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Primary Preservice Teachers' Mathematics Teaching Efficacy Beliefs: the Role Played by Mathematics Attainment, Educational Level, Preparedness to Teach, and Gender

Aisling Twohill[1,2] · Siún NicMhuirí[1,2] · Lorraine Harbison[1,2] · Anastasios Karakolidis[3]

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Abstract

This paper reports on research which explored the mathematics teaching efficacy beliefs of preservice primary teachers, where efficacy beliefs describe individuals' beliefs in their potential to enact teaching to promote learning. Efficacy was conceptualised as a bi-faceted construct consisting of personal efficacy and outcome expectancy. This research sought to establish the extent to which differences in efficacy are explained by students' mathematics attainment level prior to entry into teacher education; the educational level of the students (whether postgraduate or undergraduate); students' sense of preparedness to teach mathematics on school placement; and students' gender. A total of 186 students responded to a questionnaire designed to measure their efficacy beliefs after completing one taught mathematics education module in university and one teaching practice placement in primary schools. Bivariate and regression analysis pointed to complex relationships between the explanatory and outcome variables. On bivariate analysis, findings included statistically significant associations between gender, mathematics attainment, preparedness to teach, and one or both of personal efficacy and outcome expectancy. In the regression analysis, gender was statistically significantly associated with outcome expectancy, while preparedness to teach and mathematics attainment were statistically significantly correlated with personal efficacy. Personal efficacy and outcome expectancy were significantly correlated on bivariate analysis, but significance was not retained after controlling for other factors in the regression models. This research has implications for teacher educators in understanding factors explaining mathematics teaching efficacy and therefore helping to better prepare preservice teachers to teach mathematics in the primary school classroom.

Keywords Mathematics teaching efficacy beliefs · Mathematics Teaching Efficacy Beliefs Instrument · Outcome expectancy · Primary preservice teachers · Teacher education

Extended author information available on the last page of the article

Teacher efficacy holds international interest for researchers with a rapidly growing body of work investigating preservice and in-service teachers' efficacy beliefs across all levels of education from early childhood through to tertiary (c.f. Klassen et al., 2011; Xie & Cai, 2021). The momentum behind such research derives from the perspective that efficacy beliefs guide the application of professional teacher knowledge in the context of classroom practice and thereby have a profound influence on children's experience and achievement. Teachers with high levels of mathematics teaching efficacy have been shown to be more likely to employ inclusive teaching strategies with flexible goals, methodologies, and assessment practices that promote mathematical understanding (Enochs et al., 2000; Swars et al., 2009). Better understanding of the factors associated with self-efficacy beliefs of teachers is of both theoretical and practical importance (Tschannen-Moran & Johnson, 2011).

Bandura suggests that efficacy beliefs are most malleable in their early stages of development and research shows that teacher preparation has the potential to contribute to teachers' efficacy (cf. Tschannen-Moran & Johnson, 2011). Teacher efficacy is known to be subject specific with a teacher possibly holding stronger efficacy beliefs in relation to one subject area or demonstrating weaker efficacy beliefs in others (Bandura, 1997). This has particular relevance to primary school teachers who typically are prepared and required to teach across all areas of the curriculum and all year groups, with children ranging from 4 up to 13 years of age, with no specialised qualification in mathematics or mathematics teaching. Furthermore, research has consistently shown that the lower mathematics teaching efficacy beliefs are, the higher negative attitudes and anxieties teachers hold towards mathematics (Gresham, 2008). This has an adverse effect on teaching with more time devoted to individual generic seatwork involving the rote practice of procedures, and less time spent on problem-solving techniques and strategies (Briley, 2012). In contrast, Lee et al. (2017) found that lessons of preservice teachers with higher mathematics teaching efficacy beliefs involved tasks of higher cognitive demand, extended student explanations, student-to-student discourse, and explicit connections between representations.

It is pertinent, therefore, to examine the mathematics teaching efficacy of preservice teachers, along with the factors that contribute to said efficacy beliefs. The research study described in this paper sought to measure the mathematics teaching efficacy beliefs of preservice teachers, measure factors that research has associated with efficacy, and examine any relationships that exist through conducting bivariate and multivariate (multiple linear regression) analysis. The underpinning rationale that inspired this research is to ensure that attention is paid to the factors that influence teacher efficacy in the development of mathematics education programmes of study.

Unpacking Mathematics Teaching Efficacy

A number of literature reviews note lack of clarity in interpretations of teacher efficacy beliefs and there is ongoing debate about how efficacy should be measured (c.f., Klassen et al., 2011; Morris et al., 2017). Some of the theoretical complexity likely arises because the concept of teacher efficacy, underpinned as it is by unspoken assumptions about the role of the teacher, is further complicated by unique features of cultures which inform the foundational ideas (Klassen, 2004). Marschall and Watson (2019) document nuances in the theoretical positions of various authors who either treat teacher efficacy as a belief about competence or capability to bring about educational change. This disjunction may be linked to the two different types of expectations identified by Bandura (1997); *efficacy expectation* and *outcome expectancy. Efficacy expectations* are concerned with expectations about personal competence to attain a certain level of performance while *outcome expectations* are judgements of the outcomes that will most likely result from specific behaviours. Bandura (1997) proposes that these expectations interact to determine the initiation and persistence of behaviours. He suggests that people act on beliefs about what they are personally capable of doing so the potential of outcome expectancies to influence motivation is governed by beliefs about personal efficacy.

