Associations of students self-reported efficacy beliefs towards mathematics education on completion of their first year in initial teacher education

Lorraine Harbison, Dublin City University, Ireland, lorraine.harbison@dcu.ie

Aisling Twohill, Dublin City University, Ireland, aisling.twohill@dcu.ie

Siún NicMhuirí, Dublin City University, Ireland, siun.nicmhuiri@dcu.ie

Abstract:

Recent changes in the landscape for primary initial teacher education (ITE) in Ireland prompted the first stage of this longitudinal design-research study on Mathematics Education which sought to establish a model of teaching and learning based upon iterations of research upon practice (Borko, Liston, & Whitcomb, 2007).

The challenge was to design a research led undergraduate Bachelor of Education (B.Ed.) mathematics programme of study that would focus on the development of students' efficacy, and more particularly in Year 1, on students' knowledge of and approaches to the teaching of Measures and perceived implementation of same on their first teaching placement in schools.

This first phase of the study gathered students' views retrospectively on the B.Ed. 1 programme, and explored their perceptions of the skills and abilities they possessed whilst teaching mathematics on School Placement.

The entire cohort of 430 first year ITE students were invited to participate in an online questionnaire based upon Enochs, Smith and Huinker's (2000) mathematics teacher efficacy beliefs instrument (MTEBI) with a small number of more open questions pertaining to the particular content of the first year programme.

This paper presents an analysis of the responses to the questionnaire and the implications for future research. While the response rate to the questionnaire was disappointing (40 questionnaires completed from 430 students invited) some preliminary findings include moderate self-efficacy scores across the MTEBI subscales, many students' inclination to draw from research-based resources in planning, and a specific lack of self-efficacy relating to the use of manipulatives.

Keywords: Design research, mathematics education, student teacher efficacy

1. Introduction

In September 2016, two colleges of education, St Patrick's College and the Church of Ireland College of Education were incorporated into Dublin City University (DCU) as part of a major national reform of initial teacher education (ITE) in Ireland. The reform was carried out under the auspices of the Department of Education and Skills (DES), as recommended by an International Review Panel into the structures of ITE globally that support best practice (DES, 2012).

The incorporation resulted in a combining of two student-intake streams, and two academic teams. We, the research team and authors of this paper, welcomed the challenge of redesigning our undergraduate pre-service teacher education programme by combining elements of both previous programmes, and drawing on research in the field.

The module was researched and designed with respect to the requirements stipulated by the Teaching Council (2017) which were to:

1. offer a rationale for, and clearly define the conceptual framework;
2. identify the principles, beliefs and values underpinning the programme;
3. provide evidence of how the aims of the programme link to the conceptual framework;
4. describe how the key themes will be revisited over the course of the programme.

Therefore this paper reports on the conceptual framework that guided the research design of the first of four modules of the reconfigured Mathematics Education programme within a four-year B.Ed. degree and the perceptions of the ITE students following completion of same. The module was delivered to 430 undergraduate student teachers, over a 12 week semester. Subsequently the students engaged in a School Placement that consisted of nine weekly one-day placements and a block placement of two weeks at the end of the academic year. Having completed both the module and the placement, students were invited to complete a questionnaire, the details of which are outlined in the methodology section. In this paper we present and discuss the students' responses to the questionnaire, and identify considerations for the design of Module 1 of the four-year Mathematics Education programme. To do so we draw from literature relating to initial teacher education, and teacher efficacy beliefs, and situate our research within the Irish context.

2. Literature review

This literature review synthesises the literature which informed our design for teaching and our research methodology. In the first instance, the conceptual framework underpinning the study is discussed. Subsequently, literature pertinent to mathematics education in ITE is explored.

In the research and design of the Mathematics Education programme of study, consideration was given to the well-established and much developed notion of what constitutes the kind of knowledge needed for teaching mathematics, namely both subject matter knowledge (SMK) and pedagogical content knowledge (PCK) (Shulman, 1986). However, research has consistently shown that in order to better prepare students to be resilient in navigating school cultures, in particular at the early stages in their career, and to implement in practice the kind of pedagogical strategies advocated in university, there is an explicit need to address teaching efficacy from the outset (Dellinger, Bobbett, Olivier, & Ellett, 2008).

2.1. Conceptual framework

The conceptual framework that underpins this research, and our teaching approach, is that of developing ITE students' efficacy in relation to the teaching and learning of mathematics in the primary school classroom. In general, self-efficacy beliefs are apparent in how we think, feel, motivate ourselves, and thus in how we behave (Swars, 2005). Furthermore, self-efficacy denotes how we perceive our own personal capability to accomplish certain levels of performance (Bandura, 1997). Teacher efficacy builds on the concept of self-efficacy and comprises two conceptual elements. The first construct is that of personal teacher efficacy which concerns a teacher's perception of his/her personal effectiveness and ability to teach. The concept has been the focus of research in European contexts (e.g., Capara, Barbaranelli, Steca, & Malone, 2006) and in recent years, research into teacher efficacy has gained momentum internationally (Klassen, Tze, Betts, & Gordon., 2011). Studies have consistently shown that a teacher's impressions of mathematics and their own self-assurance or self-efficacy in their mathematical competency are essential criteria for effective teaching (Ma, 1999). This is also true in relation to ITE students' mathematics in which self-efficacy is highly correlated to confidence in teaching mathematics (Bates, Kim, & Latham, 2011). The second construct addresses teaching outcome expectancy, which is a teacher's belief that effective teaching can result in quality learning outcomes for all children regardless of a child's background, aptitude and learner disposition (Swars, 2005; Enochs et al., 2000).

What makes this conceptual framework so vital is the positive correlation between teachers with a high level of efficacy and the qualities necessary for the successful teaching and learning of mathematics. These include the likelihood that these teachers will employ strategies that promote mathematical understanding such as problem-solving, math talk and guided-discovery learning rather than a more transmission model that relies heavily on applying procedures by rote and exhibits an over-dependence on the use of textbooks (Enochs et al., 2000; Swars, Smith, Smith, & Hart, 2009). Furthermore, Bandura (1997) suggests that it is important to address efficacy beliefs from an early stage in a student teacher's career as this can have long-term effects on their self-efficacy development and also, once perceptions of efficacy are established, they can be highly resistant to change.

