REACHING OUT TO THE SPORTS SCIENCE SETTING: THE IMPACT OF ACADEMIC PRACTICE ON STUDENTS' STATISTICAL LITERACY

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ABSTRACT

It has been widely documented that many undergraduate students demonstrate antipathy towards statistics. This paper documents the findings from an investigation of statistics education in a sport and exercise science department at The University of Chichester in the UK. Sports science is a multidisciplinary subject that encompasses biomechanics, physiology, and psychology. The university had a suite of four programmes each with a different emphasis in terms of subject discipline. Academics' use and interpretation of statistics are influenced by their subject specialism within sports science. The investigation evaluated the differences in examination performance between degree programmes, gender and previous mathematics achievement. Findings from the analysis of examination results found mathematics qualification to significantly affect achievement in statistics examinations. Qualitative analysis provided contextual detail that support the need for professional and pedagogic development.

INTRODUCTION

Undergraduate sport and exercise science students in the United Kingdom (U.K.) typically follow a multidisciplinary programme that develops understanding of physiology, psychology and biomechanics in the context of sport and exercise. At the time of data collection, the sports science department at the University of Chichester offered four Bachelor of Science honours degree programmes

- Sport and Exercise Science - a balance of physiology, biomechanics and psychology in equal measure, but with limited option to focus more specifically in one of those areas in second and third year.
- Coaching Science – the same first year as sport and exercise science, followed by a specific focus on skill acquisition and coaching psychology in the subsequent two years.
- Exercise and Health Science – the same first year as sport and exercise science, followed by physiology and greater focus on the impact of exercise on health issues such as diabetes and obesity.
- Sports Therapy – In each of the three years students share physiology and biomechanics modules with other programmes, but half the year of study is devoted to therapeutic techniques such as massage or ultrasound. The programme meets the Society of Sports Therapists requirements for licence to practice as a sports therapist.

All students study research methods and statistics in the first and second year, to support reading and laboratory work and to provide the necessary skills to undertake a research project in their final year. There is a need to negotiate the place of statistics in the wider sports science community because statistics is important if sports science students are to have the ability to evaluate critically published research and design and carry out their own project.

Previous research in sports science addressed the motivation and self-efficacy of students to do statistics (Lane, Dale and Horrell, 2006; Lane, Hall and Lane, 2004; Lane, Devonport and Horrell, 2004; Lane *et al.* 2003; Lane, Hall and Lane, 2002). The stimulus to undertake statistical work is acknowledged as unlikely to come from within the individual, intrinsic motivation, so these research papers focussed on ways of making statistics more appealing to students through extrinsic motivators. Parajes (1996) claimed that self-efficacy (belief in personal capability) can be more effective than academic ability in generating a positive attitude towards subjects that students perceive to be difficult. This is an important consideration for statistics because of its association with mathematics, a subject that few sports science students pursue beyond compulsory schooling. An important finding from the studies of Lane *et al.* was that sports science students had little self-efficacy in statistics.

A considerable body of literature addresses the tension between Mathematics and Statistics. Murtonen and Titterton (2004) concluded that students' *perception* of statistics as a branch of mathematics is sufficient to adversely affect their learning experiences, and Murtonen, Olkinuora, Tynjälä, and Lehtinen (2008) claimed the similarity with mathematics to discourage student engagement and compromise the quality of learning. Murphy (2008) and Hencken (2005) advocated teaching that emphasises the purpose of the analysis and the interpretation of results in the research context, rather than computational processes. Chatzisarantis and Williams (2006) claimed a practical perspective through use of 'real' situations and data to capture students' imaginations such that motivation to solve a problem should increase; a belief shared by many other authors (for example, Murphy, 2008; Davies, 2006; Graham, 2006). These perspectives raise questions about what should be included in taught courses to enable sports science students to develop statistical literacy.

The convergence of psychology, physiology and biomechanics within sports science demands careful reflection and management if students are to have a coherent experience. Applied statistics is a discipline on the periphery of these diverse communities of practice. Students can receive mixed messages from tutors within specific disciplines, who use different statistical terminology to explain the same procedures. These inconsistencies promote insecurity, raise anxiety, and cause students to become alienated from statistics in favour of safer, more consistently presented parts of sports science. As the values of respected tutors and researchers are subconsciously absorbed as part of the students' experiences, they have a crucial influence on the development of attitudes towards statistics (Becher and Trowler, 2001).

