Journal of Mathematics and System Science 8 (2018) 153-174
doi: 10.17265/2159-5291/2018.06.001

Igniting the Statistical Spark in the Social Sciences—Abilities, Student Feedback and Teacher Observations

Rhys Christopher Jones

Room 316, Building 303, Science Centre, University of Auckland, Auckland 1010, New Zealand

Abstract: A quasi-experimental design was used to measure the impacts on student attainment in statistics, mathematics and critical thinking (16-18 years of age) on an experimental group who received a 21 week long contextualised statistics course (called the Pilot Scheme in SA (social analytics)), in South Wales. This paper will discuss the changes in statistical abilities observed, student feedback from the course and also teacher observations, in relation to the Pilot Scheme in SA. Results suggest that the course did lead to increase in students' abilities, in comparison to two control groups. Whereas students in both control groups who did not receive the treatment, showed a decrease in their abilities with respect to mathematics and statistics. Student feedback suggests they could see the value of the course to their other studies and they also felt the statistics delivered was linked well with relevant examples. Results from an analysis of teacher observations support findings from the course evaluation of the Pilot Scheme in SA, which include an increase in student confidence with mathematics and statistics.

Key words: Statistics education research, cross-curricula statistics, statistics abilities, student feedback, teacher observations.

1. Introduction

1.1 Reasons for Undertaking the Study

Several investigations have concluded that there is a quantitative deficit within the social sciences in the UK [1-7]. Reasons for this are potentially rooted within the societal negative attitudes towards mathematics. Negative attitudes towards mathematics could be a product of the traditional teaching approaches of mathematics education. Teaching methods have potentially contributed to the subject identity as being right or wrong, perceived as a difficult discipline [8, 9]. Significant changes have been made to mathematics education (years 7-13) more recently to encourage greater student uptake post-16, within England and Wales [8, 9]. Statistics has gained an important voice within mathematics education. It also cuts across many disciplines and is increasingly becoming a core subject. In addition, employers are increasingly requesting employees acquire data analysis skills, underpinned by statistical and scientific principles.

Mathematics phobia is well documented within the UK, with mathematics anxiety being widespread throughout society [10, 11]. In addition, public perception behind the differences between mathematics and statistics suggest they elide them together, imprinting negative mathematical attitudes onto statistics [11, 12]. Reasons to explain some of the antipathy towards quantitative methods within the social sciences are potentially rooted within this societal negative attitude. Attitudes towards statistics are important in statistics education because they have the potential to affect statistical achievement, literacy, or reasoning [12]. Gal [13] states certain attitudes are needed to critically evaluate statistical messages, which are important in statistics instruction. Students'

Corresponding author: Rhys Christopher Jones, Professional Teaching Fellow in Statistics, research fields: statistics education, especially across disciplines, mathematical and statistical anxiety, curriculum design, peer learning, emotional intelligence in education, quasi-experimental methods in education.

attitudes towards statistics can help statistical thinking as well as influence their utilization of knowledge and skills in a variety of contexts [12]. Therefore, attitudes play an important role in the teaching and learning process during class time. Positive attitudes could also influence statistical behaviors outside the classrooms and may also motivate them to enroll for further statistics related courses.

Mathematics as a discipline has experienced radical shifts in both applied and theoretical aspects [14-16]. Proponents for more applied forms of mathematics argue procedural mathematics; mathematical induction and proof should be limited to higher education, with a greater focus placed on mathematical reasoning, critical thinking and context at the pre-university level [13-17]. In a mathematical context, critical thinking will be treated as a form of relational understanding in this paper, as Skemp puts it, "knowing what to do and why" [18].

There is an overwhelming consensus that mathematics is of central importance to modern society [19]. It provides the vital foundations of the "knowledge economy" [8, 19, 20]. There are clear disadvantages for individuals who struggle numerically with respect to success in the labour market [11, 19]. Competency in mathematics can therefore be seen as a crucial component in the development and success of both the individual and of the society in which they hope to prosper both economically and socially. There is also an increasing demand for teachers across many subject areas to be competent in both numerical and statistical skills. This presents an enormous challenge for both the current teaching workforce, and teacher training courses in the UK [21]. In particular subjects not normally associated with statistics, such as sociology and geography, have increasing numerical and statistical content [21]. New forms of statistical content and associated pedagogical guidance could help to facilitate the essential changes needed to support teachers across disciplines.

The lack of quantitative methods in A' Level sociology provides a rationale for developing the Qualifications Credit Framework (QCF) level 3 course in SA (social analytics) to offer a suitable alternative [22]. In its current state, A' Level sociology does not truly reflect the discipline as it stands today, with no mention of the emergent interdisciplinary fields present [22]. For example, the Cardiff School of Social Sciences includes several research centers that carry out interdisciplinary research on health, crime, the environment, digital technologies, religion and medicine using large data sets and data linkage techniques with the aid of data software packages [23]. In addition, the Pilot Scheme in SA course was created to address the issues connected with current (and proposed) mathematics and statistics courses at Key Stage 5 in England and Wales. For example, current A' Level mathematics courses in England and Wales focus too much on procedural tasks, lacking critical thinking and mathematical reasoning content [8, 20]. A Pilot Scheme course in SA was developed to encourage 16-18 year old students (year 12 and 13) to study statistics within social science courses at university. This will now be discussed in more detail.

1.2 Pilot Scheme in SA Development

The Pilot Scheme in SA course was developed in collaboration with a group of FE (further education) lecturers and secondary school teachers from across South Wales, along with representatives from Agored Cymru (access to HE (higher education) Diploma providers for Wales). This group was specifically recruited for this purpose, referred to as the TPS (teacher placement scheme). The TPS encompassed a range of expertise from disciplinary backgrounds in the social sciences, politics, mathematics, political sciences, health sciences, biology and psychology. The group's expertise also included experience of teaching a variety of levels from school year 7 level (age 11) through to master's and teacher training

education levels. This enabled discussions to evolve around the core themes of curriculum design and pedagogy, intersecting several disciplines and student age groups. This range of expertise enabled the group to decide on the core skills (critical thinking and statistical concepts/analysis in relation to the course aims of SA) students needed to effectively progress from 14 years of age onwards, with the end goal of accessing a variety of higher education courses.

The Pilot Scheme in SA was constructed to align with A' Level subject areas in mathematics, biology, psychology, politics, sociology, and geography. These popular A' Levels lend themselves well to the aims of the Pilot Scheme in SA course. They also include facilitating A' Level subjects (biology, mathematics and geography), maximizing student choice for higher education study, deemed to be valuable by many universities, including those in the elite Russell Group, for example Oxford and Cambridge University [24]. The development of critical thinking skills was also central to the course development, and deemed to be good preparation for higher education in a variety of subjects [13, 25, 26]. The ability to objectively evaluate evidence and make judgments is of central importance to enable relational understanding of mathematics and statistics [13, 18, 25].

The course was designed to emphasize the importance of using statistical techniques in relation to the context, rather than performing traditionally isolated statistical calculations (as in A' Level mathematics for example). In addition, core statistical and scientific concepts were embedded throughout the module outline, to ensure students developed critical analysis skills. The course was also written to be flexible enough for teachers to use a variety of examples, without being too prescriptive. For example, the social science in practice unit requires students to explain the strengths and weaknesses of different methods used to measure health and disease and also to be able to discuss the nature of evidence. Adopting this approach to teaching statistics, focussing on statistical concepts and principles, is also a recommendation reported in the American Statistical Association's GAISE report [27].

1.3 Student Recruitment Strategies

With the TPS in place, they also acted as SA champions, promoting the Pilot Scheme course within their respective educational institutions, as well as providing opportunities for Cardiff University staff from the School of Social Sciences to deliver presentations to their students. Presentations usually included a description of the benefits of the course to their educational career, as well as developing their critical thinking skills and statistical analysis skills. At TPS meetings it was agreed that TPS members described the course as a way of enhancing students' critical thinking and statistical skills, rather than more procedural statistical calculations. This was to ensure that students were not put off, especially if they had a mathematics phobia.

1.4 Research Question

This study is concerned with exploring the impacts of delivering a contextualised statistics course (Pilot Scheme in SA), on year 12 and 13 students' abilities in mathematics and statistics. The following research question will aim to explore these impacts:

What are the student outcomes of participating in a contextualised statistics course (Pilot Scheme in SA course), in relation to mathematical and statistical abilities and attitudes in years 12 and 13?

