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An attitudinal snapshot of pre-service secondary mathematics teachers

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A teacher's attitude towards a subject has a major influence on their learning and subsequent teaching of that subject. This has a knock-on effect on the development of their own students' attitudes. However, despite such importance there has been a dearth of research in this area, particularly in relation to the attitudes of pre-service secondary teachers of mathematics. Thus, the aim of this study is to quantify the attitudes of this cohort of teachers at the beginning of their initial teacher education (ITE) program. The participants in the study are pre-service teacher cohorts (N = 98) from four Irish universities who are enrolled in a postgraduate ITE program, known as the Professional Master of Education (PME). Six sub-scales of the overall Fennema-Sherman Mathematics Attitudes Scales (FSMAS) were used to gain a quantitative measure of participants' attitudes towards the subject as they embarked on their ITE. The FSMAS scores were strongly positive, although the results of the mathematics anxiety and teacher subscales were notably lower in comparison to the others. Further analysis was carried out to identify affecting factors, particularly in relation to these two low-ranking subscales.

Introduction

Attitude, as a part of the affective domain, has long been recognised as an important aspect of mathematics teaching and learning (Fennema & Sherman, 1976). In the literature there are mentions of interest, appreciation, confidence, and perseverance in relation to attitudes, but no one singular definition (Mullis, Martin & Loveless, 2016). These terms, alongside belief, anxiety, and motivation are all common when discussing attitudes. However, there are some differing views. McLeod (1992), for example, claimed that attitude is related to, but distinct from, other aspects of affect in mathematics, such as belief (about mathematics, about oneself, etc.), emotions, anxiety, and confidence. He defined attitude specifically as "positive or negative feelings [towards mathematics] of moderate intensity and reasonable stability" (McLeod, 1992, p. 581). This is similar to the longstanding definitions of Neale (1969) who set forth mathematical attitude as a liking or disliking of mathematics and Hart (1989) who defined attitude as a favourable or unfavourable disposition.

On the other hand, Fennema and Sherman (1976) took a much broader view of attitude, and defined nine different attitudinal criteria, including student confidence, anxiety,

usefulness of mathematics, and feelings towards success in the subject. Similarly, Ma and Kishor (1997) conceived attitude towards mathematics as "an aggregated measure of a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless" (p. 27). For the purpose of this study, the authors have adopted the views of Fennema and Sherman (1976) and Ma and Kishor (1997) and interpret mathematical attitudes to refer to a broad construct of individuals' attitudes toward the subject.

There has been considerable interest in the study of individuals' attitudes toward mathematics over the past forty years (Lim & Chapman, 2013). Much of this research has centred on students' attitudes and the relationship between attitude and achievement in the subject (Ma & Kishor, 1997; Papanastasiou, 2000). Lipnevich, MacCann, Krumm, Burrus and Roberts (2011) found that students' mathematical attitudes could predict their mathematics achievements, irrespective of their ability. For example, students who are over anxious or lack confidence may be unable to apply and make sense of the mathematics knowledge they possess (Ashcraft & Kirk, 2001). On the other hand, having a positive attitude towards mathematics can influence one's willingness to engage in mathematical activities and learn (Mata, Monteiro & Peixoto, 2012).

These attitudes, whether positive or negative, are generally considered as having been learned (Leavy, Hourigan & Carroll, 2017; White, Way, Perry & Southwell, 2005), and there are a number of influencing factors such as a student's gender (Cantley, Prendergast & Schlindwein, 2017; Goldman & Penner, 2016; Prendergast & O'Donoghue, 2014), their previously attained levels of achievement (Aiken, 1970; Ma & Kishor, 1997; Mullis et al., 2016), and their teacher's attitude towards the subject (Stipek, Givvin, Salmon & MacGyvers, 2001).

Teachers' attitudes towards mathematics

A teacher's attitude towards a subject has a major influence on their learning and subsequent teaching of that subject (Young, 1998). This has a knock-on effect on the development of their own students' attitudes (Cornell, 1999; Midgley, Feldlaufer & Eccles, 1989; Prendergast & O'Donoghue, 2014; Stipek et al., 2001). For example, Ernest (1989) determined that a teacher's attitude to mathematics may affect their attitude to the teaching of the subject, which in turn can have a powerful impact on the atmosphere and ethos of their classroom. Karp (1991) found that elementary teachers with negative attitudes toward the subject frequently used teacher-centred approaches and did not actively engage students in learning mathematics. Other negative attitudinal traits such as mathematics anxiety in elementary teachers have been found to influence confidence in their teaching ability, which leads to a cyclical phenomenon, breeding higher anxiety and more negative attitudes amongst their own students (Brady & Bowd, 2005). This may then have implication in terms of their students' achievement. For example, in a U.S. study involving elementary school teachers and children, Beilock, Gunderson, Ramirez and Levine (2010) found that female teachers' mathematics anxiety affected girls' mathematics achievement.

