Primary Teachers' Mathematical Self-concept and its Relationship with Classroom Practice

Matt Thompson
Western Sydney University
matt.thompson@westernsydney.edu.au

Catherine Attard
Western Sydney University
c.attard@westernsydney.edu.au

Kathryn Holmes
Western Sydney University
k.holmes@westernsydney.edu.au

Mathematical self-concept refers to the perceived ability that one has in being able to do mathematics. While it has been shown to be a significant predictor for how students learn and apply mathematics, little research has been conducted into the relationship between the mathematical self-concept of teachers and their pedagogical practices in the mathematics classroom. This paper reports on a section of the findings from a small mixed methods study that sought to ascertain the nature of primary teachers' mathematical self-concept and how it is related to their teaching practices. Findings suggest that a teachers' mathematical self-concept does not necessarily reflect the mathematics practices evident in their classroom.

Negative attitudes towards mathematics often stem from school experiences and are exacerbated by the acceptance of an "I'm no good at maths" attitude in Australia's society (Wilkins, 2016). These experiences are often the result of teachers not having the pedagogical content knowledge or specialised subject knowledge in mathematics to design mathematical opportunities for students that are substantively engaging, purposeful, relevant and reflective of the individual student (Ball et al., 2008; Attard, 2013). Consequently, for some students, the results can be devastating (Gemici et al., 2014). Sustained student engagement, academic achievement, and future career choices are all factors that have the potential to be impacted due to negative experiences when learning mathematics (Gemici et al., 2014; Bourgeois & Boberg, 2016).

For students to successfully learn mathematics and develop an appreciation for what mathematics can bring to their lives, they need teachers who have the knowledge, skills and pedagogical understandings to be able to effectively plan, implement and evaluate mathematics teaching and learning.

Background

Previous research suggests that a teacher's belief in their mathematics ability plays a vital role in the way in which they teach mathematics (Stipek et al., 2000). Teachers who identify as being 'good' and 'able' in the subject often tend to take greater risks in challenging their students mathematically. Conversely, teachers who consider themselves not to be 'good' at mathematics often tend to be much more cautious or reserved in how they teach and engage in the subject with their students (Stipek et al., 2000).

The notion of self-concept has been widely defined. Seaton et al. (2014) state that "individuals embrace self-concepts about themselves that correspond to various aspects of their lives" (p.50). That is, self-concept is a learned trait that is developed as a result of experience. Marsh and Shavelson (1985), view the idea of self-concept as a form of social comparison whereby an individual perceives a self-impression of themselves as a result of comparing themselves to another person. Consequently, it is this direct comparison that often leads to negative associations on an individual's confidence, self-esteem, achievement and motivation (Tenisheva & Alexandrov, 2013). Kinch (1963) identifies self-concept as "the organisation of qualities that the individual attributes to himself in varying situations" (p. 481). Quite often

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these attributes stem from experiences both negative and positive that the person has encountered and endured over the course of time.

Although there has been an abundance of research conducted around the notions of “self,” there is still not a definitive consensus about “self” as an individualised construct (Guay et al., 2015). Guay et al. (2015) expressed, however, that certain aspects of a person’s “self” are crucial for understanding and driving human behaviour” (p. 6). Harter (1985) as cited in Cheng-Yu (2014) expresses the idea that an individual’s self-concept is derived from their personal description and evaluation of their strengths and weaknesses. A person’s mathematical self-concept is a significant predictor for several characteristics, including achievement in the subject, as well as motivation and attitude relating to the learning and application of mathematics (Abu-Hilal, 2000).

The attitudinal beliefs that adults have regarding their mathematical ability often stem from their experiences with mathematics when they were at school (Whitten, 2013). Unfortunately, often it is these experiences that set the trajectory for adults to adopt the mindset of not being good at or being able to ‘do’ mathematics. This idea is supported by Boaler (2016) who states that “when students get the idea they cannot do math, they often maintain a negative relationship with mathematics throughout the rest of their lives” (p. 10). The consequence for a teacher who has a negative disposition towards the subject, often, is their students also feel the same way. Seaton et al. (2014) raise the question, “should teachers focus solely on improving academic skills or is it also necessary for them to help students develop positive perceptions of their abilities?” (p. 51).

