5 (12%)	11 (10%)	16 (11%)
Neutral	18 (43%)	31 (28%)	49(32%)
Somewhat Negative	3 (7%)	23 (21%)	26 (17%)
Negative	7 (17%)	30 (27%)	37 (24%)
Total	42	110	152

Here we explore the reflections of 111 PST classified as having neutral, somewhat negative, or negative attitudes toward mathematics to determine the most common causative factors that gave rise to negative and neutral attitudes towards mathematics. We differentiate between respondents through reference to unique numerical identifiers, for example Respondent 139 becomes (139).

Mathematical experiences from primary school invoked, among 19 respondents, negative emotions associated with competition and social comparison: dread, fear, and loathing. Speed mathematics tests and times-tables competitions during primary school created challenges. Respondent 139 "cringes" when she remembers "as clear as day" competing in times table races at least a decade after finishing primary school. She is not alone. Many respondents reported feeling humiliated by their public failures associated with losing times-tables and speed mathematics competitions. Respondents recalled the shame and embarrassment they felt when reporting their low test results to the entire class (50 and 84) or being asked to swap tests with a partner for marking (98 and 145). Respondents' failures were also publicly aired through rankings on charts (92 and 147), being selected by other students to compete against because they were perceived to be 'easy targets' (39), and making errors in front of the class (31). "Traumatic experiences during primary school" (31) invoked feelings of shame and humiliation that manifested as visceral responses for respondents who recalled cringing (145, 139 & 135), freezing (111 and 136), crying, and their hearts thumping with anxiety (146). These experiences contributed to respondents' complete dissatisfaction (38) and reluctance (31) that prompted their dislike (147), dread (5), hatred (12 and 84) and fear and loathing (98 and 139) of mathematics.

Respondents recognised that publicly airing their failures established and perpetuated the self-limiting beliefs about mathematical ability that continue to reinforce current attitudes towards mathematics. These experiences provoked students to compare themselves unfavourably with others and to make early judgements about their own and others' mathematical ability. Many respondents interpreted their performance during speed mathematics competitions as evidence that they lacked mathematical ability. Respondent 31 noted that experiences such as "losing multiplication races, being slowest to answer during drill games, and getting the majority of questions wrong" ensured students were "well aware of each other's capabilities." Respondent 5 recalls that the amount of times tables tokens signified who was best and who was worst at mathematics. In extreme cases, this awareness of students' capabilities determined through their relative performance lead to teasing and bullying (31). Students interpreted these experiences using relative terms concluding that they were the slowest (31), not the brightest (36), and the worst (5). Others noted that their comparative performance demonstrated they were hopeless (92), useless (46), and incapable (44) at mathematics. Respondent 3's interpretation of poor performance during a mathematics test as a six-year-old provides an insight into how early children judge their ability compared to their peers' performances, and how interpretations of events solidify into beliefs. This learner perceived her struggle as lonely. She felt isolated and inadequate.

> I remember grade one, I was handed a test... I did not know how to complete the first question, or any of the questions. I looked around and saw many heads down their pens working furiously, there were fingers used for counting and there was the murmuring of students who failed to count on in their heads. That I was alone in my struggle made it worse. I felt so inadequate and stupid that tears flowed.

Seemingly innocuous classroom incidents shape, establish, and reinforce self-limiting beliefs. Sometimes students draw conclusions from overt messages in teacher comments. Respondent 135 recalls, when, as a nine-year-old she began to believe she was "one of those people who did not get it." She said she formed this view in response to teacher remarks:

> My teacher at the time had not learnt that I was completely oblivious to how multiplication worked. I didn't understand that three-times-three was three groups of three. So naturally when he asked me in front of the whole class if I knew three-times-three, I answered no. He was still not satisfied; 'yes you do' he said, 'don't be stupid'. As the entire class laughed at this statement, the 9-year-old me instantly assumed (in embarrassment) that I must be one of those people who did not 'get it'.