On the other hand, more positive teacher attitudes have been found to be associated with success in teaching. Teachers who have positive attitudes can establish good relationships in classes, create positive energy, and facilitate the process of learning, which all enhance the quality of teaching (ener, 2015). With reference to mathematics, White et al. (2005) found that positive attitudes and high content knowledge were two elements necessary for effective teaching of the subject, while Ransome, Mohamed and Bridgemohan (2016) found that strong positive feelings and high expectations were crucial factors in allowing teachers to perform to their optimum potential. Similarly, Stipek et al. (2001) found significant correlations between primary school teacher attitudes and classroom practices as well as correlations between teachers' and students' self-confidence and enjoyment of mathematics. More specifically, Wilkins (2008) noted a link between positive teacher attitudes and an inclination towards inquiry-based pedagogical techniques (these techniques were defined by active engagement of students and the use of meaningful mathematics problems). As such it can be reasonably deduced that a positive teacher attitude towards their subject is an important quality of effective teaching.

Pre-service teachers' attitudes towards mathematics

The importance and influence of pre-service teachers' attitudes towards their subject are no different (Rodrigues, Cézar & Rosa, 2017). Bekdemir (2010, p. 313) noted that pre-service teachers "were regular students in their past, are teacher candidates of today, and will be the teachers of tomorrow". Thus, their attitudes towards mathematics have the potential to shape those of future generations of students. However, Calderhead and Robson (1991) and Joseph (2019) cautioned that incoming pre-service teachers hold strong images of teaching, both negative and positive, and these images strongly influence how they approach their initial teacher education (ITE) programs. This is an important point and Richardson (1996) evidenced that attitudes are important considerations in conducting ITE programs designed to help pre-service teachers develop their thinking and practices. In such programmes, the attitudes of pre-service teachers strongly affect what and how they learn (Richardson, 1996). It is important that any negative attitudes from pre-service teachers own experiences as learners of mathematics are addressed, before persisting into their own classrooms, and having a continuing cyclical effect on the students whom they teach (Brady & Bowd, 2005).

However, despite the powerful influence that attitudes can have on teachers and pre-service teacher's classroom practice, there has been a dearth of research in this area. Indeed, Goldin (2002) expressed the concern that research in mathematics education was focused mainly on cognition and less on affect. This is particularly the case in relation to the attitudes of pre-service secondary teachers of mathematics. Most studies referenced thus far in the literature have been in relation to the attitudes of elementary and primary school teachers. Perhaps there is an assumption that pre-service secondary mathematics teachers all harbour positive attitudes towards the subject because they have specifically chosen to specialise and teach mathematics. However, this may not always be the case. Individuals within this cohort may have developed negative attitudes towards mathematics from their prior educational experiences as a mathematics student (in primary, secondary or tertiary level) or the influence of prior teachers and/or lecturers. These attitudes can

have significant sway in their thought processes and daily decisions around classroom practices which, in turn, influence student learning. Thus, like any other subject, at any other level, it is important that those involved in ITE are aware of pre-service secondary mathematics teachers' attitudes towards the subject and what the influencing factors may be.

With this in mind, the research conducted by the authors' measures the attitudes of incoming pre-service mathematics teacher cohorts (N = 98) in four Irish universities for three consecutive years. The pre-service teachers are enrolled in an ITE program known as the Professional Master of Education (PME). The PME program is a two-year postgraduate program and these pre-service mathematics teachers would have previously chosen to study mathematics as a substantial part of their undergraduate degree. The research sought to address the following research question: What is the overall profile of Irish pre-service secondary teachers' attitudes towards mathematics?

