Exploring the 'high' and 'low' points in primary preservice teachers' mathematics-related identity development

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We report on the use of a data-gathering task requiring preservice primary teachers to 'graph' their emerging relationships with mathematics. A cultural-historical activity approach was used to analyse data from nine final year preservice primary teachers to reveal what and how key events in their lives helped shape their current mathematical identities. Oscillations between "high" and "low" points in their relationships with mathematics was a feature of participants' graphs regardless of their current mathematical identities. Combined with semi-structured interviews, the graphing task is posited as a valuable method for researchers and practitioners to explore mathematics-related identity.

The development of a positive mathematical identity is considered critical to student learning because of its potential to influence career and higher education aspirations (Black et al., 2010). Selecting a mathematics-related career is not just about being academically successful in mathematics, it is also determined by how a person identifies with mathematics as a discipline (Sfard & Prusak, 2005). It is therefore unsurprising that the development of a healthy student identity with mathematics is considered of major importance to achieving current goals for the Australian government's mathematics and science related education agenda (Australia Government, 2015). Research indicates that teachers' personal identities with a particular discipline can profoundly influence how they teach that discipline and position their students to learn it (Leatham & Hill, 2010; Reay & Wiliam, 1999). Unfortunately, it is well established that many primary teachers have not experienced healthy relationships with mathematics as students (Maasepp & Bobis, 2014), making it difficult to nurture positive identities in their own students. Such a situation can be detrimental to primary students' long-term decisions to undertake further study in mathematics areas as early negative experiences can have enduring negative influences on students' achievements and aspirations in those disciplines (Black et al., 2010).

Numerous researchers have studied preservice primary teachers' mathematics-related identities, often with the intention of better understanding the personal experiences that shape certain identities (Darragh, 2016). Studying identity is problematic due to its complexity—commonly conceptualized as dynamic, multidimensional and formed through a blend of personal characteristics and long-term socio-cultural experiences. Such complexity has raised questions about the capacity of researchers to provide an adequate measure of mathematical identity (Kaspersen et al., 2017). With this challenge in mind, we sought to explore the mathematical experiences of primary preservice teachers (PSTs) that helped shape their current mathematics-related identities. Additionally, the merits of a relatively novel task that required participants to graph the high and low points in their relationship with mathematics was explored. We conclude the paper by advocating the graphing task as a valuable qualitative strategy for researchers and teacher educators to understand the experiences and conditions under which mathematical identities develop.

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Defining Identity

Definitions of identity vary from those who consider it to be how individuals are perceived by themselves and others (Grootenboer et al., 2006) to those who emphasise the socio-cultural context in which individuals act (Kaspersen et al., 2017). However, Sfard and Prusak (2005) conceptualized identity as discourse comprising endorsable stories or narratives about 'who one is' independent from one's actions (Kaasila et al., 2005). No matter how it is defined, researchers generally conceptualize identity as a multidimensional construct, combining elements such as knowledge, beliefs, attitudes, emotions, confidence and dispositions that influence how individuals view themselves and are viewed by others (Beauchamp & Thomas, 2009; Kaasila et al., 2012). In essence, we see identity as relational by nature, incorporating both cognitive and affective aspects (Kaasila et al., 2012; Leatham & Hill, 2010) and is dynamic in nature in that an individual's identity is considered to be constantly shifting as a result of social interactions. More specifically, in the current study, we use Lutovac and Kaasila's (2019) term 'mathematics-related' identity because it encompasses all aspects of a preservice teacher's identity related to mathematics.

Preservice teachers' mathematical-related identities can be influenced by their socio-cultural backgrounds. A study by Watkins and Noble (2008) involving 35 Year 3 students from different ethnic backgrounds revealed that Chinese parents had higher expectations for their children's achievements than their Anglo and Pasifika peers. Such cultural background influences could impact the developing identities of young children in either positive or negative ways. Socio-cultural factors that can potentially influence identity go beyond ethnicity to include a range of family, religious, educational and socio-economic background elements.