2. Method

2.1 Experimental Method

Experimental methods in both education and sociology have a long history, particularly in the USA. Donald Campbell's research was essential in establishing the experiment as a legitimate research strategy in the evaluation of social and education programmes in the USA [28]. An example of their

work includes the evaluation of the US Headstart programme (a programme of early childhood education, health and nutrition and parent involvement services offered to low income families), which involved the randomisation of participants into control and experimental groups, over a period of time. Their methods often included advanced modeling techniques, often with small sample sizes. Their results were often useful in informing policy, though rarely unequivocal and led to the formation of more complex questions [28].

There are several methodological parameters that can be difficult to achieve, for example randomisation of the control and experimental group participants [29]. Consequently, quasi-experiments have been used for many years in a variety of settings such as public health [30] and community safety [31]. Quasi-experiments have a very similar structure and methodological rationale to RCT's, the main difference being that the groups are not randomly allocated. In the context of the research conducted in this investigation, a randomised control trial was not used due to students self-selecting onto the Pilot Scheme; therefore randomisation could not be achieved. A quasi-experiment was deemed to be a suitable alternative, in the given time-frame for the research. In addition, external validity could be achieved by repeating the quasi-experiment in the future with different groups of 16-18 year old students [32]. In the case of the current research, the replicable nature of quasi-experiments has the potential to culminate the evidence base, through further experiments, to support or falsify the theory that a contextualised statistics course can have overarching benefits for students over a range of curriculum areas.

2.2 Experimental Groups

The two educational establishments selected for the quasi-experiment are located in the city of Cardiff. Senior managers from both institutes gave permission for the FE (further education) College and Sixth Form Colleges' names to be mentioned. These include CAVC (Cardiff and the Vale College) and St David's (St David's Sixth Form College). It was felt that the inclusion and description of both institutions names was essential in bringing to life the research conducted, ensuring these institutions received public recognition for their participation and cooperation in the study.

Experimental and control groups were created in August 2015, with students at both St David's and CAVC being given the opportunity to apply to take the Pilot Scheme in SA. The initial size of the Pilot Scheme was 44; 24 from St David's and 20 from CAVC. The Pilot Scheme in SA class finished with 29 students, 19 from St David's (number of year 12 students = 11 and number of year 13 students = 8) and 10 from CAVC (number of year 12 students = 5 and number of year 13 students = 5) (Table 1). Students in the Pilot Scheme in SA formed experimental group 1. Control groups 2 and 3 consisted of a combination of students from CAVC (control group 2, n = 20, number of students in year 12 = 11 and number in year 13 = 9) and St David's (control group 3, n = 64, number of students in year 12 = 30 and number in year 13 = 34) (Table 1). Students in these groups were fellow classmates of students in experimental group 1. Students from CAVC in experimental group 1 and control group 2 shared the same A' Level psychology class, with classes comprising both year 12 and year 13 students. Students from St David's, in experimental group 1 and control group 3, shared the same A' Level government and politics, sociology or psychology classes, with classes comprising both year 12 and year 13 students. A/AS Level classes in psychology at CAVC [33] and government and politics [34], sociology [22], and psychology [34] at St David's are WJEC approved specifications (WJEC are the welsh examining board).

Other demographic data was collected for this cohort of students, for example, gender and age, however these factors are not the focus of this article and have therefore been omitted.

Table 1 Numbers of students in year 12 and 13, arranged into experimental and control groups.

Group	Year 12 student numbers	Year 13 student numbers
Experimental group 1 (Pilot)	16	13
Control group 2 (CAVC)	11	9
Control group 3 (St David's)	30	34

2.3 Data Collection Time-Points

Data were collected at specific points throughout the 21 weeks of the delivery of the Pilot Scheme in SA. Data were collected from those individuals present in class using paper-based copies of questionnaires and formative tests. For a variety of methodological and practical reasons, it was decided to take snapshots of the groups' performance in formative tests, rather than tracking each individual student. Tracking individual students relies on the participant to be present for each data collection event, as well as ensuring they don't drop out, which can lead to an increased cumulative frequency of missing values [35, 36].

Data from each group were collected no later than a week apart, depending on when the A' Level classes were scheduled in the respective experimental and control groups. Strict instructions were given to the teachers giving out formative tests and questionnaires to ensure that they were handed in no later than a week after receiving them. This was to ensure data being collected represented information on those groups at that specific time point, enabling comparisons to be made between groups.

2.4 Data Collection Instruments

Participants in all groups were asked to complete several formative tests. These tests assessed statistical ability and data analysis skills, i.e. interpreting tables and graphs. Content was constructed by carefully ensuring students from all groups would have received the relevant teaching in their A' Level studies (in this case A' Levels in psychology, sociology and government and politics), to ensure that they would be able to answer the questions.

All formative tests used elements of past GCSE statistics examination papers (for 14-16 year olds), of which no one from any of the groups had previously sat. This information was ascertained by reviewing the application forms of participants on the Pilot Scheme in SA—experimental group 1 (as part of the application process, applicants were asked to list their GCSE results). GCSE results were also collected from the control groups 2 and 3, to ensure no one had a GCSE in statistics. Questions used for the formative tests came from the examinations board AQA (Assessment and Qualifications Alliance), being the only education board to offer GCSE statistics in the UK [37]. All past examination papers, with the associated mark schemes that were used to mark them, were downloaded and used from the AQA website [38]. The formative tests were created, with a progressive increase in difficulty to measure student statistical abilities. Formative test 1 (maximum total mark = 16) was used to assess statistical and mathematical concepts that covered: percentages, scientific terminology and data interpretation (using percentages). Formative test 2 (maximum total mark = 12) covered: scientific terminology, data interpretation and estimation, levels of measurement and simple rate calculations. Formative test 3 (maximum total mark = 30) covered: standard deviation calculations as well as a discussion on its usefulness with the data presented, data interpretation and simple arithmetic calculations, a description of trends and the impacts of extraneous variables, percentage decrease calculations, and the normal distribution (with students being asked to use the available data to sketch the distribution of ages).

These topics were selected and covered by all participants in experimental group 1 and control groups 2 and 3, since they represented compulsory

areas of the A/AS Level curriculum set out in the psychology, sociology and government and politics classes being taken by participants in the groups [22, 34-35]. This crosschecking was essential to ensure all participants in the quasi-experiment had the potential to be able to answer the questions in the formative tests. The formative tests increased in difficulty, to correspond to the topics being covered during their A/AS Level classes. As students in all groups progressed in their studies, the level of difficulty should concurrently be increasing. The author felt this was an important element of the formative tests, to ensure participants in all groups were being challenged with an increase in academic expectations on their own courses at CAVC and St David's.

Teachers were persuaded to make time in their classes for students to sit the formative tests, by emphasizing the relatively short time they took to complete (formative test 1 = 20 minutes, formative test 2, 15 minutes, and formative test 3, 30 minutes). In addition, since these formative tests were exploring concepts and content that were being explored within their A' Level classes, teaches could see the overlap and were happy to allot time for these tests to being completed in class. Participants in experimental group 1 were also asked to complete an evaluation form of the Pilot Scheme in SA course, at two points during the courses (Appendix 1 and 2). The evaluation forms were handed out in December 2015 and March 2016. For both evaluation forms handed out, 24 were completed. The end of course evaluation forms were given out a week after the formative test 3.

The course evaluation forms were constructed and adapted using a standard course evaluation template used to evaluate higher education courses, in a previous lecturing position that the author has held (Appendicies 1 and 2). In addition, the course evaluation forms had been used in the previous cohort of students on the Pilot Scheme in SA in 2014/15. By trialing this evaluation form out with a previous group, the questions selected generated useful data that was deemed to be a worthwhile endeavor to repeat during this research project. Both evaluation forms posed identical questions, with the March evaluation form posing additional questions to explore student destinations after their A' Level studies. Questions present on both evaluation forms were developed to explore students' judgment on whether the course aims were made clear, if the statistics was linked well with relevant examples, and also linked to their other studies. Enjoyment of the statistics elements delivered, and whether the course was enjoyable as a whole were also included in the evaluation forms. Questions present on both forms required students to tick a box on a Likert scale, which included the headings: strongly agree, agree, disagree and strongly disagree. Due to the lower number of questions in this questionnaire, it was felt reversing the polarity was unnecessary [39]. Course evaluation results were analyzed using SPSS to produce descriptive statistics [40].

