**Improving Maths Self-confidence & Maths Thinking Skills**

**John Reidy**

**Psychology Section**

**Faculty of Development & Society**

**Sheffield Hallam University**

**Abstract**

The current project aims to increase level 4 psychology students’ self-confidence at maths and their ability to think about basic mathematical concepts. The aim was to achieve this through the use of study guides which explained basic mathematics concepts along with exercises to enable students to practice thinking about these concepts. These additional resources were designed to be delivered to students via the Blackboard virtual learning environment.

Two cohorts of students have recently completed a set of baseline measurements, including measures of enjoyment of mathematics, maths self-confidence, and statistics anxiety. Additionally students completed an assessment of their mathematical abilities in six key areas.

The first two of the study guides and associated assessments were released to one cohort of students, with some positive feedback on their utility.

**Introduction**

It has become increasing apparent that students undertaking the BSc Psychology often struggle with the statistics component of the course. Research Methods and Statistics teaching forms a core area of the British Psychological Society (BPS) accredited psychology awards. As a result, all students wishing to gain a BPS degree are required to undertake introductory courses in statistics. However, students often come to the course lacking confidence in their mathematical ability and hence feel considerable anxiety and stress as a result of undertaking the research methods modules.

There is a growing literature concerning statistics anxiety which has been defined by Onwegbuzie et al. (1997) as an anxiety when encountering statistics in any form at any level. It has been proposed by Cruise & Wilkins (1980) that statistics anxiety has six components, namely worth of statistics, interpretation anxiety, test and class anxiety, computational self-concept, fear of asking for help, and fear of statistics teachers. This model of statistics anxiety was recently supported by the modeling analyses reported by Hanna, Shevlin and Dempster (2005). Onwegbuzie and Wilson (2003) have provided a good review of the factors related to statistics anxiety. They highlight research by Zeidner (1991) which showed that key factors related to statistics anxiety were prior experience of mathematics teaching as well as maths self-confidence. Onwuegbuzie & Wilson (2003) have also suggested that prior experience of mathematics was important in predicting levels of statistics anxiety, and thus engagement with learning in statistics modules. On a related note, some recent research by Mulhern and Wylie (2005) has demonstrated that students starting psychology undergraduate courses are often ill-equipped to deal with the statistical component of the course. In their study they examined the students' mathematical abilities in six key areas, including estimation, interpreting graphs, probabilities, proportions, calculations and algebra. They found that the students from a variety of UK higher education institutions particularly lacked skills relevant to understanding probability, proportions and numerical estimation. It is apparent that if the students see themselves as lacking in key mathematical skills, then this is likely to have a significant impact upon their statistics anxiety, and their confidence when confronted with the statistics component of their undergraduate courses.

One of the main recommendations from the work of researchers like Onwuegbuzie is that we need to pay close attention to how we design statistics courses to ensure that we do not exacerbate students' levels of statistics anxiety. One specific recommendation is to avoid asking students to calculate statistics by hand. Farbey & Roberts (1981) have shown that students who are required to calculate statistics by hand experience high levels of anxiety, and this is particularly the case for difficult statistical problems. Interestingly, Seabrook (2006) has demonstrated that students who undertake courses which do not require hand calculations attain higher levels of skills in statistical analyses than students who are required to do hand calculations. They also had higher attainment levels.

It should be noted that the research methods training provided to undergraduate BSc Psychology students at Sheffield Hallam University does not involve hand calculations as the aim is for students to gain a conceptual understanding of the statistical techniques covered. However, there are still very high levels of statistics anxiety among our students and this has an impact upon their willingness to engage with the materials and activities presented in the laboratory classes. It is with this in mind that the current project was designed to provide students with positive mathematics experiences, and to try to improve their self-confidence in dealing with mathematical concepts.

**Aims and objectives**

The aim of the project was to develop online resources to help improve maths self-confidence skills in dealing with mathematical concepts. In order to do this the plan was to develop:

* Online study guides
* Online self-test assessments
* Online feedback discussion board

The online resources were made available through the level 4 research methods and statistics module Blackboard site (see Figure 1 for example).

