

IGNITING THE STATISTICAL SPARK IN THE SOCIAL SCIENCES

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The Cardiff University Q-Step centre has become a national leader in developing and promoting context rich statistical courses (aimed at ages 16-18), across England and Wales for the past 8 years. These courses involve a new subject area called Social Analytics (SA) (the scientific investigation of social processes using statistical techniques and analysis). This article will focus on the development of the courses interdisciplinary curriculum, as well as a description of the pedagogical methods adopted, underpinned by a constructivist approach to learning. There will also be a brief overview of a quasi-experimental approach utilised to evaluate the impact of the course on year 12 and 13 attitudes and abilities in mathematics, statistics and critical thinking, compared to two control groups.

BACKGROUND

This article will focus on the Further Education (FE)/schools engagement work, discussing the development of the SA course, as part of the Cardiff Q-Step initiative. Better preparing students for the quantitative methods they are likely to encounter at university (e.g. social science degree courses) was a key feature of the course. This new course encompasses statistical concepts and analysis to explain various social phenomena such as health inequalities, differential educational attainment and crime in society. The course emphasises the use of the scientific method to investigate social processes using statistical analyses and techniques. The development of this qualification involved colleagues from St David's Sixth Form College (St David's), Cardiff and the Vale College (CAVC), Agored Cymru (Access to HE diploma providers in Wales) and several other secondary schools in South Wales.

THE PROBLEM

A significant factor identified as causing angst and fear among pre-university students in many disciplinary areas, in the UK, include attitudes towards statistics (Richardson and Woolfolk, 1980; Marsh, 1988). For example, geography and sociology, areas that have increasing levels of statistics within them can come as a surprise, creating anxiety (Marsh, 1988; Swan, 2005). Moreover, when students reach university, these anxieties continue to persist and even magnify in many cases (Musch & Broder, 1999; Vigil-Colet, Lorenzo-Seva & Condon, 2008).

Anxieties towards mathematics and statistics could dissuade year 12 and 13 (16-18 year old) student from studying these subjects, leaving them underprepared across a range of higher education subjects that require data analysis skills. In particular, a number of studies indicate relatively small numbers of undergraduate are likely to enter social science programmes with A' Level mathematics, which could potentially make these student's underprepared for these courses (Williams et al., 2008; Payne, 2014; Platt, 2012). Most enter social science programmes with sociology/ humanities A' Levels and are at times unaware that they will be studying quantitative methods (Williams, et al., 2008; Payne, 2014; Platt, 2012). In addition, A' Levels in sociology have marginal quantitative methods content, which severely underprepares students when they encounter them at university (Williams et al., 2015).

INTERDISCIPLINARY APPROACH

To aid in the SA course developments, a Pilot Scheme in SA was created. Constructivism formed the key learning theory in driving the Pilot Scheme in SA developments. This theory positions students at the center of the learning process, whereby they construct their own knowledge (Duffy & Cunningham, 1996; Fosnot & Perry, 1996; Von Glasersfeld, 1996). This is in stark contrast to instructionist approaches, which usually places the teacher at the centre of the learning process, incorporating typically didactic methods of delivery (a technique traditionally favoured by mathematics and statistics teachers) (Swan, 2005; Scholnik et al., 2006). A group of

FE lecturers and secondary school teachers from across South Wales helped to develop the course, as well as representatives from Agored Cymru, referred to as the Teacher Placement Scheme (TPS).

The TPS encompassed a range of expertise from disciplinary backgrounds in the social sciences, politics, mathematics, political sciences, health sciences, biology and psychology. The groups' expertise also included experience of teaching year 7 (age 11) through to master's level and teacher training. This enabled discussions to emerge and 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 Social Analytics) students need to effectively progress from year 10 onwards, with the end goal of accessing a variety of higher education courses.

The curriculum was purposely mapped to several A' Level subjects: mathematics, biology, psychology, geography and sociology. These subjects afford opportunities for quantitative data analysis and the incorporation of interesting contexts. In addition, it would enable students to recognise the value in participating in such a course, supporting their A' Level subject areas.