2.2. Approaches to mathematics education in ITE

In this section, we present literature which informed the design of our programme. In this cycle of the longitudinal design research study, we focused on the first module encountered by students in Year 1 of a four-year B.Ed. programme. The module comprised 20 contact hours, including two plenary lectures and nine two-hour workshops. Content was designed to support students in interrogating their preconceived ideas of mathematics as a subject to be taught and learned, in order to facilitate them in engaging with multiple and progressive methods of supporting mathematics learning (Kennedy, 1997). Swars et al. (2009) highlight the challenge facing ITE in foregrounding teaching for understanding, and state that for many students a "paradigmatic shift" (p. 47) is necessary to move beyond replication of a transmission method of mathematics teaching. Alongside content relating to students' perception of mathematics teaching and learning, this first module also sought to develop students' SMK and PCK within the content area of Measures (Shulman, 1986). Developing students' SMK presents many challenges for teacher educators as Aubrey (1997, p. 160) writes, "Whilst knowledge of learning and teaching and classrooms increases with experience, knowledge of subject content does not." Therefore, in order to address this problem, the programme design has to afford the students experiences that might challenge their SMK and to address shortfalls in same as students' lack of SMK is often manifested by physical and psychological symptoms of high anxiety when it comes to teaching mathematics in the classroom (Friel-Myles, 2012).

Burghes (2012) shows that having a favourable attitude to the teaching of mathematics may help in some way to compensate for teachers with lower levels of SMK. Attitudes that align with a positive outcome expectancy are associated with a more creative, problem solving approach to mathematics. For ITE students, acquiring the skills associated with PCK, emphases are placed on transforming their SMK into powerful pedagogical experiences for their learners. Nevertheless, Williams and Lockley (2012, p. 42) state: "the academic construct of PCK is the recognition that teaching is not simply the transmission of concepts and skills from teacher to students but rather a complex and problematic activity that requires many and varied on the spot decisions and responses to students' on-going learning needs" and is heavily reliant on a high level of outcome expectancy that all children are capable of being "expert learners" of mathematics (CAST, n.d.).

The design focus on Measures was not chosen at random. National studies of mathematics attainment in Ireland have shown that children attending Irish primary schools have found measurement to be a relatively challenging strand of the curriculum. In 2014, a National Assessment of Mathematics and English Reading (NAMER) researched the attainment of 8000 Irish children across four content areas of a) Number and Algebra, b) Shape and Space, c) Measures, and d) Data (Shiel, Kavanagh, & Millar, 2014). NAMER 2014 found that among the 4000 children attending 6th class[3] who were assessed, 42% of the Measures test items were answered correctly, in comparison with 63% of Number and Algebra items, 62% of Shape and

[3]In Ireland children attend primary school for eight years, typically from the age of four or five. The classes are referred to as junior infants, senior infants, and 1st through to 6th class, with children typically aged eleven or twelve years at the beginning of 6th class.

Space items and 63% of Data items. Stephan and Clements (2003) caution that children's understanding of measurement concepts may lag behind that of number because of teaching approaches that prioritise procedural fluency above conceptual understanding. It is a priority therefore in preparing teachers to teach in Irish primary schools that we foreground conceptual understanding and equip students with skills and resources to support children's developing understanding within the content area of Measures.

The research module contained theory relating to children's developing understanding of measurement, and focused on identification of the attribute, units of measurement, instrument of measurement, accuracy and comparison as core concepts of measurement (Haylock, 2011). Attended to in particular detail were the subcategories of Measure comprising length, area, weight (mass), capacity, time and money. Existing research within the Irish education system has highlighted excessive use of commercially produced textbooks, and raised concerns about their impact for classroom practices (Eivers et al., 2010; Conway & Sloane, 2005). Students were guided, therefore, towards research-based resources to support children's conceptual understanding, and practical activities with rich mathematical content were modelled during workshops.

3. Methodology

The methodology employed was that of design research. This process encompasses four discrete stages; *design, enactment, analysis* and *redesign* (Borko, Liston, & Whitcomb, 2007). In this section, a brief overview of the design and enactment stages are given. Following this, the research methods employed to facilitate *analysis* of the influence of the mathematics education module and students' experiences of School Placement are described.

The *design* stage comprised of planning content and delivery of the B.Ed. 1 module. As highlighted above, planning for the course was predicated upon a strong theoretical base, and combined the knowledge base of both pre-existing courses and the Irish Primary School Mathematics Curriculum (PSMC) (Government of Ireland (GoI), 1999). The *enactment* phase involved facilitating seminars where the students encountered problem-based learning tasks on Measures which provided opportunities for mathematical exploration, consideration of possible pathways in learning, and sample classroom activities. Core concepts of Measure (attribute, units, instrument, comparison and accuracy) were also addressed (Haylock, 2011). During the semester, the students were required to collaboratively prepare a lesson and to enact this lesson in class using a team teaching approach. Constructive feedback was provided by lecturers, and sought from peers following which each student wrote an individual reflection essay which was assessed.

The *analysis* stage of the research, which is the primary focus of this paper, sought to evaluate the impact of the research module by focusing on the students' teacher efficacy beliefs during their first experience of teaching mathematics in classrooms. In the semester following delivery of the module students spent one day a week on placement in a school followed by an intensive two-week block. Students' teacher efficacy beliefs were investigated through the voluntary completion of an online questionnaire based on the Mathematics Teacher Efficacy Beliefs Instrument (MTEBI) questionnaire developed by Enochs et al. (2000) with a small number of more open questions pertaining to the particular content of the first year programme. The primary purpose of this analysis is to inform the redesign or refinement of our Mathematics Education modules so that the iterative cycle begins anew. Previous research has shown that ITE students' sense of efficacy increases during the initial stages of Mathematics Education courses but tends to decline by the end of programme (Utley, Moseley, & Bryant, 2005). Therefore, it is important to initially determine the ITE students' efficacy and to re-design the programme year-on-year to ensure that problematic areas are identified and addressed.

In the following section we outline the steps we took in administering the questionnaire, and draw attention to the methodological decisions we made, including ethical concerns, issues relating to our sample, and the MTEBI questionnaire.

3.1. Ethics

Prior to inviting students to reply to the questionnaire, we considered the ethical implications of surveying students who had studied our modules. Clarke and McCann (2005) draw attention to the power dynamic implicit in the lecturer-student relationship, and caution that such a dynamic has implications for the notion of informed consent. Students on the education programmes in our university would not be viewed as a 'vulnerable' population in that they are academically capable, healthy adults, and normally their participation in such a study would be considered of low ethical risk. However, the ability of students to refuse consent in this context could potentially be hindered by their perceived need to maintain a positive relationship with their lecturer. The students, whose views were vital to this research, had completed one module taught by the research team, and wherein we also assessed their work. All students will engage in further modules over the next three years, to which we will contribute. Furthermore, a proportion of students will potentially encounter at least one of the research team on School Placement in which supervised visits are assessed. We endeavoured therefore to establish distance between ourselves and invitations to the students to engage in the questionnaire, and a third party managed all communications with the students regarding the research questionnaire. In the invitation to participate students were guaranteed anonymity, informed that the survey data would be collected anonymously, and advised that participation was voluntary and not monitored, in line with the recommendations of Clarke and McCann (2005). While this strong ethical stance ensured that our research would have no negative implications for our student cohort, the distance achieved between us and the students hampered us in motivating students to participate, and the response rate achieved was disappointing.

