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Web-based Student Learning of Statistics

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A need was identified for a statistical learning system that combines a statistical package offering all standard statistical procedures together with a system that helps students to learn the rudiments of statistics through experiential learning. The WebStat Data Analysis and Learning System, a web-based student learning system, is designed to fulfill this need. Currently, the system can handle large data sets from a range of sources and perform all standard and commonly used statistical procedures such as descriptive statistics, regression analyses, and more sophisticated statistical modelling such as Generalised Linear Models (GLM). WebStat utilises the program R, one of the most sophisticated and extensive statistical programs available. It can be used by many students, particularly non-statistics research students. WebStat can be further developed to suit a wide range of users. In this paper, we describe and discuss the advantages of using WebStat as a learning tool, along with identifying the main features of and possible improvements to the current design.

Keywords: web-based statistical learning system, experiential learning, statistical software

Introduction

Information and Communication Technology (ICT) is advancing very rapidly, from limited access to low speed dial-up internet less than ten years ago, to today's widely available, high speed broadband. According to Krause et al (2005), with the aid of ICT, such as iLectures, online quizzes and discussions, the methods of teaching, learning and interaction have been changing. Internet aided learning is providing greater flexibility, convenience and wider opportunities for students. Studies have also shown that flexibility through ICT enhances learning outcomes (Lockyer, Patterson, Harper, 2001; Monteith, Smith, 2001; Alha, Gibson, 2003).

Although there have been a number of web-based statistical programs developed, they have generally catered for a specific course, have only limited statistical procedures and fall far short of meeting the needs of most statistics courses (O'Connell, Ataya and Zhao, 2006; Lane & Peres 2006).

In 2006 a team of academics from the Department of Statistics began developing a web-based data analysis and statistical learning system which incorporates the fundamental steps in experiential learning in statistics courses. The aim is that this system will contain all standard

and commonly used statistical procedures and more advanced procedures using R (R development Core Team, 2006) as a backend. It will give students opportunities (a) for *concrete experience* of statistical analysis through using the system to solve problems raised in their classes; (b) for *reflective observation* by using statistical information and explanations of statistical terms, procedures and outputs; (c) for *abstract conceptualisation* through making them consider which analysis to use, why they should use it and what alternative analysis methods may be employed; and (d) for *active experimentation* through investigating alternative techniques and interpreting the results.

Rationale

In the period 2005 to 2006, 60% of Australian households had home internet access and 70% had access to a home computer (ABS, 2006). An increasing proportion of students in Australian universities choose to work full-time (23%) or part-time (32%) whilst studying part-time. More than half of all full-time students (54.9%) are in paid employment (Krause et al, 2005, pp.50-55). Their available time on campus is very restricted and many would benefit from a program that enables them to utilise their time more effectively. In other words, flexible study arrangements that enable students to access learning resources including statistical programs, possibly through the internet, are a necessity.

Students who study statistics often have access to required statistical package(s), even though this access might be limited to computers in campus laboratories. A number of statistical software packages, such as Minitab, SPSS and SAS have been widely used in university statistics courses. At Macquarie University, for several undergraduate courses, our students are using EcStat (McNeil et al, 2006), a statistical software package which is an add-in to Excel and developed to overcome access difficulties due to large numbers of students. Although user friendly and easy to install, EcStat is limited in its statistical procedures and does not provide any information on the procedures.

Many research students in non-statistics areas such as linguistics, psychology, science and education who also need to use statistical tools and techniques to support their studies are less fortunate than statistics students. They may not have access to statistical software packages at all. Even if some are able to access a statistical package, they often have little knowledge or understanding of what they can do with it or indeed how to interpret the output. Many of these students would benefit immensely from a package that can be accessed on the internet, provides statistical procedures and information relating to these procedures.

Twenty years ago, Kolb (1984, p.41) defined learning in his experiential learning theory as "the process whereby knowledge is created through the transformation of experience". Because we believe that experiential learning is one of the most effective methods of learning for technical courses such as statistics (Eickmann, Kolb & Kolb 2004), we are developing the program with this in mind. More than a half century ago, Tyler (1949, p.63) wrote "Learning takes place through the active behaviour of the student; it is what he does that he learns, not what the teacher does". We hope to motivate students to not only employ techniques, but to understand them.

Development of WebStat

For many years prior to 1999, Minitab was used in a first year statistics course at Macquarie University. For many non-statistics students studying this course, it would be the only

statistics course they would complete during their studies. Minitab is an expensive commercial package and almost none of the students opted to buy it. As the course grew in numbers, it became increasingly difficult to accommodate the needs of the students.

EcStat, the add-in to Excel which was developed by a team of statistics staff members from Macquarie University has been extremely successful over the past eight years but has its limitations. It only has a limited number of statistical procedures and does not provide any information or explanations on the statistical techniques and procedures.

In 2006 a team of academics from the Department of Statistics started the development of WebStat. The system is based on a learner-centred design, enabling students to perform data analysis online by following an interactive dialogue window.

Compared to EcStat, WebStat provides a much wider variety of statistical procedures and is designed, not just as a software package, but also as a learning system. WebStat includes all simple statistical analysis procedures and various graphical displays required in introductory statistics learning and teaching. It also supports more complex and/or advanced statistical analysis procedures, such as GLM as described by many authors, for example McCullagh and Nelder, (1989). For advanced procedures R (R development Core Team, 2006) is used as a backend. Although R is very powerful, freely available and developed for teaching purposes, it is a complicated statistical computing package which is not suitable for first year statistics courses or non-statisticians (Crawley 2005). WebStat does not require students to understand R, but rather R has been utilised as a backend for the more complicated procedures.

