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Pre-Service Primary Teachers' Mathematics Teaching Efficacy on Entry to Initial Teacher Education

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Abstract: Mathematics teaching efficacy is an important construct as confidence in one's ability to teach influences teaching practices. This paper explores pre-service primary teachers' mathematics teaching efficacy on entry to initial teacher education and the extent that pre-tertiary mathematics experiences and resultant beliefs affected their mathematics teaching efficacy. A mixed-methods approach combined the Mathematics Teaching Efficacy Beliefs Instrument (N=420) and qualitative interviews (N=30). The findings suggest medium personal mathematics teaching efficacy among participants with limited conceptions of what mathematics teaching involves. While uncertain regarding their immediate teaching ability, participants reported confidence regarding their potential. Mathematics teaching outcome expectancy was high; however, an undercurrent of conviction exists that external factors, most notably learners' natural mathematical ability, are critical to student learning.

Keywords: *Mathematics teaching efficacy, Mathematics Teaching Efficacy Beliefs Instrument (MTEBI), personal mathematics teaching efficacy, mathematics teaching outcome expectancy, pre-service teachers.*

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Introduction

The teacher is the single most important school-related factor affecting the realisation of positive change (Ekstam et al., 2017; Gresham, 2009). Enochs et al. (2000) report that effective and innovative mathematics instruction hinges on teachers' perceptions of their ability to teach mathematics effectively, that is, their mathematics teaching efficacy. Given that many of tomorrow's teachers are today's pre-service teachers, mathematics teaching efficacy should concern mathematics teacher educators (Bursal, 2010).

Mathematics Teaching Efficacy

The concept of self-efficacy originated from social cognitive theory (Bandura, 1997). Self-efficacy is formed through experiences and represents an individual's perceptions of what they can achieve with their existing skills rather than the skills themselves. Bandura's (1977) concept of self has two components: personal self-efficacy and outcome expectancy. Personal self-efficacy refers to the conviction that one can successfully execute the behaviour or task, whereas outcome expectancy refers to the belief that certain actions result in specific outcomes. Research indicates that people with the same knowledge and skills but varying levels of self-efficacy may perform differently on the same task (Salloum, 2011) as those with high self-efficacy will have visions of success and concentrate on how to enact these, whereas those with low self-efficacy will envisage failure and all possible scenarios that could go awry (Bandura, 1986). Self-efficacy is dynamic and changeable, dependent on the situation or context (Bandura, 1986, 2006).

This paper focuses on teaching efficacy, examining pre-service primary teachers' mathematics teaching efficacy. Teaching efficacy is defined as a teacher's perception of their ability to teach students with varying needs bringing about student learning (Ekstam et al., 2017). This construct also comprises two parts: personal teaching efficacy (teacher's belief that they can teach effectively) and teaching outcome expectancy (the belief that effective teaching will produce positive learning outcomes regardless of students' characteristics) (Kieftenbeld et al., 2011; Swars, 2005). Studies on teaching

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efficacy suggest that teachers' beliefs "…about their capability is a strong predictor of their effectiveness" (Gibbs, 2003, p. 3). Teaching efficacy affects the time and effort devoted to planning and teaching lessons, teachers' beliefs regarding students' capabilities, their instructional practices, demeanour in class, persistence, and speed of recovery after setbacks (Holzberger et al., 2013; Tshannen-Moran & Woolfolk Hoy, 2001). As a result, teachers with high teaching efficacy have confidence in students' learning abilities and persist longer. They are also more likely to take risks, implement inquiry and student-centred teaching strategies, and provide a greater academic focus in the classroom. Conversely, those with lower teaching efficacy are more likely to believe students cannot learn and find a reason to justify this assumption and to use teacher-directed strategies (Allinder, 1994; Ashton & Webb, 1986; Depaepe & König, 2018; Enochs et al., 2000; Lee et al., 2017; Sun, 2018). Consequently, it is proposed that improving teaching efficacy can lead to more persistence and confidence in incorporating new teaching practices (Depaepe & König, 2018; Gibbs, 2003). Teaching efficacy has also been positively correlated with student achievement (Allinder, 1994; Enochs et al., 2000). Research indicates that teaching efficacy develops mainly during initial teacher education and, once established, is resistant to change (Ekstam et al., 2017).

Teaching efficacy is difficult to conceptualise and measure as it is dependent on the subject matter, context and population being measured. Therefore, it is possible that a primary teacher's teaching efficacy varies across curriculum subjects (Gresham, 2009). The acknowledged situatedness of teaching efficacy has resulted in the desire for domain-specific research.

It is acknowledged that measurement tools to capture teaching efficacy are challenging to develop and that measures assigned by numerical scales are difficult to interpret substantively (Tshannen-Moran & Woolfolk Hoy, 2001; Wheatley, 2005). While historically, initial measures were intentionally general in design, more domain-specific teaching efficacy measures have been developed over time. The 'Mathematics Teaching Efficacy Beliefs Instrument' (MTEBI), developed by Huinker and Enochs (1995) and revised by Enochs et al. (2000), is the most widely used instrument to measure pre-service teachers' mathematics teaching efficacy (e.g., Bates et al., 2011; Briley, 2012; Brown, 2012; Bursal, 2010; Gresham, 2009; Jeffrey et al., 2018; McMahon Giles et al., 2016; Mji & Arigbabu, 2012; Moody & DuCloux, 2015; Segarra et al., 2021; Swars et al., 2009; Twohill et al., 2022). Alternative instruments include the 'Self-efficacy Beliefs towards Mathematics Teaching Scale' developed by Dede (2008) (e.g., Unlu & Ertekin, 2013; Unlu et al., 2017), the Norwegian Teacher Self-Efficacy Scale (NTSES) (e.g., Ekstam et al., 2017) and the 'Self efficacy for teaching mathematics instrument' (e.g., McGee & Wang, 2014). Other research has modified items from established instruments and previous studies (e.g., Zuya et al., 2016).

While research on general teaching efficacy has received much attention, there is a growing body of research focusing specifically on mathematics teaching efficacy (Ekstam et al., 2017) and increasing consensus that this construct is a pivotal factor for teaching mathematics effectively (Twohill et al., 2022; Unlu & Ertekin, 2013). The acknowledged significance of initial teacher education in affecting the development of teaching efficacy provides a compelling rationale for examining and addressing this construct with pre-service teachers.