The teaching associate took over teaching the Pilot Scheme in SA group, after the December 2015 Christmas break. Changing teachers half way through the course was deemed to be a useful addition to the research process, and for the students on the Pilot Scheme in SA. Removing myself from front line teaching removed some degree of bias, where resultant data from the quasi-experiment could not be completely attributed to my own teaching style and approach. For example, if experimental group 1 showed a marked improvement in A/AS Level grades and attitudes to mathematics and critical thinking, this could due to the pedagogical approaches the author adopted as an individual teacher. Introducing another teacher to deliver the course also provided an opportunity to ascertain if there would be any differences as to how the course was practically implemented from the scheme of work. The partial removal of myself from the quasi-experiment enabled a more objective analysis of the data, which could have changed my interpretation of the results. This

could be a result of making the familiar strange, partially removing myself from the research setting [40-43]. The teaching associate used different teaching styles, examples and contexts compared to those used in the first stage of the experiment. Some could argue that this has changed the parameters of the experimental process [29, 45], although it was deemed to be a price worth paying to enable more of an objective analysis of the results to be made. In addition, it also reduces the likelihood that any differences in student attitudes and abilities were primarily down to teaching style and pedagogical practices. The teaching associate used the same curriculum that the author would have followed, which was developed with the TPS. There were however differences in pedagogical styles used during the course noted. Several of these issues relating to delivery of the Pilot Scheme in SA course, will be examined in more detail in Chapters six and seven.

The teaching associate interview (Appendix 3) was added to the techniques used in this research project, to enable a two-way conversation to take place between the interviewee and myself. Specifically, a reciprocal peer interview technique was used, providing a significant opportunity for the interviewee to speak candidly and exercise control over the interview process [46]. This type of interview also enables the interviewer to participate in the conversation, and be included in the data being collected. It was felt that this format was appropriate under the circumstances, since the teaching associate and myself delivered the Pilot Scheme in SA. The interview lasted approximately an hour, and included questions exploring several themes linked to changes in student attitudes to mathematics and statistics during the second half of the course, student satisfaction with the course, and if it had made any observable difference to their A/AS Level studies (Appendix 3). Questions exploring pedagogical approaches adopted were also included, to note any potential differences used in comparison to my own teaching techniques. These questions were constructed to explore the impact of using different pedagogical techniques and approaches, in relation to student abilities in statistics (formative tests). These themes (pedagogical techniques and approaches, student attitudes to mathematics and statistics and also abilities in statistics) could then be used to further explore the research questions for the study. Aronson [47] supports the use of themes to investigate observable behavioral changes in participants.

Teachers based at CAVC and St David's were not selected to be interviewed, since it was felt that they were too close to the Pilot Scheme development phase (being members of the Teacher Placement Scheme) and the research project. The potential experimental bias from the teacher's involved could lead to unreliable results.

Qualitative data collected during the teaching associate interview were noted down and analyzed using the themes constructed above. These were supplemented with teacher observations and analyzed using the same themes.

3. Results

3.1 Abilities in Statistics Results

Fig. 1 presents the experimental and control groups mean scores for each set of formative test results. For F1, experimental group 1 achieved a mean score of 71%, while control group 2 scored slightly higher with a mean percentage of 79%. Control group 3 group scored a considerably lower mean percentage, at 53%. For F2, experimental group 1 achieved 55%, while control group 3 scored 43%. Control group 2 was unable to sit the F2 test, and therefore have no score for this set of results. For F3, experimental group 1 achieved 41%, control group 2 achieved 22% and control group 3 finished with a mean percentage mark of 17%.

3.2 Student Evaluation of the Course

Participants from experimental group 1, revealed

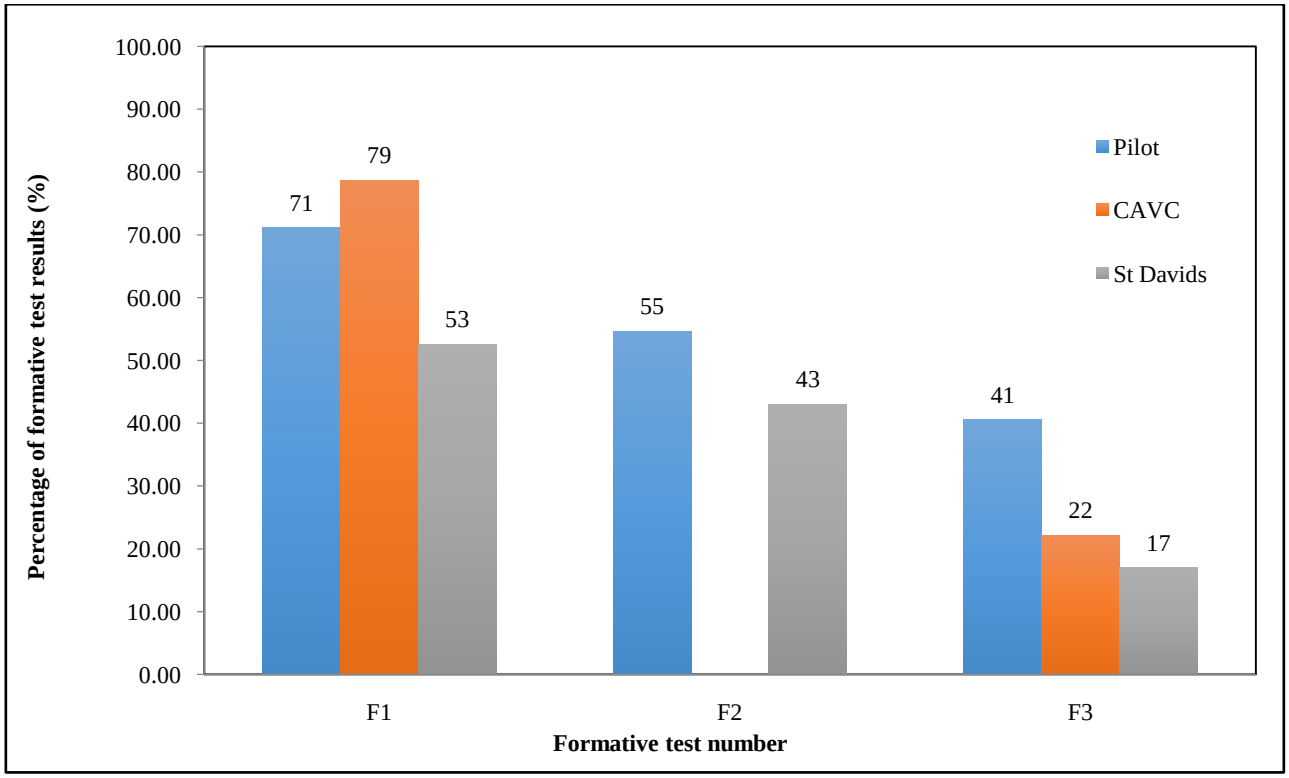

Fig. 1 Results from student formative tests (1, 2, 3), expressed as percentages. Experimental group 1 (Pilot), control group 2 (CAVC), control group 3 (St David's).

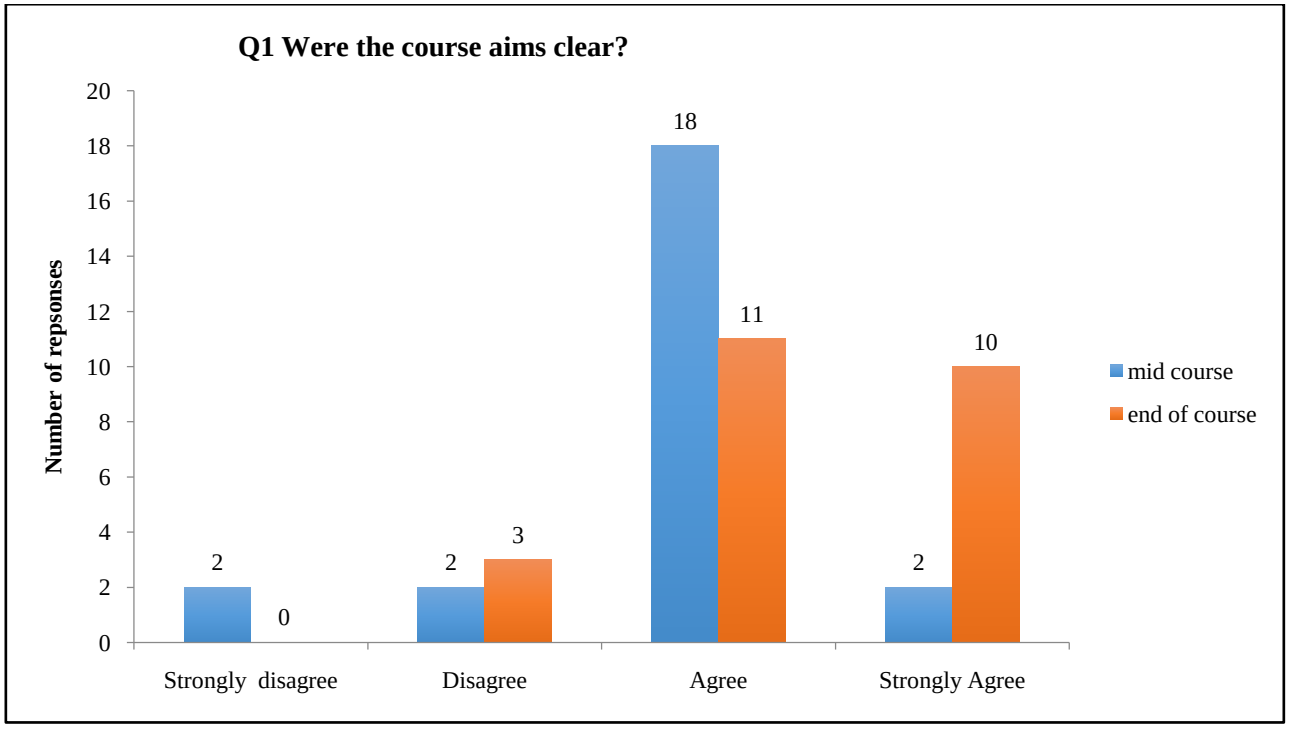

Fig. 2 Course evaluation responses from experimental group 1: Were the course aims clear?