Respondent 135 interpreted words as affirmation of natural ability in mathematics. Interestingly, nine respondents explicitly noted that they believed in the notion of a 'maths brain' or mathematical natural ability. Some respondents noted that they had to work hard to understand mathematical concepts, whereas they perceived that other students could grasp the concepts easily and quickly (3). For some respondents, a fixed mindset, or belief they did not have a 'maths brain,' was the reason they gave up if they did not understand a problem (8).

Twenty-five respondents reported that negative or neutral attitudes toward mathematics developed during the transition from primary to secondary school. They lamented the shift from an interactive primary mathematics curriculum that involved games, investigations, and group work to a secondary mathematics curriculum that was teacher-centred, text-book focused, and procedurally oriented. Respondents reported that engaging and hands-on ways of learning were a thing of the past (20, 78 and 100). Respondent 20 hypothesised that secondary mathematics teachers think that students are "too old to play games or get up and do mathematics activities." Subsequently, secondary mathematics became a "down-hill, stressful slide" (24) as the curriculum and pedagogy became "intense and dry with a summative learning focus" (24). Shifts in curriculum and pedagogy, for some respondents, "cancelled out" (9) positive experiences and beliefs established during primary school. Their attitude shifted from positive to negative and neutral. Respondents described typical secondary mathematics lessons as mini-lectures by the teacher as they explained and demonstrated mathematical processes, punctuated with individual practice from the text-book. If work was not completed, students completed it as homework, "as a form of punishment" (70). Teacher-centred lessons were "mind-numbing" (20), "boring" (2, 37, 68 and 124), "tedious" (123), and "frustrating" (7). The predominance of teacher-centred lessons and the "mundane task of completing questions from a textbook rather than engaging activities" (100) caused many respondents' fondness for mathematics to "spiral downhill" into mathematical anxiety and indifference (151). Transition to secondary school represented a great upheaval for many respondents in terms of their mathematics education. Many did not like it and said they coped poorly with the transition.

The transition from primary to secondary school coincided with increased complexity and abstraction of the mathematics curriculum that compounded respondents' mathematical angst. Consequently, many respondents came to believe that the content was irrelevant and meaningless, and lacked "links between mathematics and real life" (87). Eighteen respondents attributed the perceived irrelevance of the mathematics they were learning as causing their negative or neutral attitude that became "a barrier" (65) between the student and the content, and caused students to "go off" (91) maths. Respondent 60 described her transition experience:

> Once I got to high school I feel that it was the turning point where my mathematics began to decline and I found myself asking, "when will I ever have to use these kinds of equations in my life."

Perceptions about lack of relevance prompted others to disengage (5, 65, 87, 91 and 104). Respondents recalled being advised "you'll never know what job you might end up having" (65) or "because it was in the text book … or just because" (87). Superficial justifications failed to overcome students' beliefs about the irrelevance of the mathematics they were learning as they entered the middle years of schooling.

As the complexity and abstraction of the mathematics increased during secondary school, respondents noticed the pedagogical shift towards teacher-centred lessons. The teacher became an 'explainer' of content. Nineteen respondents said ineffective teacher explanations of mathematical content produced their neutral and negative attitudes. Students defined ineffective teaching to include explanations that were "too brief" (5), "rushed" (40 and 93), "unclear" (35 and 124), "incorrect" (87), or "superficial" (139). Respondent 37 attributed the ineffectiveness of teacher explanations to strengthening their dislike of mathematics. Respondents noted that failure to explain mathematical content clearly and accessibly (37) limited access to the content, leaving "students unaware [of] how to complete the maths topics and tasks" (124). Not being able to understand teacher explanations caused Respondent 16 to "burst into tears many times." Ineffective explanations left respondents with "no choice but to learn the mathematics by themselves" (13 and 40) outside of class. Respondents interpreted attempts at learning independent of the teacher as a last resort.