Methodology

The goal of this study was to examine the attitudes of incoming pre-service secondary mathematics teachers. The authors wished to do this through a quantitative measure. However, despite the importance attributed to an individual's attitude, the lack of proper measurement instruments has been noted by a number of researchers in recent years (Lim & Chapman, 2013; Ma & Kishor, 1997; Ren, Green & Smith, 2016; Zan, Brown, Evans & Hannula, 2006). When deciding upon an instrument the authors for this study considered a number of existing pre-validated scales such as the *Aiken Mathematics Attitude Scale* (Aiken, 1974), *Attitudes Toward Mathematics Inventory* (ATMI) (Tapia & Marsh, 2000), and its shortened version (Lim & Chapman, 2013). However, all of these instruments were developed for use with student populations. Indeed, to the authors' knowledge, no reliable and validated measure of teachers' mathematical attitudes has been widely used in the literature. While the *Fennema-Sherman Mathematics Attitudes Scales* (FSMAS) (Fennema & Sherman, 1976) has also been used mainly among student populations and rarely used with teachers, it has been used extensively and flexibly in research (Ren et al., 2016). In a U.S. study, Ren et al. (2016) validated a number of the FSMAS sub-scales to reliably measure lower-primary teachers' mathematical attitudes. Although, this was a different cohort of teachers in a different country, the authors of this study felt that the FSMAS was the best and most suitable instrument available for use, particularly because of the detail and variety of subscales that are included.

The instrument

The FSMAS is made up of nine different subscales which can be used altogether or separately. Six of the nine subscales measuring specific attitudes related to mathematics learning were selected by the authors for use in this study, namely:

(i) attitude towards success in mathematics subscale, which attempts to measure the degree to which students anticipate positive or negative consequences as a result of success in mathematics;

(ii) confidence in learning mathematics subscale, which attempts to measure confidence in one's ability to learn and to perform well on mathematics tasks;
(iii) effectance motivation subscale in mathematics, which attempts to measure effectance as applied to mathematics. This dimension ranges from a lack of involvement in mathematics to active enjoyment and seeking of challenge;
(iv) mathematics anxiety subscale, which attempts to measure students' level of mathematics anxiety and the effect on doing mathematics;
(v) mathematics usefulness subscale, which attempts to measure students' beliefs about the usefulness of mathematics currently (Table 1); and
(vi) teacher subscale, which attempts to measure students' perceptions of their teacher's attitudes towards them as learners of mathematics.
(Fennema & Sherman, 1976, pp. 325-326)

The mathematics as a male subscale was excluded on the grounds that it had not shown significant results in prior studies (Mkhize & Maistry, 2017) and the authors decided that the mother and father subscales were not relevant or appropriate for the purpose of this study.

Each of the six subscales contained twelve statements, with half worded in the direction of a positive attitude to mathematics, and the other half worded negatively. Participants had to indicate their level of agreement with each statement using a five-point Likert scale. Each of the five possible responses – strongly agree, agree, not sure, disagree, and strongly disagree – were given a value of 5 to 1, respectively, for positively worded statements and 1 to 5, for negatively worded statements. Thus, the minimum possible score on any of the subscales was 12 and the maximum possible score was 60. A higher score indicated a more positive attitude towards mathematics.

Table 1: Examples of Likert questions from the *Mathematics Usefulness Subscale* (Fennema & Sherman, 1976)

		Strongly agree	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
1.	I will need mathematics for my future work.					
2.	Mathematics is of no relevance to my life.					
3.	I studied mathematics because I know how useful it is.					
4.	I see mathematics as a subject I will rarely use in my daily life as an adult.					

Procedure and participants

The FSMAS was administered to groups of incoming pre-service mathematics teachers at the beginning of their ITE in four (out of eight) Irish universities. Convenience sampling was used in selecting the universities at which to collect the data. The authors were involved in the PME programs at each of the four universities and so had opportune

access to the sample. Currently a low number of students are enrolling in consecutive ITE programs in Ireland and this issue is even more pronounced for the subject of mathematics. For example, approximately only 70 pre-service mathematics teachers' graduate from PME programs in Ireland each year. Thus, in order to achieve a sizeable sample, the data was collected over three consecutive years. From 2015 to 2017, volunteers for participation were sought in the first mathematics pedagogy lecture of the term. At each data collection point, all pre-service mathematics teachers who were in attendance at the first lecture agreed to take part in the study and gave permission for their responses to be used for research purposes. The completed FSMASs were inputted into *Statistical Package for the Social Sciences* (Version 24) and appropriate analysis of the quantitative data was conducted.

Reliability

As this was the first time that the FSMAS was used with a group of Irish pre-service secondary mathematics teachers, reliability analyses for the six subscales of the instrument were conducted. Presented in Table 2, the Cronbach's alpha for each subscale was > 0.85, suggesting that the items in each subscale had relatively high internal consistency.

Results

In total, 98 pre-service mathematics teachers across the four universities completed the FSMAS over the three-year time period. The majority of these were female (69%), had chosen mathematics as their major teaching subject[1] (82%), and had studied higher level[2] mathematics in secondary school (75%). Most of those who had not chosen mathematics as their major teaching subject were majoring in science and had mathematics as their second subject. As the PME is a postgraduate program, the ages of participants ranged from 20 to 58 years old. However, 68% of the sample were aged in the range 20 to 23 years, suggesting that the majority had entered the program directly after their undergraduate degree (typically of four years in duration). A further 12% were aged 24 to 25 years, suggesting that they spent a small amount of time in the workforce before returning to study.

