Strategies that Enhance Student Engagement During the Teaching of Statistics in Psychology Programs

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Abstract

The profession of psychology is based on the principles of scientific investigation and analysis. However, students in psychology programs generally rate the study of research methods and statistics low on indicators such as relevance and interest. This paper will examine some methods that have been used to enhance student engagement and learning during a first year statistics course. The use of on-line and in-class computer-based interactive exercises can illustrate statistical concepts such as sampling, regression, and hypothesis testing in a novel way. A data gathering questionnaire completed in the first class can also provide raw data of interest to students for illustrative purposes throughout the course. Finally, using student-relevant and discipline-relevant examples of statistical concepts with the odd funny photo thrown in can maintain student attention during lectures. Evaluation of these approaches indicates that each can play a role to promote student learning and engagement in statistics courses for psychology students.

Introduction

The training of psychologists in Australia begins with an Undergraduate Psychology Program. According to the Australian Psychology Accreditation Council (2008), one of the core attributes that graduates should gain knowledge of research methods in psychology. The rationale for this attribute stems from the scientific nature of psychology, the need for psychologists to critically evaluate research trends and, if desired, conduct their own research. Psychology programs thus require students to complete courses in research methods and statistics. However, in our experience, many beginning students are shocked, puzzled, and even dismayed by having to study statistics to become a psychologist.

The impact that students' negative attitudes towards statistics has upon learning has been well documented. High levels of statistics anxiety are reported by between 66% and 80% of students and students report that statistics courses are the most anxiety-inducing of all courses (Onwuegbuzie & Wilson, 2003). Many students also report generally negative attitudes and low interest in statistics (Tremblay, Gardner, & Heipel, 2000). In the face of these statistics, it is reassuring that there is at least one report of students having more positive attitudes towards statistics than negative (Mills, 2004). Nevertheless, negative attitudes, poor motivation, and statistics anxiety predict poor achievement in statistics courses (e.g., Tremblay et al., 2000).

To address the impact of student perceptions, the approaches taken to teaching statistics has changed over time. The American Statistical Association recommended incorporating data, using less theory, emphasising statistical thinking, and using active learning (Cobb, 1992). Moore (1997) recommended greater integration between content, pedagogy, and technology. More recently, a focus on motivational factors has emphasised engendering positive affect in students and that students be encouraged to persist when difficulties emerge (Budé et al., 2007).

Coincident with the changing approaches to teaching statistics has been the development of specific teaching strategies. The use of computer-based activities (e.g., Morris, Joiner, & Scanlon, 2002), interactive multimedia (e.g., González & Birch, 2000), and real data sets (e.g., Morgan, 2001) are among the strategies used. In the existing literature, teachers have primarily focused on describing the strategy itself (e.g., Morgan, 2001) or on relating the strategy to improvements in student learning (e.g., Morris et al., 2002). As noted by Earley (2007), the focus on achievement outcomes has resulted in few studies exploring how various strategies influence students' *experiences*. Similarly, Gordon (2004) argued that there is a need to understand students of statistics and how the classroom environment influences their learning experiences.

The present report has two aims. First, teaching strategies that have been employed in an introductory statistics course are described. The strategies were the use of web-based interactive exercises, in-class multimedia demonstrations, real-life examples of statistical problems, a data gathering questionnaire, and the incorporation of humour during lectures. The second aim was to examine how the strategies influenced students' experiences when learning. Written feedback provided by students was coded into

broad themes and related to psychological constructs. This qualitative approach was used because it affords open-endedness, the capacity to connect experiences, and sensitivity to individual experiences (Neuman, 2006). A better understanding of how various teaching strategies influence students' experiences should inform the future teaching of statistics to psychology students.

Method

Student population

The written feedback was obtained from students enrolled in the first year statistics course in the psychology program at Griffith University (Gold Coast) during 2005 to 2007. The total student enrolment was 654 across the three years. The response rates for the requests to provide feedback were 28.8% in 2005, 17.8% in 2006, and 45.4% in 2007. Students were predominantly female (female: 80.6%; male: 19.4%) young adults (mean age = 22.9 years; range = 17 to 68).