Teachers may adopt more instructor-focussed approaches for many reasons. They may perceive pressure delivering an 'overcrowded curriculum'. Respondents realised "even as students" that curriculum coverage was prioritised at the expense of "teaching for understanding" (3). When teachers rushed through problems "instead of going slow and working through the problem ensuring everyone understood the process" (59), students became frustrated and developed the perception that "performing quickly was the most valuable skill you could possess" (99). Respondent 99 felt that there was not enough encouragement for "those who get there eventually." Fast pacing of lessons and curriculum were factors that were explicitly identified as the cause of 10 respondents' neutral and negative attitudes. Many respondents explicitly identified that feeling "rushed" (59), "bombarded" (68), "struggling to keep up" (65), and "getting left behind" (121 and 131) were reasons for becoming "frustrated" (59), "distressed" (68), and "despising mathematics" (131). Respondent 104 elaborates:

> If we didn't understand the topic, there wasn't really time to catch up and often we would get left behind the rest of the class. …this is the reason why my positive attitude towards mathematics altered.

Fast paced curricula restricted opportunities for revision (3), consolidation, and reflection (135). Students said fast paced lessons left the impression of jumping from topic to topic with limited opportunities for students to build "from what you were good at" (99).

> We would just move straight to a new topic and it seemed as soon as you got the hang of something the teacher wants you to simultaneously remember it for later on and forget it because we are starting a new type of maths that is not related to what we were just doing (99).

The parade of seemingly unrelated topics made students feel they had to “start again” because they were “back at square one” (5). Disillusionment with mathematics flowed from perceived lack of progress. Students’ disillusionment produced the belief that their mathematical ability was eroding (60 and 123) as respondents described their ability “worsening” (76), “drifting backwards” (66), and “deteriorating” (33) during secondary school. These beliefs negatively impacted on students’ confidence, influenced learning approaches and engagement, and ultimately reinforced negative attitudes (124) towards mathematics.

Respondents described “letting go” (2), “going off mathematics” (91) and “giving up” (143) as decisions they made in response to the fast paced, complex, and irrelevant mathematics curriculum. Respondent 143 elaborates:

> I often could not keep up with the teachers in my mathematics lessons, and students like myself would just give up and become disengaged because we fell so far behind. I would not misbehave but would end up being a student who ‘slipped through the cracks’ because I just sat there quietly looking like I was working when in actual fact I was so frustrated because I genuinely wanted to learn.

Disillusionment arising from beliefs about falling behind prompted capitulation and surrender from Respondent 143. Disengagement arose as a self-preservation strategy to withstand being bombarded by an overcrowded and fast paced curriculum. For other respondents, the increasing complexity of the curriculum spurred them to stop paying attention (39) and eschew “putting extra focus and attention” into mathematics (2). Students “just let it go and became extremely unproductive” (2). Others became disruptive as a strategy to conceal their struggles (117).

While some respondents actively disengaged from mathematics, others more subtly disengaged by adopting passive and surface learning approaches (93) and relied on superficial rote learning and memorisation (24) to “float” through the subject and pass the class (8 and 93). Many reported that surface and passive learning approaches hindered mastery and understanding. Respondents now realised the consequences of their choice to passively disengage in terms of the longevity, applicability, and connectivity of their learning (24, 44, 56 and 72). Students knew that memorising processes did not equate with understanding and this “raised all kinds of problems when testing was conducted and underlined the lowest level of understanding, with no critical thinking” (72). Respondent 93 explained:

> I disliked maths, always felt inadequate and often equations looked like a heap of meaningless jumbled mess. I didn’t know how to apply much to real life circumstances, I just knew irrelevant rules and not where to apply them.

Our respondents recognised their lack of mastery of mathematical content. They described feeling inadequate (24, 93 & 112). Respondent 24 attributed her feelings of inadequacy to surface learning approaches adopted to pass mathematics exams during her final year of secondary school. Although she completed mathematics to the highest level at school, she recognised that her surface learning approach was “certainly not a life-long learning experience” (24). Other respondents echoed Respondent 24’s frustrations of senior secondary mathematical experiences. Respondent 112 remained unable to reconcile surface learning approaches that impeded mastery of the content. Her lack of mathematical mastery frustrated and upset her. This frustration led to her dropping mathematics in her final year of secondary school, despite externally appearing to make solid progress. She elaborated:

> In Year 12 I dropped Maths Methods because I couldn’t see relationships between concepts. I didn’t understand why we had to learn such complicated algebra or equations, nor when to actually use them in real life situations. Furthermore, I often had trouble identifying when and how to apply certain rules to problems, or why one problem was approached in a different way

> to the next. My inability to understand the purpose and use of such concepts eventually grew into a deep frustration with the work and with myself. At times, such frustration lead to tears as I saw myself as a high performing student, yet failing in regards to math. It was a mind game, as I was never even close to failing despite how I felt, and in the end I dropped higher level maths purely to relieve stress levels in year 12.