Research on Pre-service Primary Teachers' Mathematics Teaching Efficacy

There are mixed findings concerning pre-service primary teachers' mathematics teaching efficacy (Gresham, 2009; Lee et al., 2017). Bursal (2010) revealed that a majority of Turkish pre-service primary teachers had high personal teaching efficacy in both mathematics and science. A significant correlation was evident between these two constructs, however, when compared to science, participants' personal mathematics teaching efficacy was significantly higher. High mathematics teaching efficacy was also evident in a study of 144 Turkish pre-service primary teachers carried out by Unlu and Ertekin (2013). In another study of 27 traditional (undergraduate) and 24 non-traditional (post-graduate) American pre-service primary teachers, Moody and DuCloux (2015) found that upon entry, both groups held similar mathematics teaching efficacy (in both personal teaching efficacy and outcome expectancy). Equally in Twohill et al.'s (2022) of 186 Irish pre-service primary teachers, both undergraduate and post-graduate participants demonstrated relatively high PMTE and MTOE beliefs. In contrast, half of the 65 pre-service primary teachers in the Bursal and Paznokas (2006) study demonstrated low personal mathematics teaching efficacy, suggesting poor confidence in their ability to teach mathematics effectively. While Briley (2012) reported moderately strong personal mathematics teaching efficacy among 95 pre-service primary teachers, they demonstrated lower mathematics teaching outcome expectancy.

Research examining the relationship between pre-service primary teachers' mathematics teaching efficacy and other constructs is highly prevalent. Brown (2012) reported that among the 141 non-traditional pre-service teachers in their study, factors including age, level and grade of previous mathematics courses and grade achieved in the mathematics methods course were positively correlated with mathematics teaching efficacy. Jeffrey et al.'s (2018) study of 76 pre-service primary teachers enrolled in 5 institutions in Texas reported that older pre-service teachers and those with fewer high school math classes were more likely to demonstrate below average mathematics teaching efficacy.

Various studies report a positive correlation between both mathematics knowledge and mathematics self-efficacy (i.e., a person's belief in one's ability to perform mathematics successfully) and mathematics teaching efficacy (Bates et al., 2011; Briley, 2012; Brown, 2012; Ekstam et al., 2017; Newton et al., 2012; Unlu & Ertekin, 2013; Zuya et al., 2016).

However, Bates et al.'s (2011) study of 89 early childhood pre-service teachers noted that while a significant relationship was evident between both mathematics knowledge and mathematics self-efficacy and participants' personal mathematics teaching efficacy, this was not evident for their mathematics teaching outcome expectancy. Equally, while Newton et al. (2012) reported a significant relationship between the mathematics knowledge and personal mathematics teaching efficacy of the 55 American pre-service primary teachers in their study, this was not evident for mathematics teaching outcome expectancy. Swars et al. (2007) found no correlation between mathematics knowledge and either of the two subcategories of mathematics teaching efficacy among the 103 pre-service primary teachers in their study. Twohill et al.'s (2022) study of Irish pre-service primary teachers reported a positive relationship between teachers' personal mathematics teaching efficacy and their mathematical attainment. In addition, Segarra and Julià (2022) reported a significant correlation between the mathematics teaching efficacy and mathematics achievements of the 57 Spanish pre-service primary teachers in their study.

Some studies also found that beliefs about mathematics may act as mediators, with both Briley (2012) and Mji and Arigbabu (2012) acknowledging significant relationships between mathematics teaching efficacy and beliefs about mathematics. For example, Briley reported that those with high personal mathematics teaching efficacy demonstrated more sophisticated mathematical beliefs. In contrast, those with strong mathematics teaching outcome expectancy were more likely to believe that learning mathematics involved understanding and sense making.

Although studies examining the impact of initial teacher education, in particular mathematics methods courses and field experience, on mathematics teaching efficacy are relatively rare, the research that has been completed reports that initial teacher education programmes can positively influence pre-service teachers' mathematics teaching efficacy (Charalambous et al., 2008; Gresham & Burleigh, 2019; Jao, 2017; McMahon Giles et al., 2016; Moody & DuCloux, 2015; Segarra et al., 2021; Swars et al., 2007, 2009).

While at first glance, the relevant research regarding pre-service teachers' mathematics teaching efficacy may seem to be contradictory, conflicting findings may be attributed to the variations in how the constructs were measured or different contexts. The literature does suggest that mathematics teaching efficacy is interconnected with a variety of other constructs, including mathematics self-efficacy, mathematics knowledge and mathematics beliefs. It also suggests that initial teacher education can influence mathematics teaching efficacy.

Methodology

Context of this study

Research indicates that teachers' teaching efficacy develops mainly during initial teacher education and tends to be resistant to change subsequently (Hoy & Spero, 2005). This paper provides insights into pre-service primary teachers' mathematics teaching efficacy on entry to initial teacher education. Awareness of these efficacy beliefs can facilitate the redirection of supports to those most in need at a critical stage of their mathematics teaching efficacy development. Furthermore, gaining insights into the formative experiences contributing to these beliefs can better equip mathematics teacher educators in providing needs-led interventions. Therefore, this paper addresses both Moody and DuCloux (2015) and McMahon Giles et al.'s (2016) proposal that future research should examine the extent to which pre-tertiary mathematics experiences impact pre-service teachers' mathematics teaching efficacy. While previous research carried out in Ireland acknowledges the relationship between the nature of pre-service teachers' pre-tertiary mathematics experiences and both their mathematics content knowledge (Hourigan & Leavy, 2017a, 2017b; Hourigan & O' Donoghue, 2013; Leavy & Hourigan, 2020) and attitudes to mathematics (Hourigan & Leavy, 2017b, 2019a; Hourigan et al., 2016; Leavy & Hourigan, 2018; Leavy et al., 2017, 2021) on entry to initial teacher education, there has been a lack of research in Ireland on the impact of pre-tertiary mathematics experiences on novice pre-service primary teachers' mathematics teaching efficacy.

Hence, this paper examines two research questions:

- Research question 1: What is the nature of entry-level pre-service primary teachers' mathematics teaching efficacy?
- Research question 2: In what ways did pre-tertiary mathematics experiences influence entry-level pre-service primary teachers' mathematics teaching efficacy?

Research Design

Reflecting Stromquist's (2000) commentary that no one research instrument can guarantee a holistic grasp of the 'truth,' this study used a mixed-methods approach.

Participants in the study

The participants were first year undergraduate pre-service primary teachers who entered a four-year initial teacher education programme in Ireland. 475 pre-service teachers entered this course (371 females (78%) and 104 males (22%)).

College entry criteria for most undergraduate entrants (age 17–18) are determined solely on their performance in the terminal pre-tertiary examinations called the Leaving Certificate examination. Instead of applying to individual institutions, the process is co-ordinated by the national Central Application Office (CAO), where students' best six Leaving Certificate examination grades are allocated points (CAO, 2021). Although the points required to receive a place vary annually, the cut-off points for primary teacher education programmes are generally high due to their popularity relative to the number of places available. A small number of mature students (age 23+) achieve a place on the course via an alternative route through a competitive interview process. All entrants must also achieve the necessary stated minimum Leaving Certificate mathematics grade (whether at Ordinary or Higher level) to gain entry to primary initial teacher education courses.