Skinner (1996), writing about the construct of control, describes these two constructs in relation to a distinction between agent-means relationships (I can execute the actions) for personal efficacy and contingency, or means-ends relationships (the actions will attain certain outcomes) for outcome expectancy. Our conceptualisation of teacher efficacy as a teacher's sense of ability to organize and execute teaching that promotes learning (Charalambous et al., 2008) aims to encompass agent-means (*teacher-teaching*) and agent-ends (*teacher-learning*) relationships (Wyatt, 2014). As mentioned earlier, efficacy is considered to be both a domain- and context-specific construct (Bandura, 1993); and therefore, mathematics teaching efficacy is taken to be a teacher's perceptions about their own effectiveness to organize and execute teaching that promotes mathematics learning.

It is argued that some research purporting to be about teacher efficacy is actually more closely aligned with teachers' locus of control (c.f., Bandura, 1997; Wyatt, 2014). Building on the Rand efficacy measures (as detailed in Klassen et al., 2011), early efficacy research investigated the extent to which teachers believed that they could control the reinforcement of their actions and whether they believed that teaching/teachers can be successful, even with difficult and unmotivated students, i.e. general teaching efficacy (Woolfolk et al., 1990). A number of instruments designed to measure efficacy included attention to this construct. Bandura (1997) clarified that efficacy measurements, including consideration of efficacy to overcome obstacles, should be in terms of teacher's assessment of their *own* abilities rather than beliefs about the efficacy of teachers more generally. While acknowledging this important theoretical and practical distinction, we still find value in considering general teaching efficacy beliefs. Ross et al., (1996, p. 386) describe general teaching efficacy as "the belief that students are teachable". In mathematics education, notions of fixed ability and related pedagogical practices have long been identified as problematic (c.f. Boaler et al., 2000; Sun, 2018). For this reason, in addition to developing preservice teachers' personal teacher efficacy, it is vitally important for us as mathematics teacher educators to instil ideas about the possibilities of mathematics teaching more generally, that is, to develop positive mathematics teaching outcome expectancy beliefs. Therefore, for the purposes of this research, the authors accept the distinction between the two components of mathematics teaching efficacy, namely personal mathematics teaching efficacy and mathematics teaching outcome expectancy as outlined here.

Influences on Preservice Teacher Efficacy

There have been calls for further research into the nature of the antecedents of efficacy and the context variables that are linked to higher self-efficacy (Tschannen-Moran & Johnson, 2011). For example, Zeldin et al. (2008) point to the role played by personal demographics in how individuals experience the world and by extension their opportunities to develop efficacy, while Bandura (1997) highlights the role of mastery and vicarious experiences. Mastery experiences include experiences of success in performing a role, and vicarious experiences includes experiences of others fulfilling a task. Below, we discuss research findings on variables that might predict mathematics teaching efficacy beliefs, with particular attention to factors that have been found to be significant for novice teachers: gender, levels of education, and mathematics knowledge. We then discuss the role of teacher education more generally.

Personal Demographics That May Explain Variation in Efficacy Beliefs

Tschannen-Moran and Woolfolk Hoy (2007) justify their consideration of gender as a control in their exploration of the efficacy beliefs of novice and experienced primary school teachers. They suggest that, based on existing conceptions of teacher efficacy, there is no theoretical reason to suspect that efficacy beliefs would be related to gender except in relation to the availability of vicarious experiences with similar models. This explanation is proposed to explain female teachers' higher sense of efficacy for literacy instruction found in later work (Tschannen-Moran & Johnson, 2011). Other research proposes that gender may influence the way an individual experiences the four antecedents of self-efficacy in relation to particular subject areas. In seminal work, Hackett and Betz (1981) suggested that boys are more likely than girls to experience tasks of a mechanical, scientific nature and go on to develop stronger self-efficacy expectations toward science, technology, engineering, and mathematics (STEM) careers. In a similar vein, it is suggested that the availability of suitable models in STEM careers is more likely for men than for women. More recent work on gender continues to emphasize the role of sociocultural and experiential influences on individual's participation in mathematics (c.f. Leyva, 2017). Mathematics self-efficacy beliefs, or beliefs in one's ability to do mathematics, have consistently been found to be lower in females than males, a worrying finding given that mathematics self-efficacy has also been shown to predict educational achievement and career outcomes (Zander et al., 2020). Zeldin et al. (2008) show that different sources are predominant in the development of the self-efficacy beliefs of men and women in STEM careers. Mastery experiences appear to be the primary source of men's efficacy beliefs while social persuasion and vicarious experiences were more important for women. While these results do not relate directly to the teaching of mathematics, preservice teachers' perceptions of their own mathematical competence and their experiences of learning mathematics are considered to be relevant (Briley, 2012) and we consider that investigation of gender is justified in this context.

Tschannen-Moran and Woolfolk Hoy (2007) draw attention to the 'long apprenticeships' served by teacher education students as learners in primary and secondary schools and note that this qualifies as a form of vicarious experience. In the case of preservice teachers with differing educational levels attained, those students who have graduated from tertiary courses have not just spent more time observing teachers, but are likely to have experienced qualitatively different forms of teaching in tertiary programmes of study than in primary and secondary school (Government of Ireland, 2013). In addition, they have studied a range of different areas, some of which may have included STEM components and some of which may have little or no connection with the curriculum in preceding school stages. Brown's study (2012) of non-traditional preservice primary school teachers lends further support to the idea that undergraduate and postgraduate initial teacher education students may present differently in relation to the development of mathematics teaching efficacy. She showed that teachers' ages had a significant positive relationship with their mathematics efficacy beliefs and older preservice teachers were found to have higher mathematics teaching efficacy beliefs. Here non-traditional is understood to relate to under-served students and relate to factors such as age; racial/ethnic background; a lack of access to a baccalaureate degree; or time away from the academic setting.

