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CREATING AUTHENTIC LEARNING ENVIRONMENTS: A STRATEGY FOR STUDENT ENGAGEMENT AND DEEPER LEARNING IN INTRODUCTORY STATISTICS

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Abstract

For many university students (particularly the 'numerically-challenged'!), the introductory statistics course is viewed with great trepidation. Branded 'sadistics' by some because they find it so torturous, one of the biggest challenges facing statistics educators is to convince learners of the subject's worth. Even in a Masters of Business Administration (MBA) program – the context of this study – students often fail to see the relevance of statistical thinking to their day-to-day management roles. To resolve this problem, the authors of this paper proffer an alternative approach that makes use of authentic learning environments. The key principle underpinning this approach is that, regardless of how clearly statistical concepts are explained in the classroom, students tend not to fully understand until these concepts have been validated by prior knowledge. Constructivist pedagogy is therefore of critical importance to student learning which, harnessing the power of the various information and communication technologies (ICTs), has the capacity to engage learners even in a subject traditionally regarded as dull and boring.

Keywords

Statistics, Authentic learning environments, MBA

Introduction

Traditional methods of teaching introductory statistics are often viewed as being ineffective because they fail to establish a clear link between statistics and its use in the real world (Yilmaz, 1996). In most programs, the introductory statistics subject is the only data analysis subject that students will undertake and, in many cases, there is a great deal of anxiety associated with having to do the subject. Many students also have low motivation throughout the introductory statistics classes, particularly in those situations where they fail to see any direct relevance to their workplace needs (Wild, 1995).

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As a result of these and similar observations, there has been a great deal of research into effective teaching methods for introductory statistics courses at the undergraduate and graduate level. Some of this research has focused on the content that should be incorporated while other work has investigated pedagogical issues. Common conclusions are that there should be a greater focus on 'real-world' problems and case studies using real data where possible. Prvan, Reid & Petocz (2002) suggest that a flexible learning environment with a focus on the student's extant knowledge, rather than the teacher's preconceived ideas of important content, can encourage students to develop a greater depth of learning. Their study concluded that the learning experience is enhanced if students actually *practice* statistics through a range of statistical activities supported by an appropriate computer package and discussion. A recent study by Basturk (2005) supports this conclusion, which also finds that learning can be enhanced through the used of computer assisted instruction. The reason, according to Hornby (1995) is that giving students the opportunity to use computers provides them with a hands-on, active learning experience which, in turn, supports peer group interaction and collaborative learning.

These findings are also corroborated by the case study that provides the focus for this paper; the introductory statistics subject within the Masters of Business Administration (MBA) program at the Brisbane Graduate School of Business (BGSB) at Queensland University of Technology (QUT), Australia. Historically, the students enrolling in this subject tend to be a heterogeneous group with relatively weak quantitative skills; a situation exacerbated by the fact many of them fail to see its relevance to their particular business environment.

The fact of the matter, however, is that analytical and problem solving skills are highly valued by employers. As Albright, Winston & Zappe (2003) note, technology has enabled companies to collect huge amounts of data which, in most cases, is meaningless unless analysed for trends, patterns, relationships, and other useful information. Insights gained from the analysis of this data may then form the basis for gaining competitive advantage. Technology has also given many more managers the power and the *responsibility* to analyse and make decisions on the basis of quantitative analysis of data.

It is within this context that the BGSB commenced with a project to reassess the way statistics education was delivered to its MBA students. A number of attempts to engage the student body through the production of study guides linked to a variety of text books had ended in failure, and it became clear that the pedagogy employed in these textbooks was the main source of the problem. Despite claims about their 'innovative' approaches, these books, by and large, adopted a similar tack in that they tended to focus on conceptual development and emphasise 'hand calculations' in order to solve problems, generally leaving little time for investigating case studies and practical applications. In addition, they generally afforded students with few opportunities to improve their proficiency in the use of Microsoft Excel and other packages for performing statistical analysis when, paradoxically, these software packages are widely available in the business environment.

After a survey of the academic literature on statistics education with the aim of identifying successful strategies in the delivery of an introductory statistics subject, it became abundantly clear to the project team that: (i) the development of quantitative skills is, indeed, considered to be an integral component of a world-class MBA program; and (ii) the prospects of delivering a high quality statistics course are enhanced if there is a commitment to the creation of an authentic learning environment where students gain an empathy for statistical analysis and how it might be usefully employed.

In the remainder of this paper, we provide an account of the changes that have been introduced by the BGSB in order to create such a learning environment. We begin in the next section with a brief overview of the objectives of a statistics education (specifically within the context of the graduate business school curriculum) and the extent to which these objectives are currently being met. This then leads into a discussion in the following section of the virtues of creating authentic learning environments. A detailed justification of the restructuring of the statistics course unit of the BGSB is then presented, which is followed by a summary and conclusions.

