The Effects of Mathematics Anxiety on Primary Students

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Mathematics anxiety is a known problem in mathematics education. This paper reports on a study looking at mathematics anxiety in a primary school classroom (year 6). Students were given a mathematics test and a following anxiety questionnaire to assess their levels of anxiety, to try to better understand issues that caused anxiety and to understand ways that teachers might help reduce anxiety. Results indicated that assessing anxiety itself could be pedagogically valuable. Results also offered some suggestions for reducing anxiety.

Mathematics anxiety is a significant issue in schools, universities and the work force. Beyond difficulty with poor mathematical ability (Beilock et al., 2010), is a genuine feeling of discomfort, even a phobia (Krinzinger, Kaufmann, & Willmes, 2009).

One of the largest factors in the success of mathematics education is how students feel. When students are relaxed and comfortable, success appears to come naturally, but when students feel stressed, rushed or anxious, the results are very different. Although Maloney and Beilock (2012) stated that stress can boost performance as a physiological response, personal experiences of teaching upper primary students suggest that too much stress reduces performances.

Using the literature, this research paper will define mathematics anxiety, explore whether there is any difference between the genders and if so what that might mean. It will look at the role of the teacher with respect to mathematic anxiety. The review will discuss the available testing of mathematics anxiety, and will try and link the information to primary age students wherever possible.

Literature Review

According to Lyons and Beilock (2012), mathematics anxiety is characterised by feelings of tension, apprehension, and fear about performing math. Wilson (2013) used the work of Dreger and Atkin (1957) and Richardson and Suinn (1972) to define mathematical anxiety as an emotional reaction and feelings of tension and anxiety when doing arithmetic. Among the early researchers of mathematics anxiety, Dreger and Atkin (1957, p. 344), identified "emotional reactions to arithmetic and mathematics". Richardson and Suinn, (1972, p. 551) elaborated "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" (Wilson, 2013, p.667).

Mathematics anxiety can present itself in a variety of ways. It can present as a dislike of mathematics or as a worry or pure fear (Wigfield & Meece, 1988; Hart, 1989) due to external pressures placed on a person, such as in a testing situation (Ma, 1999; Krinzinger et al., 2009; Sheffield & Hunt, 2006; Wilson, 2013). Whyte and Anthony (2012) explain mathematics anxiety as the actual situational stress experienced that is specific to personally stressful or fearful circumstances. Research also notes that maths anxiety can affect individuals in varying ways, inducing cognitive, affective, or physical reactions.

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It appears that the teacher and inappropriate teaching practices have a significant impact on the level of mathematics anxiety in students (Hasbee, Sam, Nur, & Tan, 2009; Uusimaki & Nason, 2004; Vinson, 2001). Research found a positive correlation between the level of mathematics anxiety in the teacher and the impact that this played on the students (Beilock et al., 2010). When the students had a teacher, who was anxious in his/her own mathematic ability, there was a downward trend in performance.

If the teacher makes an impact in the classroom, it is the responsibility of the universities and teaching institutions to produce good teachers. It must be incumbent on the institutions to address this issue. One possibility was explored by the University of Birmingham, where they realised there was an issue in their technology program and the student's capabilities in mathematics. Per Metje, Frank and Croft (2007) decided to ask two questions about their students:

> 1) What is the appropriate starting level for this group of students?
>
> 2) How can the students' fear of mathematics be alleviated? (p.80).

Those questions surely need to become the starting point for teacher education in mathematics. Teachers in a classroom could also implement a questionnaire at the beginning of each year, particularly at a primary level to gauge mathematics anxiety. There appears to be no research into assessing how primary students feel at the beginning of the school year, thus the teachers could make appropriate teaching changes that could positively impact students' learning.

Research by Schulz (2005) suggested that the school and teacher play a large part in providing support for the assumption that:

> self-concept and anxiety are relative measures strongly influenced by the school context of the individual. Self-judgements of 'being good at maths' or emotional distress related to this subject depend on self-comparisons with peers and the demands within schools and study programmes (Schulz, 2005, p. 22).

If the school has such a large part in the formation of the student and the levels of mathematics anxiety, how is it measured meaningfully?

There appears to be no research into assessing how primary students feel at the beginning of the school year, but it seems likely that teachers could use such knowledge to make appropriate teaching changes that could positively impact students' learning.

There are two studies regarding mathematics anxiety in primary students that we would like to mention: Krinzinger et al. (2009) examined primary students' anxiety, and Henderson (2012) looked at teacher training at university level in student primary teachers' development of mathematics subject knowledge and the effects of cognition and affect intertwined. Krinzinger and co-authors (2009) explored many ways of assessing mathematics anxiety of a primary student aged 7 to 9 years old. They suggested physiological responses, such as heart rate could be a useful indication (Krinzinger et al., 2009), but that self-report could also be useful.