The importance of mathematical content knowledge to teaching has long been recognised (Ball et al., 2008). Newton et al. (2012) contend that for novice teachers, with limited or no classroom experience, it is plausible to assume that mathematical knowledge may influence mathematics teaching efficacy beliefs, as in the absence of teaching experience, individuals will draw on their related experiences to make efficacy judgements. However, the same authors note that research results are mixed, possibly due to differences in how mathematical performance or content knowledge has been measured. Swars et al. (2007) found no relationship between preservice teachers' knowledge for teaching mathematics and mathematics teaching efficacy, while Brown's (2012) study of non-traditional preservice teachers showed that mathematics grades did correlate with mathematics teaching efficacy scores. Similarly, Bates et al. (2011) found that the mathematical performance of preservice early childhood teachers was related to their personal mathematics teaching efficacy but there was no correlation between mathematics performance and mathematics teaching outcome expectancy. This aligns with the findings of Newton et al. (2012) who found a positive moderate relationship between mathematics content knowledge and personal teaching efficacy, but no relationship between content knowledge and outcome expectancy in their study of preservice elementary teachers. Bates et al. (2011) suggest that higher levels of content knowledge may support preservice teachers' confidence that they can teach the topic but they appear to remain unsure about their ability to influence students' learning, perhaps due to lack of experience, while Newton et al. (2012) suggest that preservice teachers with different levels of content knowledge may attend to different sources of information when making efficacy judgments about teaching.

Teacher Education Programmes and Preparedness

The comprehensive literature review of Morris et al. (2017) details a range of studies which show that teachers who feel well-prepared for the classroom are more likely to give a positive appraisal of their own capabilities. Tschannen-Moran and Johnson (2011) found that the perceived quality of teacher education, rather than the quantity of same, appeared to be important to teacher efficacy. Chang (2010) notes that the specific content of teacher education programmes is important, with preservice teachers specialising in mathematics or science having higher mathematics teaching efficacy beliefs. Research also demonstrates that mathematics methods courses can explain changes in preservice teachers' beliefs about mathematics teaching and support a shift away from traditional views of teaching and learning (Jao, 2017). Swars et al. (2007) tracked significant changes in both personal mathematics teaching efficacy and mathematics teaching outcome expectancy over two mathematics methods courses. Thus, findings from research strongly indicate that teacher education programmes have the potential to enhance preservice teachers' mathematics teaching efficacy beliefs.

In considering how teacher education programmes may support the development of mathematics teaching efficacy beliefs, it is pertinent to consider the sources of efficacy beliefs identified by Bandura (1997). He proposes four sources of efficacy beliefs: mastery experience, vicarious experience, social persuasion, and physiological and affective states. Mastery experiences, commonly considered the most influential source of self-efficacy, involve the accomplishment of goals through direct personal action. The opportunities for preservice teachers to have mastery experiences of teaching are limited to their school placement experiences. Thus, within the taught components of teacher education programmes, opportunities to engage in activities that replicate elements of the practice of teaching, such as sourcing quality activities, structuring a lesson plan, and preparing key questions, may support the development of a sense of preparedness to teach by providing opportunities for mastery experiences which preservice teachers may draw on to form efficacy judgements until they experience teaching in the field. Vicarious experiences are those where a model is observed performing a relevant task. Thus, we consider, for example, that observations of lecturers facilitating mathematical discussion and problem-solving, and experiences of positive feedback in relation to tasks associated with planning for teaching can support the development of mathematics teaching efficacy in preservice teachers (Yurekli et al., 2020). We contend that preservice teachers' sense of preparedness to teach arising from engagement with mathematics education modules is particularly relevant given their lack of relevant mastery experiences.

Research Aims

Mathematics teaching efficacy has been shown to be related to the instructional practices used by preservice teachers (e.g. Lee et al., 2017) and cultivating efficacy beliefs is a pertinent goal for teacher education. Identifying predictors of preservice teachers' mathematics teaching efficacy beliefs, and associated interrelationships, is an important part of designing teacher education programmes which are responsive to students' needs. Mathematics teaching efficacy may be conceptualised as comprising two component parts, namely personal mathematics teaching efficacy and mathematics teaching outcome expectancy. From our review of research relating to this topic, we have identified two exploratory models, comprising four elements that contribute to each of personal mathematics teaching efficacy and mathematics teaching outcome expectancy, namely (1) mathematical attainment; (2) educational level (whether undergraduate or postgraduate); (3) sense of preparedness to teach; and (4) gender.

In addition to these elements, there is significant evidence to support a contention that a model predicting each of personal mathematics teaching efficacy and mathematics teaching outcome expectancy would not be complete without considering the extent to which each of these two components of efficacy predicts the other. While personal mathematics teaching efficacy (PMTE) and mathematics teaching outcome expectancy (MTOE) are themselves dimensions of the single construct of mathematics teaching efficacy, it remains appropriate to examine in what ways they interact with each other (Bandura, 1997). Swars et al. (2009) presented PMTE and MTOE as representing independent constructs in their analysis of the development of PMTE and MTOE among a cohort of prospective teachers. Indeed, Swars et al. (2009) highlighted the need for research that examines the complexities and interrelatedness of relationships between belief constructs. Our models, therefore, seek to explore how each of the two components, PMTE and MTOE, may be predicted by mathematical attainment, educational level, sense of preparedness to teach, and gender; and also how each predicts the other, as presented in Fig. 1.

Methods

Participants

There are two routes into primary teaching in Ireland. Students must complete a 4-year undergraduate degree or a 2-year postgraduate Master's degree. Approximately 450 students are enrolled each year on the undergraduate programme in the university where this study was conducted, and approximately 70 are enrolled on the postgraduate programme. In this study, age is primarily linked to educational level as the vast majority of undergraduate students enrol in the programme directly from second-level education. The participants in this study had each completed 1 year of their initial teacher education programme, whether undergraduate or postgraduate. Each student had completed one module of mathematics education and one placement in a primary school. The total number of students invited to participate from each cohort, and the number who participated are presented in Table 1.