Theoretical Perspective

Studies that are framed in cultural-historical activity theory (CHAT) view identity as essentially a social experience, whereby the context must be considered when interpreting an individual's activity or responses (Engeström, 2001). In this study, we were interested in primary PST's shifting relationship with mathematics (the context) over time (historical) and how they responded (the activity) to salient events (socio-cultural) in their lives.

The mathematics-related identities that PSTs develop as students via various socio-cultural contexts can not only influence the actions that they take regarding their own relationship with mathematics but those of their future students (Maasepp & Bobis, 2014). Thus, it is of utmost importance that primary PSTs not only develop healthy mathematics-related identities, but that mathematics educators can easily assess information about their PST's identities to ensure adequate interventions might take place.

Research Design

While most investigations adopt a qualitative tradition to explore mathematics-related identity (e.g. Black et al., 2010; Darragh, 2016), some quantitative studies exist (Kaspersen et al., 2017). Given an aim of this study was to gain a deep understanding of the socio-cultural experiences of prospective primary teachers, we adopted qualitative methods including a reflective task to elicit the historical information we needed. Hence, a second aim of our study was to explore the merits of a qualitative identity task that encourages individuals to graphically represent the high and low points in their relationship with mathematics over their life experiences. The identity graphing task, accompanied by an individual semi-structured interview, is appropriate for studies adopting a cultural-historical

approach given its capacity to capture reflective insights into the impact of past events that may not have been obvious to PSTs when they occurred. The research questions addressed were:

1. *What experiences in the lives of prospective primary teachers do they report as influencing their emerging identities with mathematics?*
2. *To what extent can an identity 'graphing' task provide information about the socio-cultural and historical contexts in which mathematical identities are shaped?*

Setting and Participants

All prospective primary teachers (N = 96) enrolled in the final year of a four-year Bachelor of Education program (B.Ed. Primary) at a large university located in an Australian state capital were invited to participate in the study. Nine PSTs (six female, three male) aged 20-24 agreed to participate. Background data were collected at the start of the interview for all participants and are summarized in Table 1. All participants completed mathematics in their final year of secondary school and were born and schooled in Australia. Four PSTs had Asian born parent(s).

Table 1
Background Details of the Nine Participants

Participant Pseudonym	Parents' Birth Country	Level of Mathematics completed in Year 12 (final year of secondary school)
Abigail	Both Australian	Intermediate
Arthur	Mother UK Father Hong Kong	Intermediate
Angela	Both Sri Lankan	Advanced
Brenda	Both South Korean	Advanced
Benjamin	Both Australian	Intermediate
Blake	Both Australian	Lowest Level
Charlotte	Both Australian	Lowest Level
Celeste	Both Australian	Lowest Level
Caitlyn	Both Chinese	Intermediate

In this paper we report detailed findings for two of the PSTs to illustrate the capacity of the identity graphing task. However, we draw upon data from all nine participants when referring to common themes. Brenda and Caitlyn were selected for closer focus due to the clarity of annotations on their identity graphs and because the end-point on their graphs (their relationship with mathematics as they perceived it at the time of this study) were very different, despite sharing some similar socio-cultural experiences.

Data Collection Tasks, Procedure and Analysis

The introductory phase of the interview involved questions intended to gather information on PST's family backgrounds, schooling and involvement in mathematics study. The second phase comprised an identity graphing task. The 'Me and Mathematics' instrument developed by Lewis (2013) was adapted to gain a visual representation of each PST's relationship with mathematics. This instrument was modified to specifically capture how PSTs' mathematical identities had been shaped by their past experiences. Participants were asked to reflect upon their memories (as far back as they could recall) and involvement with mathematics that they felt helped shape their current relationship with the discipline. They were then provided with a A4 sheet of paper containing a pre-drawn horizontal and vertical axis. The horizontal axis was labelled "key events that have shaped my identity with mathematics" and the vertical axis was labelled "degree of enjoyment/dislike/confidence/ anxiety". Participants used a black pen to construct a line graph representing the high and low points in their 'relationship' with mathematics and then annotated it with a different coloured pen to describe the nature of each experience.