Research Design

This study employed a similar process to that Beilock and Willingham (2014), who asked questions (modified to the age group) about individual mathematics anxiety (self-efficacy) and then had participants complete a standardised test to see if there was correlation between reported anxiety and test scores. For those students who display mathematic anxiety, a

questionnaire about where and how they think they developed mathematics anxiety might shed some light on their experience and provide guidance for teachers.

The purpose of this paper is to describe how Dave (a pseudonym), an in-service teacher who has 9 Years of teaching experience explored the levels, (if any) of mathematics anxiety whin his classroom. Dave taught Year 6 students at a Catholic primary school in Melbourne. He hoped to gain a better understanding of the anxiety levels of his students, and from that information he would hope to modify his teaching methods to reduce anxiety levels (if they exist).

Therefore, his specific research question for this case study is: "To what level, if any, does mathematics anxiety exist within Dave's classroom?" Given the complex nature of the phenomenon of maths anxiety, and the aim of the study to access the level of mathematics anxiety within Dave's classroom, a design research methodology (Cobb et al. 2003, p. 11) was appropriate to investigate the causes of this anxiety. Design based research embraces the complexity of classroom settings and takes into consideration the complexity of maths anxiety. In this study, we examine the level of mathematics anxiety by: a) iteratively studying the students' interactions with mathematical knowledge; b) establish cycles of iteration, ongoing reflection and feedback to refine learning environment and diminishing students' mathematical anxiety.

Methods

The research study participants were a cohort of Year 6 students of a Catholic Primary School in Melbourne. A total of 26 students (16 Males & 10 Females) ranging between the ages of 11-13 participated in the research study. The data was collected in the participants' setting.

Ethics approval of informed consent procedures was received from the university's ethics committee. The year 6 students conducted an online mathematics test, which consisted of 30 questions covering a wide range of mathematical areas. It included four questions about statistics and probability, nine questions about measurement and geometry, and seventeen questions about number and algebra. Twenty-eight questions were multiple choice (with four options) and two questions were to be answered directly. After the students completed the test, they were asked to use Google Forms to answer to a questionnaire on their feelings about mathematics. The results were collated into an Excel File.

The students were familiar with this form of testing. They used an iPad or a computer to complete the test and the questionnaire. They had access to paper for working outs, but these were not collected.

The questionnaire had 10 questions. Two (#1, #3) were five-point Likert type questions asking the students how they felt during the test and when their teachers says to get out maths books. One question (#2) asked them to predict their result for the test, another (#4) asked them to choose from a list of adjectives describing their feelings about maths. One question asked whether they felt confident doing maths (five-point Likert-type from "need help" to "capable on my own"). Questions #6 and #7 asked students to identify the areas where they struggled or felt confident. Question #8 asked students how the teacher could best help during a mathematics lesson. The final questions asked for age and name (which were not used during the report). Students were also asked which were the most difficult questions. The data were analysed using a mixed methodology approach.

Dave hoped that if there were significant levels of mathematics anxiety, then further research could help explain the causes--whether parental impact, teacher impact, a

significant traumatic event attached to mathematics or some other factor. And if there were reasons, could a whole-school approach help improve overall performance?

Results

The median score on the test was 17, with the most frequent score being 16. The students were asked to predict how they scored. The values for the answers were in groups of 5, with the difference calculated but the top or bottom score in that range. On average, the students in the class predicted that they would achieve a better result by 1.27 points. Only two students made predictions that were significantly different from their scores. Overall this demonstrates that the students have a fair feel on how they thought that they would achieve in the test.

When the students were asked to indicate which question they thought was difficult (Figure 1), from the 30 questions, some students had multiple difficult questions, while one student said that they were all equally difficult. Of the 30 responses, 15 or 50% of the questions were answered correctly by all students. No student got 100% on the test.