Statistics in MBA Programs

Most MBA programs contain an introductory statistics subject as part of the core curriculum, which is keeping with the Association to Advance Collegiate Schools of Business (AACSB) stipulation that the curriculum management process will result in undergraduate and masters programs that will include learning experiences in several areas including statistical data analysis and management science as they support decision making processes throughout an organisation (AACSB, 2005). From a pedagogical perspective, however, the AACSB is not specific (nor, for that matter, is any other international accreditation agency).

Close inspection of the syllabus and textbooks used in many business statistics programs reveals that they tend to be very similar in terms of the material covered; *viz.* descriptive statistics, set-theoretic probability (including Bayes' Theorem), sampling and confidence intervals, significance testing and then simple regression and correlation, and that classroom pedagogy also follows a similar pattern in that learners generally take a passive role within a traditional lecture format where the use of computers is limited to the occasional regression problem (Love & Hilderbrand (2002)). Bowerman (1988) summed up the status of statistics textbook design by commenting that 'most textbooks in business statistics spend at least 400 pages before getting to material that business students find interesting and useful'.

In order to improve on the situation, a series of conferences called 'Making Statistics More Effective in Schools of Business' (MSMESB) have been held annually since 1986. These conferences have focused on improving the teaching of statistics and statistical thinking, on cross-disciplinary research and the cross pollination of ideas between academia and industry, and on continuous improvement within business education (Love & Hilderbrand, 2002). The conferences have also investigated the use of alternate teaching methods which include case studies, projects, management simulations and teamwork. The resulting courses often cover less material but have been found to produce managers with a deeper understanding of practical data analysis (Love & Hilderbrand, 2002). Some of the recommendations from the conferences include the use of projects, lecturing less, the use of case studies, greater focus on statistical thinking and useful tools, the encouragement of collaboration, the use of real data and requiring students to present their findings.

Yilmaz (1996) suggests that effective statistics education must demonstrate the use of statistics in the real world with applications specific to the student's field of study. He further suggests that the overall ability to use statistics in the real world requires three specific competencies; these being, the ability to link statistics and real-world situations, knowledge of the basic statistical concepts, and the ability to synthesise the components of a statistical study (including the ability to communicate the results in a clear manner). As far as Yilmaz (1996) is concerned, the objectives of a high quality statistics education must include the development of all three competencies.

Creating an Authentic Learning Environment

Recognition of the difficulties in designing successful introductory courses in MBA programs has resulted in the generation of a great deal of literature over the past decade or so on suitable curriculum and the design of effective teaching methods (e.g. Cobb, 1992; Love & Hildebrand, 2002). The common theme in these papers is the need to place greater emphasis on the use of case studies and problem based learning (PBL) and less emphasis on the technical aspects of the statistical theory (Love & Hildebrand, 2002). In essence, the challenge has been to create more authentic learning environments for students undertaking introductory statistics subjects.

Authentic learning environments make the subject content more meaningful to students by making the content relevant to their day-to-day lives. Reeves *et al* (2002) outline ten broad characteristics of authentic activities that, among others, include activities that have real-world relevance, activities that are ill-defined, activities comprised of complex tasks investigated over a period of time, activities that can be integrated and applied across different subject areas, and activities that provide the opportunity to collaborate.

This approach also seems to be evident in the literature on statistics education. A study by the American Statistical Association (ASA) and the Mathematical Association of America (MAA) into the teaching of introductory statistics suggested that statistical thinking should be emphasised, that real data should be incorporated, and that concepts need to be emphasised using less theory while fostering active learning (Cobb, 1992). Meanwhile, Basturk (2005) has investigated the role of technology in teaching introductory statistics with the finding that learning can be enhanced through the use of computer assisted instruction. The role of technology is also acclaimed by Moore (1997), who highlights the synergy between content, pedagogy and technology. In short, technology can be used to automate many of the routine operations and, as a result, conceptual learning can be enhanced. Most importantly, it provides more opportunities for interaction and immediate feedback which serves to improve knowledge retention.

