Meena Kotecha

Reducing mathematics and statistics anxiety: questionnaires and case studies in practice

Book section

This version available at: http://eprints.lse.ac.uk/64615/
Available in LSE Research Online: May 2016

http://eprints.lse.ac.uk

Reducing Mathematics and Statistics Anxiety: Questionnaires and Case Studies in Practice

http://dx.doi.org/10.4135/9781446273050.15595376

Reducing Mathematics and Statistics Anxiety: Questionnaires and Case Studies in Practice

Link to the Research Output

- Kotecha, M. (2011a). *Enhancing students' engagement through effective feedback, assessment and engaging activities. Higher Education Academy Journal*, 11, 4–6. doi:http://dx.doi.org/10.11120/msor.2011.11020004. Retrieved from http://journals.heacademy.ac.uk/doi/abs/10.11120/msor.2011.11020004
- Kotecha, M. (2011b, September 5–6). *Promoting student led education*. CETL-MSOR conference 2011, Coventry University, Coventry, UK. Retrieved from http://eprints.lse.ac.uk/45026/
- Kotecha, M. (2012a). *New patterns in learning and teaching mathematics and statistics. Higher Education Academy Journal*. doi:http://dx.doi.org/10.11120/stem.hea.2012.065. Retrieved from http://journals.heacademy.ac.uk/doi/abs/10.11120/stem.hea.2012.065
- Kotecha, M. (2012b). *Promoting inclusive practice in mathematics and statistics. The Journal of Inclusive Practice in Further and Higher Education*, 4, 5–15. Retrieved from http://eprints.lse.ac.uk/47137/
- Kotecha, M. (2012c). *Teaching mathematics and statistics: promoting students' engagement and interaction*. Bristol, UK: University of Bristol. Retrieved from http://eprints.lse.ac.uk/42008/

I commenced my project in 2010 with a view to developing a teaching model that would make the experience of learning mathematics and statistics fun for university students enrolled on a variety of degree programmes. These students are compulsorily required to study mathematics and statistics courses as core modules of their degree work. Approximately 78% of these students, in my experience, display anxiety, fear and

SAGE research**methods**

preconceived negative notions about mathematics and statistics, which adversely affect their enthusiasm to engage with these courses. I wanted to develop a teaching model that would successfully address these anxiety-related issues and enhance their learning experience, during my 4-year study from 2010 to 2014. My study was an iterative process of analysing the data I obtained through optional open-ended questionnaires and Likert-scale questionnaires, as well as from case studies, followed by modifying my teaching model accordingly and aligning it with students' requirements. This case study summarises my research process from start to finish, describing the detailed process of data collection and how I addressed the challenges I faced.

Learning Outcomes

After reading this case, you should have a better understanding of

- The methodological challenges involved in using open-ended questionnaires in a study
- Formulating survey questions
- Using Likert-scale questionnaires
- The role of case studies in research

Project Overview and Context

Problem

Imagine students sitting in mathematics or statistics classes because they do not have any choice; it is a requirement imposed by their chosen degree programmes. They are enrolled on a range of undergraduate degree programmes which require mathematical and statistical applications, although they have all successfully completed A-level mathematics:

> About 78% of students in my classes feel confused, frustrated and unable to engage which may lead to anxiety irrespective of their

Reducing Mathematics and Statistics Anxiety:
Questionnaires and Case Studies in Practice

SAGE researchmethods

academic abilities. This anxiety is mainly associated with apprehension
and fear of underperforming in examinations. Such lack of student
engagement due to anxiety is a matter of serious concern because
it can have an adverse impact on students' confidence and their
academic performance.

I have included more details relating to this problem in my article 'Enhancing students'
engagement through effective feedback, assessment and engaging activities', *The
Higher Education Academy Journal* (http://journals.heacademy.ac.uk/doi/abs/10.11120/
msor.2011.11020004) and case study 'Teaching mathematics and statistics: promoting
students' engagement and interaction' (http://eprints.lse.ac.uk/42008/) with the
Economics Network (based at and supported by the University of Bristol).

My Goal

Now imagine students sitting in the same mathematics or statistics class:

- almost 100% of students are engaging by active participation in discussions,
  answering and asking questions and enthusiastically engrossed with
  application problem questions.
- they report enjoying their learning experience, becoming interested in the
  subjects, performing better and their confidence levels are rising. Anxiety is
  no longer a major issue.