Twenty male students participated in the study, comprising 10.75% of the sample. The proportion of male and female students in the class cohorts are not available but, for comparison, 15.4% of teachers in primary schools in Ireland are male (Department of Education, 2021). It is pertinent to highlight that this is a convenience sample with a low number of participants, and an imbalance in the response

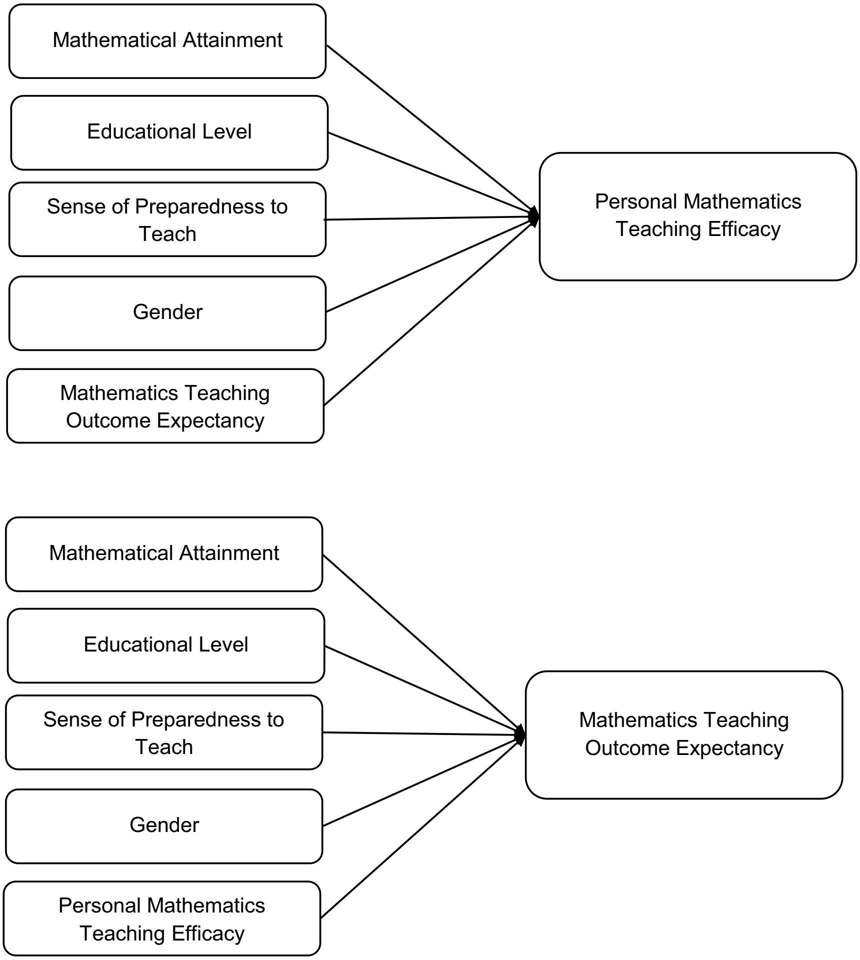

Fig. 1 Models for predicting the constituent elements of mathematics teaching efficacy beliefs

rate between the undergraduate and postgraduate students. Therefore, we do not contend that the findings represent a broader population.

Data Collection Instrument

Seeking to investigate the relationship between variations in efficacy and the participants' gender, educational level (whether postgraduate or undergraduate), mathematics attainment, and sense of preparedness to teach mathematics, the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) of Enochs et al. (2000) was employed, to which we added questions relevant to the foci of our research. In this

Table 1 The students invited to participate and the number of participants

Educational level	Number of students invited to participate	Number of students who completed the questionnaire	
Undergraduate	847	Male	14
		Female	129
		Total	143
Postgraduate	69	Male	6
		Female	37
		Total	43
		Male	20
		Female	166
		Total	186

section, we unpack our decision making relating to the data we chose to collect and the approach we adopted to analysis.

Efficacy Beliefs

The central focus of this research is the efficacy beliefs of preservice teachers attending initial teacher education. In this study, we are taking the position that mathematics teaching efficacy is a two-dimensional construct that encompasses an individual's perception of both (a) the capacity of oneself to teach in such a way as to bring about change, and (b) the capacity of teaching to bring about change in children's understanding (Bandura, 1993; Briley, 2012). Briley (2012) reiterates the assertion that these two dimensions of personal teaching efficacy and teaching outcome expectancy should be distinguished. For example, belief in one's capacity to support understanding may co-exist with a belief that some children's potential to achieve is fixed and, to some extent, predetermined. Equally, a belief that teaching has the potential to help children to achieve understanding may be held along with a concern about one's personal capacity to teach in an appropriate way.

In order to capture the students' mathematics teaching efficacy beliefs, we employed the MTEBI of Enochs et al. (2000). While the use of Tschannen-Moran and Woolfolk Hoy's (2007) Teachers' Sense of Efficacy Scale has become more prevalent (Morris et al., 2017), application of such a domain-general instrument is problematic given our focus on efficacy beliefs related to mathematics teaching. Domain-specific versions of this instrument have recently become available (e.g. Wilhelm & Berebitsky, 2019), but there remain context-specific reasons for our choice of the MTEBI (Enochs et al., 2000). The Teachers' Sense of Efficacy Scale focuses on three competencies: the ability to use different instructional strategies, the ability to manage a class effectively, and the ability to engage students (Tschannen-Moran & Woolfolk Hoy, 2007). These core competencies in effective teaching are not directly relevant to our investigation which focused on the students' sense of efficacy following completion of one mathematics education module. Within the structure of our teacher education programme, students receive dedicated *Teaching Studies* modules, and we do not cover content relating to classroom management within mathematics education modules. For this reason, we selected the MTEBI as the instrument most closely aligned with the goals of our mathematics modules.

