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Behind the Numbers
The Preliminary Findings of a Mixed Methods Study Investigating the Existence of Mathematics Anxiety Among Mature Students

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Abstract

Admitting that one is 'no good at mathematics' or 'hates mathematics' is a common admission among student cohorts. For mature students who harbour a strong dislike of mathematics, these feelings can be exacerbated when they are faced with having to do an obligatory service mathematics module as part of a programme of study. For some mature students, their dislike of mathematics can be identified as mathematics anxiety. Their experiences of mathematics as a subject throughout their lives are manifold, and depict a variety of emotions, attitudes, and beliefs about the subject. In spite of their experiences with mathematics, mature students demonstrate a persistence – and even a resilience - in respect of their engagement with mathematics. Research on mathematics anxiety is frequently conducted using quantitative methods, in particular measurement scales such as the Mathematics Anxiety Rating Scale (MARS) test or equivalent. However, while these tests reveal a numerical representation for the level of anxiety felt by the participant, there is limited insight available into the context for such anxiety, thereby limiting understanding of the origin of such feelings. To this end, as part of a mixed methods approach, the researcher looks beyond the numerical results of the mathematics anxiety scale to explore the mathematics life histories of three mature students who have taken service mathematics at undergraduate level in Ireland at both University and Institute of Technology (IOT) sectors. This paper reports on preliminary findings of the researcher's data collection.

Key words: mathematics anxiety, mixed methods

In Ireland, a mature student is defined as an adult learner aged 23 or more in the year of enrolment to third level education (CAO, 2016). The profile of the mature student is non-homogeneous; the cohort encompasses diversity in the range of ages, family situations and responsibilities, career experiences, and previous encounters with education (O'Donnell & Tobbell, 2007). Mature students comprise 13% of full-time and 19% of part-time students in higher education in Ireland (HEA, 2016).

Many students at third level are required to complete an obligatory module in mathematics – service mathematics – when they pursue a programme of study, even though mathematics is not

the main discipline (Gill & O'Donoghue, 2005). In the case of mature students, they may not have engaged with academic mathematics for at least 5 years, i.e. since they would have completed their Leaving Certificate [6] examination or equivalent, and they may be unaware of the mathematics content of their chosen programme until after the programme has commenced (Zaslavsky, 1994). The subject may not be called 'mathematics', but instead called 'quantitative methods', for example, which may not be evident to a student that it is a mathematics module. A lack of practice can result in difficulties and anxieties around mathematics for students who have not engaged with mathematics academically for a number of years (Betz, 1978).

For some mature students their dislike of mathematics can be identified as mathematics anxiety, defined as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972: p. 551). To ascertain the existence of mathematics anxiety, measurement scales are commonly used. Such scales involve the candidate reading a list of statements depicting situations involving mathematics and numbers, and expressing their level of anxiety using a Likert-scale approach. The total of the results gives a score for that candidate, which enables the researcher to determine the level of anxiety of the candidate.

The original mathematics anxiety test was the Mathematics Anxiety Rating Scale or 'MARS' test (Richardson and Suinn, 1972), which involved third level students completing a 98-item list of statements; however, this test took much time to complete and aggregate (Suinn & Winston, 2003; Hunt, et al., 2011). Variations of the MARS test have evolved over the years to be used with primary school children (Suinn, et al., 1988), and adolescents (Suinn & Edwards, 1982); however, the majority have been developed in the USA with an American audience in mind (Hunt, et al., 2011). In 2011, the MAS-UK (Hunt, et al. 2011) was developed; this emulated Suinn and Winston's MARS-30 (2003) but was designed for a UK and European audience (Hunt, et al. 2011). It comprises 23 statements, with a Likert-scale range of 1 to 5 to ascertain the level of anxiety of the candidate, with 1 being 'not at all' anxious, and 5 being 'very' anxious. The minimum score achievable is 23, and the maximum is 115. Hunt and colleagues (2011) identified three groupings of statements within the MAS-UK: mathematics evaluation anxiety (9 items), everyday/social mathematics anxiety (8 items), and mathematics observation anxiety (6 items). Of these three groupings, 'mathematics evaluation anxiety' was responsible for the 'largest share of the variance' in the MAS-UK scores (Hunt, et al., 2011: p. 462).

While research on mathematics anxiety is frequently conducted using quantitative methods, there is limited insight available into the context for such anxiety, thereby limiting understanding as to the factors that caused such feelings. Qualitative methods, in particular life histories, offer a useful way of exploring the issues throughout a student's life that may have contributed to their anxiety towards mathematics (Coben & Thumpston, 1995; Golding & O'Donoghue, 2005), or alternatively to their appreciation of mathematics.