Overall profile of pre-service teachers' attitudes towards mathematics

Initially, to provide a general picture of the findings from the data, a mean score for each of the six FSMAS subscales was found. These scores, presented in Table 2, ranged between 44.6 and 55.2 out of a possible 60, with the Usefulness subscale holding the highest score and the Anxiety subscale holding the lowest.

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[1] Generally, secondary school teachers in Ireland qualify with two subject areas (dependent on their degree choices). For the context of this study, their 'major' subject is the one which formed the main basis of their undergraduate degree and is their first choice. The 'minor' subject is their second teaching subject.

[2] Mathematics can be studied at different levels in Irish secondary education - higher level (HL) is the most challenging and ordinary level (OL) is next in terms of difficulty.

Table 2: Mean ratings for different subscales (N = 98)

Subscale	Mean	SD	Cronbach's alpha
Usefulness	55.2	4.7	0.86
Confidence	51.8	5.7	0.88
Effectance motivation	50.4	5.3	0.87
Attitude to success	49.1	6.5	0.86
Teacher	46.5	8.7	0.92
Anxiety	44.6	8.3	0.91

A repeated measures ANOVA test confirmed that a statistically significant difference existed between the six mean ratings. A pairwise comparisons post hoc test with Bonferroni-adjusted *p*-values for multiple comparisons found that there were statistically significant differences between the means of the majority of subscales ($p < 0.05$), except the following:

- Confidence and Effectance motivation subscales ($p = 0.169$)
- Attitude to success and Teacher subscales ($p = 0.156$)
- Attitude to success and Effectance motivation subscales ($p > 1.000$)
- Teacher and Anxiety subscales ($p = 0.384$)

Factors affecting attitudes

As noted in the Introduction, attitudes, whether positive or negative, are generally considered as having been learned and there are a number of influencing factors. With this in mind, further analysis was carried out with regard to factors such as students' gender, whether mathematics was their major/minor teaching subject, and whether they had studied mathematics at HL or OL in secondary school. The mean scores for each of the six sub-scales in relation to these factors are outlined in Table 3. Minor differences can be observed between the means. However, the scores were also tested using independent samples t-tests against the three factors and in each case $p > 0.05$. As such none of the factors yielded statistically significant differences.

Further analysis

As evidenced in Tables 2 and 3, the Teacher and Anxiety subscales had the two lowest mean scores. Thus, further analysis attempted to identify patterns in these two low-ranking subscales. A breakdown of scores for the individual statements of each is shown in Appendices 1 and 2 respectively. As evidenced in Appendix 1, for the Teacher subscale, highest scores were obtained from the latter statements. These regarded the perception of how seriously respondents felt their teachers took them as students, e.g. "I had a hard time getting teachers to talk seriously with me about mathematics" (Mean = 4.2). The lowest score was for the statement "I would talk to my maths teachers about a career which uses maths" (Mean = 3.2). The Anxiety subscale, on the other hand, had by far the lowest scores for statements involving tests and exams, e.g. "I almost never have gotten shook up during a maths exam" (Mean = 2.6), and "I have usually been at ease during maths tests" (Mean = 3.0).

Table 3: Mean scores of factors affecting each subscale

Subscales	Gender		Maths as major		Level of maths	
	Male (n = 30)	Female (n = 67)	Yes (n = 79)	No (n = 18)	Higher (n = 73)	Ordinary (n = 19)
Usefulness	54.3	55.6	55.3	54.7	54.9	60.00
Confidence	52.3	51.6	52.1	50.4	52.2	50.2
Effectance	50.1	50.5	50.8	48.8	50.9	48.4
Attitude	49.4	49.0	48.8	50.5	49.3	48.4
Teacher	47.6	46.3	46.6	47.1	47.4	44.1
Anxiety	45.8	44.1	44.8	43.8	45.4	41.8

Factors affecting individual statements of the anxiety subscale

Further to this, the effect of the three factors (gender, major/minor subject, and level of mathematics studied) was also tested on each of the Anxiety statements individually. Mann-Whitney tests were carried out to determine the significance of the findings. Results were mixed, with very few statistically significant differences presenting themselves, as evidenced in Table 4. In terms of gender, males scored significantly higher than females for the statements "I haven't usually worried about being able to solve maths problems" (Statement 3), and "I almost never have gotten shook up during a maths exam" (Statement 4).

