Maths anxiety in psychology undergraduates: A mixed-methods approach to formulating and implementing interventions

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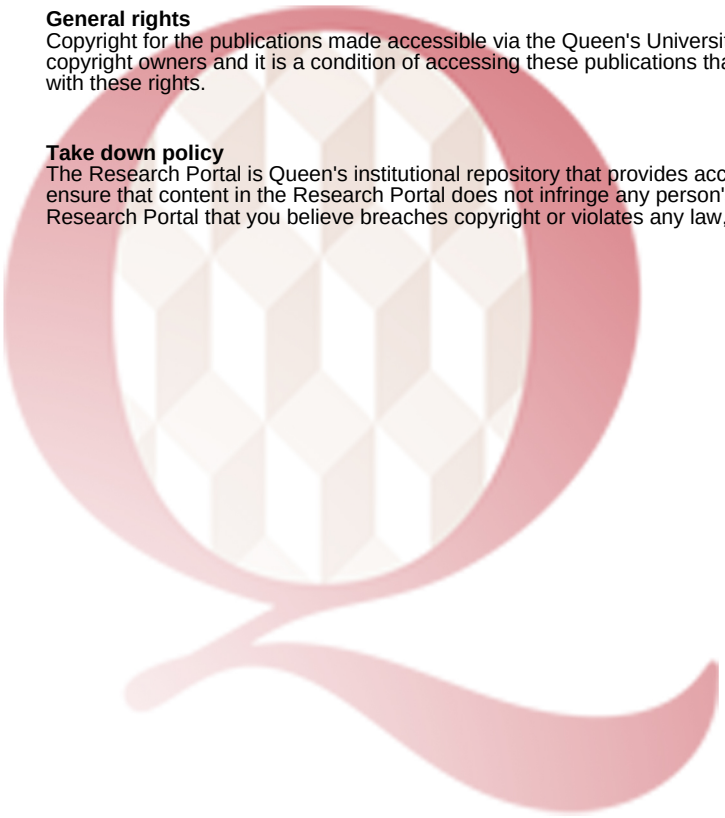

Abstract

A key challenge to educators in disciplines that, while not maths based, nevertheless contain some maths component, is mathematics anxiety. Over the years, a number of intervention strategies have been tested, seeking reduce maths anxiety in undergraduates. Many of these studies, however, contain methodological issues that challenge their validity. It is also unclear how many of these studies decide which type of interventions to use. This research sought to correct both of these issues. In Study 1, focus groups were carried out to explore which interventions students believed would most likely reduce their maths anxiety. Study 2 implemented those interventions that Study 1 showed to be practical and potentially effective, utilising a large sample of Year 1 and Year 2 psychology undergraduates, controlling for potential methodological confounds. Results showed that only one intervention (teaching quantitative research methods using real-life examples) had any significant effect on maths anxiety, and this was slight. These results, while not impressive by themselves, do suggest ways in which larger-scale interventions could seek to proceed in terms of reducing maths anxiety.

Introduction

Mathematics anxiety is generally defined in the literature as a feeling of tension, dread or fear that appears when a person is required to undertake some kind of task involving maths performance (Ashcraft, 2002). Dreger & Aiken (1957) described it as, “The presence of a syndrome of emotional reactions to arithmetic and mathematics.” At university level, it can lead to students purposely avoiding subjects or modules that have a high maths content (e.g. Hopko et al 1998; Llabre & Suarez, 1985) and, post-university, taking a less than optimum career path, simply due to their fear of doing anything mathematical (Durrani & Tariq, 2012).

A number of studies have, with varying degrees of success, attempted to reduce maths anxiety in undergraduate students through the use of interventions. Iossi (2007) categorised these interventions under three different headings: curricular strategies, instructional strategies and non-instructional strategies. This review will, for the most part, follow Iossi’s categorisations.

Curricular strategies refer to courses offered by universities that, directly or indirectly, reduce student maths anxiety. Carroll & Gill (2012) and Gordon & Nicholas (2013) discussed the use of ‘mathematics bridging’ courses to re-educate students entering university for the

first time in mathematics, their findings suggesting that such courses can ameliorate some aspects of anxiety. Other research (e.g. Keeley, Zayac & Correia, 2008; Maloney & Beilock, 2012) supports the use of lectures designed to instruct potentially at-risk students on the nature of maths anxiety, and strategies regarding how it can be reduced. In contrast, Wilson (1999a) stated that directly addressing anxiety might actually be counterproductive, increasing student discomfort. Also, it should be noted that while curriculum strategies are used in many universities, literature on the success of these interventions is comparatively scarce. Hembree (1990), in his meta-analysis of the literature, concluded that such interventions were, in fact, generally not effective in significantly reducing student maths anxiety.

Instructional strategies meanwhile, according to Iossi (2007), derive specifically from the teacher or instructor, as opposed to the general university-originated curriculum. These can include manipulation-based interventions, which involve students working with some applied, hands-on task, as opposed to traditional teaching methods. D'Andrea & Waters (2002), for example, explored the effect of teaching quantitative methods via the use of short stories. Likewise, Henrich & Lee (2011) had their participants try and reduce anxiety by introducing a service-learning component to a quantitative methods course, where the students gave maths tuition to school-children. Both studies showed positive findings (although D'Andrea & Waters' study used very small sample sizes, and Henrich & Lee did not measure any change quantifiably, drawing these results into question).