This is what I aimed to achieve and succeeded in doing so by developing an effective
teaching model.

My Student-Led Approach

I was open-minded about changing my teaching approach to achieve my goal of
developing a student-focused teaching model that would bring about such a change.
However, I specifically wanted to make the process student-led, by inviting students
to have a say in how they were taught, so that they could clearly communicate their

SAGE researchmethods

learning needs which I could address accordingly. This would increase the chance of making my teaching model aligned with students' learning needs which was my original goal. It was therefore necessary for me to gather data from my students to establish

- which aspects of my teaching approach worked well for students,
- what contributed to students' feelings of anxiety and obstructed students' engagement,
- which aspects of my teaching needed to change in order to address students' learning requirements and anxiety-related issues,
- how students received the changes in my teaching model.

I have described my student-led education initiative in my paper 'Promoting student led education' (http://eprints.lse.ac.uk/45026/), presented at the Centre of Excellence in Teaching and Learning Maths, Stats and Operational Research (OR) conference at Coventry University.

This was an on-going process of obtaining and analysing data because I wanted to assess my teaching model at various stages of my research by checking whether it was effective in addressing students' learning requirements, reducing their anxiety and improving students' performance.

I encouraged students to share

- their concerns,
- their thoughts on the aspects of my teaching that worked for them in helping them to engage in my classes as well as those that did not.

My flexibility and open-mindedness in modifying my teaching approaches based on students' input encouraged more students to respond to my requests for their comments as I explained how I was using their comments, each time I introduced any modification to my teaching approach, based on their feedback.

I have discussed how my teaching approach promoted inclusive practice in my article 'Promoting inclusive practice in mathematics and statistics' (http://eprints.lse.ac.uk/47137/) in *The Journal of Inclusive Practice in Further and Higher Education*, as well as new patterns in learning in my paper 'New patterns in learning

SAGE researchmethods

and teaching mathematics and statistics' (http://journals.heacademy.ac.uk/doi/abs/10.11120/stem.hea.2012.065) presented at The Higher Education Academy Science, Technology, Engineering and Mathematics Annual Conference at Imperial College London.

I summarise my key findings in the last section of this case.

Mathematics Anxiety and Statistics Anxiety

This set of negative emotions associated with learning mathematics and statistics is defined as mathematics anxiety (MA) and statistics anxiety (SA), respectively. The Mathematics Anxiety Rating Scale (MARS) was introduced in 1972 by Frank C. Richardson and Richard M. Suinn and involves using a 5-point Likert-scale questionnaire consisting of 98 items. The Statistics Anxiety Rating Scale (STARS) was published in 1985 by J. R. Cruise, R. W. Cash and L. D. Bolton and uses a 5-point response scale consisting of 51 items.

Mathematics and Statistics Anxiety

I focused on mathematics and statistics anxiety (MSA) as a linked issue as I believe they are inter-connected based on my experience. MSA can be caused by several factors and can have a negative long-term impact on students' academic progress and their future careers.

Previous Work

I had reviewed previous studies in this area during my postgraduate certificate in teaching statistics in higher/university education (PGCertHE (Royal Statistical Society, RSS)) study from 2008 to 2010 (co-supervised by the RSS and the London School of Economics (LSE) which also funded it) and came across studies on the age range from pre-school to 16 years. The Programme for International Student Assessment (PISA) (http://www.oecd.org/pisa/aboutpisa/) is a worldwide study by the Organisation

SAGE research methods

for Economic Co-operation and Development (OECD) in member and non-member nations, of 15-year-old school pupils' scholastic performance in mathematics, science and reading. These studies have found that students with low confidence experience high levels of MA and SA, which has an adverse impact on their academic performance. I found comparatively fewer studies on ages ranging from 16 to 18 years and even fewer studies on university students. None of these researchers actively invited students to participate in a continuous feedback process aimed at developing a teaching model to reduce MSA. A previous teaching practice focused study conducted by Amanda Williams in 2010 using MARS and STARS focused on investigating instructor immediacy and SA. The previous researchers have, for the best part, not worked on finding an effective way to communicate the subjects by drawing from students' regular input.