In the final phase of the interview and immediately after drawing their identity graphs, participants were questioned to clarify reasons for turning points in their graphs. Our focus here, is on those turning points. In particular, we wanted to gain a better understanding of the socio-cultural aspects underpinning such key events and of PSTs' behavioural, cognitive and affective responses to them. The open-ended questioning offered in-built flexibility during data collection as it encouraged PSTs to comfortably share their stories, eliciting 'how' and 'why' they possessed certain mathematics-related identities (Neuman, 2013). Blending the strengths of identity graphing and semi-structured interviews improved data validity as the focus for the data collected was specified, and the participant role in the data generation process was increased (Tashakkori & Teddlie, 2010).

Individual interviews were audio recorded and transcribed to assist with analysis. Data from the interviews and the identity graphs were combined for analysis to provide a wholistic picture of each PST's data. An across case thematic analysis was conducted involving Braun and Clarke's (2006) six phases—data familiarisation, generation of initial codes, search for themes, review and defining themes, and report production. Given our interest in primary PSTs' shifting relationships with mathematics from both a cultural and historical perspective, initial coding adopted the major theme of *culture* which was soon divided to the subthemes of *ethnicity-culture*, *family-culture*, and *school/classroom-culture* as analysis of data proceeded.

Results and Discussion

Thematic analysis involving all nine participants revealed that cultural expectations, parental and teacher influences were among the key factors that shaped PSTs' mathematics-related identities. A notable feature common to all identity graphs, was the oscillations between "high" and "low" points in PSTs' relationships with mathematics throughout their lives. This characteristic oscillation occurred regardless of whether they perceived their current mathematics-related identity in a positive or negative light. These graphic representations affirm conceptualisations of identity as a dynamic construct that is constantly shifting. Moreover, just one event has the potential to instigate a downward or upward trajectory in mathematics-related identity formation. Of interest was the nature of events that could influence trajectory changes and why some PSTs could experience similar events to others but develop very different mathematical identities. It is reassuring to note that a

downward trending relationship with mathematics can be reversed with the right combination of socio-cultural experiences. We now restrict our presentation and discussion of data to Brenda (Figure 1) and Caitlyn (Figure 2).

Brenda and Caitlyn both expressed the view that their Asian heritage greatly influenced their mathematics-related identity formation as they were growing up. Brenda, who went to a selective high school, reflected: "If I told someone who was not Asian that I did 3-Unit maths, they wouldn't be surprised … . Non-Asian students would be surprised if they did perform better than I did." While the stereotype assumption that "Asian students are good at mathematics and non-Asian students are not" in both PSTs' schooling experiences was prevalent, they responded differently. On inspection of her graph, it is clear that Brenda considered her earliest relationship with mathematics as quite positive (the first high point in Figure 1). It was recalled in terms of her academic performance relative to her peers. She used a different coloured pen (blue) to record each memory referencing her parents and family – successive comments pertaining to family appear at the two lowest points on her graph. Brenda eventually opted to take advanced mathematics for her final years of secondary school and despite some low points associated with poor test scores in Year 11 (as represented in Figure 1 at the fifth turning point), managed "through effort" to improve.