Sixteen respondents felt uneasy, frustrated, and annoyed at resorting to rote learning and memorisation. Students lost their passion (26) as frustration with mathematics transformed into loathing (29) and hatred (68) when they failed to understand the mathematical content (68) or "get the processes" (46). Students who adopted "self-preservation" strategies came to feel disempowered and disconnected from mathematics. An "intense, dry and outcome focused secondary mathematics curriculum" (24) quashed enjoyment of mathematics, positioned respondents as passive learners, impeded the development of understanding, and undermined mathematical self-efficacy and self-concept.

Respondents came to associate mathematics with strong negative emotional responses like fear (130 and 143), panic (128), terror (111), anxiety, and stress (6, 28 and 135). Unfortunately, former students' feelings of inadequacy (134), and lack of confidence (113, 126 and 147) creates anxiety about teaching mathematics. "Gut wrenching" anxiety (16 and 31), worry (119), dread (28 and 113), and fear (73) emerged among respondents "just at the thought of teaching mathematics" (31). Respondents said that fear, anxiety, and lack of confidence about teaching mathematics spurred their avoidance of teaching certain topics (73), constrained their capacity to teach mathematics innovatively, and limited their pedagogical choices to "mundane work sheet classes" (147).

Discussion

Our qualitative data demonstrated that attitudes towards mathematics can vary on a continuum from highly positive to neutral, to highly negative. Many of the preservice primary teachers we surveyed held beliefs and attitudes so negative that they were frequently described as hatred towards mathematics. Respondents ascribed their attitudes to experiences embedded in their own educational journey. Firstly, overt and covert competition and comparison with peers caused negative attitudes and beliefs to develop during primary school. Secondly, teacher-centred approaches that emphasised speed and process over understanding and relevance were the catalysts for negative attitudes during secondary school and shaped beliefs that mathematics is difficult, boring, and irrelevant. Respondents report their negative and neutral beliefs and attitudes arose as unintended consequences of their interpretations of mathematical experiences. These beliefs and attitudes invoked, and were invoked by, emotional responses from our respondents including feelings of ambivalence, dislike, frustration, alienation, isolation, fear and loathing. Ultimately, our respondents experienced challenges with their learning approaches, engagement, resilience, motivation, persistence, and their understandings and aspirations.

This study's findings are reflective of national and international research into PSTs' mathematical attitudes and beliefs (Sloan, 2010; Tobias et al., 2010). This raises the question of whether teacher education courses disproportionally attract and recruit candidates with negative and neutral mathematical beliefs and attitudes. However, reports of learners hating mathematics are so numerous that it is clear that poor mathematical attitudes, values and beliefs transcend discipline and career boundaries (Fadali, Valasquez-Bryant, & Robinson, 2004). Clearly, the problem of students with negative mathematical beliefs and attitudes is more widespread than teacher education alone. However, teacher education faces unique and complex issues related to the impact that PSTs' negative mathematical beliefs and attitudes will have on their current and future learning and teaching. PSTs who fear, loathe, or remain ambivalent towards mathematics may impart their attitudes and beliefs to future learners. It is important to understand how these negative and neutral mathematical attitudes and beliefs become established so we can proactively intervene. Without intervention, PSTs who develop negative attitudes and beliefs about mathematics will become unwitting accomplices to creating the next generation of learners who hate mathematics.