Research Methodology

I gathered data through open-ended questionnaires, case studies and Likert-scale questionnaires. I used both qualitative and quantitative methods in my practical approach to

- provide different perspectives of the same phenomenon,
- use the qualitative method to inform the quantitative approach,
- bring the approaches together to provide me with a complete view of my findings,
- improve the validity of my data and findings.

The qualitative data identified the problem areas, helping me to formulate my Likert-scale questionnaires, which in turn enabled me to

- gauge how students rated my teaching approach which I modified based on their feedback,
- monitor MSA.

There was a continuous dialogue between both the qualitative and quantitative components.

Research Practicalities

Sampling

Sampling is generally done when the population being studied is very large. A key point in the sampling process is that the participants must be chosen in a way that they represent the entire population. Survey researchers often study samples rather than whole populations except in the case of a census (which can either mean an attempt to collect data from every single member of the population being studied or a form of social survey organised by governments with the aim of collecting information from every household in the country). The best sample is a miniature version of the population from which it is taken. It is a representation or a model of the population being studied, that is, the focal characteristics such as age, gender and background of those within the sample are distributed similarly to the way they are distributed in the population. A good sample will improve the validity of your conclusions for the whole study population.

I chose the mathematical statistics undergraduate course for my study and had 66 students on average in my class groups each year throughout my project period. I met them on a weekly basis in a class setting during the teaching period from October to May each academic year. It was an ideal course from the viewpoint of my study for six reasons:

- 1. the majority of students on this course were enrolled on degree programmes such as Economics, Economic History, Actuarial Science and Finance which compulsorily required them to do this course.
- 2. approximately two-thirds of these students were from outside the United Kingdom with various countries represented. This cultural diversity presents a further challenge because of a range of learning styles students could have developed as a result of the educational systems they might be used to.
- 3. there was an approximately equal split between genders with 51% male and 49% female students; hence, there were no gender issues.

SAGE researchmethods

- 4. it was a manageable size; hence, I could include all my students registered on the mathematical statistics course.
- 5. it consisted of students from a range of programmes and wide-ranging learning requirements.
- 6. all students on this course shared some form of MSA-related issues.

Data Collection

I asked my PGCertEdHE (RSS) supervisor at the LSE for permission to seek my students' feedback in order to enhance teaching and learning. Institutional research ethics procedures, policy and guidance were provided. I followed this guidance throughout my research focused on my original goal described in the earlier sections. Institutional research ethics procedures are intended to facilitate, not inhibit, research, and hence should not put you off conducting research in your fields.

I debriefed students, both verbally and via email, that my primary goal for seeking their feedback was to align my teaching with their specific learning needs, advising them that their responses were optional and that they would be at no disadvantage should they refuse.

My institution conducted termly teaching evaluation questionnaires (TTEQ) which gave me termly snapshots of students' feedback and helped me to cross-check my cumulative data. However, they did not provide the minute details I needed for developing my teaching model; hence, I also needed to gather my own data which I did every year during my research project period from October 2010 to May 2014.

I collected students' concerns, feedback, opinions and requests which helped me to identify the factors associated with MSA and lack of enthusiasm to engage with mathematics and statistics. I was open about conveying my goal to students and encouraged them to share with me issues that obstructed their learning process so that I could use their comments to modify my teaching to suit their learning needs.

SAGE researchmethods

Aspects of my teaching approach were independent variables which I could change and modify. MSA reported by students was a dependent variable which would change as the result of changes in aspects of my teaching approach.

Challenges

My main challenges were putting students at ease and encouraging them to be forthright in answering my questions. The key aspect was to convey my vision, which was to enhance course delivery in my classes and help students achieve their full potential, so that they could understand my purpose of seeking their feedback throughout the year.

I conveyed to my students at the outset that I would periodically ask them quick questions about course-related matters and my teaching approach. I emphasised that there were no 'right' answers to my questions and it was important for me to understand their issues so that I could help them.

Research Design

Open-Ended Questionnaires

I sought qualitative data through my exploratory open-ended questionnaires in the first year of my project to enhance my understanding of the specific factors associated with MSA and aimed to address these by modifying my teaching practice. I emailed students 2 weeks after teaching commenced, advising them to share any course-related issues that caused them concern. Furthermore, I asked them to share with me aspects of my teaching that helped them engage in my classes and those that prevented them from engaging.

