Factors that Influence Primary Preservice Teachers' Self-Efficacy While Teaching Mathematics During Professional Practice

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This paper explores factors that contribute to increased self-efficacy in preservice teachers as they practise teaching mathematics in a primary classroom. Thirteen preservice teachers completing a Master of Primary Teaching contributed to the research, four of whom became the focus of intense examination during two professional practices conducted over a 12-month period. Findings revealed six factors. When conceptualised into a framework the factors contributed to a better understanding of ways to support preservice teachers' self-efficacy for teaching mathematics.

Learning to teach mathematics is challenging. Some preservice teachers (PSTs) struggle to connect education(al) theory and practice teaching in initial teacher education (ITE) programs, despite excellent support conferred by qualified supervising teachers (STs) during professional practice. Self-efficacy is essential for teaching mathematics, where teachers must teach competently and confidently. This paper examined changes to primary PSTs' self-efficacy during two professional practice placements. This study investigated the research question What factors influence primary preservice teachers' self-efficacy for teaching mathematics?

Literature Review

Self-efficacy has been studied extensively in educational contexts since the mid-1970s. While many researchers have contributed to the current understanding self-efficacy (for example, Arslan 2019; Segarra et al., 2021), Albert Bandura is widely recognised as the foremost author and the first to coin the term in his paper *Self-efficacy: Towards a unifying theory of behavioral change* (Bandura, 1977). Bandura defined self-efficacy as one's personal judgement about one's capability to complete a task to achieve a desired or required objective (Bandura, 1994). To comprehend self-efficacy more fully, one must first understand how self-efficacy beliefs are formed.

Sources of Self-Efficacy

Bandura (1994) posited that there were four main sources of self-efficacy beliefs. These are *mastery experiences, vicarious experiences, verbal and social persuasion, and emotional and physiological states*. This research also examined a fifth source which Bandura (1997) named *cognitive enactment.*

According to Bandura (1994), the most effective contributor to strong self-efficacy is mastery experiences. As PSTs experience successful mathematics lessons, there is a greater likelihood of developing a robust self-efficacy for teaching mathematics. Vicarious experiences are the second source of self-efficacy whereby learners observe successful social models with whom they identify, resulting in the belief that they too have the capabilities to succeed (Bandura, 1994). When a poor performance is observed, the learner's self-efficacy beliefs are less influenced (Bandura, 1994; Schunk & DiBenedetto, 2020).

Encouragement from others, known as verbal and social persuasion, can influence the learner's effort and motivation. This third source of self-efficacy is seen when people, such as teachers, parents, or peers, influence a learner's belief that they have the capabilities to master a challenging task. For verbal and social persuasion to succeed, there must exist a level of trust between the learner and the persuader (Bandura, 1994).

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Bandura (1994) argued that negative emotions and increased stress could impact negatively on self-efficacy, whereas positive emotions had the opposite effect. These emotional and physiological states is the fourth source of self-efficacy and occurs when an individual judges their capabilities in relation to how they feel (Bandura, 1994). Negative emotional and physiological states are less likely than other sources to impact self-efficacy (Bandura, 1994).

A fifth source of self-efficacy uses imagination to visually rehearse successful outcomes. Bandura (1997) called this cognitive self-modelling or cognitive enactment. For PSTs, imagining how their lesson could be structured when planning can be viewed as an attempt to pre-empt potential organisational, pedagogical, and behavioural problems.

Bandura and others maintain that increased self-efficacy is a higher predictor of performance, and is indicative of effort, actions, and motivation to persist with a task, whereas lower self-efficacy can negatively affect motivation and achievement (Bandura, 1994; Liljedahl & Oesterle, 2014). What is known is that self-efficacy beliefs for learning mathematics influence self-efficacy beliefs in teaching mathematics and the practices that teachers employ in the classroom (Hessen Bjerke & Solomon, 2020; Küçükalioğlu & Tuluk, 2021; Lo, 2021).

Self-Efficacy Beliefs for Learning Mathematics

Throughout many years of schooling, PSTs form a set of beliefs about teaching and learning in mathematics (Brady, 2012; Liljedahl et al., 2012). Prior learning experiences have been found to influence creativity and innovation for teaching mathematics, including the way PSTs plan their lessons and the instructional choices they make in the classroom (Chalkiadaki, 2018). Other studies revealed that primary PSTs typically lack confidence and have poor attitudes towards mathematics, before they come to ITE programs (Brady, 2012; Mapolelo & Akinsola, 2015). Hessen Bjerke and Solomon (2020) add that beliefs held about one's mathematics knowledge can influence PSTs' perceived self-efficacy for teaching mathematics.