Our data confirms the complex relationship that exists between mathematical beliefs and attitudes. Many of our respondents recounted experiences of teaching approaches or teacher actions that precipitated beliefs about their capacity as learners of mathematics, and beliefs about teaching and learning mathematics. These beliefs shaped feelings and attitudes towards mathematics. It was clear that strongly held beliefs shaped respondents' behaviour. Choices to disengage actively or passively from mathematics provide evidence of the intensity or high value with which the respondents associated their beliefs (Southwell, 1995). The strong interaction between beliefs and attitudes became evident though our analysis of qualitative data and offers confirmation that beliefs form the classroom experiences of students (Gresalfi & Cobb, 2006). As beliefs develop in intensity they shape attitudes relating to mathematics. Interactions between beliefs and attitudes influence learners' engagement, motivation and learning approaches to mathematics, which in turn impact on their understanding, achievement, and aspirations.

Beliefs about mathematical ability

Competitive and social comparative experiences of mathematics lead to self-limiting beliefs about ability and manifest in the strongest emotional responses: humiliation, fear, dread, and loathing. Competition alerts students to differences in their mathematical performances compared with their peers. Students conflate their relative mathematical performances with measures of their mathematical ability and formulate beliefs about their abilities accordingly. Instances such as the public airing of mathematical successes and failures create heightened emotional states and consequently become formative experiences for the development of mathematical beliefs and attitudes. Worryingly, these beliefs and judgements about mathematical ability can begin early in primary school. The perception that someone is faster, achieves a better score, or is in a higher mathematics group prompted our respondents to infer their mathematical ability comparatively; they saw themselves as the slowest, not the brightest, weakest, worst, and dumbest. Students' interpretations of their relative performance became the foundation for the development of self-limiting beliefs about the fixed nature of their ability (Blackwell, Trzesniewski, & Dweck, 2007; Boaler, 2013). Once students believe that they are 'bad at maths' or that they are 'never going to get it', they are usually right. Dweck (2006) demonstrated that a fixed mindset (or a belief in natural ability) contributes to diminished resilience and challenge avoidance, and leads to giving up when facing difficulties or mistakes. Some respondents explicitly linked their belief in the mathematical myth that they lacked a "math mind" (Kogelman & Warren, 1978) to experiences in primary school that involved some form of social comparison or competition. This finding confirms that competitive and comparative situations negatively affect students' mathematical self-concept (Cheema & Kitsantas, 2016; Parker et al., 2014). Low mathematical self-concept contributes to low achievement in mathematics and low participation in mathematics subjects in the senior secondary and tertiary levels of education (Boaler, 2013; Parker et al., 2014). Self-limiting mathematical beliefs, therefore, carry long term and adverse consequences for students' future mathematical intentions, their career aspirations, and their employment opportunities. The negative consequences will likely accrue as self-limiting beliefs about mathematical ability and transfer to other areas of life, and may represent incalculable diminished potential.

Beliefs about learning mathematics

Many PSTs justify negative or neutral mathematical attitudes using beliefs that mathematics is too hard, boring, and useless (Brown et al., 2008; Grootenboer & Marshman, 2016). These beliefs grew from experiences of more teacher-centred approaches and, for these respondents, were more likely to develop after the transition from primary to secondary school. The transition to secondary school was a time when our respondents said that they disengaged from mathematics as they became bored with teacher-centred approaches and the content became more difficult and less relevant (Attard, 2013; Grootenboer & Marshman, 2016). PSTs said their investment of time engaging in mathematics was a waste. The perception that mathematical content held limited relevance reinforced their beliefs.

Teacher-centred curriculum and pedagogy during secondary school prompted more passive or surface learning approaches that PST reported impacted their ability to apply, connect, and retain mathematical understandings. These respondents acknowledged that they shifted the focus of their learning from understanding and mastery to mathematical survival. A lack of mastery of mathematical content frustrated many of the PST in this study and drained many PSTs' confidence and belief that they could complete mathematical tasks. Some believed that their mathematical ability was actually deteriorating. Even outwardly successful mathematics performers felt so despondent, inadequate, frustrated and inexpert that they chose to withdraw from mathematics subjects at the senior secondary level. That externally validated high achievers at mathematics would make such decisions highlights the extent of the challenge for all mathematics learners and future teachers of mathematics in particular.