3.2. Sample

We invited all 430 students who had engaged with the programme to complete the questionnaire. Further detail pertaining to the questionnaire is presented in section 3.3 below. The students were in their first year of undergraduate study on a B.Ed. programme. Entry to this programme is competitive and based upon the students' results in state examinations on leaving secondary school at around the age of 18. The cohort invited to participate in this study obtained results within the top 15% of all students completing secondary level education in 2017.

Only 40 of the 430 students completed the questionnaire. In the analysis and findings presented in this paper we describe the responses of the students who participated, but these findings could not be said to be generalizable to the student population who engaged with the module. We suggest however that this preliminary stage of the research sheds some light on the experience of some students and in a similar manner to qualitative research the findings may be "transferable" and at the very least, we can consider the findings as a pilot in order to scale up the research process in the forthcoming academic year (Marshall & Rossman, 2011, p. 76).

3.3. The questionnaire

We compiled a questionnaire with two components: a) questions relating to the Mathematics Education module on Measures undertaken and the respondent's experience on School Placement, and b) the MTEBI questionnaire of Enochs et al. (2000). Questions relating to the research module asked students what class level they taught on School Placement, the number of mathematics lessons taught, the number of lessons taught from the Measures strand of the curriculum, the student's perceived level of preparedness and the resources the students drew from.

The MTEBI was developed as a mathematics-specific teaching efficacy instrument for use with preservice teachers (Enochs et al., 2000). It is well validated and has been used in multiple cohorts internationally (Matney, Panarach, & Jackson, 2013; Swars, 2005). There are a total of 21 items on the MTEBI with 13 items on the Personal Mathematics Teaching Efficacy (PMTE) and 8 items on the Mathematics Teaching Outcome Expectancy (MTOE) subscale. Each item has five response categories on a Likert Scale ranging from strongly agree to strongly disagree. Therefore, the minimum score on the PMTE is 13 and extends up to a possible 65 where the subscale scores range from eight to 40 on the MTOE as shown on Table 1.

Table 1: Subscales of the MTEBI

Subscale	*Number of items*	*Minimum possible score*	*Maximum possible score*
Personal Mathematics Teaching Efficacy (PMTE)	13	13	65
Mathematics Teaching Outcome Expectancy (MTOE)	8	8	40

Many items are written in the future tense which allows the ITE students to reflect on hoped for or prospective beliefs rather than being hindered by lack of experience at this preliminary stage in their professional development as a teacher. Items on self-efficacy contain both positive and negatively worded statements. Sample items include:

> Self-efficacy: I will continually find better ways to teach mathematics.
> When a learner has difficulty understanding a mathematics concept, I will usually be at a loss as to help the learner understand it better.
> Outcome expectancy: When a learner does better than usual in mathematics, it is often because the teacher exerted a little extra effort.

The two subscales are independent and are distributed randomly which further adds to the validity of the MTEBI (Enochs et al., 2000). The results were collated using Excel and were analysed separately.

4. Analysis

As our research focus is on the design of our programme in order to support and develop students' proficiency in teaching, our analysis of the data collected through the questionnaire was structured around three focus questions: a) at a practical level, did the students draw from the resources we recommended; b) in general do our students believe that will teach effectively; c) what elements of the students' self-efficacy are most or least concerning for us as teacher educators. In this section we will deal with each of these questions in turn, preceded by an overview of the opportunity the students had to enact the content covered in the research module.

4.1. Enactment of module content

As mentioned above, the content of the research module was focused on the teaching of Measures. Measures is one of five content strands of the Irish PSMC, the other strands being Number, Algebra, Shape and Space, and Data (GoI, 1999).

Of the 40 participants in this survey, 28 taught Measures on the School Placement that immediately followed their engagement with this module. Table 2 contains the number of Measures lessons taught for the cohort, compared with the number of mathematics lessons taught by students on all other content strands.

Table 2. The number of Measures lessons taught by the research participants on the School Placement immediately following their engagement with the research module.

Number of lessons taught	*Measures (number of students)*	*All other content strands (number of students)*
0	12	16
1	1	6
2	3	2
3	10	4
4	6	8
5	4	2
6	2	1
>6	2	1
Mean	2.7	2
Median	3	4
Total	107	80

As can be seen from Table 2, students taught more lessons from the Measures content strand of the curriculum than from all other strands combined (107 Measures lessons and 80 lessons from the content strands of Shape and Space, Number, Data, and Algebra). One student taught no mathematics lessons, and of the 39 students who did teach mathematics lessons, 11 students taught no Measures lessons, while 15 students only taught Measures. Among the 28 students who taught Measures, the mean number of Measures lessons taught was 3.8.

Typically, when students undertake School Placement they have limited choice in the topics that they cover, but are expected to cooperate closely with the classroom teacher, and adhere to his/her long term planning for the class. Over years of supervising students on School Placement, we had anecdotally observed a preponderance of Measures lessons on students' initial School Placement and this observation was a further motivation for focusing on Measures in Year 1 of the 4-year B.Ed. programme. The strong tendency of students to teach Measures lessons was therefore not surprising. Equally, considering the low response rate to the questionnaire, students who did not teach Measures may have been disinclined to respond if they felt that their School Placement experience was not as closely connected to their Mathematics Education module as it may have been for other students.

Within the Irish PSMC, the Measures strand is organised into six strand units focusing on the measurement of Length, Area, Weight (Mass), Capacity, Time and Money. Table 3 contains the number of lessons taught for each Measures strand units.

Table 3. The number of lessons taught by the research participants relating to each Measures content area

	Length	*Area*	*Mass*	*Capacity*	*Time*	*Money*
Total number of lessons taught	24	3	28	16	16	29
Average number of lessons per student	1.1	0.1	1.2	0.8	0.7	1.1

As can be seen from Table 3, a reasonable number of lessons were taught by the cohort on each strand unit other than Area. Within the Irish PSMC the strand unit of Area is introduced in 2nd class. On students' first School Placement they are required to teach a junior class[4], and many students would not have had the option of teaching lessons involving the measurement of area. Considering that 28 students taught Measures lessons and that 107 lessons were taught across a variety of strand units, we considered it worthwhile to explore how well prepared the students felt they were to plan and deliver these lessons.