I used these informal open-ended questionnaires for students to respond to anytime, which was usually when they were anxious about something related to the course content or classes. I ensured that students did not become subjects of experimentation

in my research and my surveys did not interfere with their study or class time as advised by my mentors during my PGCertHE (RSS) study during 2008–2010, by making this optional and without any closing date, hence giving top priority to their degree work. These questionnaires proved to be very useful in identifying problem areas. My purpose was to improve the likelihood of discovering issues that students would share spontaneously, avoiding the bias which could occur in the case of close-ended questions as a result of suggesting responses to participants such as

What do you like about my classes?

- Fun application questions
- Exam style questions
- Both

Response Rate

I had a response rate of about 10% when I attached my open-ended questionnaires to my email and about 34% when I wrote my questions in the body of the email. A further 40% shared their views verbally with me either in my office hours or classes.

Homework Feedback Sheet

I had designed a Homework Feedback Sheet (HFS) in 2010 for students' weekly formative assignments (set for practice and not counted towards the final exam grade) advising students to attach it to their work before submitting it. This included within it a text box labelled 'Student's general comments (Optional)' which students used to share their concerns and difficulties with each assignment, which gave me their detailed feedback. This approach highlighted problem areas and identified issues that required action.

Students also wrote positive things about how they had started to enjoy my classes and went on to provide information about the aspects of my classes that got them interested in the course material.

Reducing Mathematics and Statistics Anxiety:
Questionnaires and Case Studies in Practice

Furthermore, because I had clearly explained how I would use their comments to align my teaching approach with individual learning requirements expressed by the majority, they apparently felt comfortable writing both positive and negative comments on the HFS. I gathered very relevant data which pinpointed specific issues associated with MSA. To assure them, I made it a point to write detailed responses to their comments and suggested courses of action to help them as appropriate. I did this to assure them that I read and addressed their comments, and to further encourage them to continue sharing their concerns with me. I designed my HFS so that students could write their comments in a way they felt comfortable with. This worked well, especially for the shy students and for those who did not feel comfortable to express their views freely. Furthermore, it was a constant dialogue that highlighted problem areas regarding MSA which would have been impossible had I only relied on TTEQ reports.

Likert-Scale Questionnaires

What Is a Likert Scale?

In 1932, psychologist Rensis Likert devised the 5-point Likert scale for measuring the extent of attitudes in people's beliefs and feelings towards international affairs. He used it to rank people's attitudes with fewer questions and greater exactness and showed how it captured more information than competing methods at the time. It asks people the extent to which they agree or disagree with a statement on a 5-point scale. The scale ranges from *strongly agree* to *strongly disagree*.

My Likert-Scale Questions

I designed 5-point Likert-scale questionnaires to identify teaching aspects that enhanced or hindered students' class-engagement and to monitor changes in students' MSA, their perceived class participation and difficulties with specific topics. I modified my teaching in response to issues raised by the majority and advised the minority to see me during my office hours for individual support.

Reducing Mathematics and Statistics Anxiety:
Questionnaires and Case Studies in Practice

I used two types of Likert-scale questions:

- weekly 5-point question on class-related matters (as illustrated in Figure 1)
- end-of-term questions related to specific issues (as illustrated in Figure 2 and discussed in the next subsection)

Figure 1. Likert-scale questionnaire.

Weekly 5-point Likert scale question

The class was (Circle as appropriate)

Very Good	Good	Average	Poor	Very Poor
1	2	3	4	5

Figure 2. Likert-scale questionnaire.

1. I am an active participant in classes.

2. I enjoy working on group-work questions.

3. I enjoy questions that involve writing proofs.

1.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
(Circle as appropriate)	1	2	3	4	5
2.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
(Circle as appropriate)	1	2	3	4	5
3.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
(Circle as appropriate)	1	2	3	4	5

I wrote the questions with the specific purpose of giving students the opportunity to rate each class in terms of their learning experience as well as usefulness, which fitted within my research design.

End-of-Term Likert-Scale Questions

In addition to the weekly questions, I also used termly questions at the end of the first two terms each academic year. The third term consisted of only three classes that were

SAGE researchmethods

used for revision for the final examination scheduled in the week following the last class. I did not think it was appropriate to ask students such questions when they were pre-occupied with their queries and apprehensive about the upcoming examination.