The development of critical thinking skills was also central to the course development, deemed good preparation for higher education in a variety of subjects (Landers, 1999; Gal, 2002). The ability to objectively evaluate evidence and make judgments is of central importance to enable relational understanding of mathematics and statistics (Skemp, 1976; Landers, 1999; Gal, 2002). In a statistical context, critical thinking mutually supports relational understanding (Gal, 2002), as Skemp puts it, 'knowing what to do and why, '(Skemp, 1976). Developing student's judgment and critical thinking skills also align to constructivist principles, whereby students actively construct concepts and knowledge, as well as discuss and exchange ideas. This could then lead them to become aware of their own perspectives, understanding the world of the learner compared to the world of the expert (which could be the teacher in this context, or researchers) (Wood, 1995). For these reasons, opportunities for students to work in groups were encouraged by introducing games and worksheets throughout the course.

FE lecturers and secondary school teacher's involvement with curriculum development disseminated information about the Pilot Scheme in SA to their respective education institutes. TPS members' colleagues in other educational institutes then also became accessible, and were more amenable to disseminating information about the programme to their students and other colleagues.

CURRICULUM STRUCTURE

Development of the course mirrored year 12 and 13 level qualifications in the UK. The subject areas chosen include health and disease, science and technology, crime and deviance forming the social science in practice unit, with the applied statistics unit covering the psychology of learning, mass media and journalism and becoming an effective researcher. As well as aligning to popular subject areas, these subject areas reflect interesting and engaging topics for year 12 and 13 students.

Elements of the course utilised small segments of a Cardiff Q-Step module for second year undergraduates. The Cardiff Q-Step module: Lies damned lies and statistics, encourages students to think critically about data, delivered in a series of lectures, workshops and seminars. The module also aims to enable students to apply theoretical knowledge gained during lectures into practice via a series of data visualisation sessions (using SPSS). The Pilot Scheme in SA scheme of work incorporated these approaches for the same reasons as above, to enable students to develop practical skills and data analysis techniques.

The course was designed to emphasise the importance of using statistical techniques in relation to the context, rather than performing traditionally isolated statistical calculations (as is the case in A' Level mathematics for example). Embedding core statistical and scientific concepts throughout the module outline ensured students developed critical analysis skills. They were 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 require 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, to include its reliability and validity.

PEDAGOGICAL APPROACHES AND CURRICULUM REFINEMENT

Teacher observations and student evaluations helped to develop the curriculum structure and pedagogic practice from 2014/15 to 2015/16. These evaluative practices incorporated useful strategies to enable educational theory (constructivism in this case) to be translated into praxis, in essence doing something (i.e. curriculum construction, development and utilisation of pedagogical practices) and then reflecting upon those actions, i.e. were they successful? Can we make improvements?

The first run of the Pilot Scheme in SA span 21 weeks, delivered by myself, starting on the 21/10/2014 and finishing on the 28/03/2015. The initial delivery enabled the TPS group to utilise primary evidence in the form of teacher observations (from myself) to discuss how the curriculum unfolded practically. For example, was there enough time allotted through the scheme of work, for students to assimilate the information delivered? There was also an opportunity to collect evaluative data, mainly in the form of course evaluations from the students participating in the course. Responses from the 2014/15 course evaluations indicated the majority of students could see the value of the course to their other studies (39/44 students agreeing or strongly agreeing). They also enjoyed the statistical elements of the course (39/44 students agreeing or strongly agreeing) and felt the statistics was linked well with relevant examples (41/44 students agreeing or strongly agreeing). These responses suggested the approaches taken in developing and delivering the course had been successful with this group of students, in relation to the course aims and objectives.

Areas of improvement identified from the 2014/15 and subsequently implemented in the 2015/16 cohort took place after discussions with the TPS. Reflections from student responses recorded, as well as evidence from my own teaching observations, helped to frame these discussions with the TPS group to help modify the curriculum for future delivery of the course. Several recommendations made and implemented by the TPS group included: the removal of the Analysis of Variance content from the scheme of work, with more time allotted to regression analysis. Another approach included reducing didactic methods to incorporate more hands on activities. For example, in the 2015/16 cohort, students were given more time to handle data and engage with data visualisation techniques (using SPSS). This would enable participants to apply theoretical concepts into practice, providing a more varied learning experience. In addition, constructivist approaches to learning increased by providing more hands on activities for students, placing them at the centre of the learning process, encouraging them to actively construct their own knowledge and share it with their peers (Wood, 1995; Duffy & Cunningham 1996; Fosnot 1996; Von Glasersfeld, 1996).

Due to the positive feedback received from the students present on the 2014/15 Pilot Scheme in SA course, it was run it again in 2015/16. The second run of the Pilot Scheme in SA course span 21 weeks, starting on the 05/10/2015 and finishing on the 21/03/2016. I delivered a series of lectures, workshops and seminars for the course, up until Christmas 2015. A teaching associate, a joint appointment between Cardiff University and St David's Sixth Form Catholic College, delivered the remainder of the course.