Statistics is often taught by academics whose experience of statistics was gained during the study of sports science, physiology, or psychology, or through subsequent research. As a result of these experiences, the uses and interpretation of statistics have a particular disciplinary bias (Soler, 2010). In addition, tutors may not have the confidence to branch beyond their individual experiences. Hencken (2005) suggested this lack of confidence in tutors to limit the scope of problems presented to sports science students as those teaching statistics did not want to step outside their experiential comfort zone. Such constraints may limit the opportunities that students have to question and develop their statistical learning. Little research has been conducted to explore the impact of the demands of sports science on learning statistics.

The research explained in this paper was undertaken to explore the multifaceted experiences of learning statistics in a specific sport science context. Statistics was taught by three tutors, two of these were from a sports science background (a biomechanist and a physiologist) and the third (the author) from an applied statistics background. Students attended a mix of statistics seminars and practical workshops during the first and second years of a three year degree programme. In both years assessment was through a statistics examination which required students to use computer software to analyse a given data set and to interpret the results obtained. The first year examination paper provided more guidance than the second year paper and demanded less complex analysis. There was concern that the practice of assessment through examination compromised the development of statistical literacy, and also that mathematical incompetence affected the students' ability to attain high marks. Additionally, it was thought vital to gain an insight into the impact of degree programme on attainment in statistics examinations, because the choice of degree programme represented the disciplinary interest of each student.

HYPOTHESES AND RESEARCH QUESTIONS

The following hypotheses were investigated quantitatively:

- Statistics examination marks differ between male and female sports science undergraduate students
- Degree programme affects first and second year undergraduates' achievement in Statistics examinations

- Level of Mathematics qualification attained prior to registration at university affects first and second year undergraduates' achievement in statistics examinations.

Potential interactions of the above factors were also considered as part of this paper.

Qualitative research questions explored students' perspectives on their learning experiences.

METHODS

The student sample consisted of all those registered for sports science degree programmes in June 2006, and spanned three years of undergraduate students (n=336). Gender and degree programme were included in the data collection and analysis because the professional experiences of those teaching statistics modules suggested they impinged on students' abilities to do well in statistics examinations. Mathematical competence was measured by the mathematics examination grade required for entry to the university. For most students this was the compulsory UK post-sixteen GCSE grade, although 25 students (7.4%) had qualifications above GCSE level. Three students had various overseas mathematics qualifications and data were unavailable for a further 22 students, whose entry records were incomplete or because they entered with mature entry portfolios. The sample for analysis was therefore reduced to 311 students. All data were collated from university records. All students had completed the first year, but five had yet to take the statistics examination, further reducing the sample size to 306. Two hundred and six students had completed the second year. Marks analysed for the second year statistics examination were from a subset of those whose first year marks were analysed.

Three way ANOVA (Gender x degree programme x mathematics qualification) investigated potential main effects and interactions on statistics examination marks. Prior to analysis it was ascertained that such a three way split maintained large enough group sizes for results to be meaningful. Mathematics qualifications were coded to represent the UK baseline entry qualification to university (GCSE grade C), a middle mark above the baseline entry (GCSE grade B), or a 'better' mathematics qualification (GCSE grade A, or a further qualification such as a UK A level or International Baccalaureat). These codings were necessary to provide groups with sufficient numbers. *Post hoc* tests further explained the significant results.

A self-selected group of twelve second year undergraduate students volunteered to be interviewed about their learning experiences as they studied the second year statistics module. All degree programmes were represented in this sample, although representation was not proportional to the relative sizes of the programmes. Semi-structured interviews were employed to guide students to consider the same areas of learning and teaching. Questions for the interview schedule were developed from a consultation with academic staff and scrutiny of previous year's student evaluations of the module. Findings from the quantitative analysis led to the inclusion of a specific exploration of students' previous experiences with mathematics. Inductive and deductive analysis identified themes in the data.

QUANTITATIVE RESULTS

A preliminary analysis explored the means and standard deviations of statistics marks when split by each factor separately. These summary values can be seen in Table 1. Although normally distributed, the marks were not closely clustered around the means. Table 1 clearly shows that marks for the second year examination are worse than those for the first year examination, and that Coaching Science and Exercise and Health Science students, and those with GCSE grade C in Mathematics did not achieve good marks for statistics examinations.