Research suggests that there is a reciprocal relationship between academic achievement and self-concept (Marsh & Craven, 2006). Teachers play a vital role in not just the academic achievement of their students, but in the development of their students’ beliefs and perceptions of the subject. It is imperative then when considering the above-mentioned question, to also consider how a teacher who has a negative self-concept of mathematics themselves can develop their students’ mathematical self-concept in a way that is going to have a positive effect on their overall engagement and achievement in mathematics.

Engagement and Mathematics

The concept of engagement can be defined as active involvement in learning and includes the mental (cognitive), physical (operative) and emotional (affective) elements of learning (Munns & Martin, 2005). Students who are engaged at all three levels value and enjoy mathematics and see the relevance and purpose that mathematics has to their lives both within and beyond the classroom (Attard, 2013). A student who has a low mathematical self-concept typically exhibits low levels of engagement and motivation. A number of research studies (Erdogan & Sengul, 2014; Bonne, 2016) acknowledge observed declines in a student’s mathematical self-concept, their perception of the subject as being important and useful, as well as a significant decline in their motivation and interest in the subject. Watson et al. (2019) acknowledge that this decline, around the middle years of schooling typically correlates with students developing a sense of identity and an awareness of others, resulting in peer-comparison. Ma and Cartwright (2003) acknowledge that these declines quite often parallel with increased feelings of mathematics anxiety. For some students who have low achievement levels in mathematics during high school, this can influence and limit the career choices they make as adults (Gemici et al., 2014). Additionally, this type of student could potentially enter society without having the numeracy skills needed to “meet the complex demands of everyday life and work” (Seaton et al., 2014, p. 49).

Framework for Engagement with Mathematics

Engaging students with learning in the mathematics classroom is crucial if teachers want to support students in not only achieving academically, but also as learners who are able to "put forth effort, persist, self-regulate their behaviour towards goals, challenge themselves to succeed and enjoy challenges and learning" (Christenson et al., 2012, p. 5). The Framework for Engagement with Mathematics (FEM) (see Table 2) was the result of a longitudinal study that examined the influence of student engagement during the middle years of schooling (Attard, 2014). The FEM was selected to be used as an analytical and observational tool in this study as it was generated from both existing literature and research that included student perspectives (Attard, 2012).

Attard's (2014) FEM was used when exploring teacher practices, in particular their pedagogical practices when teaching mathematics. It is these pedagogical repertoires (the day-to-day practices of teaching) and the pedagogical relationships (interpersonal and interconnectedness between teacher and student and teaching and learning) that positively affect engagement and learning in mathematics (Attard, 2012).

Methodology

The purpose of this study was to ascertain the nature of primary teachers' mathematical self-concept and how it is related to their teaching practices. The central research question of this study was:

1. *What is the nature of primary teachers' mathematical self-concept and its relation to their practices in the mathematics classroom?*

The following sub-questions were used to inform the central question:

a. *What is the relationship between a teachers' mathematical self-concept and their pedagogical relationships?*
b. *What is the relationship between a teachers' mathematical self-concept and the pedagogical repertoires of their practice?*

To address the research questions a mixed methods approach was used. The study was organised into two phases. In phase one, three case study participants were identified after completing an online survey/questionnaire that identified their current level of mathematical self-concept, using Marsh and O'Neill's (1984) Self-Description Questionnaire III (SDQIII). In phase two, individual teacher interviews and two classroom observations per case study participant were conducted. The researchers' field notes and transcribed interviews were interrogated and analysed using the FEM (Attard, 2014), identifying the elements of each aspect of the Framework evident in the teachers' lessons. The data collected in phase two of this study was used to build on the findings from phase one.

In total, there were 31 respondents (25 female and 6 male) to the initial survey/questionnaire. Fifteen of the 31 participants indicated that they would be willing to take part in phase two of the study. Originally, case study participants were selected based upon their scores (low, middle, high) on the SDQIII. However, as a result of identified participants being unavailable, the researcher was required to select participants based upon those who were available.