Self-Efficacy Beliefs for Teaching Mathematics

Factors leading to improved self-efficacy for teaching mathematics continue to be debated. A growing body of evidence suggests that ITE programs positively influence PSTs' self-efficacy in mathematics. Some researchers found that positive and enthusiastic tertiary teachers played an important role in influencing PSTs' self-efficacy for teaching mathematics (Beswick & Goos, 2018; Küçükalioğlu & Tuluk, 2021). Others suggest that having opportunities to explore mathematical content in a supportive environment at university has a strong influence on PSTs' self-efficacy as learners and as prospective teachers of mathematics (Henderson & Rodrigues, 2008). Conversely, Brady (2012) claimed that when PSTs encounter the realities of teaching in the classroom and working with other teachers, it is then that they are more likely to adjust their beliefs about teaching mathematics and adopt practices that they observe. This is a similar view also held by Liljedahl et al. (2012) who state that experiences in the early years of teaching can positively influence primary PSTs' practice and beliefs for teaching mathematics.

Collectively, these studies provide important insights into some of the factors that influence self-efficacy beliefs held by PSTs for teaching mathematics. Overall, they highlight the need for further research into primary PSTs for self-efficacy for teaching mathematics. By examining changes to self-efficacy while PSTs are practicing their mathematics teaching during professional practice, additional features that contribute to positive self-efficacy for teaching mathematics can be examined.

Methodology

This study is situated in a qualitative epistemology that employed case study and narrative inquiry as merged methodologies. By choosing case study, the intention was to explore the real-

life context (Stake, 2000) of the PSTs while they taught mathematics. The key features of the second methodology, narrative inquiry, are time and temporality (Clandinin & Connelly, 2000). Given that this research spanned 12 months, narrative inquiry allowed for observations of PSTs as they progressed along a continuum of learning. Their stories told in their own words revealed changes to self-efficacy over time and revealed the factors that contributed to those changes.

Data Collection and Analysis

Thirteen PSTs participated in this research, nine of whom had completed their first professional practice and four were yet to commence their first professional practice. Data was gathered from a range of sources consisting of two data collection phases spanning one year. Phase one commenced with participant identification surveys, a semi-structured interview before attending the school and another during the four-week professional practice. Phase two also held a semi-structured interview before attending the school and another during professional practice with a focus group interview at the end. Other data sources included at least four reflections, lesson plans and lesson reflections from each participant which were submitted at various points throughout both phases.

This research adopted a thematic analysis approach to analyse data across multiple case studies (Stake, 2000). The temporal nature of this yearlong study allowed for data collection and analysis to be conducted simultaneously. Interview transcripts, reflections, and lesson plans were maintained in digital form, and initial thoughts written in track changes in the margins. Preliminary themes were also colour coded which allowed for greater control when triangulating data across multiple data sources.

Chunks of data were transferred to large Post-it notes and arranged into rudimentary categories. The Post-it notes created a dynamic matrix where data could be classified into categories, descriptors, and themes. This iterative process revealed five descriptors, *history, motivation, self-efficacy and personal agency, and transformation*. Table 1 shows the process for the descriptor history.

Table 1

Codes, Categories, Descriptors, and Emerging Themes

Codes	Category	Descriptor	Themes	Theory
Lots of textbooks Rote learning Singing times tables Photo-copied pages of maths	Mathematics lessons	History	Historical experiences of mathematics	Influence of prior learning on goals for self-mastery
Hated maths Boring Bad teachers Never any good at mathematics	Feelings about mathematics at school Self-efficacy		Personal / historical evaluation of self	Self-efficacy belief about one's capabilities

Key Findings

Analysis of the data revealed six factors that contributed to self-efficacy changes for teaching mathematics. These are *collaborative relationships, teacher feedback, resources, teaching practice, motivation and self-regulation* and *reflection*. These six factors operate in association with one another and if all six factors were apparent the PSTs were more likely to develop stronger self-efficacy for teaching mathematics. However, if any of the factors were

absent, then the PSTs experienced an emotional reaction, and they felt their progress was constrained. While some of the factors influenced self-efficacy more strongly for certain individuals, there was no hierarchy considered when presenting them in this paper.