The MTEBI consists of 13 items measuring respondents' personal mathematics teaching efficacy (PMTE) (for example, "I know how to teach mathematics concepts effectively"), and eight items measuring mathematics teaching outcome expectancy (MTOE) (for example, "The inadequacy of a learner's mathematics background can be overcome by good teaching"). Each item in the instrument has five response categories, ranging from *Strongly Agree* to *Strongly Disagree*. The MTEBI includes negatively worded questions, and their associated scores were reversed in line with the MTEBI implementation guidelines. Therefore, for all items, a score of 5 indicates strong PMTE/MTOE and a score of 1 indicates low PMTE/MTOE. The score compiled from the MTEBI for each participant is an arithmetic mean of the relevant responses, sitting therefore within the range from 1 to 5. The MTEBI is a well-established instrument that has been developed and validated by Enochs et al. (2000) and translated versions of the instrument have been used in a number of contexts internationally (e.g. Chang, 2010). Factor analytic procedures were applied to confirm the consistency of these two indices in the context of this study. Results of the factorial analyses are included in the electronic supplementary materials (ESM) to this paper. The reliability of both indices was satisfactory (Cronbach's $\alpha = 0.84$ for PMTE; Cronbach's $\alpha = 0.79$ for MTOE), with values greater than 0.70 being considered as acceptable (Cohen et al., 2003). The two indices were moderately correlated, $r(186) = 0.371$. $p < 0.001$.

Educational Level

In our discussion above of the personal demographics that may explain variation in efficacy beliefs, we have described how levels of education may be of relevance. Therefore, we anticipated that it would be revealing to compare the efficacy beliefs of the postgraduate and undergraduate students. In Ireland, entry to both undergraduate and postgraduate teacher education degrees is competitive, and students attending both programmes are typically students who have been highly successful academically (Keane & Heinz, 2015). There may however exist additional factors, as described earlier in the paper, that may lead to differences between efficacy beliefs of undergraduate and postgraduate students.

Mathematics Attainment

Drawing on the findings of Brown (2012) and Bates et al. (2011), we identified mathematics attainment as a factor that could potentially hold a relationship with students' mathematics teaching efficacy beliefs. As highlighted earlier, novice teachers with little mathematics teaching experience may draw on related experiences of doing mathematics to form efficacy judgements (Newton et al., 2012). For clarity, it is important to describe the measurement of students' mathematics attainment that we employed in the study. Within the teacher education programmes in the university, students study modules in mathematics education, but do not study mathematics. We therefore did not have a recent assessment of their mathematical attainment, and we believed that requesting students to undertake such an assessment as part of their participation would lead to a very low number of participants. Therefore, in the questionnaire that students completed, we asked for the grade they achieved in the terminal state examination of the Irish secondary school system, the Leaving Certificate. In Ireland, all children study mathematics until they complete secondary school, typically at 18 years of age. We applied a mechanism which is in place in the Irish education system for entry to higher level education, whereby grades are translated into 'points' (Department of Education and Skills, 2015). Each participant was allocated the points associated with the grade they achieved in the Leaving Certificate, and we used these points as a proxy for attainment. In the 'Results' section of this paper, we present the breakdown of the points achieved by the participants in this study and explore whether the participants' attainment in mathematics predicted Personal Mathematics Teaching Efficacy (PMTE) or Mathematics Teaching Outcome Expectancy (MTOE).

Preparedness to Teach (PT)

In line with the finding of Tschannen-Moran and Johnson (2011) that the perceived quality of teacher education programmes was correlated with teaching efficacy beliefs, we were motivated to measure the extent to which the participants felt prepared to teach mathematics as a direct result of their engagement in our mathematics education modules. Undergraduate and postgraduate students had each undertaken one module where the preparation of a lesson, the sourcing of evidence-based activities from recommended sources, and the inclusion of key questions in lesson planning were foregrounded. Seeking to draw specifically on the role of the mathematics education modules, we designed four questions relating to key content of the modules, rather than a general sense of preparedness, for example "I knew where to find good quality lesson and activity ideas that I could use in classrooms." Questionnaire items, therefore, referred to these three aspects of preparing to teach: structuring a lesson, sourcing good quality activities, and preparing appropriate questions. All questions in this section of the questionnaire were prefaced with "Please indicate to what extent you agree with the following statements regarding the Mathematics Education seminars and your level of preparation for School Placement in the following specific ways:" as we aimed to lead the students to focus on the role of the module in their sense of preparedness, rather than support from family and friends, physiological and affective states, or other extraneous factors that have been shown to support novice teachers in feeling prepared to teach (Morris et al., 2017). For consistency with the MTEBI, each item in the instrument has five response categories, ranging from *Strongly Agree*, achieving a score of 5, to *Strongly Disagree,* achieving a score of 1. Following factor analytic techniques, the Preparedness to Teach (PT) index was created, and results of the factorial analysis for this index are included in the electronic supplementary materials to this paper. The PT index is an arithmetic mean of the responses of the students on the four preparedness items. The PT index had satisfactory reliability, Cronbach's $\alpha = 0.75$.

Analysis

We sought to explore to what extent gender, educational level (whether postgraduate or undergraduate), preparedness to teach (PT), mathematics attainment, and personal efficacy (PMTE) explained variations in outcome expectancy (MTOE), and also to what extent gender, educational level (whether postgraduate or undergraduate), PT, mathematics attainment, and MTOE explained variations in PMTE. We therefore (a) gathered information relating to gender, educational level, and mathematics attainment; and (b) constructed indices to measure PMTE, MTOE, and PT. Confident of the reliability of our factors, we sought to analyse the contribution of all predictors to our dependent variables, PMTE and MTOE. We firstly took each factor in turn and examined whether the factor was statistically significantly related to either PMTE or MTOE. However, this single variable analysis does not best explain the complex situation wherein multiple factors contribute to, and thus predict, the efficacy beliefs of our students. Therefore, to unravel the relationships between independent variables, and to explore how the continuous variables, individually and in combination, could explain variations in students' efficacy beliefs, two regression analyses were conducted (Cohen et al., 2003). The regression models allowed us to explore which factors statistically significantly predicted PMTE and MTOE, while accounting for other variables.