*Figure 1. Screenshot illustrating the availability of the student resources via Blackboard.*

**Method**

At the start of the academic year students were provided with an overview of the resources as well as an online guide to their use. The students were also asked to complete a maths skills test along with some psychometric measures of their mathematics anxiety, maths self-confidence and the general levels of anxiety (trait anxiety). These were to be baseline measures implemented in order to appropriately evaluate the usefulness of the online resources provided for the students.

The study guides were designed to provide students with a basic overview of key mathematical concepts. For example, the first study guide covers some very basic characteristics of numbers. The intention here is not to teach students anything new about number theory but to refresh their memory’s for what they had previously learnt and to help them practice thinking about these basic mathematical concepts. As students progressed through the year more study guides were released to link in with the statistical concepts being covered as part of the core statistics module.

It was intended that there would be a number of self-assessments delivered via Blackboard where students can test their understanding of the concepts introduced in each guide. The self-assessment tasks were designed to enable students to undertake them as many times as necessary. The aim was to get the students to think actively about the mathematical concepts. The difficulty levels of the assessments are tailored to ensure that the students experience success rather than failure. The intention with these self-assessment was to help students appreciate the mathematics skills that they have and to gradually build their confidence.

Built in to the project design were specific means of providing evaluation of the effectiveness of the study guides and accompanying only assessments. At the start of the semester students completed a number of self-report measures. Given the project aimed to improve self-confidence in dealing with mathematical concepts it was important to measure these abilities prior to students being given any statistics teaching and before release of the new study guides. Thus, in the first week of teaching (in the first year) the following variables were measured:

* *Maths Skills Test* (based upon work by Mulhern & Wylie, 2005). This consists of 18 questions measuring six key mathematical skills identified by Mulhern & Wylie. The questions are designed to measure *Calculations, Proportions, Algebra, Probability, Interpreting Graphs,* and *Estimation.*
* *Mathematics & Technology Attitudes Scale* (MTAS, Pierce et al., 2007). The MTAS is a 20 items questionnaire measuring a number of aspects of attitudes to mathematics. The subscale of interest for the current project is the one measuring mathematics self-confidence. This consists of four items rated on a 5-point Likert scale ranging from 'Strongly disagree to Strongly agree'. The minimum score on this scale is 4 and the maximum is 20. High scores on this questionnaire indicate high levels of mathematics self-confidence.
* *Statistics Anxiety Ratings Scale* (STARS, Cruise & Wilkins 1980). The STARS is a 51 items questionnaire measuring six components of statistics anxiety. There is a growing literature which suggests that statistics anxiety is a major barrier to learning in undergraduate research methods and statistics courses and thus it is intended to determine the degree to which the use of the study guides has a positive impact on levels of reported statistics anxiety.
* *Enjoyment of maths* as measured by a 100mm visual analogue scale. The anchors for this scale were ‘I hate maths’ and ‘I love maths’. This item on the battery of questionnaires was inserted as a matter or interest to see if there are any relationships with other variables in the study.

It was proposed that students would be reassessed on these measures at the end of their first year to establish any differences between baseline and year end. Analyses would have also investigated the possibility that any reductions in anxiety, or increases in self-confidence in mathematics are related to engagement with the study guides.

A facility was also provided for students to feedback to the tutor regarding the study guides. A discussion board was set up in Blackboard to enable students to post anonymous feedback about the resources that they have used. This allowed for continuous evaluation of the utility of the resources from the student perspective. It was also designed to provide valuable suggestions as to the most effective means of improving the resources.

**Assessment (teaching practice)**

It was intended that the impact of the additional materials on student attainment would be evaluated through analyses of those who utilised the resources compared to those who did not. In any such analyses there would need to be some means of controlling for prior levels of self-confidence in mathematics and also prior levels of skill in mathematics as indicated by scores on the maths skills test. This should allow for some evaluation of the impact upon learning of the study guides. In this analysis use could also be made of the data collected in the current year when the baseline measures were taken but the study guides were not released. We should be able to compare the impact on assessment this year compared to that next year and this would allow us greater confidence in conclusions we may draw concerning the impact of the study guides themselves.