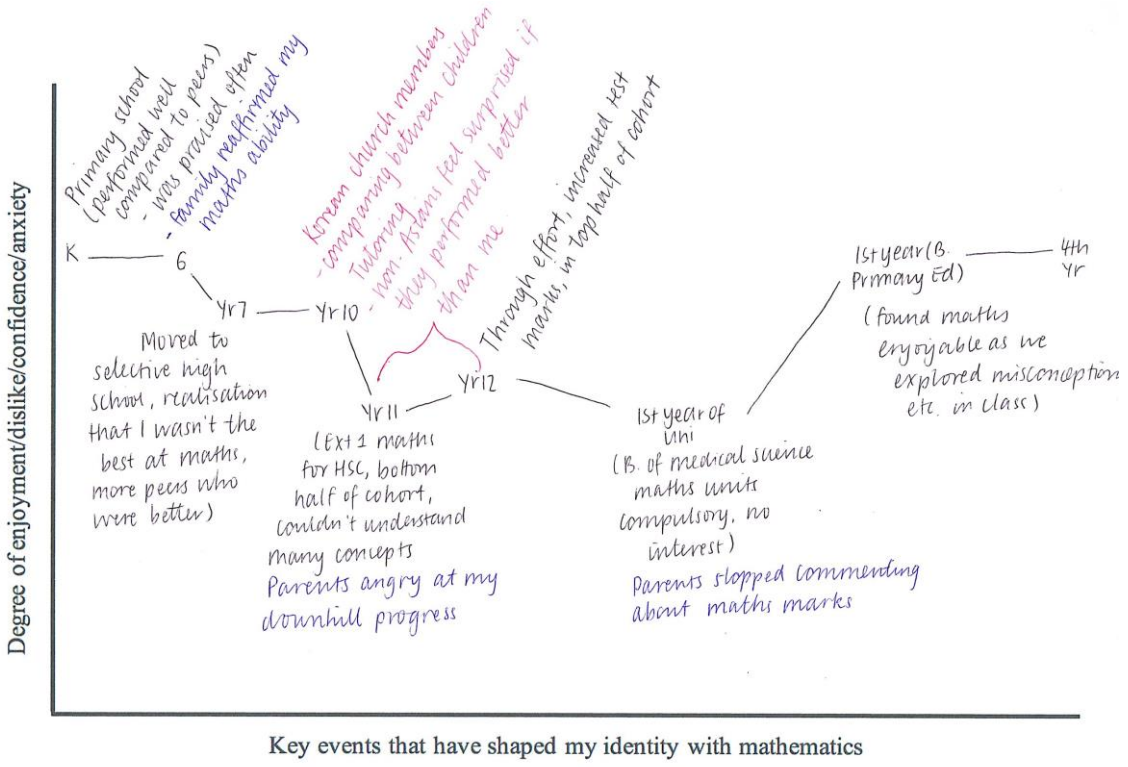

Figure 1. Brenda's identity graph

The same stereotype had a negative impact on Caitlyn. In early high school, she wanted to maintain the expectation that Asians are good at mathematics but when she achieved poorly in Years 9 and 10 (as represented in Figure 2 by the dip between Years 7 and 9/10), she actually felt "proud not fitting into that Asian stereotype". She also stopped caring or "trying" to do well in mathematics, believing she had already failed the Asian expectation.

Resistance to the Asian stereotype image by Caitlyn had a lasting impact on her relationship with mathematics, continuing into her B.Ed. program and contributed to her resultant "indifferent" attitude toward mathematics.