Other studies have attempted to use real-life examples in the teaching of quantitative methods. This is in order to make the content of such courses appear less abstract and more applicable to everyday life (e.g. Renzulli, 2000; Schumm et al., 2002; Shull, 2009). However, while much theoretical literature supports such strategies (e.g. Ramjan, 2011), when students are asked to rate the effectiveness of proposed interventions, introducing real-life examples is often considered one of the least likely to be effective (Wilson, 1999b).

Group-learning is another potential manipulation-based instructional intervention. Having students work on quantitative problems in groups (e.g. Borresen, 1990; Uusimaki & Kidman, 2004) has been shown to effectively reduce anxiety. Townsend, Moore, Tuck & Wilton (1998), on the other hand, found that group learning was not an effective intervention. Other studies have concluded that the utility of group learning seems to be strongly

dependent on the size and the content of the groups (i.e. friends as opposed to strangers) (Wilson, 1999b).

The third class of interventions proposed by Iossi (2007) consists of non-instructional strategies. These can include behavioural interventions (e.g. Zettle, 2003), cognitive treatments such as counselling and cognitive modification (e.g. Hendel & Davis, 1978; Suinn & Richardson, 1971) and cognitive behavioural strategies, such as Cognitive Behavioural Group Therapy (e.g. Karimi & Venkatesan, 2009). Reports on the efficacy of such interventions are, however, mixed (Hembree, 1990).

In conclusion, considerable previous research has attempted to find ways to actively reduce maths anxiety. Unfortunately, not only does a lack of consensus exist regarding the best form potential interventions can take but, as a number of meta-analyses confirm (e.g. Zientek, Yetkiner & Thompson, 2010) many of the studies are flawed at some fundamental level, whether this is to do with having no controls, or through not properly quantifying any changes that may have taken place. Furthermore, it cannot be assumed that every intervention will be equally effective for any group of students in any university, and so care must be taken not to generalise the results of any one study.

This research had two main aims. The first was to uncover, from the students themselves what techniques they believed would be effective in reducing maths anxiety. The second aim was to actually implement those strategies which were determined to be feasible and practical, in a way that would be experimentally valid. No research has before attempted to implement maths anxiety interventions based on both previous literature and student responses, relying on either one or the other.

Study 1

Before an effective intervention could be administered, it was deemed necessary that some research be carried out determining which interventions would have the greatest chance of success. A number of potential intervention strategies were outlined in the introduction, but these are generally formulated based on previous research carried out on potentially quite different experimental samples. While the interventions presented in Study 2 will also be informed by previous literature, their design will additionally be based on the qualitative findings of Study 1. This will, potentially, give much greater strength to Study 2.

Study 1 Method

Participants

Thirteen undergraduate psychology students and nine postgraduate psychology students (all PhD students) from a UK tertiary-level psychology institution participated in this study. Participants were recruited on a volunteer basis, with students replying to a general invitation email. The undergraduate participants were split and tested separately in their three different year groups. There were four participants in the Year 1 group, five in the Year 2 group, and four in the Year 3 group. Four of the students were male and three would have been considered as mature students (i.e. over 21 years of age).

The postgraduate participants were also recruited on a volunteer basis. They were split into two different groups, of five and four individuals, respectively. Four students were male and five were female. PhD students were included in this study as (a) all nine worked closely within the undergraduate quantitative methods course, as teaching assistants, demonstrators and / or coursework markers and (b) all of these students had, at some point in the past, been psychology undergraduates themselves, allowing further insight into the maths anxiety felt by undergraduate samples. One student was in his early forties while the remainder were between the ages of 22 and 30.

Psychology students were chosen for this study as, while the course is not mathematics-based, it nevertheless consists of a heavy quantitative component involving statistics. Despite the importance of statistics in the psychology curriculum, it nevertheless remains one of the least liked and poorly performed components of the course (Dempster & McCorry, 2009; Seabrook, 2005) with students tending to do very badly on statistics exams (British Psychological Society, 2003).

Procedure

The focus groups took place in a room within the psychology faculty. Ethical approval was obtained beforehand and all participants gave informed consent prior to testing. Only one principal question was asked; “What interventions would you suggest for curing maths anxiety? Any ideas?” This was so that participants could discuss interventions that would be directly relevant to them. Each session was recorded and transcribed, with the transcriptions then being subjected to a deductive thematic analysis based on critical realist epistemology (Braun & Clarke, 2006). From the responses specific themes were identified.

Study 1 Results

Overview

From the data, the suggestions for potential interventions put forward by the participants were separated into four distinct groups: using small groups for teaching, increasing the amount of numeracy-based classes, explaining the application of numeracy-based knowledge in greater detail and introducing more sympathetic teaching methods. Examples of student responses are presented in italics.

Using Small Groups for Teaching

The Year 1 and Year 2 undergraduates and the postgraduates suggested the use of smaller teaching groups than the class sizes adopted for the lab classes utilised as part of their psychology course (each class had, roughly, 40 students). The undergraduate participants would have taken part in, on a bi-weekly basis, tutorial groups of only about six or seven students, and these were recommended as models for how the proposed 'statistics groups' would run. The motivation behind the desire for smaller groups seems to be that it would allow the opportunity for more one-on-one teaching from an experienced staff member than would be available in the lab classes. There also appears to be less social stigma about asking for help in a small group than there would be in a fairly large class.