Only 1 student reported feeling "completely confident" when doing the test on the questionnaire. He got a score of 28, the top score, and he was one of 2 students who also reported feeling "completely confident" on question #3 ('how do you feel when the teacher says “get out your maths book”"). At the other end of the anxiety spectrum, there were 4 students who scored 2, (close to feeling really anxious/upset) when doing this test. Three of the students got 16 out of 30, while the other student achieved 12 out of 30. All four of the students used the words stressed or overwhelmed to describe how they felt during the test, but only 1 student explained further, stating “It is stressful in test situations”. That student went on to explain that one way a teacher could help would be to not indicate that it was a test. The word test itself caused panic for this student. These 4 students were pretty accurate in predicting how they performed. Two were right within their range, while the other 2 students were only one question out. This shows that some students who don’t feel confident in maths have a pretty good feel of where they are mathematically. This creates a very good building block for teaching and their own learning as their expectations are not too high or too low, hence becoming unrealistic. Working with one of the students for the past year, he has become a lot more accepting of his mathematical ability, knowing that this is an area he needs to continually focus on. At the beginning of the year, almost every time that a mathematics lesson occurred, he would present with high stress and regularly state “I can’t do this” or similar words. He needed a lot of reassurance and positive reinforcement. This is verified with his statement of “by going through it thoroughly” when commenting on how a teacher can help him. Dave had not seen him get stressed out in a mathematics lesson in a while, but judging by his response, testing was stressful. He also responded with a 3 (midpoint between anxious and confident) when the teacher said get out your maths books, but also selected the word 'overwhelmed.'

One of the four students intrigued Dave when looking at his results. The student got 16 out of 30, about where Dave expected. In class, he displayed no reluctance to do maths. He would have a go at answering any question asked of him, and in general his results were in the middle range, or just below middle. He is happy with his successes and willingly took on advice to improve. Therefore, it was a surprise to see him score a 2 on how he felt doing this test, and score a 1 (really anxious/upset) on the "take out your maths book" question. He also used the word stressed to describe how he felt and was relieved when it was all over. When Dave spoke with his co-teacher, she was surprised at the results too, as that student outwardly did not obviously display anxiety.

If we take that anyone who scored a 2 or below on the questions about how they felt with the test or how they feel when the teacher asks to take out your maths books as displaying some form of mathematics anxiety, then 7 out of the 26 or 27% of students presented as such. Their results suggest that their anxiety does have an impact on their test results. The 7 students averaged 13.9/30 and they were all in the bottom half of the class results. Each one of them used either of the words 'stressed' or 'overwhelmed' when describing how they felt during a maths test. It is interesting to note that only 2 of the students chose 2 on whether or not they need help. The rest of the students chose 3. Dave's impression of the 2 students is that they are unlikely to come and ask for help in mathematics lessons. They will greatly appreciate the help when you get to them, but they are not very proactive in asking for help. Again, if the survey was conducted at the beginning of the year, then this could increase awareness.

According to the students, the two most difficult question on the test were:

Qu14 - 'What is 36.15 ÷ 5 equivalent to?'

- 3615 ÷ 5000
- 3615 ÷ 500
- 3615 ÷50
- 361.5 ÷ 500

Qu18 – 'Two items cost $65.75 and $42.83. How much would you pay if there is a discount of 30% on both items?'

- $32.58
- $16.05
- $76.01
- $44.37

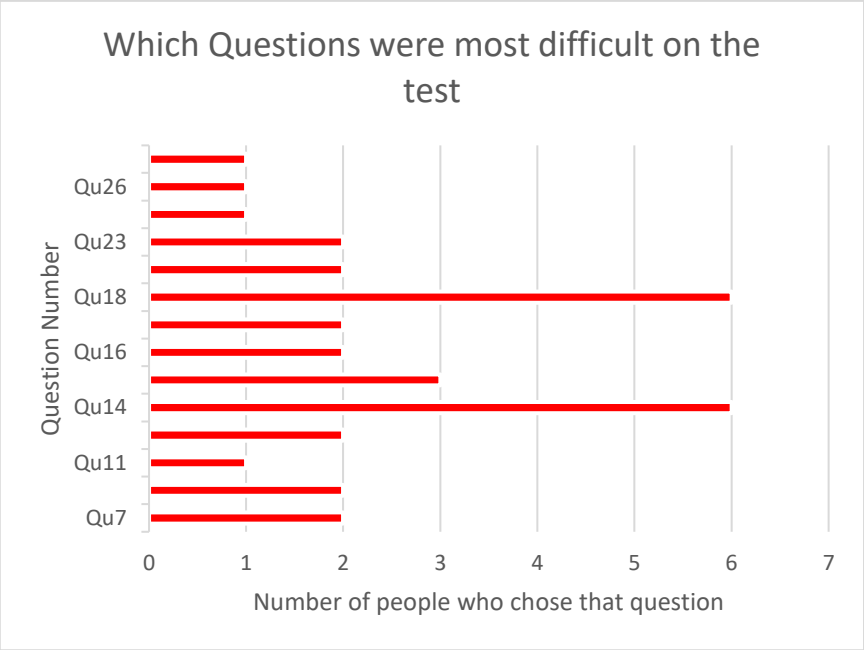

Figure 1. The most difficult questions of the test.