Beliefs about teaching mathematics

Negative responses to mathematics seem to arise predominantly from mathematical experiences that privilege process over concepts and speed over understanding. Perceptions then fall easily to the simplistic notion that teaching equates with explaining. Unintentionally, teacher-centred pedagogies confer limiting beliefs about what it means to learn and teach mathematics. Many PSTs in our study articulated admirable aspirations about how they envisage teaching mathematics. But for many, it was about what not to do. Many said they lacked knowledge about what to do. At best, teachers with limiting beliefs about mathematics will seek to avoid teaching as they learned mathematics. However, without mitigation, many PSTs will possess limited capacity to do more than relive the past and teach as they were taught using symbolic representations of mathematical concepts that they still poorly grasp. As Charalambous (2015) points out, even if PSTs are willing and inclined to engage in certain teaching practices, how they engage depends on their knowledge. These concerns also relate to the significant proportion of in-service secondary teachers (approximately 50%) who are currently teaching mathematics in Australia "out of field" (McKenzie, Kos, Walker, & Hong, 2008; Office of the Chief Scientist, 2014; Vale, 2010). Teachers with limited knowledge of mathematics and narrow beliefs about the discipline will be restricted in their capacity to design and implement engaging, divergent, and relevant mathematical lessons, provide clear explanations and appropriate representations and models, guide student's mathematical development, and teach for understanding (Ball, Bass, & Hill, 2004; RAND Mathematics Study Panel, 2003). Out-of-field mathematics teachers are likely to default to teacher-centred and text-book focused lessons, teaching approaches that our respondents and others (Boyd et al., 2014;

Tobias et al., 2010; Swan, 2004) identified as causing their dislike, disillusionment, and disengagement with mathematics in the first place. We postulate a chain of distortion occurs between untrained mathematics teachers and subsequent PSTs who become teachers who fear, loathe, and remain ambivalent to mathematics. These experiences have taught our PSTs what not to do, but not what to do. Without intervention, our teachers who harbour negative attitudes and limiting beliefs will perpetuate a suite of limiting beliefs and attitudes among future generations of students – and so the cycle continues.

Alienation

Disconnection from mathematics was a key theme that arose through respondents' reflections. This resonates with students' sense of belonging (or lack of) in mathematics. As Good, Ratten, and Dweck (2012) point out, a personal sense of belonging in mathematics is a key driver in students' intent to pursue mathematics and mathematics related careers and is related to anxiety and confidence. A sense of belonging in mathematics is influenced by students' mathematical experiences as well as more broadly by societal cues and the "culture of talent" in mathematics (Good et al., 2012), and there is some evidence that females are less likely to experience a sense of mathematical belonging. There is evidence in this study that female PSTs are more likely to report negative and neutral attitudes towards mathematics than their male counterparts and this may be partially explained by students' sense of belonging in the discipline of mathematics. The findings of this study demonstrate that alienation from mathematics develops from mathematical experiences that emphasise competition and comparison, and by the enactment of mathematical curricula as abstract, irrelevant, and fast-paced. Alienation and isolation also develop when students adopt surface learning approaches that do not encourage understanding and mastery. Students then feel that they are on the periphery or the fringe of the mathematics domain, and their participation and contributions are not valued.

Maturity

PSTs are mature learners and thinkers, and despite what some of them report, the challenges of childhood mathematics need no longer dominate their beliefs and attitudes. As mature learners, with the right guidance PSTs can conceptualise the foundations of mathematics that they may not have had the opportunity to develop during their formative years at school, shift their beliefs and attitudes, and build their expertise and capacity to teach the next generation differently. Mature and experienced learners have developed the resilience that ensures they respond in a positive way when confronted with their relative performance or the perception that their struggle is a lonely one. Indeed, mature learners may interpret these situations as calls to arms to raise expertise and seek help.

Less mature learners interpret the same confronting situations as evidence that reinforces a lack of mathematical ability. In a descending spiral, ill at ease learners become reluctant to ask for help because they are embarrassed to publicise their difficulties. Young students possess insufficient maturity, self-awareness, or resilience to discern their capacity to learn mathematics from their performance on mathematics tasks and their relative level of mathematical achievement. To cope with the pedagogy and the curriculum, respondents' recollections of their school based mathematical experiences require a level of resilience and personal belief that only mature, experienced minds have developed. The very resilience required to respond positively to challenges lay at least five to ten years in their future.