Case Study Participants

Annie. At the time of the study, Annie had been teaching for eight years and was teaching at a government primary school in South-Western Sydney. The observational data collected for Annie came from a year six class of 26 students. It was observed during both visits that there were a number of negative student behaviours apparent in the class (e.g., students calling out, students provoking other students, students back answering the teacher).

In terms of her mathematical self-concept, Annie stated that she remembers enjoying mathematics more when she was younger than when she did in high school. She said during high school, she was placed into the lowest mathematics class and was "acing every test and assignment". Annie was moved up a level for years eleven and twelve and remembers when the mathematics became challenging, "rather than pushing myself, I got a bit lazy".

Bree. At the time of the study, Bree had been teaching for five years and was teaching at a government primary school in South-Western Sydney. The observational data collected for Bree came from a year two class of 22 students. This class was located in an open plan classroom space that in total consisted of 44 students and two classroom teachers.

In terms of her mathematical self-concept, Bree referred to herself as a low achieving student and at one point stated that she "hated maths" when she was a child. Bree expressed in her interview that the thought of needing to teach mathematics almost put her off becoming a teacher.

Catherine. At the time of the study, Catherine had been teaching for fifteen years and was teaching at a government primary school in South-Western Sydney. The observational data collected for Catherine came from a year three class of 31 students. During the first observation fifteen students were absent.

In terms of her mathematical self-concept, Catherine acknowledged that during primary and secondary school, she remembers never really knowing what she was doing in mathematics or why she was doing it. She said she remembers this made her feel like she wasn't "as good" at the subject as her peers. Catherine stated that although she really enjoys teaching mathematics, she doesn't feel that she is very good at it.

Findings and Discussion

Table 1 illustrates the overall mean score for the whole sample (*n* = 31) as well as for each case study participant, for each scale of the SDQIII measured. Table 2 demonstrates the depth of evidence that existed for each element of the FEM (Attard, 2014) for each case study participant.

Table 1
Mean Scores of Each Scale

Scale	Mathematics	Academic	Problem Solving	General Esteem
Overall Mean	5.3	5.9	5.5	5.6
Case Study Participants				
Annie	4.9	4.1	5.1	5.3
Bree	3.7	4.9	5.9	5.3
Catherine	4.1	5.7	3.9	5.1

All three case study participants scored below the mean for the mathematics scale in the Self-Description Questionnaire III (Marsh & O'Neill's, 1984), indicating relatively low mathematical self-concept. However, comparison of the three case study participants indicated that Annie's mathematical self-concept score (mean = 4.9) was the highest when compared to Bree (mean = 3.7) and Catherine's (mean = 4.1) scores. Interestingly, analysis of Annie's pedagogical practices as per the FEM (Attard, 2014) indicate minimal evidence to suggest that her mathematics teaching reflects evidence of engaging mathematics teaching.

Table 2
Framework for Engagement with Mathematics, Illustrating Evidence of Practice

Aspect	Element	Annie	Bree	Catherine
Pedagogical Relationships	*Pre-Existing Knowledge:* Student's background and pre-existing knowledge are acknowledged and contribute to the learning of others	LE	HE	HE
	Continuous Interaction: Interaction amongst students and between teacher and student is continuous	LE	HE	ME
	Pedagogical Content Knowledge: The teacher models enthusiasm and an enjoyment of mathematics and has strong Pedagogical Content Knowledge	NE	HE	HE
	Teacher Awareness: The teacher is aware of each student's mathematical abilities and learning needs	LE	HE	HE
	Constructive Feedback: Feedback to students is constructive, purposeful and timely	NE	ME	ME
Pedagogical Repertoires	*Substantive Conversation:* There is substantive conversation about mathematical concepts and their applications to life	LE	HE	HE
	Challenging Tasks: Tasks are positive, provide opportunity for all students to achieve a level of success and are challenging for all	LE	HE	HE
	Provision of Choice: Students are provided an element of choice	NE	LE	ME
	Student-Centred Technology: Technology is embedded and used to enhance mathematical understanding through a student-centred approach to learning	NE	NE	NE
	Relevant Tasks: The relevance of the mathematics curriculum is explicitly linked to students' lives outside the classroom and empowers students with the capacity to transform and reform their lives	NE	HE	HE
	Variety of Tasks: Mathematics lessons regularly include a variety of tasks that cater to the diverse needs of learners	NE	ME	ME