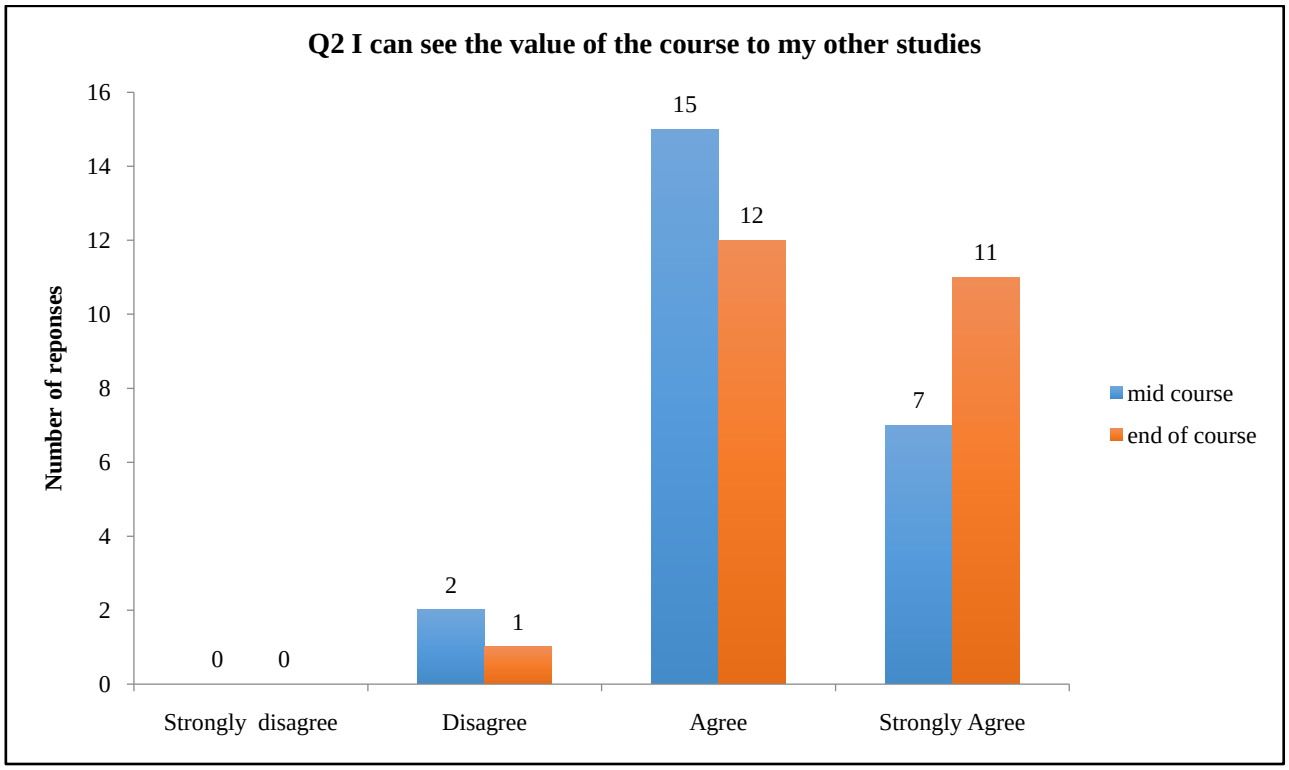

Fig. 3 Course evaluation responses from experimental group 1: I can see the value of the course to my other studies.

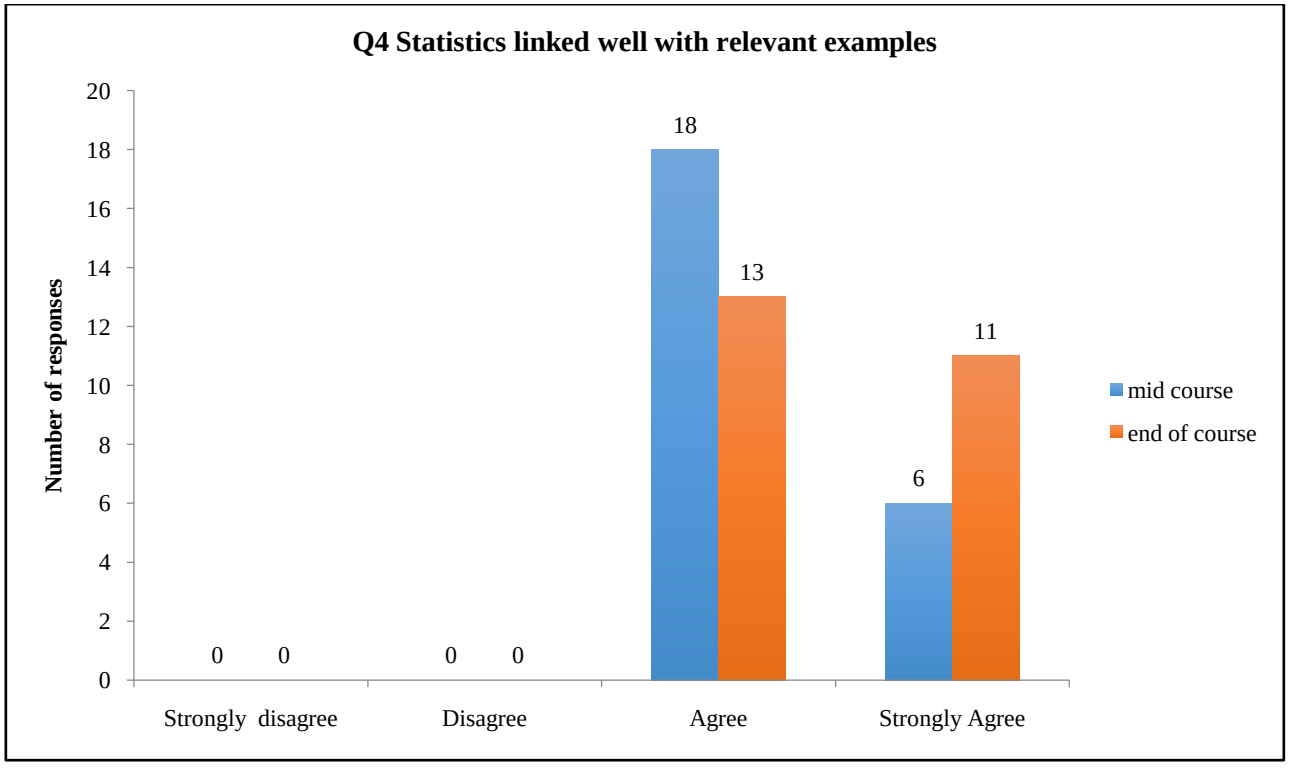

Fig. 4 Course evaluation responses from experimental group 1: Statistics linked well with relevant examples.

increases for the strongly agree option, from the mid to the end of course evaluation reports, with respect to the course aims being clear (Q1), seeing the value of the course to their other studies (Q2) and the statistics being linked well with good examples (Q4) (Figs. 2-4).

3.3 Teacher Observations

Results from the interview support findings from the course evaluation for the Pilot Scheme in SA. Teacher observations (recorded in note form) from the Pilot Scheme in SA noted an increase in student confidence with mathematics and statistics. This section will present the results from the interview, exploring several themes (pedagogical techniques and approaches, student attitudes to mathematics and statistics and abilities in statistics) related to the questions that were asked during the hour-long conversation. Teacher observations will also be incorporated where appropriate.