The scheme of work for the Pilot Scheme in SA includes a series of substantive topics, linked to two units, Social Science in Practice and Applied Statistics. Bodily-kinesthetic learning opportunities were provided as often as possible, to enable students to take ownership of their own learning as well as fostering the development of practical skills in generating data (Gardner, 1983). For example, one of the first activities involved students collecting a series of measurements from different body parts. Other forms of data were also collected, favourite types of food for example. Students were then encouraged to critically evaluate the usefulness of the different types of data collected, discussing the merits and disadvantages of both. Other Bodily-kinesthetic learning opportunities included students developing an IQ test, or a creativity test, with a definition of what they were measuring. Students were then guided to create a scale; a challenge to measure IQ or creativity (singing ability for example), then the participant's performance was measured against a grading criteria grid – all designed by the students. Students then constructed conclusions from

their findings, along with a comment on the sampling methods they had used to collect the data. These carefully constructed learning experiences enabled them to see scientific research in action; they were part of the research process and were able to incorporate scientific and statistical concepts in practice.

The scheme of work and learning outcomes also incorporated opportunities for students to develop a range of transferable skills. For example, students worked in groups to develop a presentation based on a recent scientific breakthrough, to include the positive and negative impacts on society, along with evidence to support their views. There were also other opportunities for students to develop their reading and writing skills, via a series of comprehension exercises, which evaluated the validity of a series of knowledge claims made about using guns in the USA. Providing a variety of learning experiences for students to develop a range of skills, ensured there was a pedagogically balanced delivery. Improvements in student's analytic skills have been demonstrated by adopting different pedagogic approaches (Mainemelis et al., 2002). In addition, several researchers who advocate the use of different learning styles (Lui, 1994; Boyle et al, 2003; Hey et al., 2016) have also reported improvements in student learning.

The aim of the Pilot Scheme in SA is to develop a variety of skills, which include presentation, data visualisation (using SPSS) and statistical and mathematical skills. These areas also align with other multiple intelligences proposed by Gardner (1983). These include Visual-spatial (data visualisation), Verbal-linguistic (presentation skills) and Logical-mathematical (statistical and critical thinking skills) (Gardner, 1983).

Learning styles and Multiple Intelligence theories have received extensive academic scrutiny, for example, the overuse of learning style questionnaires in education, with associated theories supported by weak empirical evidence (Curry, 1990; Reynolds, 1997; Waterhouse, 2006). Gardner's Multiple Intelligences theories are continuously being adapted because of new empirical evidence (Gardner & Hatch, 1989; Gardner & Moran 2010). His theories focus more on cognitive styles that have been utilised and perhaps misunderstood by proponents (and critiques) of learning styles (Sadler-Smith, 2001; Rayner & Riding, 2010). The cognitive development of learners includes many extraneous variables that can affect the learning processes. Discussing these issues with the TPS, along with evaluating the successes of carefully constructed learning experiences enabled us as a group to decide what worked well in practice.

Games were also created throughout the course to help engage students, which linked context and data analysis techniques, encouraging students to interact and exchange ideas (Wood, 1995). For example, a zin obelisk game created for the course encouraged students to select useful pieces of information that contain unfamiliar terms and phrases, to complete the puzzle.

Evaluation of the Pilot Scheme in SA (delivered in 2015/16) included a longitudinal quasi-experimental approach, with pre and post intervention testing. At the end of the 21-week programme, the experimental group (students on the Pilot Scheme in SA) showed an improvement in their attitudes to mathematics and statistics, as well as their abilities in statistics, compared to two control groups. Findings from this research study provide evidence to support the expansion of this course. This will also have the added benefit of providing opportunities to collect more quantitative data, to help in assessing the impact of the course on year 12 and 13 students' attitudes and abilities in mathematics and statistics. The development of teacher training programmes will utilise findings from the teacher observations collected during this study, for those interested in delivering the course with their own students.

CONCLUSION

Curriculum construction requires careful consideration to ensure the learning outcomes are appropriate, relevant and measurable. A constructivist approach to learning has been adopted to drive the curriculum development and pedagogical practices associated with the Pilot Scheme in SA (2014/15 and 2015/16). Better preparing students for the quantitative methods they are likely to encounter at university was a key feature of the course, described in detail in this article.

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which includes teaching mathematics and statistics in a variety of higher and further education institutes across the UK.

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