The use of qualitative methods to explore negative feelings about mathematics was first documented by Tobias (1978) in the form of 'mathematics autobiographies'. Briggs (1994) presented the concept of an 'automathematicsbiography' to facilitate the writer's account of their experiences with mathematics, in order that these could subsequently be explored for impressions, feelings and ideas about mathematics. Bloomfield and Clews (1994) used 'mathematical autobiography' to identify categories of student experiences, namely 'influences', 'critical points', and 'constraints'. Coben and Thumpston (1995) conducted interviews to elicit the 'mathematics life histories' of mature students to hear their life stories around mathematics. Golding and O'Donoghue (2005) demonstrated the advantages of 'topic maps' for mature students to help with confidence building and problem solving as they approach service mathematics at third level. More recently, McCulloch and colleagues (2013) have asserted the

[6] The Leaving Certificate examination is Ireland's terminal state examination taken when students are typically 17 or 18 years of age (DES, 2016)

popularity of mathematics autobiographies – particularly oral accounts – in research into individuals' attitudes, beliefs, and identities in respect of mathematics (McCulloch et al., 2013).

The life history approach provides the researcher with the opportunity to elicit stories about times of significance or change in a person's life, with a view to exploring how the candidate dealt with that change and moved on from that point. Life history research is particularly suitable for eliciting stories about education and schooling (Munro, 1998; Bold, 2012), as the subjective nature of these experiences is influenced by the individuals and the circumstances that shaped their educational journey (Goodson, 2006). It is also useful in attempting to identify the broader issues surrounding mathematics as a subject that have resulted in the mature student feeling about mathematics as they do, whether positive or negative. To enable a focus on particular aspects of the interviewee's life, a tailored approach to life history interviews facilitates concentration on focal points in their life, rather than a complete autobiographical account (McAdams, 1993; Plummer, 2001; Drake, 2006; Reece et al., 2010). McAdams's (1993) offers a practical framework for conducting life story research, allowing a particular focus on nuclear episodes (McAdams, 1993) relating to the theme at hand. In the case of exploring mathematics life histories, interviewees can be asked about their past experiences of mathematics with a focus on the following 'nuclear episodes' (adapted from McAdams, 1993):

- their earliest memory of mathematics,
- mathematics at primary school,
- mathematics at secondary school,
- mathematics after school,
- their decision to enter third level education and preparing for mathematics at third level,
- their experience of service mathematics at third level,
- their overall strategy with mathematics – past and present,
- the significance of mathematics to their future career.

These themes allow for points of comparison (Coben & Thumpston, 1995) between the candidates.

A mixed method research design

The approach taken for this research involved a sequential mixed methods approach (Mertens, 2015) comprising a quantitative phase (phase one), followed by a qualitative phase (phase two). The purpose of phase one was to ascertain the level of mathematics anxiety among the mature student respondents. An online questionnaire was compiled (using SurveyMonkey.com), piloted, revised and distributed by email hyperlink with the assistance of the mature student officer or access officer of each of four randomly selected higher education institutions (HEIs) around Ireland, namely 2 Institutes of Technology and 2 Universities. The questionnaire was distributed to a sample of approximately 500 undergraduate mature students who have a service mathematics module as part of their programme of study, and resulted in a response rate of approximately 21% (n=107). Recipients were asked for some personal details (gender, date of birth, discipline of study, year they left school) as well as to complete the MAS-UK test; participants were also given the option of including contact details – email address or phone number – to confirm if they would be interested in participating in phase two of the study.

Phase two involved conducting life history interviews with the intention of eliciting insights into mature students' individual experiences with mathematics. A total of 20 students (13 male, 7 female) responded to the invitation to attend for interview, with ten each from the Institute of Technology and University sectors. The interviews were semi-structured, with the questions guided by McAdams's (1993) framework for conducting life story research. The interviews were audio-recorded and transcribed. Each interviewee's transcript was emailed to them for

verification of the content. Initial analysis[7] of the interview transcripts was guided by McAdams's (1993) framework for conducting life story research, and focussed on references to each of the nuclear episodes as outlined in the previous section.