**Current Status of the Project**

Unfortunately, the project has not moved along as quickly as would have been expected. Currently one cohort of students have been evaluated in terms of the baseline data and have had access to two of the study guides. It was intended that six study guides be developed and made available to students. The project is thus still only in the initial stages and there is not really enough progress for a thorough evaluation of the impact of the study guides. The analyses presented here thus should be treated with some caution given its very preliminary nature.

Preliminary Data Analysis

Preliminary analysis of some baseline data has been undertaken but this has not progressed very far at this stage.

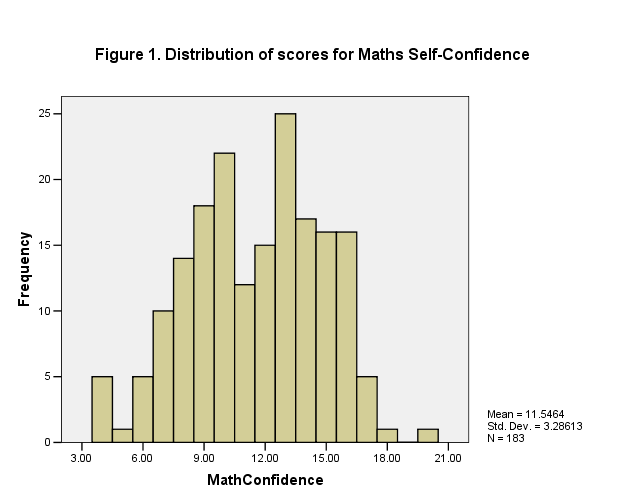
The analyses of the responses to the Maths Skill Test suggested that the cohort of students were weakest in the performance for the probability questions and the proportions questions. In addition, they struggled somewhat on the third of the algebra questions. These findings are remarkably consistent with those of published by Mulhern and Wylie (2005). The findings from this initial cohort of students are illustrated in Figure 2.



*Figure 2. Percentage of correct responses for each item on the Maths Skills Test.*

It is quite clear from these analyses that students come to their statistics training at undergraduate level with some considerable weaknesses in terms of the mathematical skills. This is particularly evident when we consider their ability to understand probabilities. This is a critical finding given the central role probability plays in statistical reasoning.

It is also interesting to note that the students reported only moderate levels of self-confidence in mathematics ability. The mean for the self-confidence in mathematics sub-scale of the TMAS was 11.55 (sd = 3.29), which according to the guidelines from the authors of the questionnaire (Pierce et al., 2007) would represent moderate to low levels of self-confidence (see Figure 3 below). There would thus be quite a bit of scope for helping students at the bottom of the scale of self-confidence.



*Figure 3. Distribution of scores for Maths Self-Confidence.*

The means and standard deviations for responses to the maths enjoyment scale and the six subscales of the STARS questionnaire are presented in Table 1. These show that…

Table 1. The means and standard deviations for the maths enjoyment scale and the subscales of the Statistics Anxiety Ratings Scale (STARS).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | STARS subscales | | | | | |
| Scale | Enjoyment of maths | Test and Class anxiety | Interpretation anxiety | Fear of asking for help | Worth of statistics | Computational self-concept | Fear of statistics teachers |
| Mean | 37.40 | 25.58 | 30.25 | 8.30 | 37.64 | 18.80 | 10.60 |
| SD | 22.47 | 5.98 | 7.26 | 3.10 | 9.89 | 5.83 | 3.55 |

The mean for enjoyment of maths suggests that the students generally had only low to moderate levels of enjoyment of maths. The visual analogue scale was 10 cm long and the mean mark was 37.4 mm from the ‘I hate maths’ anchor, perhaps suggesting that the students disliked maths more than they enjoyed it.

In terms of the STARS subscales a comparison with previous research (Hanna et al., 2008) suggests that the current cohort scores are similar to other UK undergraduate psychology students on test and class anxiety, interpretation anxiety and the fear of asking for help. However, this cohort scored considerably lower than the large sample examined by Hanna et al. (2008) in terms of worth of statistics, computational self-concept and fear of statistics teachers.