Accordingly, all entrants have completed a minimum of 13 years pre-tertiary mathematics education (8 years primary education (start age 4-5 years) and 5-6 years post-primary education (start age 12-13 years)). At primary level, the revised Primary School Mathematics Curriculum (National Council for Curriculum and Assessment [NCCA], 1999) promotes teaching for understanding and emphasises problem solving. However, while many aspects of the intended curriculum have been implemented, reported issues include problem solving, integration and reliance on teacher-led approaches (NCCA, 2005, 2006). At present, the primary mathematics curriculum is undergoing review and reform (NCCA, 2016).

At post-primary level, after extensive review and consultation, a reformed mathematics curriculum 'Project Maths' was rolled out nationally on a phased basis from 2010. This curriculum aimed to promote conceptual understanding and problem solving within realistic contexts ((NCCA, 2006; Prendergast et al., 2017). Previous reported pedagogical approaches to mathematics in post-primary classrooms were didactic and focused on rote learning (Lyons et al., 2003; NCCA, 2005a.). However, criticism has been directed towards Project Maths since its inception (Shiel et al., 2020). Alongside this, early in the implementation stage, the interim evaluation of Project Maths reported that 'overall, schools following a greater number of strands, or schools having a greater experience of teaching the revised syllabuses, does not appear to be associated with any improvement in students' achievement or confidence' (Jeffes et al., 2013, p. 5).

Additionally, from 2012 the introduction of a bonus points initiative, where students are awarded 25 bonus CAO points in their Leaving Certificate examination results if they achieve a passing grade in mathematics at Higher level, resulted in mathematics gaining a special status within the post-primary school curriculum (O'Meara et al., 2020). This initiative achieved its goal of increasing take-up of Leaving Certificate Higher level mathematics, with substantial growth evident (2011: 16%; 2017: 30%) (Shiel et al., 2020). However, research suggests that participating teachers perceive that the initiative caused some students to persist with Higher level mathematics to secure the additional points despite encountering many struggles (O'Meara et al., 2020). Studies also report deteriorating mathematical skills among Leaving Certificate students (Shiel et al., 2020; Treacy, 2018).

There is an absence of current research exploring post-primary students' experiences of Project Maths.

Quantitative Methods

The researchers considered the most appropriate scale to measure pre-service primary teachers' mathematics teaching efficacy. Many existing scales were deemed unsuitable as pre-service teachers entering initial teacher education were unfamiliar with various pedagogical concepts. Given the established reliability and validity of the MTEBI (Enochs et al., 2000) and its ongoing popularity in studies of pre-service teachers (Dofkova & Kvintova, 2018), the researchers selected this instrument for use in their study.

Development and characteristics of the MTEBI

The 'Teacher Efficacy Scale' (Gibson & Dembo, 1984), considered too general to meet Bandura's definition of self-efficacy as a situation-specific construct (Ross, 1994), was modified to include the primary science classroom setting. The resultant Science Teaching Efficacy Beliefs Instrument (STEBI-A) examined the science teaching efficacy of in-service teachers consisting of both personal teaching efficacy and teaching outcome expectancy components using Likert scale items. Subsequent modification of the STEBI-A by Riggs and Enochs (1990), involving the rewording of the items in the future tense, made it suitable for pre-service teachers (STEBI-B). Huinker and Enochs (1995) then modified the STEBI-B creating the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) to measure pre-service teachers' mathematics teaching efficacy (Enochs & Riggs, 1990). Enochs et al. (2000) report that thorough analysis of reliability and validity checks on the MTEBI revealed a high alpha co-efficient for both subscales (0.88 and 0.75 respectively). Confirmatory factor analysis confirmed the independence of the two subscales, strengthening the instrument's construct validity (Enochs et al., 2000). Moody and DuCloux (2015, p. 109) concluded that the MTEBI "…accurately measures the concept of self-efficacy and that yields the same results on repeated measures, suggesting that it is both valid and reliable". However, Kieftenbeld et al. (2011) questioned whether its reliability was as high as assumed, suggesting poor accuracy when measuring those with below average levels of mathematics teaching efficacy. Despite this, the MTEBI is an extremely popular instrument used to gauge pre-service teachers' mathematics teaching efficacy.

The MTEBI has 21 items consisting of 2 subscales. The first subscale, the Personal Mathematics Teaching Efficacy (PMTE) subscale, examines pre-service teachers' self-concept of their ability to teach mathematics effectively. This subscale consists of 13 items (8 negatively worded). Given the weighting of the Likert scale (1-5), the subscale has a minimum score of 13 and a maximum score of 65. The second subscale, the Mathematics Teaching Outcome Expectancy (MTOE) subscale, addresses pre-service teachers' beliefs regarding impact of effective mathematics teaching on student learning. This subscale consists of 8 items with a score range from 8-40. None of these items are negatively worded.

Quantitative data collection and analysis

The MTEBI instrument was administered during a programme information session for first year pre-service primary teachers at the start of the autumn semester, prior to any engagement with the pre-service mathematics education programme. Before administration, all of the necessary ethical considerations were addressed and participants were informed of the nature and purpose of the study and made aware that participation was voluntary. A project ID was used to facilitate anonymity and the tracking of pre-service teachers' beliefs throughout the programme. Of the total cohort of 475 pre-service teachers enrolled in the course, 434 participated in the study. Prior to completing the paper-based MTEBI scale, participants provided contextual information, including their gender and Leaving Certificate mathematics level. On completing the scale items, participants indicated their willingness to partake in subsequent interviews.

The data from all completed instruments were inputted (N= 434). The data set was cleaned to remove incomplete data (N= 14). Initial analysis focused on item level descriptive statistics (N= 420) including frequencies, measures of central tendency and degree of dispersion. Subsequently, items were grouped into relevant subscales (PMTE and MTOE) and all negatively worded items were reverse scored. Cronbach Alpha values were calculated for each subscale to examine the extent to which the subscale items measure the same thing (Table 1). While Cronbach Alpha values are lower than those reported in the original study for both subscales (PMTE (0.88), MTOE (0.75)) (Enochs et al., 2000), nonetheless, these values indicated acceptable reliability (0.6-0.8) (Table 1). A subscale score was then calculated for each participant by finding the total of the items. At the subscale level, descriptive analyses, as well as inferential analyses, were completed.