Results

In this section, we outline the results we found when we explored relationships between the independent variables of our models (see Fig. 1) and each of Personal Mathematics Teaching Efficacy (PMTE) and Mathematics Teaching Outcome Expectancy (MTOE), where we include PMTE and MTOE as predictors for each other.

Discrete Variables: Gender and Educational Level

In Table 2, we present descriptive statistics for both the PMTE and MTOE indices across gender and educational level.

Overall, students reported relatively high levels of both PMTE and MTOE as the mean scores of the indices are closer to the upper end of the scale. In exploring the role of gender in our participants' mathematics teaching efficacy beliefs, we compared both the mean score for PMTE and the mean score for MTOE for male and for female students, as identified in Table 2. The mean PMTE score is slightly lower for female than for male students, but the difference is not significant, $t(184) = -0.661$, $p = 0.509$. However, the mean MTOE score is higher for females than for males, and the difference is significant, $t(184) = 2.228$, $p = 0.027$. Male students had lower expectations for the impact of mathematics teaching in

Table 2 Overview of the participants' scores on the PMTE and MTOE indices

	Personal mathematics teaching efficacy (PMTE)		Mathematics teaching outcome expectancy (MTOE)	
	Mean	*Std. deviation*	*Mean*	*Std. deviation*
Overall	3.55	0.60	3.54	0.56
Gender				
Female	3.54	0.60	3.57	0.57
Male	3.63	0.55	3.28	0.41
Educational level				
Undergraduate	3.54	0.62	3.51	0.59
Postgraduate	3.56	0.54	3.64	0.46

Table 3 Points achieved by participants of this study, in comparison to all students who completed secondary school in Ireland in 2019 (State Examinations Commission, n.d.)

	N	Mean	St Dev	Minimum	Maximum
Participants	186	55.22	17.31	20	100
All students Ireland 2019	49,627[1]	39.39	24.51	0	100

[1]An additional 5467 students who completed the secondary school terminal examination in 2019 were not included in these figures because they sat a foundation-level mathematics examination that is not included in the points system for higher level education

general than did female students. The effect size of this difference is considerable, while in the moderate range, Hedges' $g = 0.52$.

As Table 2 shows, postgraduate students reported having higher levels of PMTE than their undergraduate peers, but the gap was not statistically significant, $t(184) = 0.115$, $p = 0.909$. Similarly, undergraduate and postgraduate students did not significantly differ in their levels of outcome expectancy, $t(184) = 1.380$, $p = 0.169$.

Continuous Variables: Attainment, Sense of Preparedness to Teach (PT), and PMTE and MTOE as Predictors of Each Other

The remaining two factors that we used to analyse our data were the mathematics attainment of the students, and their sense of preparedness to teach (PT) following the one mathematics education module they had undertaken. Each participant's score on the PT index, as described in the methodology section, is an arithmetic mean of the students' responses to four items. The minimum score available is 1, indicating a sense of not feeling prepared, and the maximum is 5, which indicates that the participant feels very well prepared. The arithmetic mean of the scores achieved by the 186 participants on this index is 3.34 and the median score achieved

Table 4 Regression of Personal Mathematics Teaching Efficacy (PMTE)

Predictors	B	SE B	β	p-value	R^2
					17.6%
Gender (male)	0.101	0.133	.052	.450	
Educational level (undergraduate)	−0.086	0.103	−.060	.407	
Preparedness to teach (PT)	0.251	0.053	.327	.001	
Mathematics attainment	0.006	0.003	.163	.027	
Mathematics teaching outcome expectancy (MTOE)	0.143	0.075	.134	.058	

is 3.5, both of which are nearer to the upper end of the scale, indicating that the participants reported relatively high measures of preparedness to teach mathematics.

In Table 3, we present an overview of the mathematics attainment of the participants, using the points associated with the grade they achieved on the Irish secondary school terminal examination.

As explained in the methodology section, the points presented correspond to the grade achieved in the state mathematics examination when each participant completed secondary school, where the available points range from 0 to 100. The mean score achieved by the sample of participants was 55.22 with a standard deviation of 17.31. The lowest points achieved was 20 (5 students, 2.69% of the sample) and the highest was 100 (4 students, 2.15% of the sample). In comparison, the mean points achieved by the entire cohort of students in Ireland ($N = 49{,}627$) who sat the secondary school terminal examination in mathematics in 2019 was 39.39 points, with 15.8% achieving fewer than 20 points, 12.8% achieving exactly 20 points, and 2.2% achieving 100 points (State Examinations Commission, n.d.). Our sample achieved a statistically significantly higher score in mathematics, compared to the overall population in Ireland, $t(49{,}811) = 8.800$, $p < 0.001$.

Multiple Linear Regression

Multiple linear regression analysis was conducted to indicate which factors can predict PMTE and MTOE, after accounting for other variables. Table 4 presents the results of the first linear regression model that has PMTE as the outcome variable.[1]

Two out of the three variables that in the bivariate analysis were statistically significantly correlated to PMTE (PT and attainment) retained their statistical significance in the regression model after accounting for students' gender, educational level, and MTOE. Specifically, students who reported that their university courses prepared them well for the teaching of mathematics, and those who had higher

[1] The underlying assumptions of linear regression (i.e. linearity, multivariate normality, absence of multicollinearity, homoscedasticity) were met for both models.