Table 1. Mean (*and standard deviation*) results for first and second year statistics examinations split by factors of interest

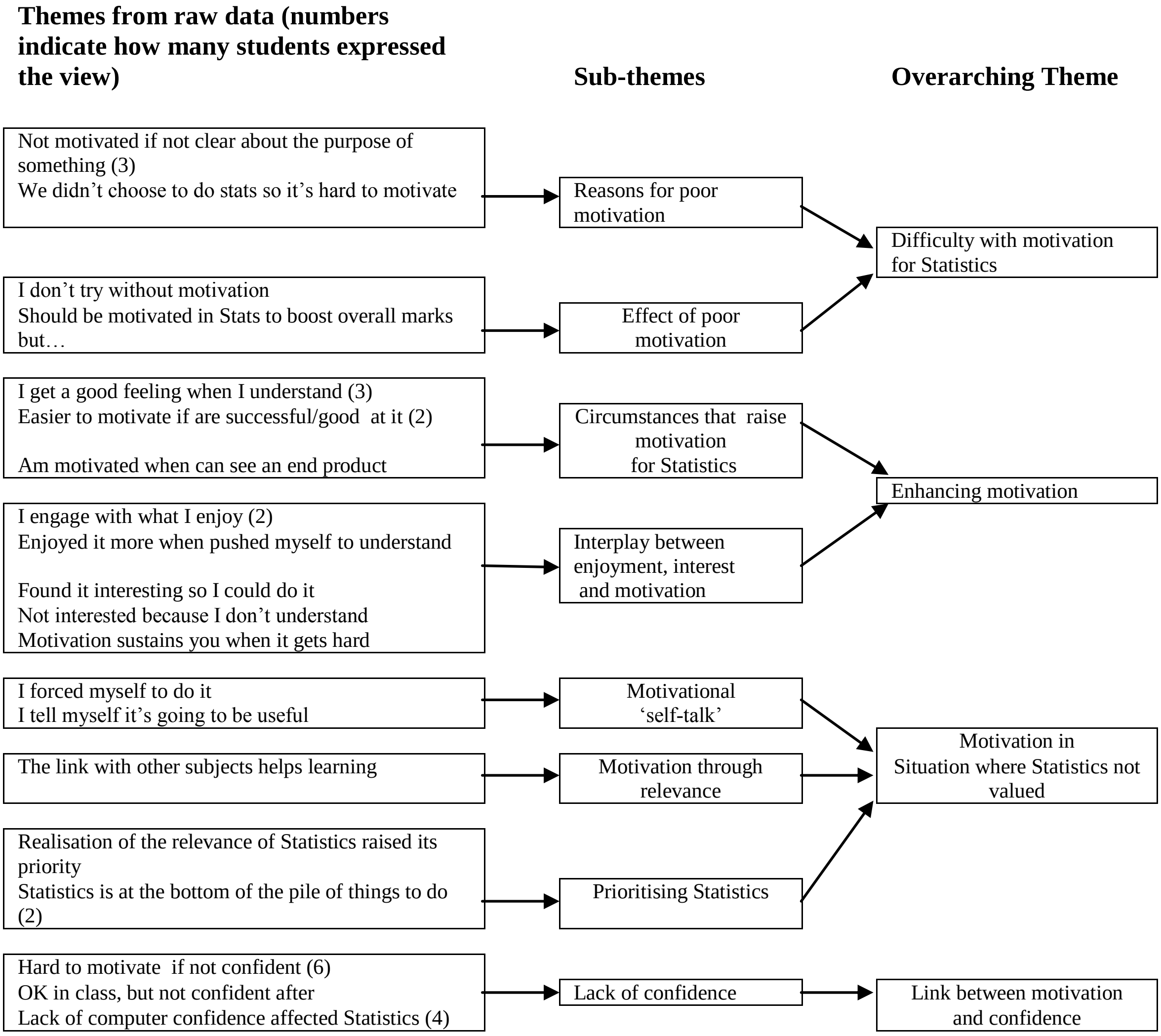
	1st Year Statistics Examination Marks	2nd Year Statistics Examination Marks
GENDER		
Male	51.19 *(15.92)*	42.74 *(18.58)*
Female	51.40 *(16.30)*	43.03 *(19.92)*
DEGREE PROGRAMME		
Sport and Exercise Science	52.49 *(16.32)*	43.51 *(20.06)*
Coaching Science	48.57 *(15.75)*	37.07 *(15.89)*
Exercise and Health Science	44.74 *(13.75)*	37.16 *(21.90)*
Sports Therapy	52.73 *(16.18)*	46.01 *(18.08)*
MATHEMATICS QUALIFICATION		
GCSE grade C	48.34 *(15.83)*	37.50 *(16.72)*
GCSE grade B	51.68 *(15.51)*	44.41 *(19.38)*
GCSE grade A or higher qualification	59.04 *(16.35)*	54.32 *(20.16)*