Collaborative Relationships

Relationships between the STs and PSTs are built on trust and rely on collaboration and reciprocal interactions. A recent study found that PSTs' greatest challenge during professional practice is to build relationships with their supervisors (Johnston & Dewhurst, 2021). Some relationships are more challenging than others where power and ill-chosen words can influence self-efficacy negatively.

John experienced a difficult relationship in his first professional practice. He said, "I became deflated when my supervising teacher said, how can we possibly get you to do 20 lessons given how hopeless you are?" and that "everything I was doing was wrong." It is important to remember that there is an inherent power differential in these relationships, which can make PSTs feel vulnerable and doubt their abilities (Waber et al., 2020).

Strongly linked with social persuasion, this type of interaction also connects with Bandura's social and emotional experiences. John's self-efficacy for teaching was profoundly impacted and he withdrew from professional practice. Contrastingly, John's second attempt at professional practice had a more positive impact on him. He said he had "developed a very strong rapport" and "feeling like I belong in the teaching team, has boosted my confidence." Even though John was already highly motivated, Land (2018) maintains that one's sense of belonging is important to self-efficacy beliefs.

Collaboration and planning as a team also had positive influences on Amy's self-efficacy and sense of belonging. She said, "The first day with Josh, I just observed, but later we planned a lesson for the next Friday, and then taught it together." Amy described this lesson as a "brilliant." She felt that she was "learning so many new things just because we are working together has given me so much confidence." The collaborative relationship between her and Josh had a strong influence on Amy's skill building and improved self-efficacy for teaching.

In contrast, Maria said she found it "difficult to engage with Peter" and "I'm not sure I trust him," and "he is still going to have to mark my report and I just don't want to rock the boat." Trust has been found to play a significant role in the supervisor, preservice teacher relationship (Tschannen-Moran, 2014). When collaborative relationships were weak or challenging, the emotion were *worry and self-doubt.*

Resources

Resources are associated with both the physical and non-physical resources required for teaching. For example, physical resources included lists of lessons the PSTs would be teaching, daily timetables and scope and sequences. Non-physical resources included information about students, such as student grouping, behaviour management or special needs, as well as opportunities to observe modelled teaching or seek advice from STs.

When non-physical resources such as guidance and support are provided, anxiety is reduced. For example, one of Emily's mathematics lessons did not go to plan. This greatly affected her emotional state and at that point her self-efficacy was significantly impacted. She said, "I burst into tears at lunch time … it brought back a flood of bad feelings because if I wasn't capable of teaching Kindy maths how on earth can I teach Year 6." After reflecting at length with her ST who modelled the lesson again, Emily retaught it. "I followed her instructions and remembered how she taught the kids so as soon as the next lesson was over the anxiety was gone again which was nice." Emily acquired the appropriate non-physical resources from her ST that assisted her to succeed.

It was apparent in this research that at the very least, PSTs needed the physical resources, such as lesson content and scope and sequences. However, it was not enough to provide these without clearly communicating their application in the context of the students, the school and the STs expectations. Ciara felt anxious because, "Neither of us knew what we had to do … I never got to see the scope and sequence for any subject never mind maths." Likewise, Yaz said, "When they sat down to do the actual Maths at their tables they couldn't trade. I didn't find out until after the lesson that the children hadn't been taught how to trade." Not having access to this non-physical resource left her feeling unsure and anxious and impacted her self-efficacy. She said, "I actually felt incompetent." When physical or non-physical resources are lacking, PSTs struggle to know what to do, and the emotional reaction is *anxiety*.

Feedback

The amount of and the perceived quality of lesson feedback was found to be a significant contributor to PSTs' self-efficacy for teaching mathematics. PSTs whose STs provided pre lesson and post lesson feedback developed good teaching strategies, were more confident, set goals and were better able to deal with challenges as they arose. However, when the PSTs felt that the feedback was lacking or that they needed more clarity, they felt uncertain about how they could improve their teaching. Amy said, "I need more information about how to improve." Maria maintained that, "He is more kind of focusing on my classroom management skills and it's really hard to know if I am improving or even where I can improve," and Cath alleged, "the feedback I received was fairly critical, and not really helpful … no feedback was ever provided prior to delivery of lessons, so I didn't know what to avoid or what to put in to improve."

The most effective feedback used a collaborative and reflective approach that included cognitive modelling and targeted goals. Emily's ST prompted her to "cognitively rehearse" (Bandura, 1989, p. 730) her lessons before teaching :

> She would ask me what are your goals? What if this doesn't happen, what will you do? If some of this blows up in your face, what are you going to do, if it goes smoothly and you have finished all the activities … what are you going to do? … She was good at making me think. (Emily)

Through this rehearsal process, Emily was able to anticipate possible scenarios and her ST could offer additional advice prior to teaching. However, when PSTs perceived the feedback to be ambiguous or limited, the resultant emotional reaction was one of *uncertainty* as they did not know what they needed to do, or how to improve their practice.