Table 4: Factors affecting anxiety components

Factor	Anxiety component											
	1	2	3	4	5	6	7	8	9	10	11	12
Mean major	48.8	49.5	47.2	49.4	48.1	**51.8**	50.8	49.0	48.8	48.7	49.5	49.8
Mean minor	49.9	46.8	54.3	47.2	53.0	**36.9**	41.3	48.9	49.8	50.2	46.9	45.4
Mann-W. U	695.5	671.0	598.0	678.5	638.5	**493.0**	571.5	708.5	696.5	689.0	673.5	646.5
Sig. (2-tailed)	.874	.702	.316	.754	.479	**.028**	.149	.994	.894	.827	.720	.518
Mean male	56.6	51.5	**57.8**	**57.3**	52.2	49.8	47.7	49.3	48.6	47.5	46.6	49.3
Mean female	45.6	47.9	**44.3**	**45.3**	47.6	48.6	49.6	48.9	49.2	49.7	50.1	48.9
Mann-W. U	777.0	930.0	**710.5**	**756.5**	908.0	980.0	966.0	997.0	994.0	960.5	934.0	995.0
Sig. (2-tailed)	.064	.544	**.023**	**.041**	.442	.837	.745	.962	.937	.705	.572	.942
Mean HL	47.8	47.4	47.2	46.8	47.6	48.1	48.2	47.7	48.9	48.3	**50.2**	48.3
Mean OL	41.6	43.2	41.6	45.2	42.4	40.2	40.1	41.8	37.5	39.6	**32.4**	39.
Mann-W. U	601.0	630.0	601.0	669.5	615.5	573.5	572.5	605.0	522.0	561.5	**425.5**	562.0
Sig. (2-tailed)	.356	.530	.417	.791	.436	.210	.217	.371	.082	.172	**.006**	.175

Factors with statistically significant differences are marked in **bold.**
Statements for anxiety components 1 to 12 are listed in Appendix 2.

Furthermore, there was a statistically significant difference in favour of mathematics majors for the statement "I have usually been at ease in maths classes" (Statement 6). Finally, those who studied mathematics at OL in secondary school scored significantly lower for the statement "A maths test would scare me" (Statement 11), thus indicating higher levels of anxiety.

Factors affecting individual statements of the teacher subscale

Mann-Whitney tests were also carried out to test the effect the three factors had on the individual statements of the Teacher subscale. The results of these tests are displayed in Table 5. As was the case with the Anxiety subscale, results were mixed with very few statistically significant differences. However, one particular statement which yielded significant differences for two of the factors was "My maths teachers would encourage me to continue studying mathematics at a higher level" (Statement 4). Mathematics majors and students who studied mathematics at HL scored significantly higher for this statement. Moreover, students who studied HL mathematics also scored significantly higher than their OL counterparts for the statements "My teachers think I am the kind of person who could do well in mathematics" (Statement 2) and "Maths teachers have made me feel I have the ability to go on in mathematics" (Statement 3).

Table 5: Factors affecting teacher components

Factor	Teacher component											
	1	2	3	4	5	6	7	8	9	10	11	12
Mean major	48.6	48.7	49.6	**51.8**	49.7	49.1	49.3	49.3	47.0	49.1	47.2	48.6
Mean minor	51.0	50.3	46.4	**36.5**	46.2	48.5	47.9	47.6	57.7	48.6	57.0	51.0
Mann-W. U	675.5	688.0	664.0	**486.5**	660.0	702.5	691.5	686.0	554.5	703.0	567.5	675.5
Sig. (2-tailed)	.740	.834	.641	**.030**	.621	.927	.859	.817	.116	.924	.150	.750
Mean male	48.1	52.2	53.0	46.6	48.2	52.6	48.6	53.2	50.2	50.5	50.4	50.3
Mean female	49.4	47.6	47.2	50.1	49.3	47.4	49.2	47.1	48.5	48.3	48.4	48.4
Mann-W. U	979.0	908.0	884.0	932.5	982.0	896.5	991.5	878.0	968.5	959.5	963.0	967.0
Sig. (2-tailed)	.833	.424	.315	.560	.853	.385	.911	.289	.760	.711	.720	.765
Mean HL	47.8	**49.5**	**49.2**	**50.0**	47.6	46.6	47.2	48.0	48.0	47.7	47.3	48.1
Mean OL	41.7	**35.0**	**36.2**	**33.3**	42.4	46.2	43.8	40.9	40.7	41.9	43.3	40.2
Mann-W. U	601.5	**475.0**	**498.5**	**443.5**	615.5	687.0	643.0	587.5	583.0	606.0	632.5	574.5
Sig. (2-tailed)	.356	**.024**	**.045**	**.011**	.437	.963	.613	.278	.258	.373	.543	.217

Factors with statistically significant differences are marked in **bold.**
Statements for teacher components 1 to 12 are listed in Appendix 1.