Table 5 Regression of Mathematics Teaching Outcome Expectancy (MTOE)

Predictors	*B*	SE *B*	*β*	*p*-value	R^2
					8.9%
Gender (male)	−0.332	0.129	−.184	.011	
Educational level (undergraduate)	−0.104	0.101	−.078	.306	
Preparedness to teach (PT)	0.088	0.055	.122	.116	
Mathematics attainment	−0.003	0.003	−.101	.194	
Personal Mathematics Teaching Efficacy (PMTE)	0.139	0.073	.148	.058	

mathematics attainment tended to have higher levels of Personal Mathematics Teaching Efficacy. Based on the standardised coefficients of these variables (*β*), PT was the strongest predictor of participants' PMTE.

After accounting for other significant predictors, students' scores on the MTOE index, which originally were positively correlated to their PMTE scores, lost their statistical significance. The remaining variables (gender and educational level) were not significantly related to PMTE. The explanatory variables included in this model accounted for 17.6% of the between-student differences in their levels of PMTE, $R^2 = 17.6\%$.

Table 5 presents the results of the multiple linear regression of students' outcome expectancy. The only statistically significant predictor of students' MTOE on the models was gender, with females tending to have significantly higher levels of outcome expectancy than their male peers. After controlling for the predictors included in the model, both PT and PMTE, which were originally significantly correlated to MTOE, lost their statistical significance. This model explained a relatively small amount of the variance in students' levels of outcome expectancy in the teaching of mathematics, $R^2 = 8.9\%$.

Discussion

In this section, we discuss findings of the statistical analysis we conducted in order to explore to what extent variations in efficacy are explained by our models, comprising students' gender, educational level, attainment in mathematics, sense of preparedness to teach mathematics, PMTE as a predictor of MTOE, and MTOE as a predictor of PMTE. Before presenting the relationships that did emerge, it is pertinent to discuss our finding that the participants' entry-route to teacher education did not hold a significant relationship with either PMTE or MTOE, among the participants of this study. This finding was surprising as in a study of preservice primary school teachers, Brown (2012) found that teachers' ages had a significant positive relationship with their mathematics efficacy beliefs, i.e. the older the preservice teacher, the higher the MTEBI score. Also, drawing from Tschannen-Moran and Woolfolk Hoy (2007), we had theorized that entry-route to teacher education would result in differences in mathematics teaching efficacy beliefs due to differences in the nature of vicarious experiences of teaching that students had undergone. It is possible, however, that in forming their mathematics teaching efficacy beliefs, postgraduate students did not draw on their experiences of tertiary education as they did not see it as relevant or related to teaching mathematics at primary level. It is important to note that 43 of the 69 postgraduate students eligible to participate in this study chose to do so (response rate of 64%), where the comparable response rate among undergraduate students was 17% (143 participated of 847 students). A more fine-grained research approach with more comparable response rates is necessary to explore this possible explanation.

Bivariate Analysis: Personal Mathematics Teaching Efficacy (PMTE)

In this study, the variables that were statistically significantly related to PMTE were mathematics attainment, sense of preparedness to teach (PT) and mathematics teaching outcome expectancy (MTOE). Personal mathematics teaching efficacy was positively correlated with students' attainment in mathematics, whereby students with higher prior attainment in mathematics indicated stronger self-efficacy beliefs. This is in line with other research where mathematical content knowledge and/or attainment has been found to be associated with personal teacher efficacy (Brown, 2012; Newton et al., 2012); however, there is no data to support a causal relationship in this case.

Participants' PMTE was also positively correlated with their levels of MTOE, indicating that students who held stronger self-belief in the power of their teaching to support learning were also more likely to believe that teaching in general could be impactful. Students' personal mathematics teaching efficacy was also positively correlated with the extent to which they thought the university module prepared them for teaching mathematics. As teacher-educators, this was an interesting finding for us and demonstrated that the students who felt more positive about the potential of their teaching also felt more prepared due to the Mathematics Education module they had undertaken. It is highly pertinent to emphasise at this point that there is no data to support a causal relationship.

Bivariate Analysis: Mathematics Teaching Outcome Expectancy (MTOE)

In addition to the positive correlation with personal mathematics teaching efficacy, mathematics teaching outcome expectancy was also positively correlated with preparedness to teach (PT). Again, causal assumptions are beyond the scope of this research, but it is interesting to note that students who felt more prepared by their studies to teach also possessed more positive opinions regarding the potential for teaching to support children's learning. It is generally accepted that efficacy beliefs are most malleable in early career and then relatively stable once set (Tschannen-Moran & Johnson, 2011). This underscores the importance of focussing on MTOE in initial teacher education, particularly given the need to cultivate teaching practices that promote growth rather than fixed mindsets (Sun, 2018); and our findings show that teacher education has the potential to support strong MTOE through supporting the students in feeling prepared to teach.

Multiple Linear Regression

Cohen, et al. (2003) highlight the rich interpretation of variables that is allowed by multivariate analysis (e.g. multiple regression), whereby researchers gain access to the significance of each variable when all others are controlled for. Our results indicate that for participants of this study on bivariate analysis, mathematics attainment, PT, and MTOE were all statistically significantly correlated with PMTE, while gender and educational level were not. In addition to a statistically significant correlation with PMTE, MTOE was also statistically significantly correlated with PT and gender.