3.3.1 Describe the Pilot Scheme Course: What Were the Aims?

The TA (teaching associate) described the Pilot Scheme in SA as a context rich statistics course, with a focus on critical thinking and mathematical skills. The TA outlined her aims for the course, indicating that she tailored the course towards the specific needs of the class, in relation to the A' Level subjects they were studying. The TA also changed some of the resources, compared to the previous years' resources, when I taught the second part of the course. Modifications to the resources and handouts were in response to the student voice, i.e. areas they felt they needed more help with. Where possible, worksheets were modified to help support students existing A' Level and Welsh Baccalaureate studies.

In comparison, I followed the scheme of work more closely, and focused resource and handout content on statistical concepts as opposed to the TA's strategy of focusing on developing students' mathematical skills to support the statistical elements and critical thinking.

3.3.2 Teaching Strategies Used—What Worked? What Did Not Work?

The TA started the second half of the course by giving the course participants few handouts and some guidance. This strategy proved to be ineffective, which led to her increasing the number of handouts given and the amount of guidance provided to complete in class tasks. Students' quotes at the beginning of her teaching period include:

"Why am I here?"

"How are these sessions useful?"

"The maths is hard."

These comments enabled the teaching associate to adapt her teaching to make the relevance of the course more explicit and directly link topics and skills being developed in the sessions to their A' Level studies. These comments also led her to change her expectations of the class, realising that the class needed more instructions than she first realised. The TA also noted kinesthetic tasks were received well by the class, leading to very good class participation.

The teaching associate, having a background in philosophy, also made the following comments on her own mathematical ability:

"I like a challenge and enjoy mathematics, which edged me on to learn more about statistics."

These comments suggest the teaching associate perceived statistics as being underpinned by mathematics, which encouraged her to learn more about statistics. These considerations could explain the differences in pedagogical approaches adopted between the teaching associate and myself.

In comparison, I provided the Pilot Scheme in SA class with regular handouts from the start of the course, and continued to do so up to the point where the TA took over in January 2016. I also found the class responded well to "hands on" tasks. I have no recollection of students questioning the usefulness of the course for the first half of delivery. This could due to several reasons, perhaps they were giving the course time to assess its usefulness, or they could have

just kept these comments to themselves. Of course, these conclusions are just speculation from my own observations.

3.3.3 Student Attitudes and Confidence to Mathematics/Statistics—Did It Change During the Course?

The TA noted several participants in the Pilot Scheme in SA group liked mathematics, while others enjoyed the challenge of the course. She also noted than many participants gained confidence in their abilities in statistics and critical thinking, displayed by greater engagement with discursive activities, and asking more insightful questions on questioning the validity of data for example, during the time she had with them.

Since I taught the class for the first half of the course, identifying changes in student confidence would be less likely, potentially due to an insufficient amount for the intervention to have an effect. As a result, I noted no change in student attitudes towards mathematics and statistics.

3.3.4 Comment on Student Ability

The TA noted no change in student ability, from her own observations of student participation in class activities, completing worksheets etc. She did however reiterate the largest difference she noticed was that of an increase in confidence with handing data and engaging with mathematics and statistics.

As with the TA, I noted no change in students' ability in mathematics and statistics, for the relatively short period of time I taught the group.

3.3.5 Did the Students Enjoy the Course?

The TA noted students participating in the group indicated that the Pilot Scheme in SA was the most enjoyable course of all their A' Level studies. She also noted that within the Pilot Scheme SA group, students from CAVC were more actively engaged with debate and critical thinking activities, while the students from St David's were happy to listen to her talk for longer periods.

My experiences with the Pilot Scheme group were similar to the TA's, especially with regards to the preferences of class activities and teaching strategies of the students from CAVC and St David's.

3.3.6 Notice Any Difference in the Students—Linked to Their A' Level Subject Choice? Did This Impact on Their Learning? Could You Tell What They Were Studying?

The teaching associate noted that it was difficult to ascertain what the students were studying just from teacher observations. The students did however tell the TA what they were studying, which enabled her to modify her handouts to help support their subjects. In addition, she noted the students enjoyed looking at real world examples, drawn from different disciplines. The students noted that it enabled them to perceive their own A' Level subjects from different perspectives, helping to consolidate their learning.

3.3.7 Are There Any Other Comments You Would Like to Make?

The teaching associate noted variation in attendance for participants on the course, for example some students only attended when their friends were present. And since the course was in the evening, several students commented on the difficulties in committing to an extra curricula activity. These important sources of feedback will be used to modify future runs of the course.

3.4 Outcomes of the Research

The research focused on the development and evaluation of a contextualised statistics course called the Pilot Scheme in SA. The evaluation of the course used a quasi-experimental approach, with the use of questionnaires as the primary instrument to generate data. The findings showed that by engaging year 12 and 13 students with a contextualised statistics course (Pilot Scheme in SA course), their attitudes and abilities with respect to mathematics, statistics and critical thinking led to a series of measurable changes. The course has potentially contributed to increases in their statistical abilities. In comparison, students in

both control groups who did not receive the treatment, showed lower levels of ability with respect to statistics.

4. Discussion

The experimental group 1 scored higher marks than the control group 3, across all formative test results. This suggests that the intervention could have had a positive impact on the statistical abilities of experimental group 1, when completing the formative tests. Since experimental group 1 participated in the Pilot Scheme in SA course, they were trained to develop their critical thinking and data analysis skills. This unique training has potentially contributed to improving their statistical abilities, demonstrated in their higher formative test results in F3.

Experimental group 1 revealed increases in agreeing with the statement that the statistics delivered during the course was linked well with good examples. The 2015/16 group also revealed increases in agreeing that the course was valuable to their other studies, as well as the course aims being clear. These results could be attributed to the over-arching rationale behind the development of the course, with the TPS group identifying what students should know and how they come to know it [48]. The contextualised nature of the statistics and fostering of critical thinking skills throughout the course also support Skemp's relational understanding skills which he suggests are key concepts that students need to develop "knowing what to do and why" [18]. In addition, the direct mapping of course content and skills to current A' Levels many of the students studied have led them to report that they felt the course supported them in their other studies.

Research conducted on current statistical modules within A' Level mathematics [49-51] reported students and teachers describing these modules as boring, laborious and unimaginative. These findings are worrying, especially with the growing importance of pre-university students needing to be statistically literate in an increasing range of HE courses, for example social sciences and geography. The mathematical, statistical and critical thinking skills identified as being important for HE study, and consequently incorporated into the Pilot Scheme in SA by the TPS gave the course a unique identity. Skills highlighted as being essential preparation for HE study across a range of subjects [13-17]. These skills incorporated into the Pilot Scheme in SA could have contributed to the positive feedback, observed in the course evaluations from experimental group 1.

Results from the reciprocal interview revealed several interesting patterns, which support findings from the course evaluation for the Pilot Scheme in SA. Teacher observations from the Pilot Scheme in SA noted an increase in student confidence with statistics. In addition, students enjoyed the Pilot Scheme in SA, engaging with the critical thinking elements of the course (as identified in the course evaluations). Differences in teaching style and approaches were identified, specifically in relation to the main aims of the course. The TA focused on the students' mathematical skills to support statistical techniques being delivered, while I focused on statistical principles and critical thinking. The differences in the TA and my own perceptions as to what statistics is could explain these slightly divergent approaches. These different loci could have had some bearing on the outputs from the questionnaire data (mathematics and critical thinking questionnaires and course evaluations). For example, the focus of the TA on mathematical skills could have contributed to the increased levels of mathematical confidence observed in experimental group 1. Whereas the areas I concentrated on (statistical techniques and critical thinking) could have contributed to the increases in enjoyment of statistics and also the increased levels of agreement with the responses from the critical thinking questionnaire (e.g. ability to think of possible results before they take action and also whether they can tell what they did was right or wrong).

It was interesting to reflect on the different approaches taken by the teaching associate and myself,

on the Pilot Scheme in SA course. When I handed over the course content and scheme of work to the teaching associate, as well as discussing the course aims etc., I wanted to ensure that the teaching associate felt comfortable enough to put her own stamp on their sections of the course to be delivered. I did not want her to feel like they had to follow a prescribed way of delivering the course. And this was indeed the case; the teaching associate produced different teaching resources and materials for the second half of the course. The teaching associate's interpretation of the courses aims translated to providing slightly more mathematics than I had covered in the previous year's group. These differences could have given the course a different identity to the previous year, which might have had an impact on the participant's responses to the course evaluation, and also their attitudes to mathematics and critical thinking.