Discussion

Overall, the pre-service secondary mathematics teachers who participated in this study had positive attitudes towards the subject, as shown by the mean score for each of the six subscales which ranged between 44.6 and 55.2 (out of 60; Table 6). The authors are not aware of any other research which utilised the FSMAS with pre-service secondary mathematics teachers and so it is hard to make a direct quantitative comparison with similar groups. However, indirect comparisons with other groups strengthen the inference that the participants of this study had positive attitudes towards mathematics. For example, Table 6 compares the mean FSMAS scores of participants in this study with the scores of pre-service accounting teachers in South Africa (Mkhize & Maistry, 2017). As evidenced in Table 5, the pre-service mathematics teachers in the authors' study had higher mean scores in four of the five subscales that were comparable. This finding is unsurprising given that the pre-service mathematics teachers chose to study mathematics

as a substantial part of their undergraduate degree. Such a choice would indicate that these individuals already had a positive disposition towards the subject.

Table 6: Comparison of FSMAS scores between different groups

Subscale	Pre-service mathematics teachers (n = 98)	Pre-service accounting teachers (n = 225)
Usefulness	55.2	47.4
Confidence	51.8	41.6
Effectance motivation	50.4	40.1
Attitude to success	49.1	50.0
Anxiety	44.6	37.0

In the findings section, the mean results for each of the six subscales were also examined in relation to the respondent's gender, whether they had chosen mathematics as a major or a minor subject, and whether they had studied mathematics at higher or ordinary level in secondary school (Table 3). Although minor differences could be observed between the means, none of the factors yielded statistically significant differences. However, a more in-depth look at the two lowest ranking subscales, the Teacher subscale (Mean = 46.5) and the Anxiety subscale (Mean = 44.6), revealed some noteworthy findings.

The Anxiety subscale in the FSMAS measures feelings of anxiety, dread, nervousness, and associated physical symptoms related to doing mathematics. The Teacher subscale measures students' perceptions of their past teacher's attitudes to them as learners of mathematics (Fennema & Sherman, 1976). One may not expect either of these domains to be areas of concern for future specialist teachers of the subject. However, as mentioned previously, individuals within this cohort may have developed negative attitudes towards mathematics from their prior educational experiences as a mathematics student (in primary, secondary or tertiary level) or the influence of prior teachers and/or lecturers. These attitudes can have significant sway in these pre-service teachers thought processes and daily decisions around classroom practices which, in turn, can influence student learning. Thus, like any other subject at any other level, it is important that those involved in ITE are aware of pre-service secondary mathematics teachers' attitudes towards the subject and what the influencing factors may be.

With specific reference to mathematics anxiety, Martinez and Martinez (1996, p. 2) determined it to be a "construct with multiple causes and multiple effects interacting in a tangle that defies simple diagnosis and simplistic remedies". It has been defined by Richardson and Suinn (1972, p. 571) as "feelings of tension … that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations". Peker (2009) noted that it is common amongst many pre-service teachers at all levels of the education system. One of its main causes may be linked to negative classroom experiences undergone in the past. Such experiences may include the use of traditional teaching practices, where mathematics involves the memorisation of formulas, and the following of rules and procedures (Idris, 2006; Prendergast et al., 2014). Harper and Daane (1998) went further and proposed the causes

for mathematics anxiety as rigid class applications, examinations and grades being continuously emphasised by teachers, and problem-solving activities with little relevance to daily life. The origins of mathematics anxiety being linked to examinations and grades may be particularly relevant to the findings of this study, as the Anxiety subscale had by far the lowest scores for statements involving tests and examinations e.g. "I almost never have gotten shook up during a maths exam", and "I have usually been at ease during maths tests".

Such low scores on these statements may be linked to the assessment driven culture associated with the Leaving Certification (upper secondary) state examinations in Ireland. Students' entry to third level education is determined by how well they perform in these high stakes terminal examinations. This is particularly the case for mathematics, as a student's attainment in this subject is a key determinant of entry to higher education in Ireland (McCoy & Byrne, 2010). Such pressures have often resulted in a high proportion of teaching to the test and students learning for the sake of reproducing material. These practices may also be linked back to the traditional teaching methods which Idris (2006) noted as being at the root of mathematics anxiety in students. A noteworthy finding of the study was that OL students had significantly greater levels of anxiety than HL students for the statement, "A maths test would scare me". Hoyles (1982) determined that past experiences of mathematics influence students' current mathematics anxiety. Given they may find the subject more difficult, OL students may have more negative memories of mathematics tests than their HL counterparts.