The end-of-term question set consisted of the following three questions using 5-point Likert-scale format with the scale ranging from *strongly agree* to *strongly disagree*:

- 1. I am an active participant in classes.
- 2. I enjoy working on group-work questions.
- 3. I enjoy questions that involve writing proofs.

I formulated these based on the three main problem areas identified in the qualitative data I obtained through open-ended questionnaires, students' comments on the HFS and case studies (covered in a later section). My aim was to monitor changes in these areas. I mainly looked through the qualitative data for

- words that were repeated most frequently (e.g. 'bored', 'scary', 'worried'),
- points that were important to students (e.g. 'hate writing proofs …').

The purpose of these questions was to identify topic-related problem areas as each weekly class was focused on a specific topic. Furthermore, it was to monitor changes in students' perceptions of proof questions, group-work and their class participation.

I displayed my Likert-scale questions on the screen at the end of my classes asking for a show of hands for their chosen options and recorded their responses, which took about a minute. My reason for doing this was to save the students' time. The average response rate was about 70% because some students were in a rush to leave for various reasons. Some of the possible advantages of this method are that it is time-effective, may achieve higher response rates and doesn't require documentation. Possible disadvantages include the likelihood of some students being influenced by their peers' responses or leaving early to avoid responding because of the non-anonymity aspect of this method, prejudicing the validity of the results.

Reducing Mathematics and Statistics Anxiety:
Questionnaires and Case Studies in Practice

Case Studies

These mainly consisted of my detailed notes on students who regularly sought individual support in the office hours I held on a weekly basis. At my institution, these office hours are offered to provide additional academic support. Students can drop in anytime during these hours and the setting is informal.

The time each student stayed in my office ranged from 15 to 25 min, depending on the following:

- the number of students waiting for their turn outside my office,
- type of queries,
- missed classes or assignment submission,
- approaching examination.

Immediately after my office hours, I made notes on the issues raised by students and any related matters that influenced their academic progress as transpired in my conversations with them. My notes were mainly in agreement with the contributing factors of MSA-related issues highlighted in the data gathered by the open-ended questionnaires. However, they also provided me with an in-depth insight into students' issues. This improved my overall understanding of the situation and highlighted issues which I would not have found otherwise. Furthermore, I was able to monitor changes in these students' attitudes as well as their academic performance throughout the academic year, which helped me evaluate my constantly evolving teaching model. One of the main benefits of case studies is to provide detailed information about the phenomenon being studied.

Case studies also helped me to identify personal issues related to confidential information which adversely influenced students' academic progress and enabled me to provide additional support and guidance. These were temporary factors such as health issues or family matters such as bereavement or ill health of a family member which required interim arrangements and extra consideration. Because of the informal setting, students seemed to feel relaxed enough to trust me with sensitive issues. It would have been practically impossible for me to find out about such issues via email or HFS.

SSAGE researchmethods

Finally, the case studies provided an explanation for those few outliers that were not in line with the general trend on how students viewed and benefitted from my teaching model. These did not have a significant impact on my final findings, but I found it useful to make sense of such cases because it helped me to understand reasons why those students' opinions differed from the majority.

Incidental Information

Another form of case studies belongs to the category of students who continue to update me on their career-progress years after their graduation. They report being appreciative of the impact my teaching approach had on their successful careers or higher studies. Having graduated and entered employment, they generally seem better able to articulate their comments on aspects of my approach that specifically contributed to reducing MSA.

Discrepancies

There were discrepancies during the period from 2010 to 2012 between the data I gathered through

- open-ended questionnaires, HFS and case studies;
- Likert-scale questions.

Students made extremely positive comments on my teaching approaches and reported fewer MSA-related issues. However, the outcome of my Likert-scale questions reflected a view that was not as positive and lacked consistency.

I wanted to identify the true picture of how students were receiving my teaching model. This inspired me to devise an innovative approach which, rather than hampering my research progress, re-focused and fine-tuned my research methodology by being creative as well as open-minded.

