

## ADDRESSING MATHEMATICS & STATISTICS ANXIETY

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**Abstract** This paper should be of interest to mathematics and statistics educators ranging from pre-university to university education sectors. It will discuss some features of the author's teaching model developed over her longitudinal study conducted to understand and address mathematics and statistics anxiety, which is one of the main barriers to engaging with these subjects especially in non-specialist undergraduates. It will demonstrate how a range of formative assessments are used to kindle, as well as maintain, interest in teaching rooms and their impact on students' engagement with these subjects.

**Keywords:** Mathematics and statistics anxiety, student voice, assessment, feedback, undergraduates

### Introduction

Mathematics and statistics anxiety (MSA) refers to the negative emotions learners experience while engaging with these subjects. These emotions could either be triggered by prior unpleasant learning experiences during pre-university education or preconceived negative notions formed outside the school environment.

MSA continues to challenge educators across the globe as shown by The Programme for International Student Assessment (PISA) survey outcomes. PISA is a triennial international survey which aims to evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students representing more than 70 economies. PISA findings (2012) have shown that students with low confidence experience high levels of mathematics anxiety, which has an adverse impact on their academic performance.

### Context, problem and related issues

MSA is also a challenge in higher education and can dampen non-specialist undergraduate's (NU) enthusiasm to engage with mandatory mathematics and statistics courses. MSA is usually accompanied by test anxiety, negative attitudes toward mathematics and fear of failure (Bessant, 1995) hence a complex issue which requires extremely delicate handling. Its adverse influence on students' academic performance is known (Ashcraft and Krause, 2007) and should be appropriately addressed. The increasing diversity of the British university student population as a result of the high proportion of international students, widening participation and access to higher education, adds new dimensions to this challenge. This range of cultural, socio-economic and academic backgrounds of students manifests itself through diverse expectations and individual learning requirements that need

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to be carefully considered. De Vita and Case (2003) argue that this diversity creates an opportunity “to reflect on and rethink not only what we teach but also how we teach.”

Approximately 80% of NU students enrolled on mathematics and statistics courses display MSA to some extent. They often find it hard to handle the information delivered in lectures and feel overwhelmed as a result, also finding the courses lengthy, tedious and irrelevant to their respective career paths. Low academic self-efficacy also contribute to MSA which obstructs learning; “...students are likely to have trouble with statistics due to non-cognitive factors, such as negative attitudes or beliefs towards statistics. Such factors can impede learning of statistics...” (Gal & Ginsburg, 1994).

## **Main hypothesis**

The use of short formative assessment questions (SFAQs) followed by spontaneous feedback in lectures and classes will reduce MSA by enhancing self-belief and self-confidence.

## **Methodology**

Optional open-ended questionnaires, case studies and observation are used to understand MSA. Questionnaires are periodically used to monitor changes in students' perceptions of mathematics and statistics. The course chosen throughout the study was mathematical statistics.

## **SFAQs**

SFAQs such as multiple choice questions (MCQs) and short questions (SQs) are used by the author to create curiosity, get students' attention, identify misconceptions, maintain interest and enhance student engagement throughout lectures to large lecture groups as well as small classes.

## ***Getting their attention***

At the start of the lecture/class an SFAQ relating to previously covered material is displayed on the screen asking students to work on it with their peers after which the solution is displayed with a brief recap. This gets students' attention, makes effective use of the first five minutes and makes them receptive to course material. Students who get the correct solution become receptive to the rest of the session as a result of enhanced self-belief and others get a sense of achievement from being able to make sense of the theories or underlying concepts. This process is repeated half way through the lectures and again at the end of each lecture which extends student interaction beyond the lecture halls. The rationale behind this approach is to break the monotonous nature of lectures, introduce interaction and make the pace of delivery more manageable.

Students are put at ease by the author emphasising that the purpose of these questions is to help/support their learning which breaks the pattern of “test anxiety” (Benson 1989; Kotecha M, 2012) associated with students' prior learning experiences.

MCQs are carefully set on key concepts that are generally misunderstood by students. An example is as below:

Type II error, associated with hypothesis testing is committed when the researcher

- a) Rejects the null hypothesis when the alternative hypothesis is true.
- b) Rejects the null hypothesis when it is true.

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- c) Fails to reject the null hypothesis when it is not true.

“...your slide shows summarising in a few lines and in a simple way the main points of the previous lectures are extremely important in reminding us of the material and getting us in the mood of the lesson” (student).

## ***Diagnostic purposes***

SFAQs are also effective for diagnostic purposes and help highlight misconceptions or problem areas. They promote student interaction and questions during which such misunderstandings surface and can then be addressed in a timely manner.

## ***Maintaining interest***

SFAQs are set on practical applications of statistical theories using themes students can relate to which helps maintain their engagement. This maintains their interest and contributes positively towards changing their perceptions about the abstract nature of statistical concepts. “I used to dislike Statistics. However I do really enjoy the course now...” (student). This positively contributes towards enhancing the learning climate in teaching rooms by replacing negative emotions with positive ones.