With regard to the Teacher subscale, the lowest score was for the statement "I would talk to my maths teachers about a career which uses maths". This may indicate that Irish teachers are not doing enough or are not knowledgeable enough to talk to their students about prospective professions in which mathematics plays a key role. More needs to be done to encourage better uptake of mathematics at tertiary level and better promotion and communication of related careers. Internationally, research shows that STEM disciplines such as mathematics have experienced problems in producing adequate numbers of graduates to meet workforce needs (Hall, Dickerson, Batts, Kauffmann & Bosse, 2011). Although entrance into the STEM fields has grown, this growth is not keeping pace with the overall needs of the labour market (Hall et al., 2011; Hunt, 2011). This has repercussions for nations' economies, particularly in relation to the technology and industrial sectors. Hayden, Ouyang, Scinski, Olszewski, and Bielefeldt (2011) determined that it is important for those involved in education to help develop an individual's potential to become a professional in such areas. Indeed, fostering positive attitudes amongst students has a key role to play here. A study by Ma (2001) concluded that positivity toward mathematics is one of the most important factors affecting participation in advanced study of the subject.

There were some significant differences in the scores of some of the individual statements on the Anxiety and Teacher subscales. Perhaps the most noteworthy of these differences are in relation to respondents' gender. The results showed that female pre-service mathematics teachers were more likely to 'worry about being able to solve maths problems' and get 'shook up during a maths exam'. As noted in the review of literature,

this is in line with recent research in the area (albeit at a school level) which shows that gender still exerts an influence on attitude to mathematics, with girls showing more negative attitudes (Cantley et al., 2017; Goldman & Penner, 2016; Prendergast & O'Donoghue, 2014). In terms of the Teacher subscale, significant differences in some of the individual statements indicate that teacher expectations of their students played an important role in whether students studied mathematics at HL in secondary school. Again, this is in line with previous research in the area which indicates that teachers' expectations of their students can become self-fulfilling prophecies. Students that teachers expect to do well, tend to achieve better, while students who are expected to do badly, usually tend to fulfil these expectations as well (Muijs & Reynolds, 2017). This is a noteworthy finding in the Irish context as there have been a number of policy initiatives undertaken in recent years in an attempt to encourage greater participation in the study of secondary mathematics at an advanced level (Treacy, Prendergast & O'Meara, 2019). While these national policy initiatives have been successful in increasing the proportion of students studying higher level mathematics on a macro level, the results of this study indicate that individual teachers' expectations of their students can also be important in achieving the same objective on a micro level.

Limitations of the study

While this study has resulted in some noteworthy findings, it is important to be cognisant of any limitations before attempting to draw conclusions. The first limitation of the study relates to the instrument used to collect the data. To the authors' knowledge, no reliable and validated measure of teachers' mathematical attitudes has been widely used in the literature. Although the FSMAS were validated for use with lower primary teachers, this was with a different cohort of teachers in a different country. Thus, while reliability analyses for the six subscales indicated relatively high internal consistency, caution must be applied when interpreting the findings of this study.

Secondly, the research was conducted using convenience sampling methods, with participants drawn from universities to which the researchers had access. While this may raise concerns in relation to the sample being representative of students across the country, the universities involved were geographically located in three of the four provinces in Ireland. Furthermore, while the sample size of 98 students may be relatively low for a quantitative study, we feel it is a representative proportion of incoming pre-service secondary mathematics teachers enrolled on PME programs in Ireland over a three-year period.

Thirdly, the data collected was solely quantitative in nature and thus provides a snapshot of incoming pre-service teachers attitudes as they were beginning the PME program. There may have been some instances of the pre-service teachers providing what they believed to be 'correct' answers, rather than answering honestly. It would be very beneficial to gather qualitative interview data in order to complement the quantitative results and to explore the students' attitudes in more depth.

Finally, and perhaps most significantly, the data presented herein does not represent a longitudinal study. Philippou and Christou (1998) determined that mathematics ITE

programmes can positively influence pre-service teachers' attitudes. However, from the data presented in this study, it is not possible to make any claims about changes in pre-service teachers' attitudes as they progress through their ITE and into their first year as newly qualified teachers. This is something that could be looked at in future research.