It's way easier to learn something in a smaller group. That's why probably in lab classes it's easier to learn stuff in. (Y2 undergraduate – female)

That would be really good. Groups of ten just with their personal tutor with a computer, who goes through things. (Postgraduate – female)

Closely related to this point was the suggestion, from all undergraduate groups, that having access to a single individual whose task was to help students with their statistics would reduce anxiety. It was pointed out to the students that the university did run 'stats clinics' for those students with particular problems. The response to this was that such 'clinics' were extremely generalised, having to cater for a wide variety of disciplines, and so were often not useful for answering the psychology students' particular problems.

(If the intervention) offered help. If (it) said, like, "I'll help you, I'll take you one-on-one and help you or something," then that would probably help a bit. (Y1 undergraduate – female)

The idea of a personal tutorial or something like that would be brilliant, just to have that opportunity to raise questions. Because, like when it came to the group project…em…I'm not getting too bad marks on stats but I still didn't know where to even start, as to what I should do to analyse the data that we have. (Y2 undergraduate – female)

The postgraduate students, however, had mixed feelings about this. It was pointed out that most undergraduates would probably feel awkward in going to someone for help. Also, for such an intervention to be successful, it would need the formation of a long-term mentor-student relationship. A framework for such an intervention had existed in the Y1 lab-classes a year previous to the focus groups, but had since been discontinued.

In the first year of my PhD, when I did demonstrating, we were always split up into smaller groups within the lab. It was really good. Like, that group I had genuinely used to email me all the time and I'd help them with stuff. (Postgraduate – male)

Approach of the Lecturers

The Year 3 undergraduates and the postgraduates suggested that the teaching style of quantitative lectures could be changed to reduce anxiety. Comments suggested that the current lectures appeared dry and potentially intimidating and that making them more fun and accessible would help. Also, active steps by the lecturer to assuage each student's fears were recommended.

Make it fun, yeah. That's a big one. And make sure the lecturer says: "Please don't panic. This is not going to be as bad as it sounds." (Y3 undergraduate – male)

Lecturers sometimes say, "Today, we're going to cover a mixed ANOVA or something," you know. Even if they say to us things like, "Don't be panicking. It's O.K. It's not as difficult as it looks." (Y3 undergraduate – male)

The postgraduates also stressed the importance of lecturers combining both theoretical and practical elements into a single class, as opposed to having the two separate.

They do all the theory stuff in the lecture and when it comes to the lab class it's just how to press buttons and that sort of thing, whereas when you combine the two in the one class it really is possible to have, like, genuinely engaging…like a positive learning experience for people to do statistics. (Postgraduate – male)

Increasing the Amount of Maths Exposure

Participants stated that increased exposure to numeracy would most likely reduce student fear of it. This could be in the form of additional quantitative lectures / classes, homework to do after each lecture / class and additional practice exams throughout the year. Increased assessment would also allow students to be able to see the areas in which they need to improve, as well as to chart improvements in their numeracy ability across the semesters.

Increase practicals, increase exposure to maths. Don't just make it a one-off, one-semester and one-a-week… Just repeated exposure to it. I think that would take away a lot of the anxiety. For me anyway. (Y1 undergraduate – female)

When I first started, yes I worried about it, but once I got in, it was a lot of hand-written labs and things and then, once you got into second year there was a level of worry because you're having to submit these lab reports every week. But, by the end of the first two labs, you kind of…you know, you're very proficient in it. You know what words to put, you knew what instruction to follow and by the end of second year I was happy and confident I could go into my third year and do the thesis part on my own. (Postgraduate – female)

Explaining the Application behind Numeracy

The second and third year undergraduates and the postgraduates posited that anxiety towards the numeracy-based component of the course could be reduced if the quantitative component could be rendered less abstract and more applicable to real-world examples.

Instead of just telling you the formula and how to get it done I think it would be nicer and easier just to break it down and go like, you know, "Why are we using this set of numbers?"… So instead of just memorising it and having no idea what idea about what it means, just kind of getting used to it. (Y2 undergraduate – male)

For me, I think, just tying it into just how it's going to be used is the important thing as it does seem like two very separate ideas and that's what's the scary part- just trying to link them together so I think…em…just making sure that it's more practically applicable and not…em…not always just, "O.K. we're just going to do this exercise," and not sort of understand how that could work in the thesis project or whatever. (Y3 undergraduate – female)

Study 1 Discussion

The responses gathered here seem to suggest that any intervention would have to, in some form, come from the course itself. Participants recommended increased amounts of quantitative tuition, more sympathetic teaching, smaller class sizes and the availability of one-on-one guidance. It is necessary, though, to be careful in the interpretation of these findings. Firstly, it should, in no way, be construed that all of the above are lacking in the psychology department in which testing occurred. One-on-one guidance was available during the lab classes and students were given the names of lecturers and postgraduate students who they could contact if they have any queries. Likewise, many quantitative psychology textbooks contain exercises that enterprising students could use as a form of additional tuition, and most staff members do make an effort to teach numeracy in a non-abstract way.