Acknowledgement of the need to redesign introductory statistics courses to create authentic learning environments is becoming apparent in many of the more recently published statistics textbooks. As Love and Hilderbrand (2002: 108) have noted: 'more and more real and realistic data situations have appeared that require the reader to assess the evidence and develop a recommendation about a real managerial decision'. One textbook, in particular, by Albright *et al* (2003) seems to have adopted many of the features recommended in the literature. The aim of the authors in developing the textbook is best summed up in the preface which outlines their goals in writing the textbook as follows:

- 'Reverse negative student attitudes about statistics and quantitative methods by making them real, accessible and interesting;
- Give students hands-on experience with real problems and challenge them to develop their intuition, logic and problem solving skills;
- Expose students to real problems in many business disciplines and show them how these problems can be attacked with analytical methods;
- Develop spreadsheet skills, including experience with powerful spreadsheet add-ins, that will add immediate value to other courses and in their careers.' Albright *et al* (2003: xvii)

The Revised Introductory Statistics Course

As a result of the observations made during the teaching of the subject, from student feedback collected from centrally administered end of subject surveys, and from discussions with student focus groups who had undertaken the subject, we redesigned the course unit to incorporate many of the suggestions in the literature. Integral to this was the adoption of the textbook by Albright *et al* (2003). After considering the options available we designed the course with the following objectives in mind:

- A focus on the needs of managers
- Use of widely used statistics software (*viz.* Microsoft Excel)
- Use of online tools and resources
- Case based pedagogy
- An emphasis on group work

The syllabus generally follows the textbook chapters and contains six modules covering similar material to other programs including describing and summarising data, probability and probability distributions, sampling distributions and confidence intervals, hypothesis testing and regression analysis.

Focusing on the needs of managers

The great difficulty in developing an introductory statistics course in an MBA program is the heterogeneity of the students in each class. Typical classes have a wide variation in age, educational background, and employment backgrounds. We also find great variation in mathematical ability with students from engineering and science backgrounds generally having little difficulty, while students from other fields of study tending to struggle with some of the most

basic of mathematical concepts. With this in mind, our focus has been to move away from hand calculations to the more realistic situation of interpreting output from statistics packages. The hard reality of the situation is that very few managers will be directly responsible for the detailed statistical analysis of data but most will be required at some stage in their careers to make decisions based on the analysis presented to them.

It is also difficult to generate enthusiasm for the subject if the student cannot see the relevance of what they are doing to their day-to-day experiences. The challenge has been to integrate the course content with the needs of most managers in the business community, and in particular with other subjects in the MBA program. Our focus here has been to develop case examples and problem solving activities across a broad range of subjects including finance, marketing, and human resources management.

Microsoft Excel based

The development of spreadsheet skills is a key feature of the restructuring of the subject. Many of the current core units in the MBA assume a working knowledge of spreadsheets. Spreadsheet skills are also highly regarded in the workplace with one survey finding prospective employers ranking spreadsheet skills second (behind word processing skills) as highly desirable and expected skills of new hires (Davis, 1997). The study also found employers highly valued the ability to create presentations and graphs with 86% expecting new hires to go beyond the spreadsheet basics and be able to perform detailed analyses.

A recent article by Warner & Meehan (2001) investigated the use of Microsoft's spreadsheet program, Excel, as a tool for teaching basic statistics. Compared to alternative statistical packages they found Excel to offer several advantages and found it the natural choice for a statistics course, as it performs most basic analyses, creates easily customisable graphs, and is the market leader in its category. Although there has been some criticism of the accuracy of Excel's statistical procedures (e.g. McCullough & Wilson, 1999; Knusel, 1998), we generally find that Excel is sufficient as an analysis tool for many of the common problems students face in the workplace. In addition, the availability of several statistical plug-ins has reduced problems in this regard.

The textbook adopted for the subject, *Data Analysis & Decision Making* by Albright, Winston and Zappe is spreadsheet-based and focuses on the use of Excel for the statistical analysis. In addition, one of the assessment items is a project which requires the use of Excel. Many students have subsequently commented that the Excel skills developed during the collection, analysis and presentation of data for the project were extremely useful throughout the rest of their MBA and in the workplace environment.

One unexpected benefit of using Excel has been the enthusiasm of the students for the spreadsheet approach. In our experience, many students enter the subject with very limited ability in the use of Excel and are strongly motivated by the knowledge that the spreadsheet skills developed during the subject will be invaluable in their other MBA subjects and also in their workplace. To this extent, we try and ensure that students in each class are exposed to as many useful features in Excel as possible to enhance their spreadsheet proficiency.

Use of online tools and resources

As it has been noted above, traditionally, statistics courses have tended to follow the standard lecture format with the majority of class time dedicated to explaining the various concepts relevant to the material in the module being studied. Time permitting, example problems relevant to the material can then be investigated, although in many cases instructors find little time left for detailed discussion on any of these examples. One of the major challenges in creating authentic learning environments is the reduction in time available for conceptual development. Focussing on problem and case-based teaching necessarily involves significantly less time available for detailed development of the statistical concepts.