Conclusion

Teaching has been described as an intensely psychological process (Watson & Ecken, 2003) and teachers' abilities to perform effectively in their profession often depends on their personal qualities and their ability to create individual relationships with others. This ultimately comes down to the attitudes employed by each specific teacher (Prendergast & O'Donoghue, 2014b). With specific reference to mathematics, it is important for teachers to possess positive attitudes towards the domain since attitudes are closely linked to classroom practice and in turn, student achievement. The results of this study show the domains of the FSMAS to be strongly positive, particularly for pre-service teachers' confidence to learn and to perform well on mathematics tasks, their beliefs about the usefulness of mathematics, and their enjoyment and seeking of challenge in the subject. However, the data also highlights that the results of the mathematics anxiety and teacher subscales were notably lower in comparison to the others.

With these findings in mind, it is important that ITE programs are aware that pre-service teachers are entering their courses of study with differing attitudes and concerns towards mathematics (Johnson, Ní Shúilleabháin, Ríordáin & Prendergast, 2019). It cannot be assumed that every pre-service secondary mathematics teacher has a highly positive attitude towards all aspects of the domain. There may have been influencing factors in their own learning experience with the subject that have affected their outlook. It is important that such factors are addressed in their ITE and do not continue post-graduation and influence their teaching careers. For example, Bekdemir (2010) determined that if pre-service teachers are mathematically anxious, they have a very good chance of becoming teachers who have a negative attitude towards the subject, and hence teach in ways that may unintentionally develop mathematics anxiety in their own students. This, as mentioned previously by Brady and Bowd (2005), leads to a cyclical phenomenon. Hence, it is important that any negative attitudes that pre-service teachers harbour from their own experiences as learners of mathematics are addressed in their ITE programs.

Negative attitudes may well have been learned by students and have developed over a long period of time. However, Larsen (2013) found that they can also modify and change with time. ITE programs, like the PME in Ireland which takes place over the course of two years, have an opportunity to focus on the affective domain with students. Indeed, several studies have reported a decrease of mathematical anxiety in pre-service teachers at the end of their ITE (Philippou & Christou, 1998; Rodrigues et al., 2017). These pre-service teachers' attitudes are generally improved by focusing on how mathematics can be taught in more creative and innovative ways, with a focus on student understanding and engagement. This can result in new viewpoints about the teaching of mathematics and new thinking about learning, about their students, and about themselves (Bonner, 2006). Depending on the specific attitudes and the mitigating factors, particular interventions

may be required on the part of the teacher educators. For example, Bekdemir (2010) noted that teacher educators can provide students with proper skills to handle harmful experiences from their own past. In any case, the first step is to build an overall profile of pre-service teachers' attitudes towards mathematics, like has been done in this study. Only then can the necessary interventions and supports be designed and implemented.

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Appendix 1: The teacher subscale mean scores

	Statement	Mean	SD
1	My teachers have encouraged me to study more mathematics.	3.9	1.0
2	My teachers think I'm the kind of person who could do well in maths.	3.9	.9
3	Maths teachers have made me feel I have the ability to go on in maths.	3.9	1.0
4	My maths teachers would encourage me to continue studying maths at a higher level.	3.7	1.1
5	My maths teachers have been interested in my progress in mathematics.	3.7	1.1
6	I would talk to my maths teachers about a career which uses maths.	3.2	1.2
7	When it comes to anything serious I have felt ignored when talking to maths teachers.	3.8	1.0
8	I have found it hard to win the respect of maths teachers.	4.0	.9
9	My teachers think I should not have continued studying maths.	4.1	.9
10	Getting a mathematics teacher to take me seriously was usually a problem.	4.2	.8
11	My teachers would have thought I wasn't serious if I told them I was interested in a career in science and maths.	4.2	1.0
12	I had a hard time getting teachers to talk seriously with me about maths.	4.2	.8

Appendix 2: The anxiety subscale mean scores

	Statement	Mean	SD
1	Maths doesn't scare me at all.	3.3	1.1
2	It wouldn't bother me at all to take more maths courses.	3.8	0.9
3	I haven't usually worried about being able to solve maths problems.	3.3	1.1
4	I almost never have gotten shook up during a maths exam.	2.6	1.2
5	I have usually been at ease during maths tests.	3.0	1.1
6	I have usually been at ease in maths classes.	3.8	1.0
7	Mathematics usually makes me feel uncomfortable and nervous.	4.0	0.9

8	Mathematics makes me feel uncomfortable, restless, irritable, and impatient.	4.3	0.7
9	I get a sinking feeling when I think of trying hard maths problems.	4.2	0.8
10	My mind goes blank and I am unable to think clearly when doing maths.	4.3	0.8
11	A maths test would scare me.	3.8	1.1
12	Mathematics makes me feel uneasy and confused.	4.2	0.8

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