Findings: Quantitative

Collectively, the candidates presented varying levels of mathematics anxiety as determined through the MAS-UK test. The range of MAS-UK scores among the 107 respondents was from 23 to 94 (Figure 1) out of a potential range of 23 (not at all anxious) to 115 (very anxious) (Hunt, et al, 2001); thus no candidate was coming in as 'very' mathematics anxious, the highest level of mathematics anxiety. While the majority of the scores lie within steps 1 to 3 of the MAS-UK (a range of 23 to 69) there is a cluster of 10 students (9.3%) in the range of scores from 82 to 94, demonstrating higher levels of mathematics anxiety.

Analysis of scores for the 23 individual statements in the MAS-UK

Closer analysis of responses to the MAS-UK instrument indicated that the statements with the highest proportion of 5s (very anxious) answered by the entire cohort were:

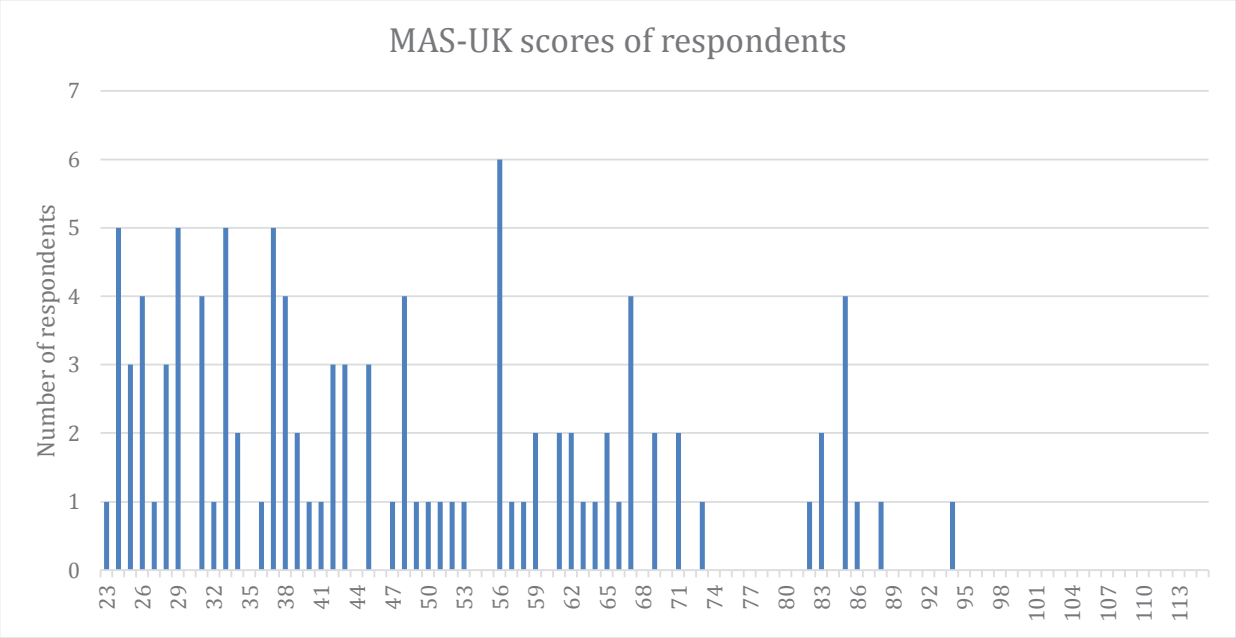

Figure 1. Frequency of MAS-UK scores among respondents to questionnaire

6. Taking a mathematics exam (31%)

18. Being given a surprise mathematics test in a class (27%)

23. Being asked a mathematics question by a teacher/lecturer in front of a class (22%)

3. Being asked to write an answer on the board at the front of a mathematics class (18%).

When the scores for 4 (much) and 5 (very) are combined, the same statements emerge but the order changes, with statement 18 leading with 47%, followed by statement 6 (43%), statement 23 (43%), and statement 3 (28%). When scores of 3 (somewhat), 4 (much), and 5 (very) are

[7] Further analysis of the transcripts will be conducted subsequent to completion of this paper.

combined, once again statements 6, 18, 23, and 3 emerge, with cumulative percentages of 66, 63, 58, and 53 respectively.

The common themes within these four statements are the evaluation of one's mathematical knowledge and, in particular, being singled out to do a mathematics question in front of the entire class. These four statements belong to the 'mathematics evaluation anxiety' grouping within the MAS-UK.