4.2. Student perception of preparedness and use of recommended resources

Within the questionnaire, the students were asked questions relating to their perception of preparedness for the teaching of Measures on School Placement, and also the resources they drew from. This is an important factor as a teacher's sense of efficacy can be partly influenced by their judgement of the resources and constraints in relation to the specific context that they teach in (Tschannen-Moran, Woolfolk Hoy, & Hoy, 1998). In other words, a teacher's perceived access to mathematics resources as well as their perception of their preparedness for teaching mathematics on School Placement may lead to teachers' efficacy judgments regarding their ability to teach mathematics (Bandura, 1997).

In Figure 1 we present the student responses to questions relating to preparation for teaching:

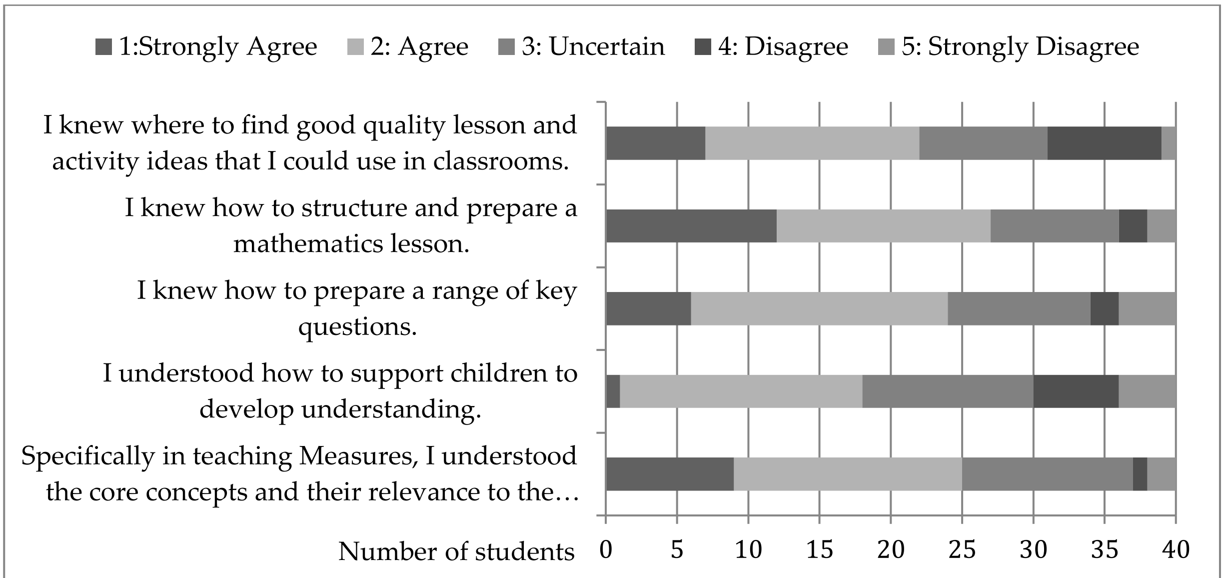

Figure 1. The students' responses to questions relating to preparedness for the teaching of Measures

[4] Junior class refers to junior infants, senior infants, first class and second class.

We designed these statements with an underlying hierarchy of complexity, beginning with locating lesson activities, progressing to structuring a lesson, preparing key questions, supporting the development of understanding, and understanding the key theoretical aspects of the mathematics of measurement. This hierarchy may be visible in Figure 2 in the gradual decline of certainty as students responded to statements 2, 3, and 4. With regard to the fifth statement, the students responded positively with 25 of the 40 indicating that they agreed or strongly agreed with the statement. It is possible that the wording of this statement focused solely on understanding, and if it had referred to enactment of the understanding the students' response may have been less positive.

Mindful of the tendency of teachers to revert to traditional teaching methods within a short time of completing their initial teaching education, we felt it pertinent to alert the students to research based teaching manuals that they might draw from throughout their careers (Kennedy, 1997). As highlighted above, during seminars we emphasised moving beyond school textbooks and drawing from such teaching resources, for example teacher handbooks, and websites. Figures 1 and 2 contain the responses of students to the questions relating to preparedness and resources.

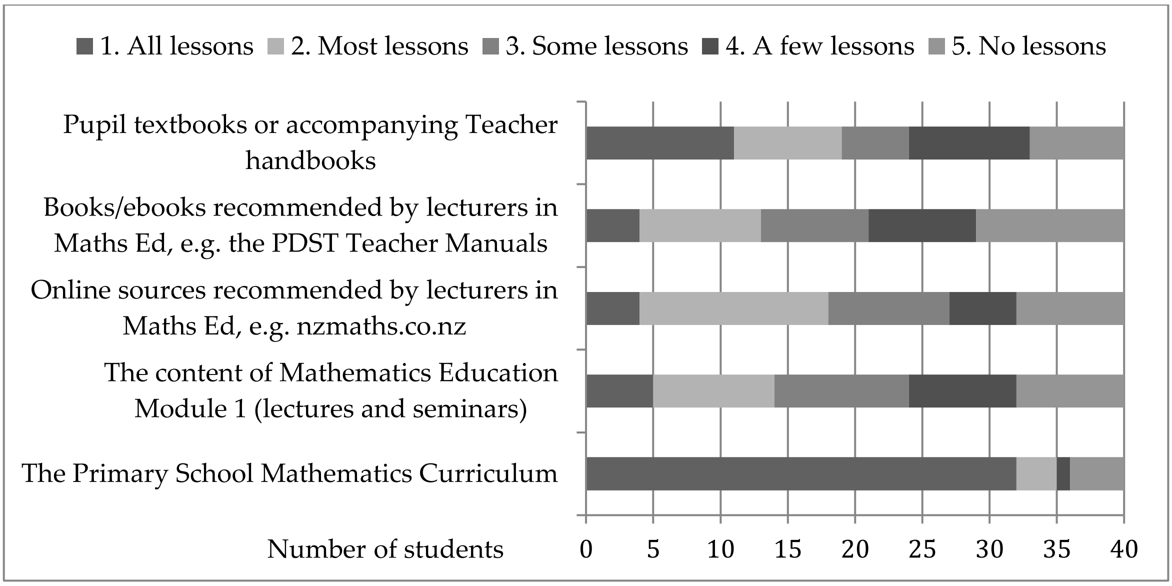

Figure 2. The students' responses when asked how often they drew from specified resources during School Placement

While DCU students are strongly encouraged across all subject areas of the B.Ed. to draw from research based texts recommended in seminars and lectures, they face multiple pressures within the School Placement structure. As guests in a teacher's classroom, they need to show deference to the teacher's methods, and this at times includes eschewing the guidance of their university lecturers. That said the responses of students to this question relating to how often they drew from specified resources was encouraging. Almost all students drew from the Irish PSMC (35 of 40) in all or most lessons. While only five students indicated that they drew from the content of the research module in all lessons, 32 of the cohort of 40 responded that they drew from university course content in at least a few lessons. Findings were similar for online sources and books recommended by lecturers, with only a few students indicating that they did not draw from these sources at all. Combining the responses relating to course content and recommended sources, most students indicated that they drew from one or other of these research based sources for some lessons with only three students indicating that they never drew from them, and two additional students indicating that only drew from them in planning 'a few' lessons.