## ***Enhance students' engagement***

Further, SFAQs are also used during the class with a view to enhancing students' engagement. “Efficacy beliefs influence how people feel, think, motivate themselves and behave” (Bandura, A. 1993). SFAQs are set on topics already covered and relate to knowledge, comprehension and simple application levels of competences (Bloom, B. 1956). They used in exactly the same way as described earlier. Some students are pleasantly surprised when they get a question correct making them confident about tackling future questions as well as participating in discussions. Further, these questions are set on themes of students' interest which improves the learning climate in the teaching rooms, livens up the lecture/seminar rooms and have always been a huge success with the author's students (Kotecha, M. 2012).

“... I am now much more familiar with the combinations formula, and the Binomial distribution; Overall, I'm thoroughly enjoying myself and my understanding of stats is growing” (student). It is ensured that all students are clear about the underlying statistical concepts and theories relating to the SFAQ before moving on to the rest of the material.

SFAQs help reinforce key concepts and make the pace of delivery more manageable. The cognitive structure of the working memory is limited in its capacity and duration (Simon, H. 1974) and MCQs help students revise as well as practice the delivered material.

SFAQs can be used successfully to assess a variety of learning outcomes relating to all of the competences in Bloom's taxonomy (Bloom, B. 1956) especially at the advanced stages of course delivery and also during exam revision sessions.

## **Previous work**

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Mathematics anxiety has been a theme of research interest to neuroscientists, psychologists and educators since 1972 when Richardson and Suinn, introduced the Mathematics Anxiety Rating Scale (MARS). MARS involves using a 5-point Likert scale questionnaire consisting of 98 items. The Statistics Anxiety Rating Scale (STARS) was published in 1985 by Cruise, Cash and Bolton and uses a 5-point response scale consisting of 51 items.

Much work has been done on mathematics related anxiety displayed by primary as well as secondary school pupils. These studies have developed wide ranging shortened versions of MARS. They also made a valuable contribution to understanding the impact of gender difference, cultural backgrounds as well as socioeconomic backgrounds on such anxiety. There are comparatively fewer studies on ages ranging from 16 to 18 years and even fewer studies beyond this age range. None of these researchers have focused primarily on student voice to develop a teaching model to reduce MSA.

## **Author's teaching model**

The author developed her teaching model by analysing her students' feedback during her longitudinal study.

The two papers "Enhancing students' engagement through effective feedback" (Kotecha, M. 2011). and "Teaching mathematics and statistics: promoting students' engagement and interaction" (Kotecha, M. 2012) are both about students' perceptions of mathematics and statistics and their impact on students' engagement, enthusiasm and academic self-efficacy. The strategies developed in order to improve learning and teaching in statistics and mathematics service course are discussed in detail in these papers. These are developed for class settings but some of them also worked extremely well in the author's lectures to large audiences.

The author's advocated student-led education initiative discussed in her paper, "Promoting student led education" (Kotecha, M. 2011) explains the outcomes of a study in which she encouraged her undergraduates to actively contribute to various aspects of their education.

In her next paper she extended the applications of her teaching model to provide academic support to students who identified with Asperger Syndrome in "Promoting inclusive practice in mathematics and statistics" (Kotecha, M. 2012).

Students were encouraged to view mathematics and statistics positively in seminars and lectures designed to focus on breaking the negative patterns students have developed by addressing their unpleasant associations with learning. This is discussed in the author's publication "New patterns in learning and teaching Mathematics and Statistics" (Kotecha, M. 2012).

## **Findings and discussion**

Findings show that SFAQs enhanced student interaction, students' self-beliefs and academic self-efficacy which contributed towards reducing MSA. Students liked the thrill of getting questions right and were pleasantly surprised to encounter questions they enjoyed working on. They showed greater commitment to the course and actively engaged with the seminar questions. Further, their attendance, engagement and participation in the author's lectures and seminars were enhanced. They started associating mathematics and statistics questions with pleasant experiences and hence began to view the subjects, as well as their practical applications, enthusiastically. This positively contributed towards enhancing their confidence and academic self-efficacy.

Students who had unpleasant learning experiences during their pre-university years gradually began to perceive mathematics and statistics positively. They began to enjoy the interaction and became

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convinced of the accessibility of the subjects as the course progressed. The most popular feature of the author's teaching model was the use of SFAQs to commence each class. It helped students to get actively involved in classes right from the start. Their confidence was enhanced as they participated in solving questions, which was reflected in their meaningful contributions to class discussions, improved participation and the questions they asked. The learning climate in the teaching rooms improved as students became more willing to work with their peers. No particular impact of gender difference was found.

In adopting this approach, the main issue is the amount of additional preparation time required. A considerable amount of time is spent on writing SFAQs for lectures and classes. They also have to be revised and amended every year, taking into account students' academic/cultural backgrounds and other factors, which creates further work. The enhanced student interaction can make the lecture halls noisy as students continue with their discussions. This could make it challenging to resume the lecture but some patience, additional planning and effort can help students get used to time keeping with their discussions. Overall, SFAQs are highly effective tools that can make a huge positive difference to reducing MSA.

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