The implications of these differences in teaching style raise several issues that need to be addressed. Firstly, the approach I adopted, giving the teaching associate flexibility to select her own contexts and style of teaching (within a given curriculum), is a generally uncommon approach adopted within secondary schools in England and Wales [9]. Teachers currently follow prescribed national curriculum and A' Level curriculum syllabi constructed by local authorities and examining bodies [9]. If this course was to be rolled out on a larger scale, there is the propensity for teachers to feel overwhelmed and perhaps unconfident with having so much freedom to teach a less constrained curriculum. In addition, there is evidence to suggest that teachers struggle when new government initiatives are introduced, raising standards in preparation for mathematical elements of the PISA examinations for example Ref. [52]. In this particular case, Tanner and Jones [53] highlighted how teachers battled to keep up with yet more change in mathematics curricula and styles of teaching, in Wales. This evidence brings into question the success rate of attempting to not only introduce a statistics course that draws on a range of contexts (the Pilot Scheme in SA), but also a variety of pedagogical styles and increased teacher freedom. There is however a curriculum included with the Pilot Scheme in SA course, and examples of handouts and activities for teachers to follow. These guidelines could help teachers become familiar with the curriculum content, while at the same time giving them enough space to design their own student activities and handouts. Achieving the right balance of teacher freedom and guidance for teachers to feel confident in delivering a distinct course, such as the Pilot Scheme in SA, will require careful construction of teacher training programmes that exemplify successful approaches, that were identified through the reciprocal peer interview (for example, teacher observations).

The different emphases placed on the course in terms of delivery, noted between the teaching associate and myself, potentially reduced the likelihood that any differences in student attitudes and abilities were primarily down to my own teaching style and pedagogical practices. The teaching associate used the same curriculum that I would have followed, created by the TPS. Using the same scheme of work could be operationalised differently by different teachers, in the form of different handouts or activities for example. Having these practical insights could inform future training programmes for other teachers, giving them the space to be creative and come up with their own worksheets, but at the same time giving them examples of how different teachers used the scheme of work to deliver the course in potentially different ways. There is no right or wrong approach in terms of adopting and operationalising the scheme of work for the Pilot Scheme in SA. The decision I made to focus more on statistical concepts and critical thinking, especially during the earlier stages of the course, were perhaps partly out of fear not to expose students to too much mathematical content. Being mindful of the societal negative attitudes towards mathematics could have influenced

the approaches I decided to focus on. However, this approach to teaching statistics, focussing on statistical concepts and principles, is also a recommendation reported in the American Statistical Association's GAISE report [27]. After reviewing the reciprocal interview data and course evaluations, it appears that a combination of the two approaches has been successful in terms of improving mathematical confidence and also enjoyment with statistics.

Teachers would also need to be convinced of the benefits to the students who would take this course, if it was to be rolled out, as well as benefits to their own teaching practice. These benefits could include increases in mathematics teacher's ability to draw on different contexts linked to the underlying mathematics that support the statistics. Evidence from this research study support this approach, since the Pilot Scheme in SA students reported that they found the examples interesting and engaging. This movement away from clinging to prescribed curricula and towards focusing on teaching skills (mathematical, statistical and critical thinking skills) is also a prominent recommendation made by Porkess [8], Donaldson [9] and Smith [54].

Student feedback on the length and time of the course suggest modifications should take place to enable better attendance in future iterations of the course. A 21 week extra curricula course in the evening is a big commitment for 16-18 year old students. After discussing these issues with the TA and the TPS, suggestions to shorten the course into a ten week block could make it more appealing.

5. Limitations

The majority of the limitations discussed here will be with reference to the quasi-experiment method selected, although other considerations will also be discussed.

The small-scale quasi-experiment took place within Cardiff, involving participants from two educational institutes. Issues pertaining to generalisability and conflicts arising and the advantages afforded by insider research [55, 56] need to be discussed. In particular, partially removing myself from the research environment (helping become somewhat more objective and making the familiar strange, partially mitigating problems that can arise with insider research), could have contributed to a deeper level of reflexivity [41-44, 55-57]. Since I delivered half of the Pilot Scheme in SA course however, the problem with insider research still remains. Drawing on the work of Brannick and Coghlan [58], Drake [56] and Mercer [55], objectivity is closed to impossible when investigating sociological phenomena, and to think otherwise would be naive. Researchers draw on their own social, cultural and historical background, which is a strategy I adopted and increasingly reflected upon when collecting and analysing data from this research project [58]. For example, as a statistically literate biologist, I perhaps undervalued the benefits of the Pilot Scheme in SA to students studying A' Levels in humanities subjects. However, the critical thinking elements of the course could have helped to nurture valuable transferable skills that all students from a variety of disciplinary backgrounds could draw upon, especially when applying for HE courses.

Further issues that could have had an impact on the validity of the data include whether the groups themselves had equal statistical abilities [32, 59]. From the formative test results the St David's group appear to have the lowest ability. However their results were captured and included as a useful comparison (being a less statistically able group), ascertaining if their attitudes were different to the other groups.

Another issue that could have impacted on the results relates to whether a participant was in year 12 or 13. The actual numbers of year 12 and 13 students in the quasi-experiment were roughly equal. These students were mixed and not always in separate classes, since many of them were completing an A'

Level in a year (so they would have been in both AS and A2 classes). In future quasi-experiments with larger numbers of participants the results for each year group could be considered and comparisons made.

An additional limiting factor throughout the quasi-experiment was the problem of participant dropout. From the data, dropout did occur, which could have had an impact on the characteristics of the group, i.e. participants who dropped out could have differed systematically from the characteristics of the remaining group members [45, 60]. And the perceived differences in attitude and ability could just be a product of the students left on the course being perhaps more pro mathematics and better at statistics [60]. The results seem to suggest that this is not necessarily the case, since several students on the Pilot Scheme in SA group still reported they did not enjoy statistics at the end, and the shift in positive response to questions in the course evaluation were greater than the dropout rate, which means that students must have changed their opinion (i.e. it was not just the case that the students who did not like the course dropped out, which made it appear that the group had become more positive towards the course). Reasons for students dropping out of the course include; wanting to focus more on their A' Level studies, personal reasons linked to ill health and also other out of school commitments taking precedence over the Pilot Scheme in SA course.

The method used to collect data at various time points did lead to small sample sizes. Choosing to take data from individuals present during data collection points, effectively resulted in missing data points causing the sample size to drop even further. Gibbons et al. [60] and Daniels et al. [61] suggest the use of baseline and end point data to create Bayesian models to calculate an estimate of the missing observations. However, adopting this strategy could prove to be problematic, due to the many extraneous variables that would need to be built into the model, as well as accounting for the interactional effects of the variables from the baseline and end-point data [60, 61]. To elaborate further, the characteristics of the participants in this study included an insufficiency of data, socioeconomic class and gender for example, due to the scope and time restraints being limited. To create an accurate model that could predict responses from the questionnaires included in this study would also require larger sample sizes from multiple populations, necessitating research funding to facilitate the increased activity of work.

6. Recommendations

The recommendations for practice relate to the Pilot Scheme in SA course.

7. Practice—Expansion of the Pilot Scheme in SA and Teacher Training

The positive outcomes identified in this study supports an expansion of the course (increasing student numbers), to enable other students to enhance their abilities in critical thinking and statistical analyses. These skills will also benefit students embarking on HE courses across an increasing range of subjects, as well as being identified as highly valuable skills by a multitude of employers [13, 15-17]. Statistical education in its current form (in schools) underprepared students for HE, as outlined by the recent ACME recommendations to the Department for Education [62]. Even with the changes to statistics curricula within the new A' Level mathematics, for first teaching in September 2017, there are still concerns that more work needs to be done to ensure the course is fit for purpose and prepares students to apply statistical skills and concepts across a range of disciplines [8, 21, 54, 62, 63]. Therefore, a wider rollout of the Pilot Scheme in SA could help to prepare students to apply statistical skills across different subject areas.

The positive outcomes experienced by the participants, potentially due to the Pilot Scheme in SA, calls for the course to be expanded and offered to

other schools and FE colleges across Wales and potentially England. The results outlined benefited a small group of students from two educational establishments in Cardiff, and the quasi-experiment was conducted on groups with relatively small numbers of participants. However, the course that ran in 2014/15 resulted in similar positive course evaluations, and although there is no comparable data, it suggests that the benefits students experienced in both cohorts calls for the course to be made available for others. Future runs of the course should also consider being reduced in length, perhaps into a 10-weeks block. This would reduce the amount of commitment year 12 and 13 students would need to allot to engage with this course.