4.3. Student efficacy beliefs: an overview

Overall the results of the MTEBI indicate that average students' self-efficacy scores (2.39) and outcome expectancy belief scores (2.54) hover around the midpoint of the Likert Scale (see Table 4).

Table 4. Overall results on the Mathematics Teaching Efficacy Beliefs Instrument

	Overall responses Mathematics Teaching Efficacy Beliefs Instrument (MTEBI)	*Personal Mathematics Teaching Efficacy Belief (PMTE)*	*Mathematics Teaching Outcome Expectancy (MTOE)*
Average	51.35	31.025	20.325
Max	79	52	34
Min	37	18	13
Mode	51	31	17
Max possible	105	65	40

As mentioned previously, the items on the two subscales are distributed randomly throughout the MTEBI and were analysed separately. Therefore a more in depth analysis is provided in the next section to rationalise the responses.

4.4. Personal mathematics teaching efficacy belief (PMTE)

Research has demonstrated links between effective teaching and teachers' self-efficacy beliefs and confidence in their own mathematical competency. Teacher efficacy is pertinent to our programme design as teachers with high levels of efficacy have been shown to be more likely to be confident in teaching mathematics and to employ inclusive teaching strategies with flexible goals, methodologies, resources and assessment practices that promote mathematical understanding (Bates et al., 2011; Enochs et al., 2000; Swars et al., 2009; CAST, n.d.). The responses to the five positively worded PMTE items as on Figure 3 below exhibited a high level of self-efficacy with the exception of one item which states that "I know how to teach mathematics concepts effectively" in which only 15 of the 40 participants responded that they either agreed or strongly agreed with this statement. It is not surprising that students exhibited low efficacy on this item considering that this is only their first year of the four year programme in which the students have engaged with the concept of teaching Measures alone.

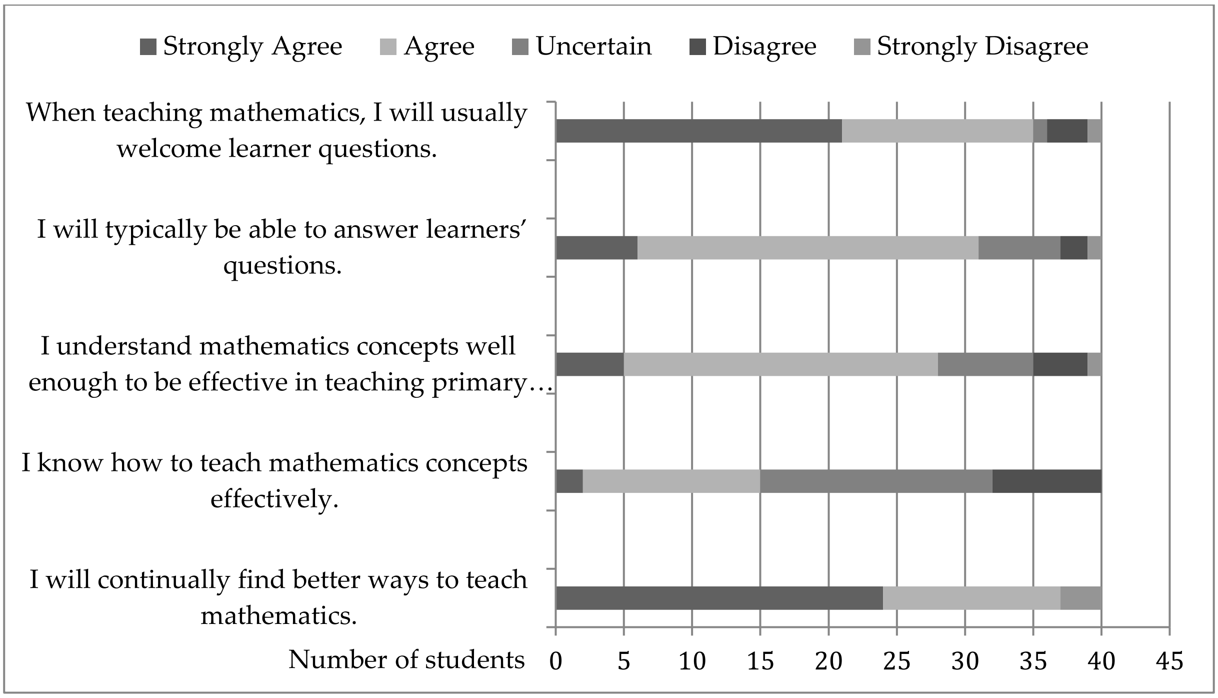

Figure 3. Responses to the five positively worded Personal Mathematics Teaching Efficacy items

The eight items in Figure 4 below were negatively worded. These responses were reversed in the overall scoring system to produce a consistent value for those producing high scores having high PMTE and vice versa. For the purpose of this analysis, the responses have not been reversed and are grouped together into three categories; those who strongly agreed or agreed: those who were uncertain: and those who either disagreed or strongly disagreed.