Table 1. Cronbach Alpha Values for MTEBI Subscales

MTEBI subscale (No. of items; reversed)	Cronbach Alpha value
PMTE (13; 8)	0.76 (N= 420)
MTOE (8; 0)	0.67 (N=420)

The researchers also believed it beneficial to examine responses for each item, obtaining additional insights into the participants' beliefs (Tables 4, 5). When analysing the item responses, given its use of the Likert scale (range 1-5), it was considered that mean scores falling in the range 1–2.49 suggested disagreement with statements, 2.50–3.49 implied uncertainty and 3.50–5 denoted agreement with statements.

Qualitative Methods

Many previous studies examining mathematics teaching efficacy highlighted that the lack of qualitative insights was a limitation. In response to the recommendations of Unlu and Ertekin (2013), Unlu et al. (2017) and Zuya et al. (2016) to use qualitative data collection to reveal further the factors influencing pre-service teachers' mathematics teaching efficacy, additional data were gathered using interview. The particular focus of interviews was to explore pre-service teachers' mathematics teaching efficacy and the sources of these beliefs on entry to the course; thus, adding depth to the quantitative data already collected, triangulating the data and strengthening the findings (McMahon Giles et al., 2016).

Qualitative data collection and analysis

Purposive sampling was used in order to select '...information-rich cases' (McMillan & Schumacher, 2001, p. 400). Selection was based on MTEBI scores (e.g., particularly low/high scores on the PMTE and MTOE subscales). Despite initial agreement (during the instrument administration), several pre-service teachers with lower scores did not respond to subsequent invitations to participate in the interview process. However, 30 of the 45 pre-service teachers invited participated in interviews. While the researchers developed the interview schedule (Table 2), they did not administer the interviews, given that they also developed, taught and evaluated the pre-service teachers' mathematics education programme. Hence, the researchers feared that taking on the role of an interviewer would result in pre-service teachers being conservative in their responses. However, the researchers provided training for the six research assistants who administered the interviews. This training session explained the purpose of the study and examined the interview schedule. While the interviewers were encouraged to ask all of the questions on the schedule to each interviewee, a semi-structured approach was promoted, allowing interviewees the opportunity to raise issues of importance to them. Equally, this structure facilitated interviewers to seek clarification of responses and probe further where deemed appropriate.

Interviews were conducted on-campus at a time convenient to the interviewees. Interviews ranged in length from 21 minutes to 32 minutes and on average, lasted 25.6 minutes. Strategies used to enhance the reliability and validity of the data collected included using the same schedule of questions for all participants, member checking, verbatim accounts of dialogue, and a meeting between interviewers and researchers to debrief and discuss the interview data (Mertens, 2005).

The qualitative data gathered were analysed using a grounded theory approach. Initially, the interview data transcriptions required correction and editing. This process supported the researchers in becoming familiar with the thrust of responses and, in turn, considering possible trends. The data were examined, focusing on evidence of participants' mathematics teaching efficacy and the influence of their pre-tertiary mathematics education. Initially, the raw data was organised into natural units of related data. These units were assigned preliminary codes (e.g., mathematics hard, traditional approach, maths brain, teach as taught, negative attitude, confidence, naivety). The data were revisited repeatedly to examine the consistency of code assignment and interrogate relationships and exceptions. This resulted in the development of broad themes representative of the central issues in the study. Although one of the researchers was responsible for coding the raw data, both researchers met regularly to discuss and interrogate the established codes and agree on themes. This process counteracts personal bias and ensures the findings are both grounded and relevant (Suter, 2012). The researchers were particularly interested in instances where data supported, illuminated or contradicted previous findings (Creswell, 2009). Following this process, the qualitative data were transformed into descriptive frequencies that summarise and highlight the dominance of the various findings.

Table 2. Interview Protocol

A: MATHEMATICS BELIEFS AND EXPERIENCES.
When you hear the word 'mathematics' what do you think of?
Tell me about your experience of studying mathematics to date.
Describe a 'normal' mathematics lesson when you were in school.
What do you remember about: the topics you covered? materials used? opportunities for group work? to share strategies? your experiences of testing?
What is your level of understanding of the primary mathematics concepts (e.g., number, algebra)? Why do you think this? What evidence do you draw from?
B: BELIEFS REGARDING MATHEMATICS TEACHING
What do you think teaching mathematics will involve?
What do you consider the main factors that affect a child's ability to learn mathematics? What influences your beliefs? Give an example of an experience to support your beliefs.
What role do you believe the teacher plays in a child's level of success in learning mathematics?
Do you think you could teach mathematics effectively? What rating would you give yourself out of 10? Why did you give yourself this rating? Why do you feel like that?
Do you feel you can be an effective mathematics teacher in the future?

Merging Findings

The mixed methods approach provided opportunities to gain a clearer picture of pre-service primary teachers' mathematics teaching efficacy and the influence of pre-tertiary mathematics experiences. Agreement between data sources provided support for emerging findings. In contrast, when the data diverged, it facilitated further consideration of the data sources and meaning making. This was a process of continual refinement. Within the confines of this paper, a sample of illustrative quotes provides the reader with insights into the qualitative findings.

Results/Findings

Predominantly traditional pre-tertiary mathematics experiences

The interview sought insights into pre-service teachers' pre-tertiary mathematics experiences and their beliefs and attitudes. The majority (80%, N= 24) reported a traditional mathematics education across their pre-tertiary mathematics experience:

> All the way through, the lesson began with take out your maths book and go to page... We then listened to the teacher read the question in the book and do an example on the board. We then were asked to complete the full page (P#26)

The remaining six pre-service teachers acknowledged a reform approach to mathematics education during primary education:

> In primary school, … you didn't even realise you were doing maths…a lot of the time it would involve a lot of actual materials, so we would be able to do it ourselves…I remember division …we used unifix cubes (P#5)

It was apparent that senior cycle post-primary had a significant impact on participants. For example, in response to the question 'When you hear the word mathematics what comes to mind?' almost two-thirds of the interviewees (N= 19) immediately identified negative experiences and feelings associated with this period:

> Probably relating back to secondary maths, lots of different maths equations over and over. I did Higher level maths, so I automatically think of negativity, nerves and pressure (P#24).
>
> I've always liked maths, I was always quite good at it, it was one of my better subjects. I loved it in primary school but my attitude towards it changed in secondary school...It was kind of a catch-up game really … by the time I grasped the concept, we were moving onto something different. I did honours for Leaving Cert and I just associate it with stress. I found it really difficult and I just felt pressure to do it because of the extra 25 points. I hated maths in 5^{th} and 6^{th} year (P#25)

Reported attitudes towards mathematics were consistently linked to participants' mathematics self-efficacy i.e. beliefs regarding their ability to 'do mathematics':

> I was very good at maths. I think I always liked it. Maths was my favourite subject all the way up along (P#2)
>
> I wasn't good at maths…primary maths, they took me out for resource class and then in secondary school it all went downhill. I was really bad and I would get so stressed out. I hated it (P#1)

These insights into the nature of pre-service teachers' pre-tertiary mathematics experiences and attitudes to mathematics provide context to support the interpretation of subsequent findings regarding their mathematics teaching efficacy.