SAGE research methods

Action

I addressed this issue in 2012 by including both my weekly and the end-of-term Likert-scale questions in my HFS rather than asking for a show of hands after displaying them on the screen. This approach gave students the option of providing anonymous feedback by putting their unnamed responses in my pigeon hole as per my suggestion. Approximately 75% of my students seemed open about their feedback whether it was positive or negative. To put all students at ease about responding fully, I made my questionnaires flexible by offering all students the option of remaining anonymous while responding to my questions. This new approach addressed the issues relating to the previous discrepancies, making feedback more reliable by removing peer pressure and giving students more time to reflect and respond.

Improved Response Rate

The general response rate to my Likert-scale questions via my HFS was about 91%; of the 9% who did not complete this, 8% of students did not wish to provide a rating (although they provided qualitative comments), and the remaining 1% did not provide any explanation. This re-focused approach improved data on overall changes in students' perceptions of proof questions, group-work and their class participation. Furthermore, approximately 85% of all students continued to write qualitative comments on the HFS which gave me relevant and detailed information about their MSA-related issues.

Why Did the Combined Approach for the HFS Approach Work?

I think my revised approach of including Likert-scale questions on the HFS yielded data that were more independent and reliable, hence more valid, due to the removal of both time pressure and peer pressure because students could complete it in their own time and were not influenced by their peers. They could complete these just after they had

SAGE researchmethods

finished their weekly formative assignment which they submitted sometime after each class and well before the next class to get timely feedback on their work. Furthermore, they had time to reflect on their class experience and issues related to homework that were fresh in their minds. I continued with this approach during the period from 2012 to 2014.

Data Gathering from 2012 to 2014

There was no discrepancy between the quantitative and qualitative data I gathered during this period. My data analysis outcomes were also in line with the TTEQ reports both in terms of qualitative and quantitative aspects.

Key Findings

I have listed my key findings by summarising the difference my teaching model made by comparing my data analysis outcomes during the two periods - 2010–2012 (A) and 2012–2014 (B):

- the reported MSA levels reflected a significant reduction in B.
- students' perceptions of their own participation in class showed a significant increase in B.
- students' engagement with proof questions showed a significant increase in B.
- students solved a significantly greater number of group-work questions in B.
- the main feature of my teaching model was enhanced interaction which positively contributed towards reducing MSA.

Practical Tips and Discussion

- 1. In my experience, open-ended questionnaires would work best if asked face to face. While I could obtain qualitative data using this approach, the response rate was not consistent or systematic via email. Students did

Reducing Mathematics and Statistics Anxiety:
Questionnaires and Case Studies in Practice

answer my questions, but about 40% of students preferred to share this information with me verbally. It was time consuming to collate responses because they kept coming in throughout the year via email.

- 2. Explain to the respondents your purpose of asking questions and put them at ease in order to encourage them to be open in their responses which may yield more reliable data for your topic of study. Otherwise, people may provide the type of responses they think you want, especially if they are eager to please or impress you.

- 3. Formulate research questions by using exploratory work before you design your survey questionnaires. Be prepared to modify or change your research questions depending on how you progress.

- 4. Don't expect a smooth and seamless transition from the start to completion of your research. Have an open-minded approach and try not to panic when things do not go as planned because it is perfectly normal to have glitches.

- 5. Research students generally believe that they ought to do intensive research before they commence writing. I would advise you to start writing about your ideas early on; you may be pleasantly surprised to see how your writing can promote high-quality research by inspiring you with interesting research questions, research methodology, as well as new ideas.

- 6. If you get the opportunity to do so, present your research during its early stages. It may help you to develop your reasoning, reflect on your work and get constructive feedback. Research does not have to be a solitary process. I did this in my project which promoted discussions and questions that seemed challenging at times but proved to be extremely productive in the long run.

- 7. To get data that are unbiased and independent, hence more valid, it is important to phrase statements carefully and keep statements simple when you use Likert-scale questionnaires. Avoid covering more than one issue in a statement, for example, 'I enjoy mathematics and understand its practical application in my degree programme'.

- 8. Likert-scale questionnaires can be used either by placing the favourable response options on the left-hand side or on the right-hand side. Make sure you explain your approach to your participants in case they have previously come across a different version from yours.