Secondly, it is debatable if many of the proposed curriculum changes would, in fact, be welcomed by students as a whole. While students might *say* that doubling the amount of statistics lectures and introducing homework would help them, most likely the reaction to such changes occurring would be, initially at least, very negative. Also, as stated before, facilities are already available for students to ask, for example, selected postgraduates for help but, from the personal experience of the first author, very few actually choose to avail themselves of these (although it is possible that this system needs to be advertised more). It must be remembered that for an intervention to be successful, work must be put in by the recipient of the intervention as well as by the organisers of the intervention. It is possible that some kind of general change in undergraduate attitudes to university-work is required before their maths anxiety can be targeted.

Thirdly, there is the issue of practicality. Many of the changes proposed would involve major alterations in course content and teaching that could only be initiated from a departmental level. Also, something as simple as having a postgraduate student appointed to deal with statistics queries could be potentially hazardous, as that person may find themselves totally swamped by undergraduates with questions. Nevertheless, even if this study is unable to, in itself, implement the changes recommended by the participants, it is recommended that any psychology institution with both a strong quantitative methods component and high levels of numeracy-based anxiety should seriously consider these.

Additional issues that may have resulted from the testing include the fact that participant numbers were quite small, with only 22 participants in total. Also, social desirability is a potential drawback of focus groups, and so there was always the risk that

participants were simply telling the experimenter what he wanted to hear. While it is possible that this may have happened, to a minor degree, the responses do not reflect this.

Study 2

By implementing three different types of intervention on undergraduate psychology students, it was hoped that they would reduce student maths anxiety. Additionally, by exploring the efficacy of these different interventions, using a large sample size and rigorous scientific methodologies, it is hoped that the results of this study will assist towards the formulation of larger-scale, more effective interventions in the future.

Undergraduate psychology quantitative methods courses at the UK university in which testing occurred, have a clear and concise structure. For the Y1 students, the course begins with the development of fundamental research methods skills. This shifts to basic statistical techniques by the end of the first semester. At the end of the academic year, students are expected to be familiar with means, standard deviations, z-scores, correlations, chi-squared tests and t-tests. In Y2, there is a greater focus on statistical techniques, with students being introduced to one-way and two-way within-subjects, between-groups and mixed methods ANOVAs, linear regressions and factor analyses. For both years, the quantitative methods course encompasses weekly lectures and practical lab classes. All statistics work is carried out on computer (SPSS) and, with the exception of effect-size calculations, students are not expected to undertake calculations manually. Assessment consists of lab reports submitted as coursework and exams that take place at the end of each academic semester.

All the proposed interventions in this study follow directly from previous literature and the qualitative results of Study 1. Participant responses regarding interventions were split into four categories: the use of small group teaching, making the instructor's teaching methods more reassuring, increasing the amount of maths exposure, and explaining the real-world application behind the statistics being taught. For this study, 'increasing the amount of maths exposure' was not followed up because it would have required major changes to the university-set curriculum.. Likewise 'making the instructor's teaching methods more reassuring' would have been too difficult to control as an intervention, as each teacher and teaching assistant would have to be trained to be equally as 'reassuring' to the students.

The ‘explaining the real-world application’ idea for an intervention was adopted for use in this study. Although some previous research (e.g. Wilson, 1999b) has cast doubts upon the utility of such interventions, participants in the focus groups almost unanimously agreed that this would be an effective method for reducing anxiety. Two different interventions were extracted from the ‘small groups teaching’ idea for intervention. The first was that students would be split into small groups for their class assignment, each group with an instructor assigned. It was expected that students would feel less embarrassed about asking for help if they were in a small group, as opposed to being in a class of approximately 40 individuals. The second intervention drawn from the ‘small groups teaching’ intervention idea was that students would be given the email address of someone in the department they could go to for help if they could not understand the statistics in their classwork. It was expected that this would reduce the embarrassment associated with asking for help and allow students to be less fearful of the topic, knowing that there was someone who could assist them.

Overall, it is expected that the interventions will result in reductions in maths anxiety amongst the students, compared to those students who do not receive any intervention. What is less clear, at this stage, is whether one particular intervention will be more effective than any of the others. The study will also suggest ways in which more powerful, long-term interventions could be utilised in future studies within the department.

Study 2 Method

Measures

The maths anxiety subscale of the Fennema-Sherman Mathematics Attitude Scale (Fennema & Sherman, 1976) was employed here to measure changes in maths anxiety amongst the participants. The subscale had 12 items, item responses given on a five-point Likert-type scale, with a score of one indicating strong agreement and a score of five indicating strong disagreement. Half of the items were positively valenced (e.g. I am usually calm during maths tests) and half were negatively valenced (e.g. a maths test would scare me). Reliability coefficients were carried on the baseline Fennema-Sherman maths anxiety scores for the Y1 and Y2 groups. Each coefficient is acceptable ($\alpha = .931$ (Y1), $\alpha = .946$ (Y2)). Age and gender were asked of the participants. For gender, students were given the option of circling either ‘male’ or ‘female’ and for age, they were asked to choose between <21, 21 – 30, 31 – 40, 41 – 50 and >50.