Expansion of the Pilot Scheme in SA course will require additional investments to ensure the expansion is resourced well. In addition, teacher training will enable the transmission of this style of contextualised statistical course and associated resources to be adopted more widely across secondary schools and FE colleges. The quality of teachers has been repeatedly shown to be more important than any other factor of schooling in predicting student academic outcomes [64]. Teachers are often underprepared and under skilled to teach numeracy, an increasingly important part of many subject areas on a global scale [54, 65]. By investing in teacher training programmes to up-skill teachers in the areas of contextualised statistics, there is the potential a knock-on effect that addresses several of the key issues identified by Refs. [9, 54, 64, 65] highlighted above. By creating a teacher workforce that can draw on engaging context, underpinned by statistics and critical thinking, students will become confident consumers of data, potentially leading to an enhanced preparedness for HE and employment [8, 21, 62, 63, 66, 67]. Expansion of the course will also provide further opportunities to conduct educational research to investigate its effectiveness, which could include action research strategies [68, 69].

Acknowledgements

Tha author would like to thank the funders of this project: the Research Councils UK School-University Partnership Initiative and also the Nuffield Foundation.

The research presented in this article occurred during my time as a EdD research student, and also in my previous post as a Lecturer in Quantitative Methods FE in the Cardiff School of Social Sciences, Cardiff University. My EdD thesis can be accessed using this link: http://orca.cf.ac.uk/111418/.

References

[1] Fonow, M., and Cook, J. 1991. *Beyond Methodology. Feminist Scholarship and Lived Research*. Indiana University Press.

[2] Payne, G., Williams, M., and Chamberlain, S. 2004. "Methodological Pluralism in British Sociology." *Sociology* 38 (1): 153-63.

[3] Williams, M., Payne, G., and Hodgkinson, L. 2008. "Does Sociology Count? Student Attitudes to the Teaching of Quantitative Methods." *Sociology* 42 (5): 1003-22.

[4] MacInnes, J. 2009. *Proposals to Support and Improve the Teaching of Quantitative Methods to Undergraduate Students in the UK*. Swindon: Economic and Social Research Council.

[5] Platt, J. 2012. "Making Them Count: How Effective Has Official Encouragement of Quantitative Methods Been in British Sociology?" *Current Sociology* 60 (5): 690-704.

[6] Payne, G. 2014. "Surveys, Statisticians and Sociology: A History of (a Lack of) Quantitative Methods." *ELiSS* 6 (2): 74-89.

[7] Williams, M., Sloane, L., Cheung, S. Y., Sutton, C., Stevens, S., and Runham, L. 2015. "Can't Count or Won't Count? Embedding Quantitative Methods in Substantive Sociology Curricula: A Quasi-Experiment." *Sociology* 1-18. Accessed January 07, 2018. http://m.soc.sagepub.com/content/early/2015/06/29/0038038515587652.full.pdf.

[8] Porkess, R. 2013. "A World Full of Data. Statistics Opportunities Across A' Level Subjects." Accessed January 07, 2018. http://www.rss.org.uk/Images/PDF/influencing-change/A-world-full-of-data.pdf.

[9] Donaldson, G. 2015. "Successful Futures. Independent Review of Curriculum and Assessments Arrangements in Wales." Accessed January 06, 2018.

https://hwbplus.wales.gov.uk/schools/6714052/Documents/Donaldson%20Report.pdf.

[10] Harrison, S. 2014. "History of Numeracy Education and Training for Print Journalists in England." *Advancing Education in Quantitative Literacy* 7 (2): 1-13.

[11] National Numeracy. 2017. "A New Approach to Making the UK Numerate." Accessed July 22, 2017. https://www.nationalnumeracy.org.uk/sites/default/files/nn124_essentials_numeracyreport_for_web.pdf.

[12] Gal, I., and Ginsburg, L. 1994. "The Role of Beliefs and Attitudes in Learning Statistics: Towards an Assessment Framework." *Journal of Statistical Education* 2 (12): 1151-1159.

[13] Gal, I. 2002. "Adults' Statistical Literacy: Meanings, Components, Responsibilities." *International Statistical Review* 70 (1): 1-25.

[14] Nunez, R. 2006. *Unconventional Essays on Nature of Mathematics. Chapter 18: Do Real Numbers Really Move? Language, Thought, and Gesture: The Embodied Cognitive Foundations of Mathematics.* New York: Springer, 160-81.

[15] Walshaw, M., and Anthony, G. 2008. "The Teacher's Role in Classroom Discourse: A Review of Recent Research into Mathematics Classrooms." *Review of Educational Research* 78 (3): 516-51.

[16] Durrand-Gurrier, V. 2015. "Reasoning, Proof and Proving in Mathematics Education." In *Proceedings of the 12th International Congress on Mathematical Education, Part 7*, 453-7. Springer International Publishing.

[17] Schleppegrell, M. J. 2007. "The Linguistic Challenges of Mathematics Teaching and Learning: A Research Review." *Reading and Writing Quarterly: Overcoming Learning Difficulties* 23 (2): 139-59.

[18] Skemp, R. R. 1976. "Relational Understanding and Instrumental Understanding." *Mathematics Teaching* 77: 20-6.

[19] Smith, A. 2004. "Making Mathematics Count." Accessed January 07, 2016. http://www.mathsinquiry.org.uk/report/MathsInquiryFinalReport.pdf.

[20] Swan, M. 2005. "Improving Learning in Mathematics: Challenges and Strategies." Sheffield: Teaching and Learning Division, Department for Education and Skills Standards Unit.

[21] RSS and ACME. 2015. "Embedding Statistics at A' Level." Royal Statistical Society and Advisory Committee on Mathematics Education. Accessed January 11, 2018. http://www.rss.org.uk/Images/PDF/publications/embedding-statistics-at-a-level.pdf.

[22] WJEC. 2016. "Sociology A' Level Specification." Welsh Joint Education Committee. Accessed October 27, 2016. http:/a/www.wjec.co.uk/qualifications/sociology/wjec-gce-sociology-spec-from-2015.pdf?language_id=1.

[23] SOCSI. 2016. "Research Centres and Groups." School of Social Sciences Cardiff. Accessed June 01, 2017. https://www.cardiff.ac.uk/social-sciences/research/centres-and-groups.

[24] Russell Group. 2016. Accessed October 27, 2016. http://russellgroup.ac.uk/for-students/school-andcollege-in-the-uk/subject-choices-at-school-and-college/.

[25] Landers, M. 1999. "Is Socrates Dead (in Mathematics)? The Role of the Mathematics Teacher in Higher Education Now and for the Next Ten Years." *Bollinger-Rosado Teaching & Learning Effectiveness Symposium Proceedings. Seventh Annual Symposium on Teaching Effectiveness.*

[26] The Critical Thinking Community. 2016. *Higher Education Workshop in Critical Thinking.* Accessed October 27, 2017. http://www.criticalthinking.org/pages/higher-education/431.

[27] Carver, R., et al. 2016. *Guidelines and Assessment for Instruction in Statistics Education (GAISE) College Report.* Alexandria, VA: American Statistical Association.

[28] Cook, T. D., and Campbell, D. T. 1979. *Quasi-Experimentation: Design and Analysis for Field Settings*. Chicago: Rand McNally.

[29] Cartwright, N. 2007. "Are RCT's the Gold Standard?" *Biosocieties* 2 (1): 11-20.

[30] Petticrew, M., Cummins, S., Ferrell, C., et al. 2005. "Natural Experiments: An Underused Tool for Public Health?" *Public Health* 119: 751-7.

[31] Bennet, T. 1988. "An Assessment of the Design, Implementation and Effectiveness of Neighbourhood Watch in London." *Howard Journal of Criminal Justice* 27 (4): 241-55.

[32] Gersten, R., Baker, S., and Lloyd, J. W. 2000. "Designing High-Quality Research in Special Education: Group Experimental Design." *The Journal of Special Education* 34 (1): 2-18.

[33] Welsh Joint Education Committee (WJEC). 2017. "Psychology A' Level specification." Accessed April 06, 2015. http://www.wjec.co.uk/GCE%20Psychology%20Spec%202009%20onwards%20(31-03-14).pdf?language_id=1. on: 06/04/2015.

[34] WJEC. 2017a. "Government and Politics A' Level Specification." Welsh Joint Education Committee. Accessed April 04, 2015. http://www.wjec.co.uk/qualifications/government-and-politics/government-and-politics-gce-from-2010/GCE%20G

overnment%20Politics%20Spec%202010%20onwards%20(31-03-14).pdf?language_id=1.

[35] Schilling, K., and Applegate, R. 2012. "Best Methods for Evaluating Educational Impact: A Comparison of the Efficacy of Commonly Used Measures of Library Instruction." *J. Med Libr Assoc.* 100 (4): 258-69.

[36] Trautwein, U., Luke, O., Marsh, H. W., Koller, O., and Baumert, J. 2006. "Tracking, Grading, and Student Motivation: Using Group Composition Status to Predict Self-Concept and Interest in Ninth-Grade Mathematics." *Journal of Educational Psychology* 98 (4): 788-806.