Personal mathematics teaching efficacy (PMTE)

This section examines participating pre-service primary teachers' PMTE on entry to initial teacher education (research question 1), reflecting the impact of pre-tertiary mathematics experiences on this construct (research question 2).

Given that the total PMTE subscale scores range between 13 and 65, the researchers consider that a sub-scale score between 13 and 29 evidences low PMTE, a score between 30 and 46 reflects medium PMTE, and a score between 47 and 65 suggests high PMTE. The findings indicate that incoming pre-service primary teachers possess medium to high PMTE, reflected in the high minimum subscale score of 29, the relatively high mean and median subscale scores (46.19 and 46 respectively), as well as the fact that three-quarters of participants achieved a subscale score of 43 or higher (Table 3, Figure 1).

Table 3. Mean, Standard Deviation and Range for the MTEBI Subscales

MTEBI Subscale (No. of items; reversed)	Number of Participants	Range for this cohort	Mean (Standard Deviation)
PMTE (13; 8)	N=420	29-60	46.19 (5.2)
MTOE (8; 0)	N=420	19-39	29.64 (3.48)

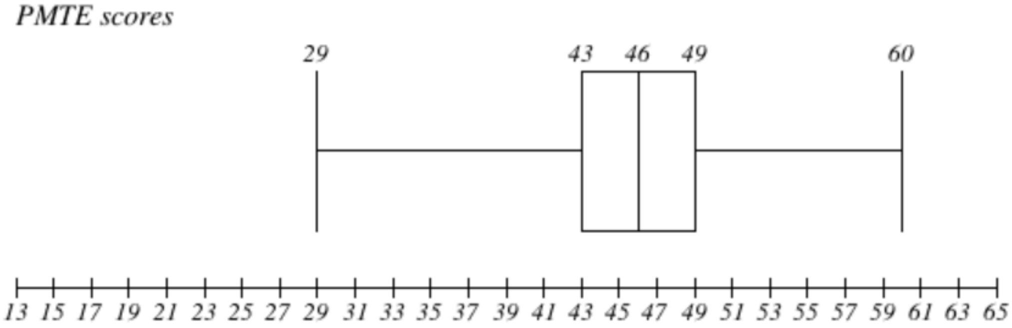

Figure 1. Distribution of Participants' PMTE Subscale Total

It is important, however, to interpret these findings with some caution, given that these participants had limited insights regarding the demands of effective reform mathematics teaching, due to the gap between the intended mathematics curricula at both primary and post-primary level and the teacher-led and didactic nature of the implemented curricula reported as their 'lived' experience. Therefore, in light of this, it may well be that these scores reflect naivety or uninformed beliefs regarding what constitutes effective primary mathematics teaching. Interview data supported this hypothesis as when asked 'What do you think teaching mathematics will involve?' a small group reported being unsure (N=4) and a similar number (N=3) perceived that teaching mathematics would be relatively uncomplicated:

> I think it will be more straightforward than the Leaving Cert. I think it will be a lot of learning the tables [basic facts] (P#5)

> Teaching the basics really (P#2)

The majority of pre-service teachers (N=19) acknowledged presuming that mathematics teaching would reflect their own pre-tertiary experiences, which were almost exclusively traditional:

> I don't know... I presume it will be like what I experienced in school? You know- working with books and on the board do 10 questions and correct them… (P#12)

Some of those who experienced reform mathematics at primary school reported that they expected students would be active:

> Probably a lot of doing –hands on stuff…(P#6)

Additional insight into pre-service teachers' PMTE came from consistently evident trends within both individual PMTE subscale items (Table 4) and interview data. While expected, it is interesting that responses to PMTE items examining participants' perceptions of their immediate ability to teach mathematics effectively (i.e., items 5, 11, 21) (Table 4) were generally neutral (2.50-3.49), suggesting uncertainty. Qualitative interview findings support this, for example, in response to the interview question 'Do you think you can teach mathematics effectively?', seven interviewees disagreed: 'No, definitely not' (P#13). Some had an issue with reference to 'effectively': 'I would be able to teach it I'd say but I wouldn't say I'd be able to teach it effectively' (P#24). A further eight pre-service teachers were unsure: 'Ah I'm not sure, I don't really know.... It's the one I'm most iffy about' (P#1). Only a third (N= 10) believed that they could, 6 of whom reported only feeling confident to teach easier concepts: 'I suppose with the straightforward operations I would be confident' (P#12). Similarly, despite high overall PMTE subscale scores, respondents were generally uncertain regarding their understanding of mathematics concepts (Table 4, item 11), a finding also apparent in responses to the interview question 'What is your level of understanding of primary mathematics concepts?' Although a sixth (N=5) reported possessing adequate understandings: 'Fairly good. I remember a lot of it' (P#10), half of the pre-service teachers (N=15) were unsure:

> It's very basic, just literally what I have learned in school. I wouldn't know how to go about teaching it or the science behind it… (P#14)

Participants' varying levels of confidence in their immediate ability to teach mathematics effectively were also reflected in interviewees' self-ratings (from 1-10) (Table 2). Almost half of the pre-service teachers (N=14) rated themselves between 1-5 and the remainder rated themselves 6+. Their justifications evidenced the influence of their pre-tertiary mathematics experiences, with almost half of the pre-service teachers (N= 14) acknowledging that their personal mathematics teaching efficacy was closely related to their personal mathematics efficacy:

> I think I have some knowledge of maths. I'm good at maths so I think I'll be able to teach it, to pass it on (P#4)

> I'm nervous because I wasn't good at math in school. I'm really worried about teaching it (P#1)

Equally, other responses (N= 9) reflected the profound impact of pre-service teachers' beliefs about mathematics, as a result of their pre-tertiary mathematics experience, on their personal mathematics teaching efficacy:

> I think it's just from secondary school... I hated maths so much in secondary school that now I automatically hate maths as a subject (P#8)

> I think maths might be boring for kids. Also, I'm not confident in maths myself after secondary school (P#3)

Evidence of a positive relationship between pre-service teachers' personal mathematics teaching efficacy and personal mathematics efficacy, which was closely tied to their pre-tertiary mathematics experiences, were substantiated by pre-service teachers' responses to the interview question: 'When you hear the word mathematics what comes to mind?' A third of interviewees (N=10) reported uncertainty and nervousness regarding teaching mathematics. Generally, pre-service teachers reporting high mathematics self-efficacy conveyed high personal mathematics teaching efficacy and vice versa. However, a small number of participants, despite reporting high mathematics self-efficacy, had reservations about their ability to teach mathematics due to an awareness of the transition required:

> I was always confident math myself, I'm not sure about how I would be teaching it. Yeah…Because I don't know how to bring it back to the basic level (P#28).