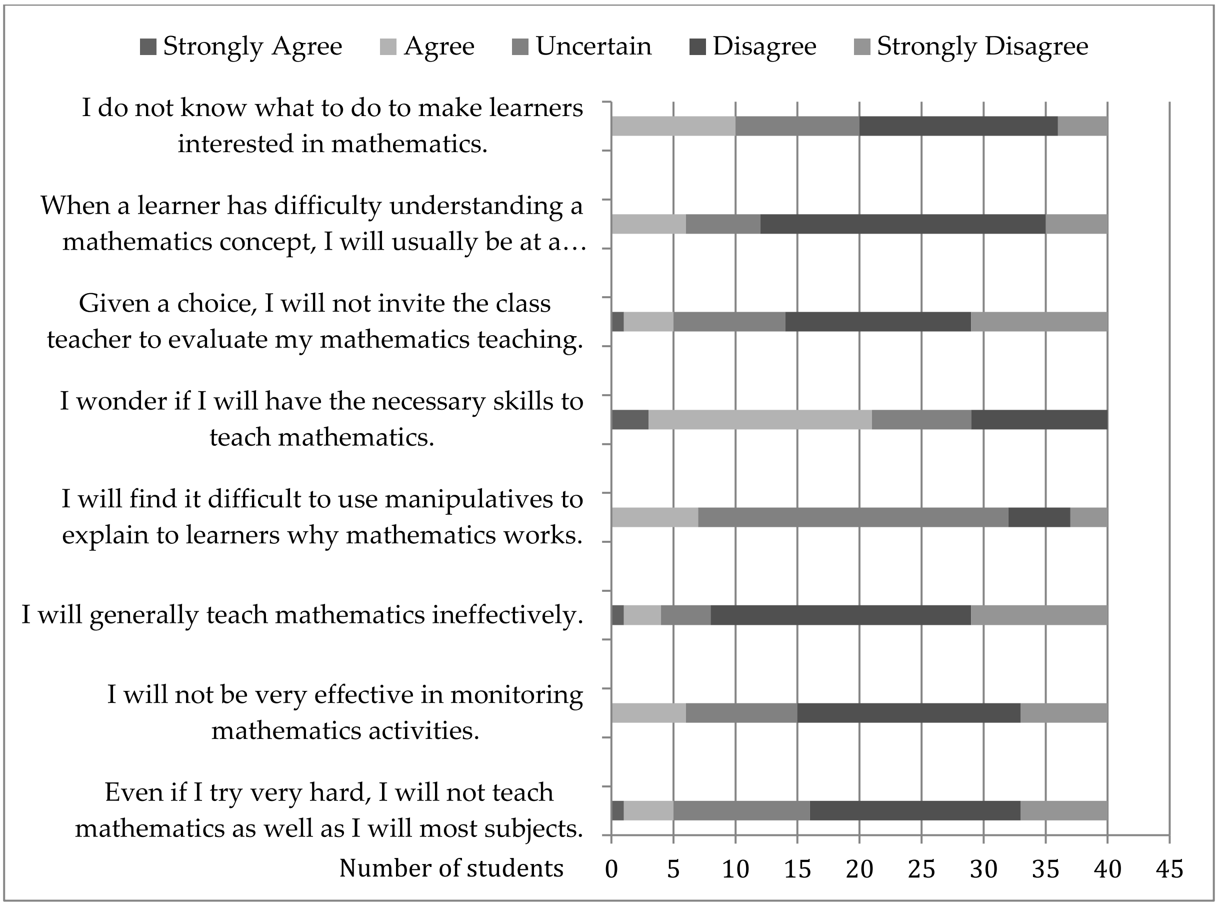

Figure 4. Responses to the eight negatively worded Personal Mathematics Teaching Efficacy items

There is a low sense of PMTE in three items. Nearly three-quarters of respondents believe that they may not possess the skills necessary to teach mathematics and half of the respondents believe that they have a difficulty making mathematics engaging for the learners in their classrooms. As mathematics educators, it is of interest to us whether these beliefs are general beliefs about teaching or whether they are specific to mathematics teaching. Klassen et al. (2011) discuss the affordances and constraints of domain specificity in teacher efficacy research and this is one example where comparing the mathematics teacher efficacy beliefs with the general teacher efficacy beliefs of the same students might illuminate subject-specific issues.

Of note, only 20% of responses (8 students) indicated that they would not find it difficult to use manipulatives to support the teaching of mathematics with understanding. This has direct implications for the research team in the design of the programme to ensure that manipulatives are embedded in the teaching and learning of mathematical concepts.

4.5. Mathematics teaching outcome expectancy (MTOE)

The second construct which contributes to teacher efficacy is teaching outcome expectancy. This relates to whether a teacher believes that effective teaching can result in quality learning outcomes for all children regardless of a child's background, aptitude or disposition (Enochs et al., 2000). This construct has particular relevance in mathematics education where mathematics has been recognised as a 'gatekeeper' and notions of fixed ability and related pedagogical practices such as ability grouping have long been identified as problematic (Boaler, Wiliam, & Brown, 2000).

There is some contradiction in the responses to items on the MTOE scale. It appears in Figure 5 below that ITE students believe that when the mathematics grades of learners improve, then this is due to the effectiveness of teacher. However, the corollary is not true. That is, that underachievement is not a reflection on teacher' effectiveness.

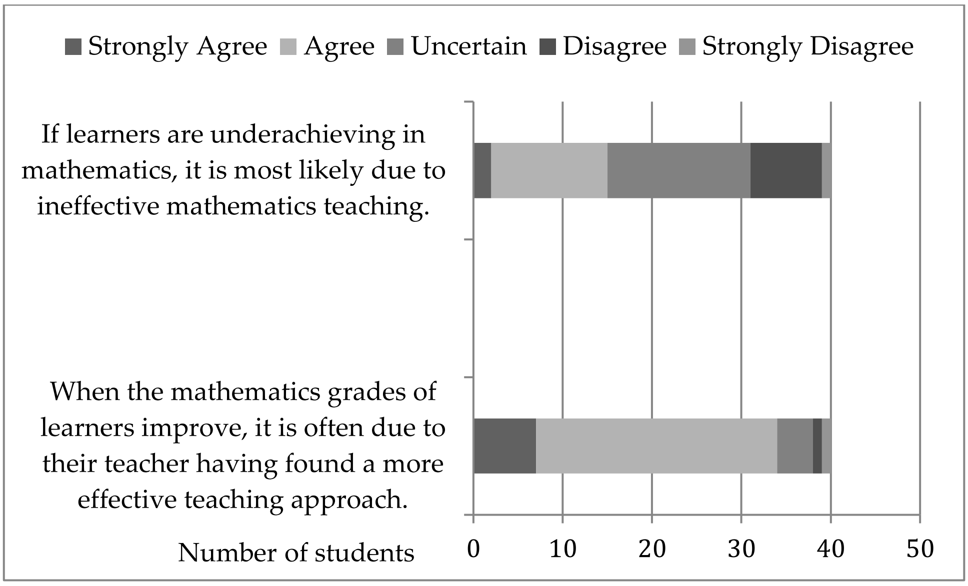

Figure 5. Learner's achievement in mathematics as a consequence of effective teaching

It is also interesting to note that there were fairly consistent responses to four further items from over half of the participants to the statements that suggest a positive correlation between teacher efficacy and learner achievement as in Figure 6.