Course description

The course provides students with a basic introduction to research methods and statistics as applied in psychological research and practice. The core topics include basic research methods, descriptive statistics, probability, sampling, confidence intervals, and hypothesis testing using *t*-tests. It is taught via a weekly two hour lecture and one hour tutorial. SPSS is also used. The course is a pre-requisite for several second year psychology courses. Most students were in their second semester of study when completing the course.

Teaching strategies

Web-based interactive exercises Technological advances have been applied to the teaching of statistical concepts. While this has mainly been in the form of commercially available computer software packages for calculating statistics, a number of programs have focused on the learning of statistics. Examples include *StatPlay* (see Finch & Cumming, 1998), *Fathom* (Meletiou-Mavrotheris, 2003), and *ActivStats* (Morris et al., 2002). The common feature of these programs is that they are interactive in that students can see how changes in data alter various statistics, simulate statistical procedures, and see visual relationships between data and statistics. Computer-based activities can improve understanding of central tendency measures (Morris et al., 2002), sampling distributions and some concepts of inference (Meletiou-Mavrotheris, 2003), and variability (Finch & Cumming, 1998).

The interactive exercises used in the present course were designed to allow students to engage with the material on their own, outside of a classroom setting via the World Wide Web. Supplementary material was provided either on screen or to be printed out separately. The material included instructions on basic controls, exercises, and review questions. Students were thus guided through their learning. In 2005 and 2006, the interactives were included as part of the course assessment. In a quasi-experimental design, it has been found that the use of web-based tutorials similar to the approach used in this course lead to improvements in understanding of scale of measurement, central limit theorem, means, and hypothesis testing (Bliwise, 2005).

The complete suite contained nine interactive exercises. The topics were (a) using graphs (pie chart, bar chart, histogram, stemplot), (b) scatterplots and correlation, (c) probability, (d) sampling data, (e) sampling distribution of the mean, (f) confidence interval of the mean when σ is known, (g) power and errors in hypothesis testing, (h) confidence interval of the mean when σ is unknown, and (i) degrees of freedom. In the scatterplots and correlation interactive, for example, students could interact with real data sets (violence in Disney movies as a function of production year, lung function as a function of cigarettes smoked, and income as a function of education level). The student could plot the data on a scatterplot, calculate the correlation, and draw a least squares regression line. In addition, the student could change values of the data to see the effect it had on the correlation and the regression line. The interactive taught concepts related to the strength and direction of the correlation, influential observations, regression line of best fit, and interpretation of association.

In-class demonstrations of statistical concepts A blended learning approach aims to integrate the strategic use of technology with the best features of face-to-face teaching. This principle was applied in the course by using several interactive exercises and multimedia (e.g., video) as in-class demonstrations. The main focus of this strategy was to use technology to demonstrate what was happening either theoretically or practically in relation to particular statistics (Dunn, 2004). The sampling distribution of the mean computer demonstration illustrates this concept. A verbal explanation of how sampling distributions are formed is laborious. The computer demonstration makes it easier because it actually shows the process in action. Using a graphical interface that incorporates real data sources, the process of taking random samples from a population is animated and linked to the calculation of the mean from those samples. The mean value is next added to the sampling distribution and relevant statistics for the distribution (e.g., mean, standard deviation) are updated. In addition to showing how to form a sampling distribution, the demonstration also teaches that the mean of the sampling distribution is the same as the population mean, that sample size and the population standard deviation influence the standard error of the mean, and the Central Limit Theorem.

Real-life examples of statistical problems The inability to connect statistics to daily life can contribute to statistics anxiety (Pan & Tang, 2005). In addition, the use of example data in classes is an old, but effective strategy that has been used to enhance learning of statistics (Morgan, 2001). Accordingly, real-life data sets and examples of research are used liberally throughout the course. Some examples are focused on psychological issues (e.g., driving behaviour, gender differences in brain size and relationships to IQ, and buying from a friend vs. a stranger). Other examples are more general, but highly interesting to students (e.g., data set on the 500 richest people in the world, how a 10 year old girl tested the claims of therapeutic touch, the apparently amazing survival rates of cats who fall from high-rise apartment windows, and relating traces of cocaine on banknotes to the prevalence of drug use).