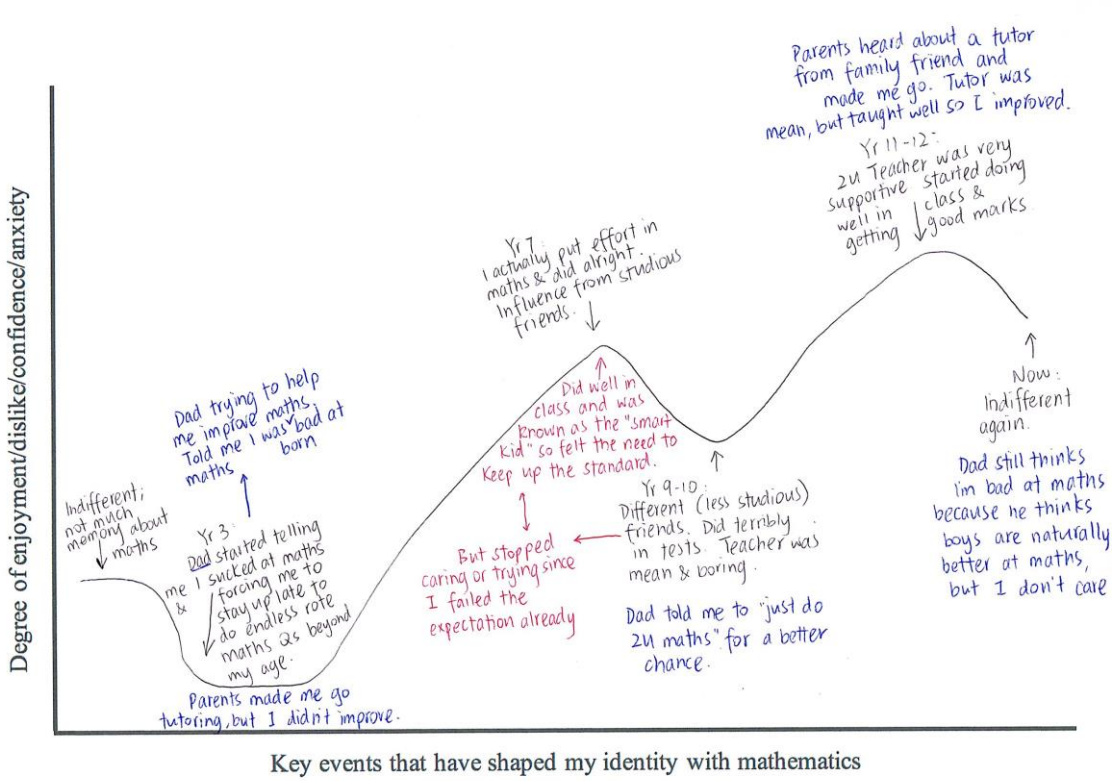

Figure 2. Caitlyn's identity graph

Brenda's Korean parents placed significant pressure on her to perform well in mathematics. She shared that her parents "put a lot of emphasis on maths" and that "other subjects weren't considered" as important. Brenda experienced reduced self-confidence in mathematics, as illustrated by the dip between Year 10 and 12 (Figure 1). A relaxing of parental pressure to achieve in university mathematics was one of the factors that Brenda attributed to regaining enjoyment in mathematics during her preservice program. Similarly, Caitlyn's parents, particularly her father, applied a great deal of pressure to perform well in mathematics and attributed her 'less than expected' performance to the belief that "boys are naturally better at maths". Caitlyn indicated that once her parents concluded that she was not going to achieve the level they expected of her, she stopped trying to improve and became content to be "indifferent" to mathematics (see final down-turn in Figure 2). Sadly, such indifference can be detrimental to her ability to nurture positive relationships with mathematics by her future primary students.

Mathematics teachers and friendship groups were also substantially involved in shaping PSTs' mathematical identities. For example, Caitlyn attributed her upward slopes and peaks on her identity graph to the "better", "kind and amazing" mathematics teachers she had late in high school and to the influence of "studious friends" in her first year of high school. Similarly, Brenda considered her positive experience of mathematics teaching in first year university as the reason for a spike in her interest and enjoyment of mathematics—a

relationship that steadily increased to her final year of the program (as represented by the final two turning points in Figure 1).

Conclusion

The identity graphs revealed that a range of socio-cultural experiences, including cultural stereotypes, parental expectations, peer pressure, school culture, teacher expertise and teacher empathy had the potential to shape PSTs' personal views of and attitudes towards mathematics, resulting in different mathematics-related identities. The semi-structured interviews were critical to the interpretation of the reasons underlying individual PST's responses to each critical experience.

In this paper we have shown how personal mathematics-related identities can be elicited from primary PSTs using a simple graphing task and interpreted via a cultural-historical activity perspective. We posit the graphing task as a valuable qualitative method for researchers and teacher educators to understand the experiences and conditions under which mathematics-related identities develop. Combined with a semi-structured interview, the task encourages participants to provide rich descriptions of past experiences and reasons as to how/why they were considered influential in the formation of their mathematics-related identities. Such information can assist mentoring processes to help prospective teachers reflect upon identity formation and the experiences that can positively shape the mathematics-related identities of their future primary students.

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