No Evidence (NE) *Low Evidence (LE)* *Medium Evidence (ME)* *High Evidence (HE)*

Subsequently, this was reflected by way of her students seeming to "comply" with doing the mathematics as opposed to enjoying and valuing the mathematics being taught. Comparatively, Bree and Catherine's pedagogical practices as per the FEM (Attard, 2014) suggest that they are in fact demonstrating evidence of engaging mathematics teaching, reflective of best practice. Subsequently, this was reflected by way of their students seeming to be authentically enjoying mathematics and valuing what they were learning because of the relevant links that the mathematics had to their lives.

Pedagogical Relationships

Annie, although scoring the highest mathematical self-concept score out of the three case study participants, demonstrated the weakest pedagogical relationships. Annie's weak pedagogical relationships were paralleled in her weak pedagogical content knowledge, the minimal opportunities she provided her students to interact with each other as well as her inability to provide her students with constructive and purposeful feedback throughout the learning process. Bree and Catherine demonstrated that they had strong pedagogical relationships, evidenced in their classrooms by their interactions with their students, their understanding and knowledge of individual students' abilities and learning needs, their enthusiasm for teaching mathematics, and their strong pedagogical content knowledge.

Pedagogical Repertoires

As she did with pedagogical relationships, Annie demonstrated the weakest pedagogical repertoires. Annie's weak pedagogical repertoires were reflected by the prescriptive nature of conversations that took place between her and her students as well as her lessons seeming to be stand-alone lessons that provided students with the opportunity to practice content, as opposed to being something that was purposeful and meaningful to their lives. Comparatively, Bree and Catherine demonstrated that they had somewhat strong pedagogical repertoires, evidenced in their classrooms by the opportunities they provided their students to work collaboratively whilst problem solving and investigating. Additionally, there was evidence of purposeful planning in Bree and Catherine's lessons to ensure their students were challenged and that the mathematics being taught was done so in a way that provided relevance to their students' lives.

Mathematical Self-concept and Teacher Practice

Contrary to previous research (Stipek et al., 2000), this study found that a teacher's self-concept score in relation to mathematics does not necessarily reflect the mathematics practices evident in their classroom. It emerged through case study interviews that personal experiences with mathematics in childhood appear to have the potential to affects one's self-concept. This reflects the understanding in the literature that self-concept is often attributed to the negative and positive experiences a person has encountered and endured over the course of time (see for example, Tenisheva and Alexandrov, 2013; Seaton et al., 2014). During interviews, all participants identified negative experiences with mathematics when they were children. It was noted in this study that the three case study participants appear to have responded in different ways to these experiences. Annie, for example appears to have maintained a negative association with the subject, now resulting in her own teaching of the subject in a way that does not reflect effective practice. However, Bree and Catherine appear to have channelled their negative experiences with the subject into an opportunity to ensure that they are teaching mathematics to their students in a more positive way, conducive of practices that embrace quality mathematics teaching.

Conclusion and Limitations

This study has revealed that a teachers' mathematical self-concept does not always reflect their pedagogical practices. Individual school contexts, the proactive engagement in the attainment of professional learning as well as a teacher's personal engagement with the profession, all appear to be factors that influence this finding.

The study had some limitations that should be noted. The first limitation was the small sample size (n = 31) of participants (those who responded to the survey/questionnaire in Phase 1). According to Cohen et al. (2011) for quantitative research "the larger the sample the better, as this not only gives greater reliability but also enables more sophisticated statistics to be used" (p. 144). That being said, it is important to acknowledge that the findings of this study are not able to be generalised across all contexts. Another limitation of this study was that the analysis of observed teacher practice was based on only two observed lessons. A more sustained study with a greater number of observations may have revealed deeper insights.

Additionally, as this study was concerned with the relationship between mathematical self-concept and teacher practices, further research that investigates the impacts that the mathematical self-concept of primary teacher's has on student's mathematical self-concept would be beneficial in adding to the existing research around student engagement in mathematics during the primary years of schooling.

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