On regression analysis, the correlation between PMTE and attainment in mathematics retained positive statistical significance when gender, educational level, PT, and MTOE were accounted for. Participants who had attained a high level in mathematics tended to have strong personal efficacy beliefs, whereas mathematics attainment was not a contributing factor in explaining variation in MTOE. This finding mirrors the results of previous studies including those of Bates et al. (2011) and Newton et al. (2012) and highlights the potential of teacher education programmes to engender robust beliefs of personal efficacy by supporting students in achieving in mathematics. Newton et al. contend that mathematics attainment is relevant when students do not have teaching experience to draw on to form efficacy judgements. Chang (2010) underlines the importance of success in early school-based experiences and warns that students who lack a mathematical background or active external support may not have mastery experiences or access to the vicarious models that are necessary to develop positive efficacy beliefs. For this reason, attention to developing ways to support the cohort of preservice teachers with poor mathematical attainment is warranted.

As presented in our results, when controlling for all other variables in this study, the only variable statistically significantly associated with MTOE was gender, where male participants tended to hold weaker beliefs in the potential of teaching to bring about learning in mathematics. As highlighted earlier in this paper, there are gaps in the research literature relating to the role of gender in predicting the PMTE or MTOE of preservice teachers. In contrast with our finding, Koutsianou and Emvalotis (2019) and Kim et al. (2014) both found that gender did not predict mathematics teaching efficacy beliefs (PMTE or MTOE), whereas Briley (2012) pointed to strong correlations between mathematics efficacy and mathematics teaching efficacy, and as discussed above, there is a body of research to support the contention that male students hold stronger mathematics efficacy beliefs than their female peers.

PT and PMTE, which had been significantly correlated with MTOE under bivariate analysis, lost their significance, indicating that correlations between MTOE and each of PMTE and PT are explained by relationships with other variables. The loss of statistical significance of the correlation between MTOE and PMTE cannot be attributed to gender, entry-route to teacher-education, or mathematics attainment as none of these three variables is statistically significantly associated with both PMTE and MTOE.

Our findings indicate that students' personal efficacy (PMTE) can predict their belief in the potential of teaching to enact change (MTOE), until we control for preparedness to teach (PT) through regression analysis. When we control for MTOE, the statistically significant correlation between PMTE and PT is retained. It may be that PMTE does not predict MTOE, but rather that PT predicts both PMTE and MTOE. This would seem logical as the preparedness to teach index (PT) sought to measure how prepared participants felt to teach on their first graded placement in a classroom, having completed one module in mathematics education. Along with a sense of preparedness supporting students in holding strong beliefs of personal efficacy (Morris et al., 2017), the extent to which participants feel prepared to teach predicts their belief in the potential of teaching. Whether this correlation is causal or not is beyond the scope of this study, but our findings may suggest that students who believe that teaching has strong potential to enact change tend to feel better prepared to teach, and also hold more positive beliefs of personal efficacy than their peers who do not believe that teaching has strong potential to support children's learning. Equally, this finding may reflect a cohort of students who do not perceive teaching as potentially impactful are therefore less engaged in preparing, feel less prepared, and hold weaker beliefs of self-efficacy. However, these interpretations rest upon an understanding of students valuing the content of the mathematics education module they attended. Low scores on the PT index could also reflect conflict between the pedagogies promoted in the module and student experiences on School Placement or students' negative perceptions of the teacher education programme. The latter would reflect findings of Tschannen-Moran and Johnson (2011) that the perceived quality of teacher education predicted teacher efficacy.

In addition, the correlation between personal efficacy beliefs (PMTE) and preparedness to teach (PT) was retained when controlling for teaching outcome expectancy (MTOE). From this, we can say that the participants who identified that they felt better prepared to teach than their peers tended to have stronger beliefs in their personal potential to support learning, regardless of their general beliefs in the potential of teaching to support learning.

Limitations

While we contend that preparedness to teach, mathematics attainment, and gender are contributory variables to the variance in efficacy of our participants, it is important to note that the explanatory variables included in this model accounted for 17.6% of the between-student differences in their levels of PMTE. There exist therefore further extraneous variables beyond the scope of this study that also play a role in the self-efficacy beliefs of student teachers. For example, we suspect that a measurement of mathematics attainment that explicitly assesses conceptual understanding may contribute more to the variance in efficacy than the summative assessment that we had access to in this study. It is also pertinent to note that our sample size was small ($N = 186$), of which only 43 were post-graduate students. It cannot be said therefore that the findings are generalizable beyond this specific cohort. In particular, our finding that male students demonstrated weaker mathematics teaching outcome expectancy beliefs is drawn from a sample comprising 20 male and 166 female participants.

Conclusion

Our findings demonstrate that the content and nature of teacher education programmes matter, as preparedness to teach and mathematics attainment are contributory variables to the variance in efficacy of our participants. Within ITE programmes, attention should be given to developing students' sense of preparedness to teach through attention to those aspects that proved important for the students in this research: familiarity with structuring lesson plans, writing key questions, and sourcing lesson ideas. Furthermore, our findings highlight the responsibility on teacher educators to attend to the mathematics attainment of their students. It may be possible to dedicate attention to groups of student teachers who are at risk of low self-efficacy due to their attainment in mathematics. Similarly, our findings demonstrate a link between participants' gender and their belief in the potential of teaching to bring about understanding in mathematics. This finding prompts consideration of how best to support male students in interrogating their beliefs about fixed and growth mind-sets, in light of the recently established relevant body of research.

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Authors and Affiliations

Aisling Twohill[1,2] · Siún NicMhuirí[1,2] · Lorraine Harbison[1,2] · Anastasios Karakolidis[3]

✉ Aisling Twohill
aisling.twohill@dcu.ie

Siún NicMhuirí
siun.nicmhuiri@dcu.ie

Lorraine Harbison
lorraine.harbison@dcu.ie

Anastasios Karakolidis
anastasios.karakolidis@erc.ie

1 Dublin City University, Dublin, Ireland

2 Centre for the Advancement of STEM teaching and Learning (CASTeL), Dublin City University, Dublin, Ireland

3 Educational Research Centre, Dublin, Ireland