**Discussion, summary and/or evaluation**

It is rather disappointing that the project has not moved on from the initial stages of the development and implementation of the first study guides. As suggested above the intention was to generate at least six study guides to be released at specific intervals during the students first year of study. Currently only two of the study guides have been written and made available to students. It was also envisaged that a follow-up assessment of the students would occur towards the end of the teaching year to assess changes in self-confidence in mathematics, statistics anxiety and the six key areas of analytical skills in mathematics. Given the limited progress made on developing the study guides this follow-up assessment has not taken place.

Despite the limited progress on the project the initial verbal feedback from students has been positive and it is anticipated that other work commitments will now allow a full implementation of the study guides and associated resources in the next academic year. This will allow for a much fuller evaluation of the project which will then guide future developments. It was interesting that a considerable number of students (approaching 30%) accessed the first year study guides. It is evident that the students are demonstrating here a notable level of learner autonomy. When introducing the project to the students they were informed of the purpose of the resources and that they were to use these as and when they felt they needed help. It was also made clear to students that there was no content directly relevant to the statistics modules in these study guides. The degree of uptake of the initial resources by students suggests that the students are actively thinking about their numerical skills and actively doing something to support their own learning. The fact that many students used the initial study guides suggests that they are happy to use appropriate resources to enhance their abilities to undertake the study of core material for the modules. This is a very promising finding from the perspective of promoting learner autonomy. It should be noted, however, there is no evidence to suggest that students accessing the study guides in Blackboard are engaging with it in any meaningful way.

One of the positive outcomes from being involved with the project is realisation that there is considerable interest in supporting students in their numerical and mathematical developments across the higher education sector. I have been fortunate to be in communication with researchers/lecturers in other institutions who are developing resources along similar lines to those being generated in this project (e.g. the Centre for Excellence in Mathematics and Statistics Support based at the Loughborough University and Coventry University). Perhaps the key difference here at Sheffield Hallam University is that the guides currently being developed are more basic than those that have been developed elsewhere. The emphasis of the current project is on reactivating mathematical/numerical concepts which students have previously mastered but may have forgotten or which through practice may have become non-conscious. Thus the aim has been to illustrate to students how much they already know and make the links between this knowledge and their methods/statistics course more explicit, thereby improving the students' self-confidence.

**References**

Cruise, R.J. & Wilkins, E.M. (1980). STARS: Statistics Anxiety Ratings Scale. Unpublished manuscript, Andrews University, Berrien Springs, MI.

Farbey, L.J. & Roberts, D.M. (1981). *The effect of calculator usage and task difficulty on state anxiety in solving statistical problems*. Paper presented at the Annual Meeting of the American Educational Research Association, Los Angeles, CA, April.

Hanna, D., Shevlin, M. & Dempster, M. (2008). The structure of the statistics anxiety rating scale: A confirmatory factor analysis using UK psychology students. *Personality and Individual Differences, 45*, 68-74.

Mulhern, G. & Wylie, J. (2005). *Assessing numeracy and other mathematical skills in psychology students as a basis for learning statistics*. Mini-project for the HEA Psychology Network.

Onwegbuzie, A.J., Daros, D. & Ryan, J. (1997) The components of statistics anxiety: a phenomenological study, *Focus on Learning Problems in Mathematics*, 19(4), 11–35.

Onwegbuzie, A.J. & Wilson, J.A. (2003). Statistics Anxiety: nature, etiology, antecedents, effect, and treatments – a comprehensive review of the literature. *Teaching in Higher Education, 8,* 195-209.

Pierce, R., Stacey, K. & Barkatsas, A. (2007). A scale for monitoring students’ attitudes to learning mathematics with technology. *Computers & Education, 48,* 285-300.

Seabrook, R. (2005). Is the teaching of statistical calculations helpful to students’ statistical thinking? *Psychology Learning and Teaching, 5,* 153-161.

Zeidner, M. (1991). Statistics and mathematics anxiety in social science students- some interesting parallels. *British Journal of Educational Psychology, 61,*319-328.