Participants

Year 1 and Year 2 undergraduate psychology students, all from the same UK tertiary psychology institution that had been the focus of Study 1, were approached for participation in this study. Both of these groups must attend compulsory, weekly statistics lab classes and it was in this context that testing occurred. For reasons of practicality each lab is held once on four different days per week, Y1s having theirs in the afternoon, and Y2s in the morning. The student year group is equally divided (based on alphabetical order of surname) so that, for example, a quarter of the year attends the Monday class, another quarter attends the Tuesday class etc. Three of the classes were designated as intervention groups for this study, with the remaining class assigned as a control group. Year 3 students have no such suitable context and so were not approached for testing. Out of a total combined potential sample of approximately 330 individuals, 141 Y1 participants and 105 Y2 participants completed all stages of this study and only these participants are included in the analysis. It should be noted that such participant numbers are considerably higher than is normal for many intervention studies of this sort (e.g. Carroll & Gill, 2012; Van Gundy, Morton, Liu & Kline, 2006). The majority of participants (77.3% for the Y1s, 79% for the Y2s) were female. Also, the vast majority of participants were under the age of 21 (79.4% for the Y1s, 84.4% for the Y2s).

Procedure

Study 2 was split into 3 stages. At the beginning of the first semester (week 3 for the Y1 sample and week 2 for the Y2 sample) all participants were presented with the Fennema-Sherman maths anxiety measure while in class. This was done in order to establish an attitudinal baseline for the entire group. Stage 2 occurred during academic week 7 (roughly half-way through the first semester) for the Y2 students, and academic week 9 for the Y1 students. Here the interventions were carried out. For the statistics lab classes, each year was split up into four groups, with each group attending the labs on different days. One of these groups was designated as a control group while the remainder were the experimental groups. The Fennema-Sherman measure was given out at the end of these classes, to explore if the interventions had any immediate effect. These particular weeks were chosen because both year groups were studying challenging numeracy-related topics here. Stage 3 occurred one to two weeks later. Participants were given the Fennema-Sherman measure for the final time, to explore if the interventions had any longer-term effect on anxiety.

Interventions

Three different interventions were utilised. Firstly, participants were given a talk by the principal experimenter before they started working on their class assignments (‘Talk’). The talk was short (approximately 5-10 minutes) and was specifically related to the topics being studied (z-scores for the Year 1 students, and one-way repeated-measures ANOVAs for the Year 2 students). The experimenter described how these topics could be related to real-life examples in a less abstract way.

The second intervention involved the class of participants being given the email address of the principal experimenter and being told that if there was anything about the topic they did not understand or they needed help with, they could contact him (‘Email’). The third and final intervention involved additional help being given to students while in class (‘Small Group’). During statistics lab classes, the usual procedure is that students can ask for assistance from the lab demonstrator and one or two assistants who are stationed in the room. For the intervention, the class was split into seven to eight groups, each group being assigned a helper, thereby ensuring that smaller groups have greater access to a helper. Each helper had experience with the course content and training in how to assist in psychology lab classes. A timeline of the three experimental stages and interventions can be seen in Figure 1.

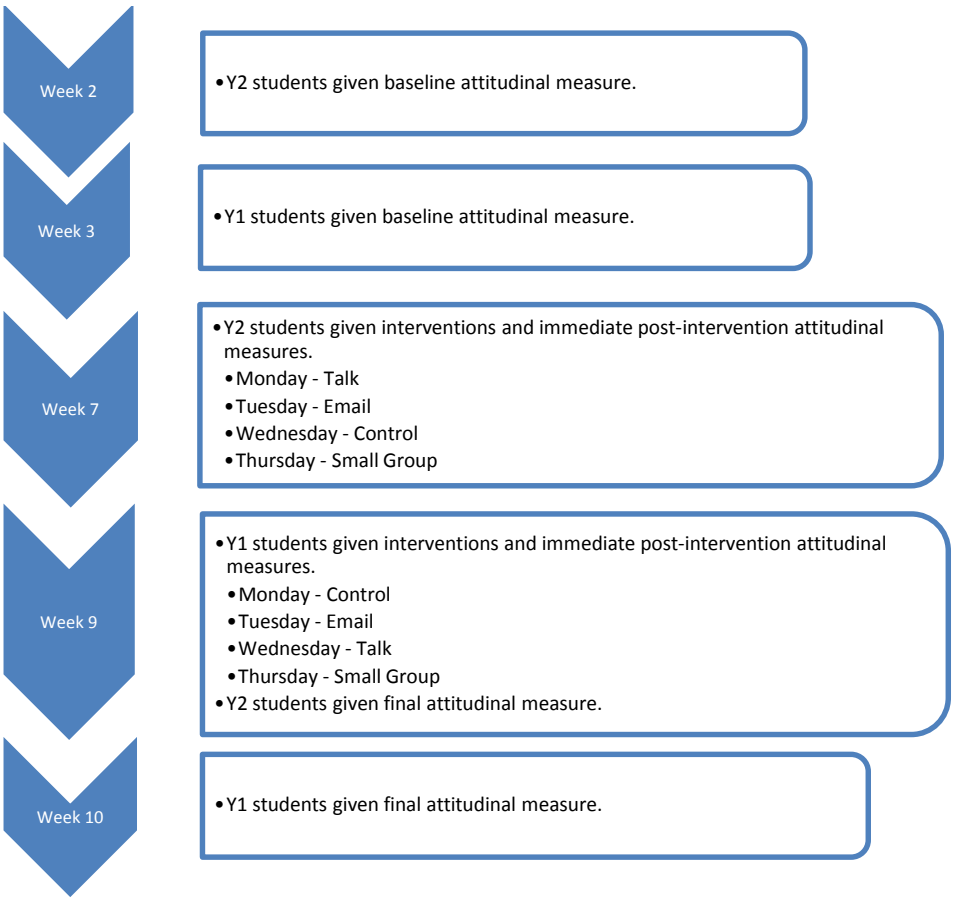

Figure 1. Flow-chart of Intervention Testing Schedule

Study 2 Results

Year 1 and Year 2 results will be explored separately. The reason for this is that, because of external factors such as course content and experience with the course, the pattern of results could feasibly be quite different between the two year groups, and that any attempt to combine the two would be invalid. A high score in the Fennema-Sherman maths anxiety scale reveals strong maths anxiety while a low score would indicate weak levels of anxiety. All analyses were carried out using SPSS.