Pre-service teachers' acknowledgement of the need to develop teacher knowledge was also evident in the overwhelming agreement with the relevant PMTE subscale item (Table 4, item 2) and during interviews, where a small but notable group (N=6) demonstrated an awareness of the distinction between learner knowledge and teacher knowledge:

> I know the maths, but I don't think I'd be very good at explaining it. I don't fully understand why you do certain things (P#7)

It is to a welcome finding that participants exhibited a commitment to development.

Generally, responses to PMTE items referring to participants' beliefs about their future mathematics teaching competence reflected high efficacy beliefs (3.5-5) (Table 4). While item 15 did not follow this pattern, with responses indicating uncertainty, the researchers query whether ambiguity regarding the meaning of the term 'manipulatives' was the issue given participants' dearth of knowledge of mathematics pedagogy terminology. This trend was also reflected in the interview findings. Regardless of PMTE subscale scores, the nature of pre-service teachers' mathematics self-efficacy or beliefs about mathematics, all (N=30) reported a belief that into the future they could be effective mathematics teachers: 'I definitely can be' (P#12).

Table 4. Descriptive Statistics for Items in the PMTE Subscale of the MTEBI Scale

Item No.	PMTE Item	Mean [1](Standard Deviation)
2	I will continually find better ways to teach mathematics.	4.4 (0.65)
3*	Even if I try very hard, I will not teach mathematics as well as I will most subjects.	3.89 (0.82)
5	I know how to teach mathematics concepts effectively.	2.58 (0.82)
6*	I will not be very effective in monitoring mathematics activities.	3.83 (0.70)
8*	I will generally teach mathematics ineffectively.	4.23 (0.69)
11	I understand mathematics concepts well enough to be effective in teaching elementary mathematics.	3.20 (0.93)
15*	I will find it difficult to use manipulatives to explain to students why mathematics works.	3.062 (0.76)
16	I will typically be able to answer students' questions.	3.78 (0.67)
17*	I wonder if I will have the necessary skills to teach mathematics.	2.56 (1.02)
18*	Given a choice, I will not invite the principal to evaluate my mathematics teaching.	3.14 (0.96)
19*	When a student has difficulty understanding a mathematics concept, I will usually be at a loss as to how to help the student understand it better.	3.81 (0.77)
20	When teaching mathematics, I will usually welcome student questions.	4.60 (0.59)
21*	I do not know what to do to turn students on to mathematics.	3.11 (0.81)

Note: * Negatively worded items have been reverse scored
[1] Means and standard deviation values were rounded to the nearest two decimal places

The researchers also examined whether students' previous level of study (Higher or Ordinary level) in Leaving Certificate mathematics examination affected their PMTE subscale scores (research question 2). Using the relevant data (N= 346, 35% Ordinary (O) level, 65% Higher (H) level), analysis revealed that while 54% of Higher level participants scored in the high PMTE category (i.e., 47+), only 36% of Ordinary level participants scored in this category. In addition, the PMTE scores of Higher and Ordinary level (mean of 47 and 44.8 respectively) were found to be significantly different when measured using a t-test (p= 0.000). In support of this finding, two thirds (N=6) of the interviewees who studied mathematics at Ordinary Level self-rated their ability to teach mathematics effectively between 1-5 (out of a possible 10), compared with a third of Higher level pre-service teachers (N=7) alongside comments such as 'I'm kind of nervous because I did Ordinary level maths for Leaving Cert... I'm most nervous to teach maths than any other subject' (P#11). These findings suggest a relationship between pre-service teachers' level of study and their personal mathematics teaching efficacy.

Mathematics Teaching Outcome Expectancy (MTOE)

The findings in this section explore participating pre-service primary teachers' MTOE on entry to initial teacher education (research question 1), hence reflecting the impact of pre-tertiary mathematics experiences on their MTOE (research question 2).

A MTOE subscale total was calculated for each participant. As the range of MTOE subscale scores could be between 8 and 40, the researchers considered subscale scores between 8 and 18 to signal low MTOE beliefs, scores between 19 and 28 to indicate medium MTOE beliefs and scores between 29 and 40 to reflect high MTOE. Findings (Table 3, Figure 2) collectively suggest that the participants' possessed relatively high MTOE beliefs. This is reflected in the negatively skewed distribution of MTOE subscale scores, the high minimum subscale score and the measures of centre (mean of 29.64 and median of 30) falling in the high MTOE category.

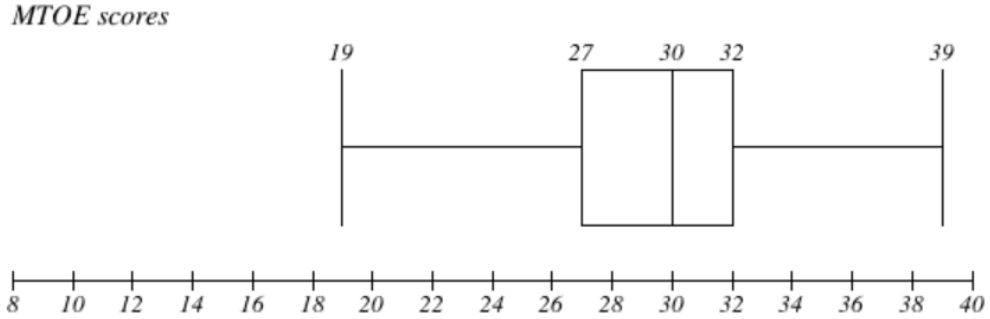

Figure 2. Distribution of Participants' MTOE Subscale Total

Further insights regarding participants' beliefs about the relationship between effective teaching and student learning were gleaned from individual MTOE subscale items (Table 5) and interviews. For the vast majority of MTOE items (6 out of 8 items), positive responses suggest agreement (3.5-5.0) that effective teaching can produce positive learning outcomes for all students (Table 5). However, there is evidence of more uncertainty (2.50-3.49) in responses to items that determine beliefs regarding the extent to which teaching quality is the sole factor to affect student learning (items 7, 13) (Table 5). This trend also came through strongly within the interview data. Interestingly, when asked 'What factors affect a child's ability to learn mathematics?' just under half of pre-service teachers (N= 14) acknowledged the role of the teacher: 'Probably the teacher and how they explain it, that's probably the main one…' (P#15). However, when subsequently asked 'What role do you believe the teacher plays in a child's level of success in learning mathematics?' all interviewees (N=30) concurred regarding the importance of the teacher using terms including 'a very significant role' (P#15), 'the biggest role' (P#27) and 'Oh a key role' (P#30). In justification, pre-service teachers outlined what they perceived to be their core functions. A third acknowledged the importance of teacher enthusiasm towards mathematics (N=10, P#12), whereas a similar number identified the central role of the teacher in shaping children's beliefs about and attitudes towards mathematics (N=10, P#15). The teacher's role in making the subject accessible to all students was also acknowledged (N=7, P#26).