Data gathering questionnaire Students anonymously completed a 16-item questionnaire in the first lecture. The responses were used to create a data file that was examined in subsequent lectures. Schacht and Stewart (1990) argued that using students as the source from which data are collected can enhance learning. However, the data gathering questionnaire goes further than this. Each question is designed with a particular purpose in mind. For instance, students are asked the guess the lecturer's age and number of children he has (aims to personalize the teacher), rate their level of statistics anxiety, self-esteem, and mathematics knowledge (to examine factors related to statistics anxiety), to select any number between 1 and 10 (shows non-random nature of people as one third will answer "7"), to say whether they have ever lied about their age (used to "prove" that more females lie, but this is actually a response rate artifact because of more females in the course), and to guess the diameter of Mars (shows response bias due to anchoring because different versions of the questionnaire have different "examples" e.g., 5970 km vs. 59700 km). In some years the data has been used as the basis for the assignment (e.g., correlation on factors related to statistics anxiety).

Humorous pictures during lectures Lomax and Moosavi (2002) suggested incorporating humour into statistics classes and note that many teachers currently do so. They suggest opening each class with a piece of humour and occasionally presenting humour throughout classes. In their article, they provide numerous examples of statistics-related jokes and riddles. In contrast to the use of written humour, the course used humorous photographs. These included photographs of bizarre car accidents (used when discussing data on driving behaviour), a cow wearing sunglasses (used to illustrate the correct pronunciation of *mu* and not *moo*), and a squirrel drinking from a beer can (used when discussing data on the psychological effect of alcohol). Although the statistical concept was not necessarily the focus of the humour, it was found that using pictures rather than written jokes or comics had a more instantaneous impact. The humour was more infectious and students would laugh together as a group.

Data collection

During the last lecture (in 2005 and 2007) or on-line during the exam period (in 2006) students provided written feedback on aspects of the course. Students were asked to comment on specific teaching strategies used, how they influenced their experiences and learning, what was done well and should be continued, and what was in need of improvements. Students provided responses voluntarily, anonymously, and without the course lecturer present.

Data collation and coding

The written responses were coded using the methods described by Neuman (2006). Initially, open coding was used separately for each strategy to group similar responses together into preliminary analytic groups. The groupings were made on the basis of key terms and their synonyms (e.g., anxiety, stress, tense) in the statements. In some cases, complex multipart statements were placed into more than one group. Short statements that were representative of the responses in each grouping were generated to summarise the theme of that grouping. Next, axial coding was used by focusing on the representative statements that were generated. Similarities and differences between the representative statements were examined to determine if two or more could be combined into a single, broader theme. At this stage, the representative statements were also compared across strategies to determine if the same statement could adequately summarise similar themes and thus facilitate interpretation across the strategies. Finally, selective coding was used to confirm the identified themes. In addition, actual responses that were considered to be representative of a given theme were selected for illustrative purposes when reporting.

Results and Discussion

Major themes

The major themes relating to the students' experiences are considered separately for each strategy.

Web-based interactive exercises Seven themes were identified of which four related to the students' experiences. The first, labeled as *Helps Learning* indicated that the interactives helped students to "grasp key concepts", "get a clearer picture of the material", and "assisted deeper understanding". The second theme *Helps Confidence* revealed that the interactives restored students' belief in their ability to learn about statistics, particularly if they did poorly in prior assessments. Two

additional themes of *Practice Concepts* and *Alternative Learning Tool* reflected that the interactives enriched the students' learning experiences in new ways and provided a different way to check their understanding than relying on paper-and-pencil based exercises.

The finding that students perceived that the interactives helped their learning is consistent with prior research that used objective tests of learning (Meletiou-Mavrotheris, 2003; Morris et al., 2002). However, the boost that the interactives gave to students' confidence is novel. Any positive motivational benefit from a learning tool is particularly welcome because of the negative perceptions students have towards statistics. Moreover, the interactive exercises appear useful as an additional means for students to practice their skills and check their understanding. In our experience, repeated exposure to fundamental statistical concepts is vital for students to consolidate their understanding.

The final three themes identified in the analysis were summarized by the labels *More Exercises, Make Compulsory,* and *See Mistakes*. The benefits seemed sufficiently apparent to students for them to suggest that more interactives be developed. The latter two themes were related to the use of the interactives in course assessment in some years. Students stated that it should be compulsory assessment because it "helps one learn" and to "review what is covered in the course". However, students also wanted to have access to the answers after the assessment due date to "help people to learn by their mistakes".