At baseline level, mean anxiety scores ranged from 2.74 – 3.16 for the Y1 students, and 2.73 – 3.16 for the Y2 students, depending on experimental group. Twenty-three Y1 students (16.3% of the Y1 sample) and 21 Y2 students (20% of the Y2 sample) indicated mean anxiety levels of 4 and above at baseline, indicating very strong levels of anxiety towards numeracy. Figures 2 and 3 show that, for both Y1 and Y2 students, anxiety seems to spike at the second data collection point, immediately after the intervention, before decreasing to roughly equal or slightly below the score at baseline. The exception to this was

the Talk intervention group, whose anxiety decreased post-intervention for the Y1s, and stayed roughly the same for the Y2 students. See Table 1 for the exact mean values across year, intervention condition and testing point. Figures 2 and 3 show, graphically, the changes in maths anxiety score across all three test points (baseline, the immediate post-intervention testing point and the later post-intervention testing point).

Table 1. Means and Standard Deviations for Fennema-Sherman Anxiety Scores across Year and Experimental Condition

Condition	Time 1 (Baseline)	Time 2 (Immed. Post-Interv.)	Time 3 (Later Post-Interv.)
Control (Y1) (*n* = 41)	2.92 (.83)	3.01 (.88)	2.92 (.84)
Control (Y2) (*n* = 31)	3.17 (1.06)	3.26 (1.17)	3.14 (1.09)
Talk (Y1) (*n* = 37)	3.16 (.92)	3.05 (.84)	3.05 (.78)
Talk (Y2) (*n* = 29)	3.11 (.87)	3.14 (.89)	2.95 (.91)
E-mail (Y1) (*n* = 37)	3.01 (.78)	3.21 (.84)	3.11 (.87)
E-mail (Y2) (*n* = 22)	2.93 (.90)	3.12 (.86)	2.96 (.79)
Small Group (Y1) (*n* = 26)	2.74 (.76)	2.78 (.72)	2.61 (.80)
Small Group (Y2) (*n* = 23)	2.73 (.76)	2.87 (.83)	2.73 (.78)

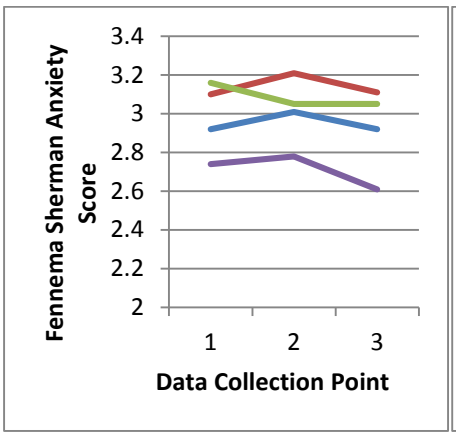

Figure 2. Intervention effects on Maths Anxiety (Y1)

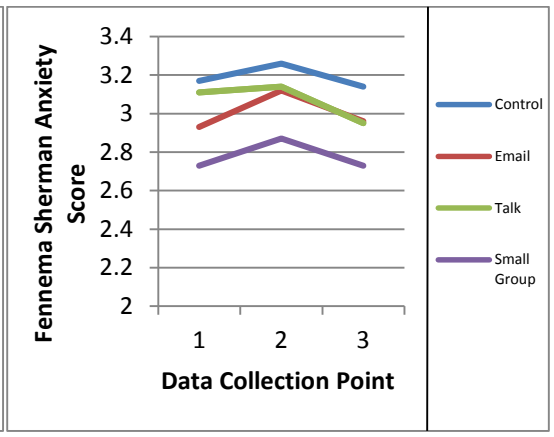

Figure 3. Intervention effects on Maths Anxiety (Y2)

Mixed ANCOVAs were used to identify whether or not there was a significant main effect of week of testing and intervention on the Fennema-Sherman scores. In each case, time of testing was the repeated measures independent variable (with two levels: immediate post intervention testing and later post intervention testing), while intervention type was the independent groups independent variable. Post-intervention Fennema-Sherman subscale

scores were the dependent variable while participant scores at baseline were used as the covariate in each case. The use of ANCOVAs, as opposed to mixed ANOVAs, was deemed necessary due to unexpected differences in the baseline affect scores across the different intervention groups, as shown by descriptive statistics. It was hoped that covariate analysis would allow accurate comparisons to be made between how each testing group responded to the different interventions, countering for the varied baseline scores.