Three-way ANOVAs enabled the evaluation of the interaction between degree route and mathematics qualification, with the addition of potential gender differences in choice of degree programme. Mathematics qualification, categorised by examination grades, was the only factor to significantly affect achievement in statistics examinations, at second year undergraduate level ($F_{(2,185)}=3.671$, $p=0.027$) and the same factor approached the significance level ($\alpha= 0.05$) at first year level ($F_{(2,284)}= 2.947$, $p=0.054$). No interaction effects were found. *Post hoc* testing of the main effect of mathematics qualification confirmed that significant differences occur between each of the mathematics qualification categories. Means in table 1 indicate better statistics marks for students with higher mathematics qualifications.

QUALITATIVE FINDINGS

Very low examination marks influenced the choice of the second year module as a focus for qualitative investigation. Students provided evidence that motivation for statistics is low among sport science students (figure 1). Enjoyment and challenge emerged as key components for intrinsic motivation. However, a perception that the challenge is achievable is crucial. Most interviewees articulated a lack of security with mathematics and a perception that statistics *is* mathematics and therefore beyond their capabilities. Students used words like ‘forced’ and ‘tell myself it is going to be useful’ to describe how they learned but ‘statistics is at the bottom of the pile of things’. Most of the Sports Therapy and Coaching Science students said that statistics was on the periphery of their degree experience and they did not ‘see the point’ of studying it.

Figure 1 Inductive thematic analysis of students' motivation for Statistics



Interviewees were asked to evaluate the three main pedagogic strategies encountered during the module. These were described to them as

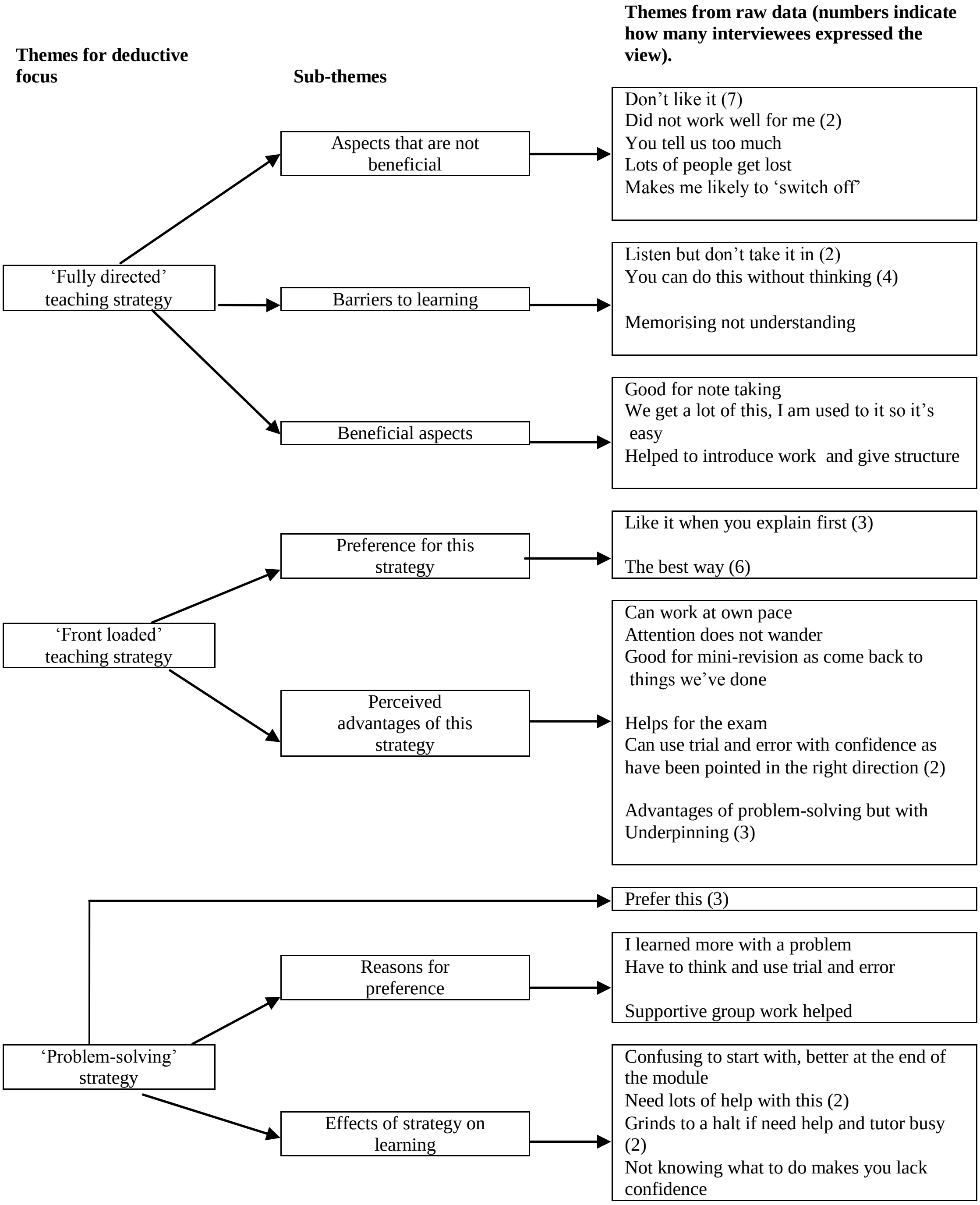
Fully directed: whole class activity led by a tutor;