SAGE research methods

Presenting the Likert-Scale Questionnaires

There are several alternatives to presenting Likert-scale questionnaires. I tried and tested the Personal Response System (PRS) (http://lti.lse.ac.uk/instant-voting/) and SurveyMonkey (https://www.surveymonkey.com/home/) before choosing the paper format approach which I used in my study as it seemed more appropriate for my research.

Personal Response System

PRS (also known as an Electronic Voting System) describes a technology that works as a Microsoft PowerPoint plug-in. It enables lecturers to poll students in large teaching rooms anonymously and displays the results instantly. Interactive multiple choice question slides are created in a PowerPoint presentation. PRS handsets (small remote control devices commonly known as clickers) are distributed by the lecturers before commencing lectures. Students select their responses by clicking on their handsets to answer the questions displayed on the PowerPoint slides. When a poll closes, the aggregated results representing students' votes are displayed in graphs on the question slides. The responses can be exported to a data file and saved for analysis.

SurveyMonkey

This is an online survey software and questionnaire tool founded in 1999 which can be used by setting up a free account that allows researchers to create anonymous online surveys. Likert-scale questionnaire surveys can be created by using a template and sent to respondents as a web link via email, Twitter or Facebook fan page. The survey can be embedded into a researcher's blog or website. Once the responses are collected, charts, tables and basic statistics are displayed at the click of a button, by choosing the option 'Analyze Results'. It can also carry out detailed data analysis at a cost.

SAGE research**methods**

Exercises and Discussion Questions

- 1. What is the difference between research methodology and research methods?
- 2. What is the main aim of the literature review (reviewing existing work/ studies/research)?
- 3. Do you think I would have improved the quality of my research had I invited student volunteers to participate in case studies and questionnaires from all mathematics and statistics–related courses I taught?
- 4. What are the main limiting factors when carrying out open-ended questionnaires?

Further Reading

Brindle, P. (2014). *Oral history interviewing: History in the classroom in pre-war Britain.* In *SAGE research methods cases.* London, England: SAGE. http://dx.doi.org/10.4135/978144627305013516584

Bryman, A. (2012). *Social research methods.* Oxford, UK: Oxford University Press.

Flick, U. (2014). *An introduction to qualitative research.* London: SAGE.

References

Cruise, R. J., Cash, R. W., & Bolton, D. L. (1985, August). *Development and validation of an instrument to measure statistical anxiety.* Paper presented at the annual meeting of the Statistical Education Section. Proceedings of the American Statistical Association, Chicago, IL.

Kotecha, M. (2011a). *Enhancing students' engagement through effective feedback, assessment and engaging activities.* Higher Education Academy Journal, 11,

4–6. doi:http://dx.doi.org/10.11120/msor.2011.11020004. Retrieved from http://journals.heacademy.ac.uk/doi/full/10.11120/msor.2011.11020004

Kotecha, M. (2011b, September 5–6). *Promoting student led education. CETL-MSOR conference 2011*, Coventry University, Coventry, UK. Retrieved from http://eprints.lse.ac.uk/45026/

Kotecha, M. (2012a). *New patterns in learning and teaching mathematics and statistics. Higher Education Academy Journal*. doi:http://dx.doi.org/10.11120/stem.hea.2012.065. Retrieved from http://journals.heacademy.ac.uk/doi/full/10.11120/stem.hea.2012.065

Kotecha, M. (2012b). *Promoting inclusive practice in mathematics and statistics. The Journal of Inclusive Practice in Further and Higher Education*, 4, 5–15. Retrieved from http://eprints.lse.ac.uk/47137/

Kotecha, M. (2012c). *Teaching mathematics and statistics: Promoting students' engagement and interaction.* Bristol, UK: University of Bristol. Retrieved from http://eprints.lse.ac.uk/42008/

Programme for International Student Assessment. (2012). *UK country reports*. Retrieved from http://www.oecd.org/pisa/keyfindings/pisa-2012-results.htm

Richardson, F. C., & Suinn, R. M. (1972). *The Mathematics Anxiety Rating Scale: Psychometric data. Journal of Counseling Psychology*, 19, 551–554. doi:http://dx.doi.org/10.1037/h0033456

Williams, A. (2010). *Statistics anxiety and instructor immediacy. Journal of Statistics Education*, 18.

http://dx.doi.org/10.4135/9781446273050.15595376