42% of the class got Question 14 correct, while only 31% of the class got Question 18 correct. Of the 7 students identifying themselves with some form of anxiety, no one got question 14 correct and only 1 got question 18 correct.

Both questions had been covered in class throughout the year. The first question is place value and the second is percentage and estimation. With support, Dave assumed most of his students would be able to answer these questions correctly as the issue is more comprehension rather than mathematical skill. For question 14, the students saw it as a division problem. For the class' least favourite aspects of mathematics, division was mentioned 8 out of 26 responses. This is good to know as a teacher, and that it requires work as a class. If the students were feeling less anxious, would they realise that it is more a place value question? This answer could only come from a one on one discussion with each child.

For question 18, if the students used estimation, then finding the answer is quite easy in a multiple-choice situation, especially when there is no response close to the answer of $76.01. It has been discussed throughout the year on numerous occasions to estimate if not sure. $60+$40 = $100. Take away 30% of $100 would leave $70. The only answer close is $76.01. Do the anxious students look at the maths and go it is too hard? Do they freeze up. In regards to testing, are looking at how to work it out, mathematics comprehension or real-life problem solving? Do we as teachers need to place a bigger emphasis on the real-life aspect of mathematics, especially for our more anxious students?

All of the 7 students who reported feeling anxiety were in the bottom half of the results in the test scores, but they were not the lowest scores. It is interesting to note that the 7 students identified as anxious during mathematics tests or lessons struggled a lot more in the number and algebra areas of mathematics. Admittedly there were more questions asked compared to the other areas, perhaps offering greater differentiation in the questioning, but this does present as a clear area of weakness. A reason behind this difference could be in the type of questions presented. For Statistics and Probability, there were 2 graphs shown, which they had to answer questions from. For Measurement and Geometry, there were 2 questions

relating to timetables and 2 questions with a diagram. None of the Number and Algebra questions had graphs or other images. The difference between questions that had some kind of picture or not was striking in this sample for students who identify as suffering some form of mathematical anxiety. For the non-anxious students, there was a smaller difference in performance with questions that were picture based or not.

Finally, the results suggest that poor performance in the test is not a direct indication of mathematics anxiety. The student, whose performance was the least successful, did not demonstrate anxiety. He was not confident at all, but when asked how he felt when the teachers ask to pull out your maths book, he replied with "not fussed." He scored his feelings as 3/5 for both the test and the maths lessons. His expectations of his results were extremely unrealistic, missing the target by 11 points. He only got 5/30 on the test, but thought that he was in the 16-20 bracket. This is with him even considering similar performances on similar tests held previously[6]. Additionally, three students who performed better than average on the test, with one of them scoring the top results, used the words stress and overwhelmed when doing maths. Only one of those students didn't use a positive word to describe how he feels during a maths test. Does this mean that some form of stress can help performance?

Conclusion

One indication from the results was that the use of more pictures while teaching might help those who are little more anxious. With respect to the result that questions with graphs or pictures caused less anxiety, does this mean that anxious students are more comfortable with the visual question in mathematics that with questions that are number based? Does dyscalculia, which "means to count badly and is used to describe people who have difficulties with numbers" Cohen and Walsh, (2007, p. 946) play a part in the anxiety levels? As Soares and Patel explain (2015):

> Children with dyscalculia tend to be less accurate in single-digit subtraction and multiplication than controls and also significantly slower on addition, subtraction, and multiplication. They may also depend more on "immature strategies," such as counting on their fingers to solve problems. The majority of dyscalculic children have problems with both knowledge of facts and knowledge of arithmetical procedures. Difficulty with basic arithmetic is a common characteristic, but dyscalculics appear to perform poorly on tasks requiring an understanding of basic numerical concepts, especially the concept of numerocity. This affects even very simple tasks such as counting or comparing numerical magnitudes (p. 20).

Although this study had a low sample size from a small timeframe, it is clear that there is some anxiety in the classroom when it comes to mathematics.

There might be some value in administrating this questionnaire at the beginning of the year to students in the higher levels of Primary School. This could give an indication of how they are feeling regarding mathematics and could point towards problem areas, providing direction for teaching in mathematics. It could be used as a screening test for the students, giving the teachers some indication on how students feel in mathematics. It would allow the teacher to be more perceptive to how each student internalises their feelings. If we had known how this student felt, would that have enabled us to move him from being an average student to being above average?

[6] Of course, this is based on self-report, and this is the kind of situation where self-report is problematic--is this boy telling the truth about his feelings, or is he projecting a confidence he doesn't actually feel?

As a school, this study might help the teachers to be more aware or mathematics anxiety and it will hopefully lead to an open discussion so it can address the needs of the students.

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