At the lower end of the scale were the following situations, with the percentages representing the number of 1s selected among the cohort (1 = 'not at all' anxious):

2. Adding up a pile of change (78%)

11. Working out how much time you have left before you set off for work or place of study (74%)

13. Working out how much change a cashier should have given you in a shop after buying several items (73%)

22. Working out how much your shopping bill comes to (67%)

4. Being asked to add up the number of people in a room (65%).

When the scores for 1 (not at all) and 2 (somewhat) are added, the same 5 statements reoccur, but the order changes: statement 2 (91%), statement 4 (89%), statement 11 (88%), statement 13 (86%) and statement 22 (86%). These situations belong to the 'Everyday/Social Mathematics' component of the MAS-UK, and are reflective of everyday situations that students would engage with and be familiar with (Hunt et al., 2011).

Focus on the three candidates with highest levels of mathematics anxiety

Among the respondents to participate in the life history interviews, there were clusters of candidates between 'not at all' anxious and 'a little' anxious (n=6 or 30%), as well as between 'a little' anxious and 'somewhat' anxious (n=11 or 55%). Three candidates scored higher, with MAS-UK scores of 83, 86 and 94. These represented the students with the highest scores among the candidates.

Analysis of the three highest candidates' MAS-UK results revealed that four situations were given a score of 5 ('very' anxious) by each of the three candidates:

3. Being asked to write an answer on the board at the front of a mathematics class

18. Being given a surprise mathematics test in a class

21. Being asked to calculate three fifths as a percentage

23. Being asked a mathematics question by a teacher/lecturer in front of a class

Further analysis of the situations given a 4 or 5 by the three candidates reveals the following additional situations that feature as 'much' or 'very' mathematics anxious:

6. Taking a mathematics exam

7. Being asked to calculate €9.36 divided by 4 in front of several people

8. Being given a telephone number and having to remember it

9. Reading the word 'algebra'

12. Listening to someone talk about mathematics

17. Sitting in a mathematics class

20. Watching a teacher/lecturer write equations on the board

Two of the three candidates did not give a score of 1 (not at all anxious) to any statement. All three candidates gave a score of 2 to statement number 2: Adding up a pile of change. Scores of 1, 2, and 3 were given between the candidates for statement 4: Being asked to add up the number of people in a room. These two statements were the lowest scoring within the MAS-UK test, and are included in the Everyday/Social mathematics section of the MAS-UK.

The findings for the three candidates with the highest MAS-UK scores are reflective of the findings of the entire group; in particular, the statements with the highest scores reflect Mathematics Evaluation anxiety which features as a prominent factor in contributing to mathematics anxiety among this group of students. Similarly, the lowest scores reflect Everyday/Social mathematics anxiety. In order to get an insight into the aspects of the three students' life experiences with mathematics, the following section explores the findings of the life history interviews.

Findings: Qualitative

This section focuses on the three highest scoring candidates in the MAS-UK test, with scores of 83, 86, and 94. The following paragraphs provide a synopsis of each of their life histories with mathematics as guided by McAdams's (1993) framework. Each synopsis refers to the nuclear episodes, i.e. the student's experiences of mathematics at primary and secondary school, after school and returning to third level, as well as their strategy for mathematics, and significance of mathematics for their future.

Mature student 1: James

(male, aged 37, attending Uni, studying Sociology, MAS-UK score: 83)

At primary level, the basic calculations – addition and subtraction – were not an issue, it was multiplication, division, fractions, and later negative numbers that caused problems. At second level, he was lost in class, and didn't want to ask questions in class. He felt that the teacher didn't have time to help him; and he had a perception that the other students in his class were much better than he was at mathematics. He sensed he was falling behind, and in preparation for the Leaving Certificate examination he got extra tuition ('grinds') in mathematics. In University his approach to mathematics has been very strategic, in that he is aware of what he needs to pass each component of the mathematics module, and aims to that target. However, he is aware of the relevance of mathematics to real life, and appreciates how great mathematics can be when it makes sense. He does not envisage that mathematics will play a large part in his future career, but is not afraid to try mathematics.

Mature student 2: Gayle

(female, aged 38, deferred Science course at IoT, MAS-UK score: 86)

After 6 weeks in term 1 of first year, Gayle deferred her course until the following September because of the mathematics content. Her negative feelings toward mathematics stem from primary school and saying tables in class, standing at the top of the class, and when you got it wrong you had to sit down. Students who knew the answers would shout them out, and she felt left behind, and continually falling behind as a result of this. She was aware that she was in the second lowest class in secondary school for the junior cycle (age 13-15 age group). She felt that the teacher gave most of his attention to the better students in the class, and he didn't seem to care if the others got the concepts or not. In the IoT she wasn't aware of any mathematics support available to students. Since she deferred her place, she has been getting extra tuition in mathematics to help her prepare for re-entry to the programme. She enrolled in a course to become an outdoor sports instructor, not realising the sailing element would require calculations of degrees, but she persevered with

that, despite her reservations. She is determined to continue her studies in Science at the IoT, and acknowledges the need for support in mathematics, and will pursue this when she returns.