This challenge can be met through the use of on-line resources to enable the students to investigate the concepts in each week's module *prior* to coming along to class. Students can use these resources as required and collaborate with other students on the concepts in question. One of the more successful of these web based resources is the Rice Virtual Laboratory in Statistics (http://www.ruf.rice.edu/~lane/rvls.html) which contains a number of useful Java applets and other resources used throughout the course. As an example, in the old syllabus the module on sampling distributions and the central limit theorem would consume more than half the allocated time period for a class leaving little opportunity for discussion of examples or to work through problems. Using the central limit theorem Java applet on this website has proved to be of enormous benefit in that it provides a graphic interactive demonstration of this concept. The students can also access this resource outside the class environment and reflect on the significance and application of the concept – something they had precious little opportunity to do under the old model . Other web based resources for visually demonstrating concepts have also proved successful. One of these has been the classic 'three door problem' to demonstrate some of the concepts in probability and introduces the students to the concept of Bayes' Theorem (http://www.stat.sc.edu/~west/javahtml/LetsMakeaDeal.html).

On-line resources have also allowed us to develop authentic activities online through web-based activities that require students to collect data related to real world problems. The data is usually readily available and easily imported into Excel workbooks (including Excel's web query feature). As an example, one of the case studies requires the students to collect data on their favourite stock. Data is usually readily available from the stock market in any particular country. As Reeves *et al* (2002) make clear, one of the defining characteristics of an authentic learning environment is that tasks can be investigated by students over a sustained period of time and, in the BGSB case, there has been a serious attempt to integrate these datasets throughout the semester. Stock market data, for example, can be used for generating descriptive statistics, graphical analysis of time series data, in discussions on probability (eg. distributions on daily returns), and later in regression analysis through calculating betas for the stocks.

Collaboration is also encouraged through the use of discussion boards and chat rooms which allow the students to interact outside the classroom. Other online resources are also being investigated in order to improve teamwork and collaboration outside of the classroom environment.

Case and Problem Based

One of the strongest themes in the literature is the use of real world problems and cases. Parr & Smith (1998) provide guidelines for the development of cases in business statistics subjects and outline a number of benefits including the requirement for unstructured problem solving and self-discovery by the students which, in turn, translates into improved knowledge retention and greater understanding of the concepts and their applications. The case-based approach also allows for the integration of the statistics subject with the other subjects in the MBA program which use the case method. Furthermore, as Parr & Smith (1998) point out, cases have the added benefit of providing an environment for practising team-based skills such as negotiation and group decision making. Equally important is the clear message to emerge that realistic cases effectively communicate the need for statistical methods in the business world.

The Albright *et al* textbook includes a number of cases, which are supplemented by cases developed independently. Several statistics case collections are also available although there is a drawback in that they are typically based on aging data and, in many cases, quite US-centric which may have the effect of reducing their authenticity.

In a given class we begin with a discussion of the problem to be investigated with the data, in most cases, being supplied in Excel format prior to class. Following the recommendation of Parr & Smith (1998), the cases in the most part are ambiguous with little or no guidance about which statistical technique should be applied, although cases are provided which tend to be related to the module being investigated in that particular week – this, in effect, provides the student with a hint regarding which technique might be appropriate. Given the conceptual difficulty of the techniques

in each case the students are encouraged to work in groups. The students are then required to analyse the data for the initial part of the class.

The most difficult (and arguably most important) part of the exercise is the class discussion at the end of the case. While we do not require any write-up and do not grade the results of the case analysis, we do expect participation in the class discussion at the end of the case. To ensure participation we randomly select groups to argue their case analysis and to provide their recommendations.

Emphasis on group work

Class sizes can range between 20 to 50 students. We prefer to have students work in groups of three to four throughout the semester in order to encourage collaboration. As Love & Hilderbrand (2002) have clearly articulated, the ability to work in teams is critical in business and students learn better in an atmosphere of cooperation. This is supported by Reeves *et al* (2002) who suggest that authentic activities provide a prime opportunity to collaborate. While laptops are not currently compulsory in the MBA program, students are strongly encouraged to bring a laptop along to each class. Encouraging group work generally ensures that a sufficient number of laptops are available for the class to function effectively.

Conclusions

The introductory statistics course remains an integral part of the MBA program in all high quality business schools around the world but – as the literature clearly reveals – there are frequently deficiencies in the pedagogies adopted which have contributed to student resistance to statistics education with the attendant poor learning outcomes. The case discussed in this paper is a serious attempt to rectify this problem, and by adopting an alternative approach making use of authentic learning environments, the statistics subject has been redeveloped to the extent that students now enthusiastically sign up for a statistics elective that follows on from the core statistics course unit. This, the authors of this paper believe, is a resounding endorsement of a redesigned introductory statistics course that is student-centric, problem and case-based, interactive (making extensive use of various information and communication technologies), and collaborative through the increased use of group work.

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