In-class demonstrations of statistical concepts Only two themes emerged in relation to this strategy. The first *Helps Learning* indicated that the demonstrations were useful to understand statistical concepts and applications. The second theme of *Provides Interaction* reflected that the exercises enhanced interaction during the lecture. The opportunity to make lectures more interactive can be particularly advantageous in the teaching of statistics because many students reported that it is otherwise a "dry" or "boring" subject.

Real-life examples of statistical problems The analysis resulted in five themes. Four of these related to student experiences and were labeled as *Enhances Interest, Can Relate To, Makes Relevant,* and *Helps Learning*. The first theme reflected that using examples enhanced interest in statistics and during the lectures. In the second theme, students indicated that they were able to relate to the examples based on their prior knowledge or experiences. The theme *Makes Relevant* reflected that the examples made statistics "relevant", helped to "understand the importance of statistics" and helped to relate statistics to "real living" and "everyday life". The examples also enhanced learning as reflected in the theme *Helps Learning*. It was noted that the examples helped to understand "statistical concepts" and the "relationship between data and its use". The final theme was coded as *Continue Strategy* in which students recommended that the strategy be continued and enhanced through more examples.

Data gathering questionnaire Comments regarding the questionnaire centred around three themes. The theme *Enhances Interest* reflected that examining statistics related to the questionnaire made the lectures more interesting. *Makes Relevant* was a theme that reflected how explaining statistics by using the questionnaire data made the content "more relevant because it is about us". Finally, students indicated that the questionnaire was *Linked to Course Material*. This theme captured the fact that the questionnaire was used at several points throughout the course in relation to various statistics. In effect, the questionnaire provided a common thread across different statistical applications.

Humorous pictures during lectures Five themes emerged of which four related to student experiences. The first was coded as *Emotional Benefits* and reflected increased enjoyment during classes. The second was coded as *Anxiety Benefits* in which it was noted that using humour lowered anxiety and stress. *Attention Benefits* was the third theme and reflected that the strategy improved attention and interest during the lectures. Related to this was the theme of *Helps Learning* in which it was noted that learning was helped by breaking up the lecture content. The final theme was *Continue Strategy* in which it was recommended that the strategy be used again in the future. Although they did not present any supporting data, Lomax and Moosavi (2002) suggested that using humour can minimize anxiety, motivate students, deepen conceptual understanding, and engage students. The present results provide evidence consistent with these claims. Importantly, using humour does not merely seem to increase enjoyment, but also has pedagogical benefits by enhancing attention and learning.

Conclusions

The aim of the present report was to describe several strategies that have been used with success in the teaching of a first year statistics course and to examine how they influence students' experiences. Some strategies that were used have been previously shown benefits to student learning outcomes (e.g., computer-based exercises, statistical demonstrations, and use of real-life data), whereas others are less common and the effects on student learning are yet to be determined (data gathering questionnaire, humorous pictures). The present results indicated that students perceived that the strategies helped their learning. The use of real-life examples and the data gathering questionnaire also increased the relevance of statistics for students.

Comparatively few studies have evaluated teaching strategies in relation to the effects they have on student

experiences, particularly on experiences other than statistics anxiety (e.g., Pan & Tang, 2005). Affect has shown a direct relationship with achievement outcomes (Budé et al., 2007). The present results indicated that some strategies had affective benefits like increased confidence, enhanced interest, more enjoyment, and less anxiety. Cognitive benefits that were found, evident as increased interaction and enhanced attention, are also likely to have a positive impact upon learning.

While the present report has provided unique data on useful teaching strategies for statistics courses, the low response rates to the questionnaire in some years is a limitation. The voluntary nature of participation and collection of the data during the last lecture in 2005 and 2007 and on-line in 2006 may have contributed to the low response rates. The on-line administration had a particularly low response rate, perhaps because of the extra requirement to log on and complete the questionnaire via the computer. Response rates may be higher if the questionnaire is administered in class at a key time in the semester (e.g., when assessment is handed in). The voluntary nature of participation may have also biased the results towards more positive aspects of the strategies. However, these preliminary results can help frame future research that is more focused in the information it aims to elicit from students. It is pleasing to note that there are positive things that teachers can do to enhance the learning experience in students who must study statistics as part of an accredited program in psychology.

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