For both the Y1 and Y2 students, the mixed ANCOVAs, with baseline maths anxiety score as a covariate, showed no significant difference between the two post-testing sessions in terms of participant score. An independent groups main effect, however, was found for the Y1 students, with there being a small but significant main effect of intervention on anxiety score (F (3, 136) = 3.470, p = .018; η^2 = .0712). Pairwise comparisons found that these differences primarily occurred between the email and talk interventions (with the talk condition producing less anxiety) (p = .027). For the Y2 students, the mixed ANCOVAs found no significant main effect of intervention between any of the groups. Figures 4 and 5 show the significant differences in mean anxiety scores between groups, at both post-intervention data collection points, adjusted for the covariate (baseline scores).

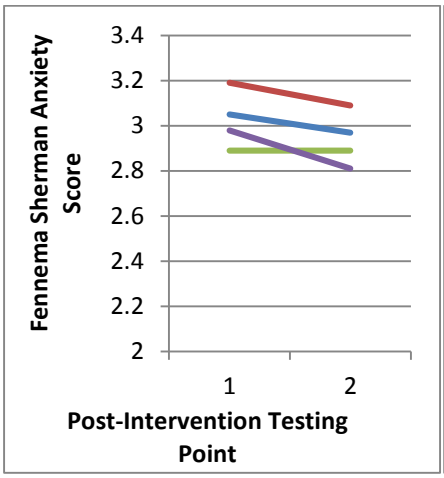

Figure 7.4. Intervention effects (adjusting for covariate) on Maths Anxiety (Y1)

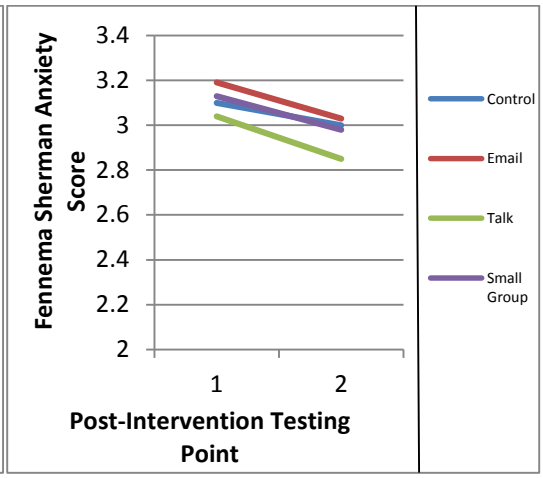

Figure 7.5. Intervention effects (adjusting for covariate) on Maths Anxiety (Y2)

Study 2 Discussion

The purpose of this study was to explore the utility of various different interventions, each derived from the results of Study 1, as well as from previous literature. All three of the

interventions could be classified as being based on instructional manipulation strategies (i.e. alterations in the way that numerical methods are taught). While some doubts do exist in the literature (e.g. Wilson, 1999b), the value of instructional manipulation interventions is largely supported (e.g. Ramjan, 2011) and, indeed, general participant responses in Study 1 seemed to indicate that these would be the most practical and effective of all possible interventions.

While there have been a considerable number of studies attempting to ameliorate the effects of negative numerical affect in undergraduate students, many of these contain methodological issues, such as very small sample sizes and high drop-out rates (e.g. D'Andrea & Waters, 2002), a lack of control groups (e.g. Uusimaki & Kidman, 2004) or a failure to include any quantitative analysis on the effects of the interventions (e.g. Henrich & Lee, 2011). This study, on the other hand, attempted to rectify these issues by including larger groups, controls and a thorough statistical analysis of the results.

Descriptive statistics show that there was a definite need for an intervention to be implemented amongst many individuals in this particular sample, with substantial minorities within both year groups strongly agreeing with items that asked whether or not students had high maths anxiety. However, in both year groups, the majority of individuals did not report, at baseline, strong anxiety, although it should be noted that only a small minority of students stated that they did not have maths anxiety at all. This general lack of very strong negativity (as opposed to more moderate negativity) might go part of the way towards explaining why the interventions were not as effective as was hoped. Improvements were noted in certain areas, particularly for the Talk condition, but these were minimal, and it cannot be conclusively said that they were not the result of additional factors.

The Email condition ended up being the least effective of the three interventions, possibly having a small, and short-lasting, *negative* impact on maths anxiety. Anxiety increased from the baseline to the immediate post-intervention test, before decreasing back down to roughly baseline levels at the later post-intervention stage. As the anxiety levels in the control group seem to follow an almost identical pattern to the email group it is possible that these findings are simply reflecting the fact that students get more anxious as the course goes on and becomes more difficult.

It is possible that, in telling participants that they could contact someone if they found the material they were working on challenging, this merely served to accentuate any, already present, negative affect by drawing attention to it. Wilson (1999a) predicted that this might be

an issue with certain types of curricular intervention strategies. Nevertheless, if the intervention had a negative effect, it was both small and short-lived.

The effect of having a single, contactable individual who can give support to students struggling with numeracy-related issues has not been directly investigated as an intervention before, this particular one originating from the focus group results. Ironically, despite the enthusiasm students showed regarding this particular form of intervention in the focus groups, not one individual actually availed themselves of the offered assistance. It is possible that, as the students knew the experimenter to be a researcher and not a professional tutor, they did not trust him to be a useful source of advice. If students were given the email address of a known individual working with quantitative methods, preferably someone with whom they had had a previous working relationship it is possible that this intervention might be more effective.