For a substantial proportion of PSTs who held negative attitudes towards mathematics, their hatred and fear began early during their primary years. For some, negative mathematical experiences that involved competition or social comparison prompted negative, visceral responses, responses that some respondents still experience when faced with mathematical tasks today. These humiliating and isolating experiences shaped their mathematical self-efficacy and self-concept as they conflated their relative performance with their mathematical ability.

In the absence of the maturity of thought they need, students come to associate mathematics with highly negative experiences and consequential psychological responses that they say do long term harm. Learners fearful of their own mathematical inadequacies in environments of heightened sensitivity come to interpret events negatively. That respondents recall words, phrases, and tones of voice from early mathematics education that shape attitudes and direct behaviours over two decades later demonstrates amplification of the experiences. We might ascribe these formative experiences to a lack of intellectual maturity at the time they occurred. We recognise the absence of resilience negatively influenced their experiences at the time and subsequently. To equip students with the necessary skills in resilience and self-regulation of their learning, introducing programs to build these skills early in the primary curriculum offers one promising avenue to avert challenges reported among these PSTs.

Conclusion

This study recognises that nearly three quarters of PST participants reported fear, loathing, and ambivalence towards mathematics. Their responses arose from mathematical disengagement, disempowerment, disenchantment, disconnection, and disillusionment. Our qualitative data reveals self-rationalisations for PSTs who have developed limited and limiting views about mathematics through their reflections about their mathematical journeys. Many said that their experiences of the mathematical curriculum and pedagogy have done more harm than good. Their experiences provide a reminder of a broader, intractable, and entrenched problem in mathematics education. Declining uptake of advanced mathematics subjects beyond the compulsory years (Forgasz, 2006), an increasing trend of low and underachievement in mathematics (Stanley, 2008; Thomson, de Bortoli, & Buckley, 2012), concerning levels of mathematical disengagement amongst students (Boaler, 2009; Sullivan & McDonough, 2007) and an undersupply of qualified mathematics teachers (Clarke, 2009; McKenzie et al., 2008) are symptoms of our challenge. A predominant theme that arose from the findings of this study was that a teacher-centred, procedurally focused, and text-book oriented enactment of the mathematics curriculum constrained engagement, self-efficacy, motivation, and authentic approaches to learning. These findings provide further confirmation, therefore, that more student-centred, investigative, and conceptually-oriented mathematical learning environments are more conducive to the development of students' motivation (Tuan et al., 2005), self-efficacy (Fast et al., 2010), and self-regulation (Paris & Newman, 1990; Perels et al., 2009).

Many of our respondents developed limiting views about what mathematics is and what it means to succeed in the discipline. Our future teachers with negative attitudes and beliefs about mathematics will accept responsibility for the mathematics education of this and future generations. With negative attitudes we can expect an unfortunate bias that will shape PSTs' own mathematics teaching approaches (Cross, 2009; Jacobson & Kilpatrick, 2015) and will sculpt their future students' mathematical beliefs, attitudes, understandings, and achievement (Baumert et al., 2010; Hattie, 2003; Hill, Rowan, & Ball, 2005). Whether our future teachers can teach mathematics effectively and empathetically depends on how teacher educators address entrenched negative beliefs and attitudes. Through understanding the nature and genesis of PSTs' mathematical beliefs and attitudes, PST programs may instigate strategies to create supportive environments that build capacity, capability, and beliefs about what mathematics could and should be for all. To depolarise PSTs' beliefs about mathematics we could enrich and support conceptual understandings to break down limiting attitudes and promote membership in the mathematical community. Here, we have provided a platform for PSTs to share the nature of their mathematical beliefs and attitudes and their experiences of the mathematics curriculum. Through our use of PSTs' qualitative descriptions of their experiences we seek to include their voices more directly in discussions about addressing the negative beliefs and attitudes that represent an intractable and entrenched challenge in mathematics education. Using attitudinal and belief cues, we possess the preliminary insights to halt enduring inter-generational fear and hatred of mathematics.

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