Teaching Practice

Practising teaching is fundamental to learning how to teach. In this study, opportunities to prepare mathematics lessons, practice teaching, and reflect on areas for improvement offered PSTs multiple ways to develop their skills. With practise, PSTs experienced mastery, resulting in increased self-efficacy for teaching mathematics.

Most of the PSTs had ample opportunities to teach mathematics during their professional practices. However, having only taught two mathematics lessons during the three-weeks of the first professional practice Amy expressed her frustration stating, "I've taught lots of [other] lessons, but I don't feel like I've done enough [mathematics lessons] to say I can teach maths well." While Amy's self-efficacy for teaching mathematics seemed unchanged to that point, her self-efficacy for teaching more broadly had improved. This appeared to be positively influencing her self-efficacy beliefs for mathematics. In a reflection, she said, "even though I didn't teach many [mathematics lessons] I felt really confident." If opportunities to teach mathematics were limited, the resulting emotional response was *frustration*. This was because PSTs were unable to determine areas of deficit, or to verify areas of growth that might contribute to improved self-efficacy for teaching mathematics.

Motivation and Self-Regulation

All PSTs participating in this study were highly motivated to improve their mathematics lessons. This research examined three motivational sources. These were *extrinsic*, *intrinsic* (Ryan & Deci, 2000) and a source I termed *influential* motivation. This construct contains many of the attributes of intrinsic motivation, that is, it is an internal source motivated by personal satisfaction. However, there is an additional element found in influential motivation which is related to the sense of responsibility that the PSTs felt towards their students. For example, Amy was motivated to ensure that she was "enthusiastic so the kids pick up on that. You don't want to go in there going, oh maths is horrible." Jen's responsibility was directly related to her fear of mathematics "it's quite scary thinking I am going to go into a classroom with my fear and trying to actually teach kids with confidence … it's a huge responsibility."

Influential motivation was a strong indicator of the behaviours and self-regulation choices PSTs made for teaching mathematics. Of note was the goals they set when preparing to teach mathematics. Maria stated that she struggled to connect the learning theories to her practice in the classroom. However, this did not dissuade her from setting specific pedagogical goals for her lessons such as cooperative learning "and not just doing mindless activities." She believed that "maths is really important to get it right, to teach it correctly". While it is true that all PSTs in this study were motivated at various levels, without motivation, it is anticipated that the emotional reaction may be *indifference*.

Reflection

In this study, reflecting-in practice, reflecting-on practice (Schön, 1991) and reflecting-for practice (Olteanu, 2017) were important to strengthening self-efficacy. For example, John reflected-for practice after he " … talked to Marcel [student] today and he said it [lesson on division] was much too easy, so now it's crucial to follow up with extension work at each skill level." He also reflected-in practice, when observing the whole class and offered to reteach the content in small groups to students who "were really struggling" with a concept.

While John's personal reflection contributed to improving his practice, joint reflection was found to strengthen self-efficacy for teaching mathematics more effectively. After bursting into tears following what she perceived to be a failed lesson, Emily reflected-on her practice with her ST. She said, "[Paula] was really good at going through the reflection with me [which] gave me an opportunity … to really brainstorm for myself what went wrong." In this study, lesson feedback from the ST acted as the conduit to reflection and when PSTs and their ST reflected jointly, self-efficacy for teaching was strengthened. However, when feedback lacked substance, the result was a shallow reflection and PSTs felt that their *progress was limited*.