Of the three interventions explored in this study, the Talk condition was the most effective, although the positive benefits of were slight and effect sizes small. For the Y1 students, descriptive statistics showed that anxiety decreased immediately post-intervention (while this may simply be as the result of chance, it should be noted that, in every other condition, anxiety *increased* immediately post-intervention), remaining at this level for the final data collection point. Adjusting for baseline anxiety scores, the Talk group had the lowest level of anxiety post intervention in both Year groups (although this was only significant for the Y1 students). This was the only significant between-group effect found in this study.

It should be considered that this intervention consisted of only a very brief supplement to the regular tuition, and the fact that positive effects are observed, at all, supports the utility of such a method. The concept of using everyday examples and case studies to make quantitative methods less abstract has been championed by previous research (e.g. Everingham, Gyuris & Sexton, 2013; Shull, 2009) and was also explicitly mentioned by students in the focus groups as being potentially helpful. The much stronger findings of previous studies reflect the greater resources that were at the disposal of the researchers in these cases. Everingham, Gyuris & Sexton's (2013) study involved major overhauls of the curriculum at the Australian university in which testing occurred. Likewise, Shull (2009) was able to implement semester-long interventions. In comparison, this study merely offered a single, five minute, one-off addendum to a class. It is logical that a more in-depth

intervention, in the manner of Shull's (2009), would produce far more sizeable results than were achieved here.

It is not inconceivable that the positive effects produced by the Talk intervention may have resulted, not from the content of the talk exactly, but the fact that it provided students with a small degree of extra tuition. Again, the use of extra tuition to improve affect and performance is supported by the literature (e.g. Juhler, Rech, From & Brogan, 1998) and by student responses. Future interventions may seek to replace, as opposed to supplement, aspects of the quantitative methods teaching, to explore the source of the positive effects.

According to the descriptive statistics, the Small Group condition seems to have had some effect, but this is to a very small degree. The changes in anxiety for this condition, across the three data points, were very similar to that in the Control and Email groups, with anxiety increasing at the immediate post-intervention testing point, only to drop down to baseline levels at the third data point. This seems to be a general pattern within the data that the intervention is doing nothing to suppress, as opposed to there being a negative effect of the intervention itself. Adjusting for the baseline scores, the post-intervention Small Group participants were less anxious than the controls, but not significantly.

Unfortunately, no previous research has directly examined the effect of having larger numbers of teaching assistants in numeracy-based classes. Crowe, Ceresola & Silva (2013) explored the utility of including teaching assistants in a quantitative methods class but did not explore whether the number of assistants had any significant effect. It is possible that students viewed the increased number of assistants as a 'crutch' that they could avail themselves of to help them get their compulsory class exercises finished, as opposed to a resource they could use to help further their understanding of the numerical concepts involved.

There are a number of other possible explanations, unrelated to specific interventions, why the results did not turn out to be as positive as they were expected to be. Firstly, for whatever reason, there was something of a disparity between the intervention groups, in both Y1 and Y2, in terms of class size and general class attitudes. Lab classes are allocated on the basis of alphabetical order, and swapping between classes is generally not allowed. As a result of these precautions, there should have been no significant differences between groups. As can be seen from Figures 2 and 3, differences nevertheless existed. While the effect of the varying attitudinal baseline was countered for by the ANCOVAs, to an extent, it cannot be ruled out that this had a negative influence on the study.

Also, it could be argued that topics chosen for the interventions (z-scores for the Y1s and one-way repeated-measures ANOVA for the Y2s) were not the most challenging and that it would have been more appropriate to focus the intervention on some of the quantitative topics that students have the greatest difficulty with. Unfortunately, the study, with three different data collection points per year group, had to be fitted around the course syllabus, and so the choice of topics for the intervention condition had to encompass their position in the semester as well as their difficulty. A more effective future intervention would be formulated along with the course syllabus, to allow greater flexibility. It must be noted though, that the majority of students appeared to find the topics chosen in this study challenging enough, and so it is possible that no significant advantage would be gained from focussing on different topics.

General Discussion and Conclusion

While the results from this research are, by themselves, fairly weak, valuable implications can be drawn from them. Firstly, all the interventions presented in this study were formulated independently to the course curriculum, and were run as addendums as opposed to being part of the course. Student focus group responses, however, indicate that, for an intervention to be truly effective, it has to initiate from changes made to the course itself. Specifically, this could involve alterations in the format of the classes, the attitudes and methods of the teachers, and the way in which the course information is presented to students. Adding something 'extra' to a set curriculum is, most likely, not going to make any significant change.

It appears that the Talk intervention was the most effective of the three methods used in Study 2. However, it is unclear whether this was as a result of the use of everyday, non-abstract examples, or whether it was as a result of the additional tuition afforded to the students. The future exploration of both these avenues would be advantageous. Both are supported by previous literature (e.g. Juhler, Rech, From & Brogan, 1998; Renzulli, 2000) and both were strongly endorsed by the students themselves. It is clear though that, to be significantly effective, any intervention focused on these topics would have to be on a much more substantial scale than the brief 5-10 minute talk students received here. In conclusion, this research has shown potential ways forwards for future intervention studies. A need for further interventions definitely exists, and it seems likely that greater efforts to focus on real-life examples in quantitative methods teaching would yield fruitful results.

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