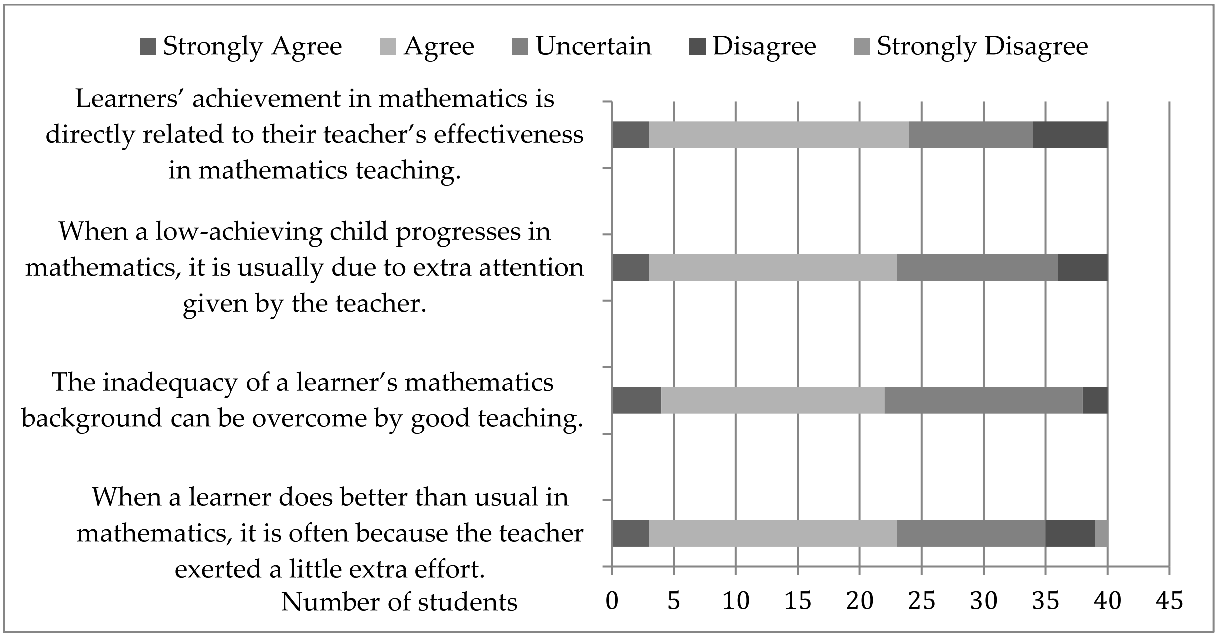

Figure 6. Learner's achievement in mathematics as a consequence of teacher efficacy

However, in response to a further two items on outcome expectancy, it is noted that the majority of participants did not believe that the teacher is responsible for a child's interest or performance at school. No one strongly disagreed with either of these statements. As above, it would be informative to compare these domain-specific findings with consideration of general teacher-efficacy beliefs.

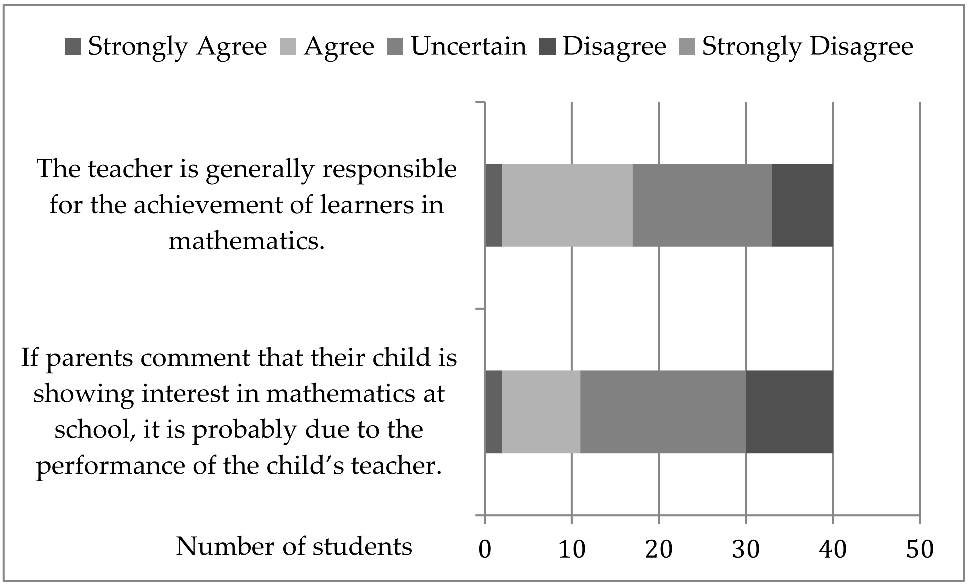

Figure 7. Learner's achievement in mathematics as a consequence of the teacher

5. Discussion and conclusion

This research was initiated as a proactive response to a major reform of the structures of ITE in Ireland to support best practice (Teaching Council, 2017). We are undergoing an iterative process of design research with the intention of investigating and refining the Mathematics Education modules undertaken by students on our undergraduate B.Ed. programme (Borko et al., 2007). This first phase of the research involved the design of a module on Measures for 460 first year ITE students. Students' perceptions of the module and their mathematics teacher efficacy beliefs were investigated using an online questionnaire based on Enochs et al. (2000) MTEBI. All 430 students were invited to complete the questionnaire but only 40 did so. Despite the low uptake, the analysis gives insight into the experience of some students and offers future potential for scaling up.

The results of this first phase indicate that students' scores on the MTEBI were moderate for both PMTE and MTOE. Overall, average students' scores tended towards the midpoint of the Likert Scale for both subscales but while the responses to the five positively worded PMTE items generally exhibited a high level of self-efficacy, responses to three of the eight negatively worded statements appear to contradict this. The students' responses to questions relating to their capacity in preparing for teaching were encouraging; while their self-efficacy relating to children's conceptual understanding or 'effective' teaching was less assured. Many students expressed determination to "find better ways to teach mathematics" and demonstrated this commitment in drawing from a variety of research-based sources in their teaching. However, nearly three-quarters of respondents reported believing that they may not possess the skills necessary to teach mathematics. Of particular interest was the students' lack of self-efficacy regarding the use of manipulatives in explaining how mathematics works to children. Only 20% of responses indicated that they would not

find it difficult to use manipulatives to support the teaching of mathematics with understanding and half reported that they have difficulty making mathematics engaging for learners. Some contradictory results also arose on the MTOE subscale. Students responses appear to suggest that they believe increases in pupils' mathematics achievement are due to the effectiveness of the teacher but pupil underachievement is not a reflection on teachers' effectiveness. Responses also suggest that the majority of respondents did not believe that the teacher is responsible for a child's interest or performance at school. In total, 32 respondents stated that they drew from the course content in at least a few SP lessons.
While caution is necessary regarding interpretations of these findings, they raise important issues for programme design. Currently, we have designed and taught the first module of a four-module programme. The questions that guide us at present relate to students' current efficacy beliefs, students' perceptions of the module and how prepared they felt to teach Measures on School Placement. Interrogation of students' perceptions of SP was included because early career experience has been shown to have a powerful influence on perceptions of efficacy and efficacy levels have been shown to be malleable at this career stage (Woolfolk Hoy & Burke Spero, 2005).