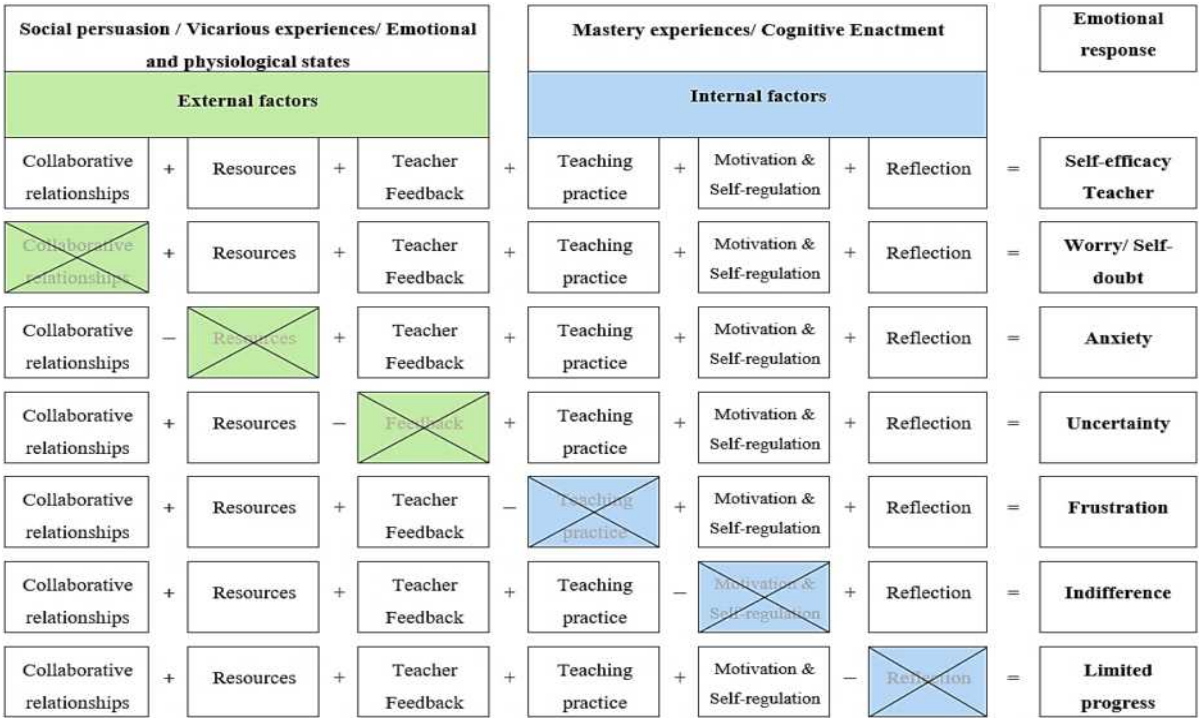
Implications for Practice

With any learning comes change and because there were observable self-efficacy changes over the two professional practices, the six factors collaborative relationships, resources, teacher feedback, teaching practices, motivation and self-regulation, and reflection contributed to this transformation. Drawing from Knoster's et al.'s (2000) Model for Leading and Managing Complex Change, I conceptualised the Building Teacher Self-Efficacy Framework (BTSE Framework, Figure 1). Although the BTSE Framework provides a graphical representation that appears organised, there is the human element that should be considered. It is true that neither PSTs nor their STs fit into neat rows or columns and learning to teach does not follow a linear progression (Khoshnevisan & Rashtchi, 2021). In fact, PSTs in this study repeatedly vacillated between high self-efficacy and self-doubt when teaching mathematics. Therefore, one should employ the framework knowing that some factors are dependent on the relationship that exists between PSTs and STs as well as the context in which they are working.

The six factors are divided into external and internal factors. Collaboration, resources and teacher feedback were factors that PSTs have limited control over and are therefore considered external to the PSTs. External factors were observed in three sources of self-efficacy. These were social persuasion, vicarious experiences, and emotional and physiological states. Factors that PSTs had greater personal control over included their teaching practice, motivation self-regulation and reflection. These are classified as internal factors and were analysed in relation to Bandura's mastery experiences and cognitive enactment.

Figure 1

Building Teacher Self-Efficacy Framework (BTSE Framework)



Limitations

While focusing on a small sample of participants (13) allowed for a deep analysis into factors that contributed to self-efficacy for teaching mathematics, including the ST's perspectives in future research may reveal additional insights. Furthermore, this study analysed qualitative data from a variety of sources. While these data revealed the narratives of the PSTs as they progressed through professional practices, by employing self-efficacy scales to evaluate their self-efficacy may have offered another dimension to the research.

Conclusion

This research has highlighted the complexities surrounding PSTs' self-efficacy for teaching primary mathematics. The findings of this study identified six factors that influence positive self-efficacy. Conceptualising these factors into the BTSE Framework, PSTs' specific learning needs can be identified to support self-efficacy for teaching mathematics during professional practice. It is clear that these factors are interconnected. I am not suggesting that PSTs' self-efficacy and professional development will only occur if all the factors in the BTSE Framework exist. However, this study has revealed that where weakness exists within one factor, it may add to deficits in other factors and therefore reduce positive influences on self-efficacy.

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