> A very strong role because, if you had a teacher who might not have overtly said 'I don't like maths' but they kind of don't show their own confidence and interest, that'll definitely translate over to the class. So, the teacher has to be enthusiastic and creative (P#12)
>
> I think the teacher has a big impact on how the child sees maths, whether they like it or not and then I suppose that will kind of translate to whether they enjoy it and want to do it or whether they struggle (P#15)
>
> …the teacher has a big role to play. If the teacher explains/ teaches different concepts well, the child will learn and understand the topic (P#26)

However, while acknowledging the role of the teacher, some pre-service teachers concomitantly referred to factors outside of teacher practice. In particular, a small number (N= 2) argued that mathematical ability might be outside of the teacher's control:

> I think to a certain extent, it's a very large role, but to some extent, sometimes there's nothing a teacher can really do…Because I think some children just might not get it…(P#11)

Further challenge to the centrality of the teacher's role in students' learning was apparent in pre-service teachers' response to the interview question 'What factors affect a child's ability to learn mathematics?' with over half (N=16) making no mention of the teacher. Instead, these interviewees prioritised a variety of other factors that they considered pertinent to children's mathematics learning; namely the student's natural mathematical ability (N=12, P#7), the student's attitude (N=13, P#2) and supports outside of school (N= 5, P#22).

> I think that you can be born, with just a better kind of cognitive ability about maths- you just are born better at maths…You either like maths and can do it or not- it's your thing (P#7)

> I think some people just have a negative thing towards maths and it think that automatically puts them off. So, like their attitude towards the subject. I think people need some natural ability at maths too, like you can rote learn and regurgitate things like history, but you need to have some basic understanding of maths (P#2)

> I suppose their parents. My parents were always very good they were always very helpful. Whereas my cousin's parents had no interest in school at all, so, she struggled (P#22)

Interviewees consistently reported that their insights came from personal pre-tertiary mathematics experiences:

> …that's what I remember happening to me… (P#1)

> I saw it in school, some people just seem to get maths easier than other people (P#7)

Table 5. Descriptive Statistics for Items in the MTOE Subscale of the MTEBI Scale

Item no.	MTOE item	Mean (Standard Deviation)[1]
1	When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.	3.5 (0.85)
4	When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	4.05 (0.66)
7	If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.	3.19 (0.95)
9	The inadequacy of a student's mathematics background can be overcome by good teaching.	4.03 (0.58)
10	When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher.	3.99 (0.67)
12	The teacher is generally responsible for the achievement of students in mathematics.	3.7 (0.79)
13	Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.	3.42 (0.93)
14	If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.	3.72 (0.83)

Note: [1] Means and standard deviation values were rounded to the nearest two decimal places

Across all data sources, there was no evidence of any consistent relationship between pre-service teachers' mathematics teaching outcome expectancy and their mathematics beliefs, mathematics self-efficacy, or level of study. For example, little difference was apparent between the mean MTOE subscale scores of participants based of level of study (research question 2) (i.e., Higher: 29.42, Ordinary: 29.97) and the t-test confirmed that the difference was not significant. Equally, analysis of the interview data revealed no evidence of differences in beliefs among the respective subgroups of pre-service teachers.

Discussion

This paper explores pre-service primary teachers' mathematics teaching efficacy when they enter initial teacher education (research question 1). It builds on prior research, using a mixed methods approach to uncover the extent to which pre-service teachers' pre-tertiary mathematics experience affected their mathematics teaching efficacy (research question 2) (McMahon Giles et al., 2016; Moody & DuCloux, 2015). However, unlike other research, this study focuses on newcomers to initial teacher education. It uses qualitative methods to reveal the nature of their mathematics teaching efficacy and its relationship with their mathematics beliefs and attitudes developed from engagement in their pre-tertiary mathematics education.

Despite the existence of reform mathematics curricula that promoted a focus on conceptual understanding and realistic problem solving across pre-tertiary education (NCCA, 2016; Prendergast et al., 2017), this study echoes previous research that suggests that the 'lived' mathematics experiences of Irish students continued to be predominantly traditional and didactic (Hourigan & Leavy, 2017b; Hourigan et al., 2016; Lyons et al., 2003; NCCA, 2005). More child-centred approaches to mathematics teaching were experienced by less than a third of interviewees during their primary mathematics education. The remainder reported a traditional, text-based approach to teaching and learning. All commentary of second level mathematics education evidenced a teacher-led, didactic approach to mathematics teaching and learning reflective of pre-reform practices (Hourigan & Leavy, 2017b; Hourigan & O' Donoghue, 2013; Hourigan et al., 2016; Lyons et al., 2003). Interestingly, there was robust evidence of the impact of the bonus point initiative, with many of the higher level leaving certificate students acknowledging continuous struggle and stress associated with mathematics education during their senior cycle (O'Meara et al., 2020; Prendergast et al., 2017).

Participants' mathematics teaching efficacy was measured using the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI), which consisted of a Personal Mathematics Teaching Efficacy (PMTE) subscale and a Mathematics Teaching Outcome Expectancy (MTOE) subscale. Subsequently, semi-structured interviews were carried out with a purposive sample of pre-service teachers to gain further insights into their responses.

Participating pre-service teachers' PMTE on entry to the initial teacher education programme was considered medium to high, reflecting their beliefs regarding their future potential to teach mathematics effectively. While these beliefs are slightly lower than those reported by Bursal (2010), Unlu and Ertekin (2013) and Twohill et al. (2022), they are more positive than the findings of Bursal and Paznokas (2006). However, this study provides a unique perspective examining these beliefs before any initial teacher education experience. On analysis of trends within the subscale items and interviews, pre-service teachers communicated uncertainty regarding their immediate ability to teach mathematics effectively. Generally, those who reported being confident in their ability to teach mathematics effectively reported high mathematics self-efficacy, reflecting the findings of previous studies (Ekstam et al., 2017; Zuya et al., 2016). However, their comments suggest a tendency to underestimate the complexity of mathematics teaching (Hourigan & Leavy, 2019b) believing that knowing the content as learners would facilitate them to teach it and given their experience of a traditional approach to teaching mathematics they assumed that mathematics teaching at primary school was a relatively simplistic and straightforward task. On the other hand, those who reported low mathematics self-efficacy beliefs were less confident about their ability to teach mathematics effectively. They identified their attitudes and personal mathematical ability as barriers to effective mathematics teaching. Interestingly the findings suggested that those who completed the Ordinary Level Leaving Certificate mathematics examination were less confident in their ability to teach mathematics effectively when compared to their Higher level peers. Interviews revealed that this was related to a perception regarding the adequacy of their mathematics knowledge. These findings support previous studies regarding the interconnectedness between pre-service teachers' PMTE and their previous mathematics study levels (Brown, 2012), mathematics attainment (Segarra & Julià, 2022; Twohill et al., 2022) and their mathematics self-efficacy accrued (Bates et al., 2011; Ekstam et al., 2017; Zuya et al., 2016). A small group of pre-service teachers demonstrated an awareness that learner knowledge alone was inadequate and that they did not possess the sort of knowledge required to teach mathematics effectively. All pre-service teachers were more confident about their capacity to teach mathematics effectively in the future.