Front loaded: initial guidance and classroom discussion followed by group or individual work on a problem;

Problem solving: work on a sports science problem with no prior guidance towards a solution.

Tutors aimed to maintain constructivist perspectives on learning and teaching through each of these strategies. They aimed to provide practical experiences within which students could share prior knowledge and build solutions to problems. Figure 2 shows the commonality and differences of opinion expressed by the twelve individuals. The most important finding was that students disliked the fully directed strategy, but perceived this method to be used most often.

Figure 2 Deductive analysis of students' feelings about each pedagogic strategy



CONCLUSIONS

The perceived importance of mathematics was evidenced by the results. It was concluded that these findings could be partially attributed to a mathematical bias in teaching. The organisation of statistics classes was around a particular statistical technique, with session titles such as 'Measures of Variability' or 'The t-test'. Students felt that they were directed to conduct analysis. In an applied setting such as Sports Science data handling and interpretation needed to be brought to the fore. Assessment through examination, dominated by computational demand, emphasises the procedure over application of statistics. It is likely that the situated, contextual nature of statistics was not sufficiently explicit for students to appreciate the need to look beyond a numerical answer.

Statistics requires data from other disciplines, but its value is compromised if a dominant focus renders it invisible. There are three issues here. Firstly, there is a need to locate specifically what statistics means in sports science. Secondly, innovative pedagogic strategies need to be explored that emphasise the characteristics of statistics that distinguish it from mathematics. Finally, the rationale for assessment through examination should be considered carefully. Not only did examinations appear to strengthen the perceived relationship between statistics and mathematics, but they encouraged superficial memorisation of facts. This transient knowledge does not prepare students to assimilate the volumes of data that are a facet of modern society. Teaching through relevant sports science problems rather than from the perspective of statistical procedures is beneficial, but only if the 'real-world' data that the students collect or are exposed to is *real for them*. As one student explained to the author, 'it has to matter to us'. Scientific reports and projects are better forms of assessment if statistics teaching is problem-centred.

Hencken's (2005) claim that many sports science lecturers lacked the confidence necessary to teach statistics effectively, resonates with my experiences. Dialogue between lecturers within the dominant sports science and the non-dominant statistics disciplines needs to be enhanced through purposeful professional development opportunities that push the boundaries of modular degree structures, prevalent in higher education in the UK. Continuing professional development for tutors is vital if statisticians are to be aware of developments in sports science, and tutors from sports disciplines are to gain confidence with statistics. This situation would be the case for any academic degree programme that includes statistics modules. Professional development should be available to assist tutors to have the confidence to abandon teacher-centred, transmission modes of teaching and allow students to challenge their understanding.

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