[37] AQA. 2017. "GCSE Statistics Specification." Assessment and Qualifications Alliance. Accessed April 04, 2017. http://www.aqa.org.uk/subjects/mathematics/gcse/statistics-4310.

[38] AQA. 2017a. "GCSE Statistics Specification." Assessment and Qualifications Alliance. Accessed April 06, 2017. http://www.aqa.org.uk/subjects/mathematics/gcse/statistics-4310/past-papers-and-mark-schemes.

[39] Linacre, J. M. 2002. "Optimizing Rating Scale Category Effectiveness." *Journal of Applied Measurement* 3 (1): 85-106.

[40] Miller, R., Acton, C., Fullerton, D., and Maltby, J. 2002. SPSS for Social Scientists.

[41] Delamont, S. 2002. *Fieldwork in Educational Settings*. Abingdon: Routledge.

[42] Evans, L. 2002. *Reflective Practice in Educational Research. Developing Advanced Skills*. London: Continuum Books.

[43] Greene, M. 2014. "On the Inside Looking in: Methodological Insights and Challenges in Conducting Qualitative Insider Research." *The Qualitative Report* 19: 1-13.

[44] Van Heugten, K. 2004. "Managing Insider Research: Learning from Experience." *Qualitative Social Work* 3 (2): 203-19.

[45] Slavin, R. E. 2008. "Perspectives on Evidence-Based Research in Education. What Works? Issues in Synthesizing Educational Program Evaluations." *Educational Researcher* 37 (1): 5-14.

[46] Porter, E., Neysmith, S. M., Reitsma-Street, M., and Collins, S. B. 2009. "Reciprocal Peer Interviewing." *International Review of Qualitative Research* 2 (2): 291-312.

[47] Aronson, J. 1994. "A Pragmatic View of Thematic Analysis." *MCC Behavioral Care* 2 (1): 1-3.

[48] Prideaux, D. 2003. "Curriculum Design." *BMJ* 326: 268.

[49] Lee, S., Harrison, M. C., and Robinson, C. L. 2007. "Recent Changes in A' Level Mathematics: Is the Availability and Uptake of Mechanics Declining Yet More?" *Teaching Mathematics and Its Applications* 26 (3): 111-8.

[50] Minards, B. A. 2013. "An Exploration of High-Achieving Students' Experiences of Learning and Being Examined in A' Level Mathematics." Ph.D. thesis, University of Birmingham.

[51] Cole, J. S. 2015. "A' Level Mathematics Options—Views of Secondary-Level Teachers." *8th IMA Conference on Mathematical Education of Engineers*, Lougborough University. Accessed July 22, 2017. http://pure.qub.ac.uk/portal/files/15608345/JCole_IMA_paper_2015.pdf.

[52] Andrews, L. 2011. "Teaching Makes a Difference." Accessed January 07, 2018. http://gov.wales/topics/educationandskills/allsectorpolicies/ourevents/teachingmakesadifference/?lang=en.

[53] Tanner, H., and Jones, S. 2013. "Developing Mathematical Literacy in Welsh Secondary Schools." *University of Wales Journal of Education* 16: 21-6.

[54] Smith, A. 2017. *Report of Professor Sir Adrian Smith's Review of Post-16 Mathematics.* Accessed July 23, 2017. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/630488/AS_review_report.pdf.

[55] Mercer, J. 2007. "The Challenges of Insider Research in Educational Institutions: Wielding a Double-Edged Sword and Resolving Delicate Dilemmas." *Oxford Review of Education* 33 (1): 1-17.

[56] Drake, P. 2010. "Grasping at Methodological Understanding: A Cautionary Tale from Insider Research." *International Journal of Research & Method in Education* 33 (1): 85-99.

[57] Delamont, S., and Atkinson, P. 1995. *Fighting Familiarity: Essays on Education and Ethnography*. Cresskill, NJ: Hampton Press.

[58] Brannick, T., and Coghlan, D. 2007. "In Defence of Being 'Native': The Case for Insider Academic Research." *Organizational Research Methods* 10 (1): 59-74.

[59] Maxwell, J. 2004. "Causal Explanation, Qualitative Research, and Scientific Inquiry in Education." *Educational Researcher* 33 (2): 3-11.

[60] Gibbons, R. D., Hedeker, D., Elkin, I., Waternaux, C., Kraemer, H. C., Greenhouse, J. B., Shea, T., Imber, S. D., Sotsky, S. M., and Watkins, J. T. 1993. "Some Conceptual and Statistical Issues in Analysis of Longitudinal Psychiatric Data. Application to the NIMH Treatment of Depression Collaborative Research Program Dataset." *Arch Gen Psychiatry* 50 (9): 739-50.

[61] Daniels, M. J., Hogan, J. W., and Chapman, H. 2011. "Missing Data in Longitudinal Studies: Strategies for Bayesian Modeling and Sensitivity Analysis." *Statistics in Medicine* 30 (11): 1327-8.

[62] Advisory Committee on Mathematics Education (ACME). 2011. *Mathematical Needs: Mathematics in the*

Workplace and in Higher Education.

[63] Forman, E. 1996. "Learning Mathematics as Participation in Classroom Practice: Implications of Sociocultural Theory for Educational Reform." In *Theories of Mathematical Learning*, edited by Steffe, L. Lawrence Erlbaum Associates.

[64] Petty, G. 2006. *Evidence-Based Teaching a Practical Approach (2nd Edition)*. Oxford University Press, 311.

[65] Dolphin, T. 2015. *Technology, Globalisation and the Future of Work in Europe: Essays on Employment in a Digitised Economy, IPPR.* Accessed January 06, 2018. http://www.ippr.org/publications/technology-globalisation-and-the-future- of-work-in-europe.

[66] Dowling, P. 1998. *The Sociology of Mathematics Education: Mathematical Myths/Pedagogic Texts*. London: Falmer.

[67] Mercer, N., and Sams, C. 2006. "Teaching Children How to Use Language to Solve Maths Problems." *Language and Education* 20 (6): 507-28.

[68] Bryden-Miller, M., Greenwood, D., and Maguire, P. 2003. "Why Action Research?" *Action Research* 1 (1): 9-28.

[69] Hine, G. S. C. 2013. "The Importance of Action Research in Teacher Education Programs." *Issues in Educational Research* 23 (2): 151-63.

Appendicies

Cardiff School of Social Sciences

Appendix 1: Pilot Scheme Level-3 Social Analytics Mid-course Evaluation Form—Dec. 2015

Please estimate your attendance on this module: 0-49% 50-74% 75-100%	Strongly agree	Agree	Disagree	Strongly disagree
1. The aims and objectives of the course were made clear				
2. I can see the value of the course to my other studies				
3. The course covers material in my other studies				
4. The statistics is linked well with relevant examples				
5. The course is sufficiently challenging				
6. There is enough hands on work				
7. I enjoy the statistical elements of the course				
8. The resources for the course are good				
9. The course is enjoyable				
10. A variety of teaching techniques are used				
11. The methods used have helped to facilitate my learning				
12. I enjoyed the sessions from guest speakers/postgraduate students				

13. What do you like about this course?

14. What do you dislike about this course?

15. How could this course be improved?

16. Any other comments?

Appendix 2: Pilot Scheme Level-3 Social Analytics End of Course Evaluation Form—March 2016

Please estimate your attendance on this module: 0-49% 50-74% 75-100%	Strongly agree	Agree	Disagree	Strongly disagree
1. The aims and objectives of the course were made clear				
2. I can see the value of the course to my other studies				
3. The course covers material in my other studies				
4. The statistics is linked well with relevant examples				
5. The course is sufficiently challenging				
6. There is enough hands on work				
7. I enjoy the statistical elements of the course				
8. The resources for the course are good				
9. The course is enjoyable				
10. A variety of teaching techniques are used				
11. The methods used have helped to facilitate my learning				
12. I enjoyed the sessions from guest speakers/postgraduate students				

13. What did you like about this course?

14. What did you dislike about this course?

15. How could this course be improved?

16. Are you considering going to university to study? If yes, which one, and which course?

17. Are you going to apply to Cardiff University? If yes, which course?

18. Any other comments?

Appendix 3: Prof. Doc. Ed.—Interview with Teaching Associate of the Pilot Scheme in SA

Crosscheck responses with student feedback from the Pilot Scheme in SA (student course evaluation forms from December 2015 and March 2016)
Describe the pilot scheme course? What were the course aims?
Teaching strategies used—what worked? What didn't?
Student attitudes and confidence to mathematics/stats and critical thinking—did it change during the course?
Comment on student ability
Did the students enjoy the course?
Notice any difference in the students—linked to their A' Level subject choice? Did this impact on their learning? Could you tell what they were studying?