Mature student 3: Pat

(male, aged 34, attending IoT, studying Culinary Arts, MAS-UK score: 94)

Pat's self-perception is that he was never good at mathematics. His experience of times tables was just going along with the class as they recited the tables; but when asked a question on his own, he would go blank. He liked counting on his fingers, and is comfortable doing that. His approach to mathematics is step by step at a slow pace. He reflects on his experience in secondary school with an element of regret, blaming the teacher for not teaching him. He uses the word panic throughout his interview. In his mathematics module, he does not ask questions as he is anxious about slowing down the class. This results in him not understanding the topic, and anything he did understand being forgotten by the next class. However, he does avail of the mathematics support service and likes the slower, one-to-one pace there. He needs to get closure on a mathematics problem before he leaves the class or support session. That is his approach to successful learning of mathematics. He also expressed anxiety towards accounting, and using spreadsheets. His characterisation of his relationship with mathematics is avoidance if at all possible, but if he has to do it he will make his best attempt.

Discussion

Mathematics anxiety exists among mature students at third level, albeit with different levels of intensity, and with varying consequences for students of service mathematics. This mixed method study has recorded both the measuring of mathematics anxiety levels of the mature student candidates, as well as allowing insight into the past experiences that may have contributed to the level of anxiety the students feel at this stage of their lives. It offers a bigger picture in respect of the students' experiences of and engagement with mathematics to-date and provides a platform for understanding the students' feelings about mathematics. The analysis of the statements in the MAS-UK combined with the stories of these three candidates reflect the findings of previous separate quantitative and qualitative studies of mathematics anxiety.

The findings show higher levels of anxiety in situations where the student is or has been faced with an examination of their knowledge of mathematics, as well as being in a public situation involving mathematics, typically in front of their peers and the teacher of mathematics. The life history interviews reveal that the three students' experiences at school contributed to the way they feel about and interact with mathematics as mature students. The effects of what happened in the students' past experiences with mathematics has had long term consequences for these three candidates, particularly in respect of their confidence and self-efficacy towards mathematics. The effect of this is that they have experienced considerable levels of mathematics anxiety at third level, and particularly in the context of mathematics evaluation. To this end, engagement with mathematics support, as well as peer support, has been significant for these students in both academic achievement and confidence-building.

Less anxiety was reported in everyday situations where the use of numbers and calculation is carried out in a more realistic situation, where engagement with numbers has a relevance to the student. This is reflected in the students' personal experiences with mathematics and a preference for doing calculations that have relevance to their lives. In spite of their experiences with mathematics, these mature students have demonstrated a persistence - and even a resilience - in respect of their engagement with mathematics.

These findings have presented three different mature student stories with very different attitudes and strategies towards their study of service mathematics. The considerable negativity towards mathematics can lead to avoidance tendencies, as is evident particularly with two of these

candidates. Their stories reveal the importance of support in mathematics – both academic and peer – in order to help boost their confidence in mathematics. While there is considerable support available at third level, this research demonstrates the importance of such support for students with higher levels of mathematics anxiety. In this regard, there is scope at third level to conduct testing to ascertain levels of mathematics anxiety in addition to giving time to students to talk about their experiences with mathematics. It is also the author's contention that measures be taken to address the concerns of potential students that might consider entering third level, in order that they are aware of what may be involved in service mathematics, and be informed of the levels of support available to help them with mathematics.

Conclusion

The mixed method approach facilitates a means of comparison between the quantitative and qualitative findings, but it allows an insight into the numbers presented in the quantitative approach. McAdams's framework provides a succinct, but comprehensive tool for the analysis of a person's life history experiences in a tailored way. In this study, the framework allows both researcher and interviewee to direct attention to the mature student's experiences with mathematics throughout their life, thereby allowing for efficient data collection.

While the emphasis in this study has been confined to three mature students from the University and Institute of Technology sectors, there is scope to roll out the MAS-UK within all HEIs in Ireland where service mathematics features within programmes of study with the particular intention of compiling a dataset that reflects the prevalence of mathematics anxiety among mature students at third level in Ireland. The researcher contends that this study presents an opportunity to examine the possibility of developing a revision of the MAS-UK to suit the Irish HEI environment, but in light of the context of the mature student.

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