Pre-service teachers' beliefs concerning the impact of the teacher on learning were examined using both the MTOE subscale and interviews. Pre-service teachers generally acknowledged the importance of the teacher in affecting learning, reflected in their relatively high MTOE subscale totals. While this finding mirrors that of Twohill et al. (2022) who also demonstrated high MTOE beliefs, it contrasts with Briley's (2012) finding that pre-service teachers demonstrated less agreement with the MTOE subscale relative to the PMTE subscale. Qualitative findings revealed that pre-service teachers identified teachers' level of enthusiasm towards mathematics and approach to mathematics teaching as influential in affecting learners' beliefs about mathematics and their attitude to the subject. However, the relevant individual MTOE items and qualitative findings suggest that they did not consider the teacher the sole determinant of student learning. Interestingly, when asked about the contributing factors and not prompted regarding the role of the teacher, approximately half the interviewees instinctively identified a range of other factors, which they considered to affect students' mathematics learning. While these included learner attitude and support outside school, the learners' natural mathematics ability was particularly prevalent. This finding suggests a fixed rather than growth mindset among these pre-service teachers, evidencing a belief that one's mathematical ability is static. This is a particularly concerning belief among future primary mathematics teachers, given the established connection between this construct and teacher practices. In particular, teachers' confidence in students' learning abilities has been found to affect their willingness to adopt and persist in using reform teaching strategies to support student learning (Depaepe & König, 2018; Lee et al., 2017). The researchers' concern reflects previous studies acknowledging that the notion of fixed abilities among prospective teachers is problematic (Sun, 2018). Given that all interviewees reported that these beliefs resulted from their experiences as learners during pre-tertiary mathematics education, the findings suggest the powerful influence of their apprenticeship of observation (Lortie, 1975). The findings evidence that pre-service teachers' experience of a predominantly traditional pre-tertiary mathematics education has led a notable number of them to conclude that mathematics is not for all and that 'effective' teaching alone may not suffice. However, it is also important to be cognisant that at this early stage of the initial teacher education programme, given their accounts of their pre-tertiary mathematics experiences, many pre-service teachers may assume that 'effective' teaching equates with traditional teacher-led, text-based practices. The findings also support previous research suggesting an absence of a positive relationship between novice pre-service teachers' MTOE and their mathematics self-efficacy (Bates et al., 2011) or their mathematical knowledge (reflected in their level of study) (Newton et al., 2012; Swars et al., 2007; Twohill et al., 2022).

Conclusions

The research contributes to the broader research field as it builds on previous research and, using a mixed method approach, increases our understandings of pre-service teachers' mathematics teaching efficacy on entry to initial teacher education. The findings of this study uncover the interactions between novice pre-service primary teachers' emerging mathematics teaching efficacy and their pre-tertiary mathematics experiences and resultant beliefs. It uncovers the range of factors that affect their PMTE and the specific experiences that shape their MTOE. Overall it confirms the significant impact of pre-tertiary mathematics experiences on pre-service teachers' mathematics teaching efficacy at this early stage of their initial teacher education. It also contributes to the area, given the importance of each country undertaking its own inquiry at a local level. There is a dearth of Irish research on pre-service teachers' mathematics teaching efficacy. Thus, this study acknowledges this important affective dimension which is known to impact teaching practices. Such insights inform the design of a mathematics education programme that includes opportunities to acknowledge, challenge and nurture these related constructs simultaneously (Gresham, 2009; Gresham & Burleigh, 2019; Jao, 2017; McMahon Giles et al., 2016; Moody & DuCloux, 2015; Segarra et al., 2021). It also provides base-line data that will facilitate future analysis of changes in this construct due to engagement in the initial teacher education programme.

Recommendations

Going forward, to break the cycle, change is necessary at all levels. Policy must acknowledge the impact of the nature of pre-tertiary mathematics experiences on all students and in particular aspiring pre-service teachers' beliefs about mathematics. A move away from the sole use of terminal examination towards the use of more continuous assessment may reduce the prevalence of exam-led teaching thus allowing students to have more meaningful and positive pre-tertiary mathematics experiences. Further large-scale research is necessary. In order to develop both their mathematics self-efficacy and mathematics teaching efficacy, novice pre-service teachers must receive substantial opportunities during their initial teacher education to reflect on and share their pre-tertiary mathematics experiences and related mathematics beliefs, as a springboard for considering their role as future teachers in fostering positive beliefs and attitudes among their pupils. Pre-service teachers must also receive ongoing opportunities to gain first-hand experience of reform mathematics education, to engage with the mathematics they will teach, as both learners and teachers, thus fostering an appreciation for the benefits of a socio-constructivist approach, alongside the development of appropriate knowledge and both mathematics self-efficacy and mathematics teaching efficacy required to support them in feeling prepared to enact reform approaches in their classroom practice. In addition, during teaching placement, it is essential that pre-service teachers receive focused support and guidance when implementing the recommended practices.

The effect of the mathematics teacher education programme on pre-service teachers' mathematics teaching efficacy will be measured at various junctures during their initial teacher education programme.

Limitations

Like all research, this study has limitations. The interview used purposive sampling, however, given the lack of response from participants with low PMTE scores, the interview data does not adequately represent the views of this subgroup of pre-service teachers. While the interview relies on self-report data, the study sought the 'lived' pre-tertiary mathematics experiences of participating pre-service teachers. Equally, the mixed methods approach facilitated the triangulation of findings.

Authorship contribution statement

Hourigan: Concept and design, data acquisition, data analysis/interpretation, drafting manuscript, critical revision of manuscript, statistical analysis, final approval. Leavy: Concept and design, data acquisition, data analysis/interpretation, drafting manuscript, critical revision of manuscript, statistical analysis, final approval.

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