This first phase provides the necessary context for both scaling up the research and considerations for the design of the second year programme. It is crucial that a minimum response rate of 25% to the online questionnaire is achieved in order to establish the baseline efficacy of the current cohort of first year students. It is also anticipated that in order to acutely analyse the effectiveness of the first year programme, qualitative data will be obtained. To this end, the same cohort of students will be invited to participate in a semi-structured focus group interview (Freebody, 2003). In these interviews, we propose to discuss issues arising from the MTEBI analysis as well as students' experiences of teaching mathematics on SP and their perceptions of the (dis)connections with the taught research module using an adapted interview protocol by Swars (2005). It is intended that thematic analysis (Braun & Clarke, 2006) of transcripts will be undertaken. We further intend to track these students as they progress through the BEd programme. In this way our design-research study aligns with recommendations by Klassen et al. (2011) who call for more qualitative, longitudinal studies which explore sources of teacher efficacy. Our aim is more than simply an evaluation of our ITE programme (Adler, Ball, Krainer, Lin, & Novotna, 2005). We expect that the questions and conjectures which will arise at various points during our longitudinal research will inform theories of teacher learning as well as improvements in our teaching practice (Borko et al., 2007).

6. Acknowledgements

With special thanks to DCU Incorporation, Shared Research Fund (SRF), 2017.

7. References

Adler, J., Ball, D., Krainer, K., Lin, F. L., & Novotna, J. (2005). Reflections on an emerging field: Researching mathematics teacher education. *Educational Studies in Mathematics*, 60, 359 - 381.

Aubrey, C. (1997). *Mathematics teaching in the early years: an investigation of teachers' subject knowledge.* London, UK: The Falmer Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York, USA: Freeman.

Bates, A.B., Kim, J., & Latham, N. (2011). Linking preservice teachers' mathematics self-efficacy and mathematics teaching efficacy to their mathematical performance. *School Science and Mathematics, 111*(7), 325-333.

Boaler, J., Wiliam, D., & Brown, M. (2000). Students' experiences of ability grouping: Disaffection, polarisation, and the construction of failure. *British Educational Research Journal*. 26(5), 631 - 648.

Borko, H., Liston, D., & Whitcomb, J. (2007). Genres of empirical research in teacher education. *Journal of Teacher Education*, *58*(1), 3 – 11.

Braun, V., & Clarke, V., (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101.

Burghes, D. (2012). *Enhancing primary mathematics teaching and learning* (Research Report). Plymouth: CfBT Education Trust in collaboration with the Centre for Innovation in Mathematics Teaching.

Caprara, G. V., Barbaranelli, C., Steca, P., & Malone, P. S. (2006). Teachers' self-efficacy beliefs as determinants of job satisfaction and students' academic achievement: A study at the school level. *Journal of School Psychology*, 44, 473– 490.

CAST (n.d.). *Top 5 UDL tips for fostering expert learners.* Retrieved from http://castprofessionallearning.org/project/top-5-udl-tips-for-fostering-expert-learners/

Clark, E., & McCann, T. V. (2005). Researching students: an ethical dilemma: *Nurse Researcher*, *12*(3), 42-51.

Conway, P., & Sloane, F. (2005). *International trends in post-primary mathematics education.* Dublin, Ireland: NCCA.

Dellinger, A., Bobbett, J., Olivier, D., & Ellett, C. (2008). Measuring teachers' self-efficacy beliefs: Development and use of the TEBS-Self. *Teaching and Teacher Education, 24*, 751–766.

Department of Education & Skills (2012). *Report of the International Review Panel on the Structure of Initial Teacher Education Provision in Ireland.* Dublin, Ireland: DES.

Eivers, E., Close, S., Shiel, G., Millar, D., Clerkin, A., Gilleece, L., et al. (2010). *The 2009 national assessments of mathematics and English reading.* Dublin, Ireland: The Stationery Office.

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics, 100*(4), 194-202.

Freebody, P. (2003). Qualitative research in education: Interaction and practice. London, UK: Sage.

Friel-Myles, S. (2012). *How can a maths anxious teacher promote positive attitudes towards mathematics?* (Unpublished B.Ed. graduate dissertation). University of Dundee, Dundee, Scotland.

Government of Ireland. (1999). *Irish primary school curriculum mathematics.* Dublin, Ireland: The Stationery Office.

Haylock, D. (2011). *Key concepts in teaching primary mathematics*. Los Angeles, California, USA: Sage.

Kennedy, M. (1997). The connection between research and practice. *Educational Researche*r, 26(7), 4-12.

Klassen, R. M., Tze, V. M. C., Betts, S. M., & Gordon, K. A. (2011). Teacher efficacy research 1998 –2009: Signs of progress or unfulfilled promise? *Educational Psychology Review*, 23, 21– 43.

Ma, L. (1999). *Knowing and Teaching Elementary Mathematics*. Mahwah, New Jersey, USA: Lawrence Erlbaum Associates.

Marshall, C., & Rossman, G. B. (2011). *Designing Qualitative Research (5th edition).* Thousand Oaks, California, USA: Sage.

Matney, G., Panarach, Y., & Jackson, J. (2013). Translating mathematics efficacy. *6th East Asia Regional Conference on Mathematics Education.* 17-11 March 2013, Phuket, Thailand.

Shiel, G., Kavanagh, L., & Millar, D. (2014). *The 2014 National Assessments of English Reading and Mathematics, Volume 1: Performance Report*. Dublin, Ireland: Educational Research Centre.

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4–14.

Stephan, M., & Clements, D. H. (2003). Linear and area measurement in prekindergarten to grade 2. In D. Clements & G. Bright (Eds.), *Learning and teaching measurement: 2003 Yearbook of the National Council of Teachers of Mathematics* (pp. 3-16). Reston, VA: NCTM.

Swars, S. (2005). Examining perception of mathematics teaching effectiveness among elementary preservice teachers with differing levels of mathematics teacher efficacy. *Journal of Instructional Psychology, 32*(2), 139-147.

Swars, S. L., Smith, S. Z., Smith, M. E., & Hart, L. C. (2009). A longitudinal study of effects of a developmental teacher preparation program on elementary prospective teachers' mathematics beliefs. *Journal of Mathematics Teacher Education*, 12(1), 47-66.

The Teaching Council (2017). *Initial teacher education: Criteria and guidelines for programme providers.* Kildare, Ireland: Teaching Council.

Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68* (2), 202-248.

Utley, J., Moseley, C., & Bryant, R. (2005). Relationship between science and mathematics teaching efficacy of preservice elementary teachers. *School Science and Mathematics, 105*(2), 82-87.

Williams, J. & Lockley, J. (2012). Using CoRes to develop the pedagogical content knowledge (PCK) of early career science and technology teachers. *Journal of Technology Education*, *24*(1), 34-53.

Woolfolk Hoy, A., & Burke Spero, R. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and Teacher Education*, 21, 343–356.