Features of WebStat

On the technical side, WebStat includes all the standard and more advanced statistical procedures that are available in most other statistical packages. It can also support more recently developed statistical procedures which have not yet been implemented in commercial packages, using the R program, since R is being continuously developed by academics and keeps up-to-date with new developments in statistics. Because WebStat was conceived to enhance teaching and learning of statistics and statistical computing, it is becoming more powerful. In terms of access, WebStat will be freely available on the web when its development is finalised.

The main feature that makes WebStat unique is that statistical information of many common statistical terms and procedures are available via a mouse click. Students can learn more about the procedures whilst using them. This is demonstrated in Figure 1, which highlights information provided when double-clicking on r (correlation coefficient).

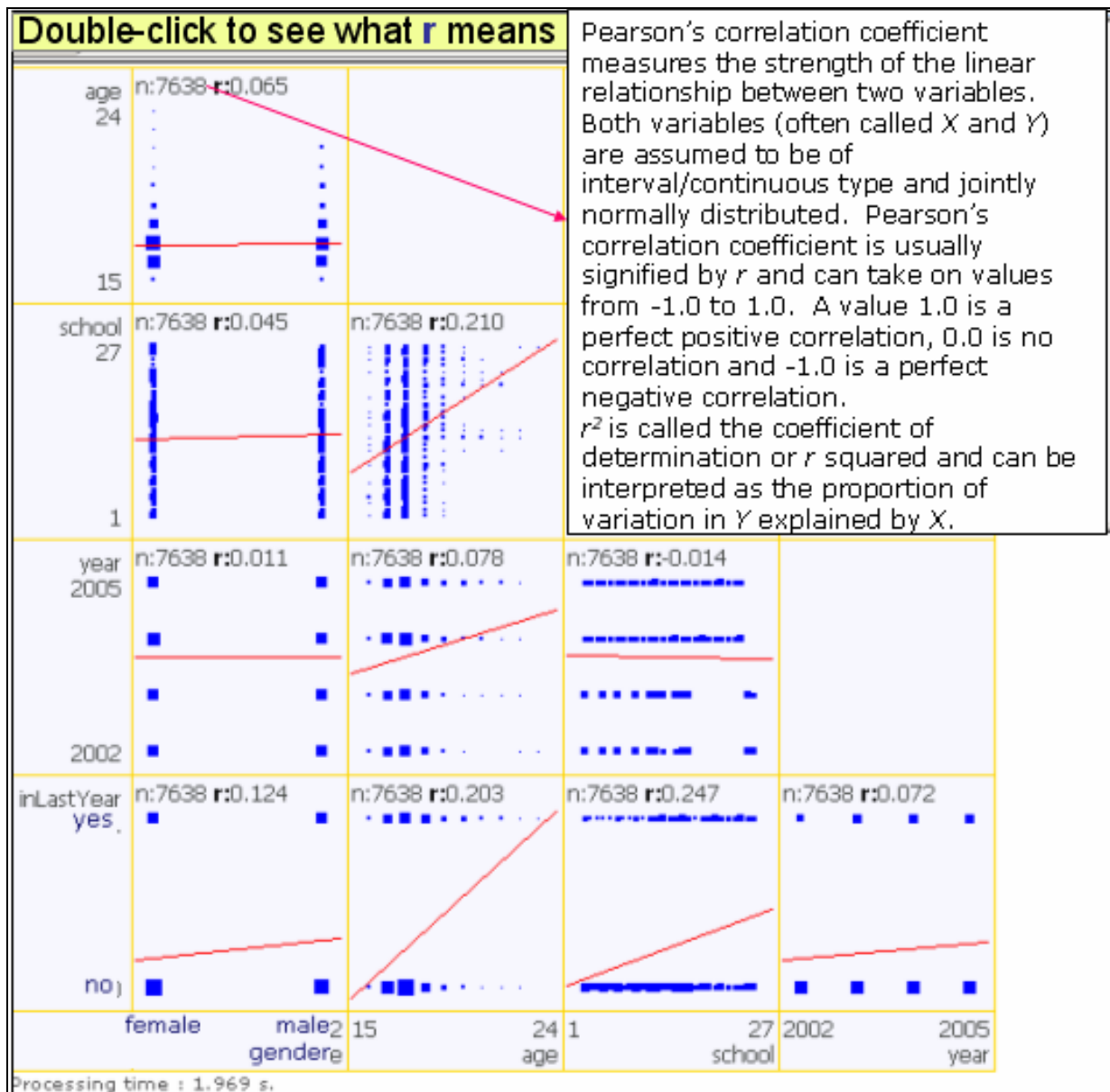


Figure 1: A visual display of WebStat Learning System

As well as having a portfolio of statistical procedures, WebStat also guides users in the interpretation of their findings. A prototype version of it is currently running on the Statistical Information Systems Laboratory at Macquarie University. This has enabled us to obtain feedback from its users. To date, we have many favourable comments from users of WebStat including ease of use, flexibility and extended coverage of statistical analysis procedures. The provision of information on statistics that is provided by the system was also appreciated. A number of advantages of WebStat have been identified by the developers and the current users as presented in Table 1.

Table1: Some features and advantages of WebStat

Feature	Explanation
Flexibility	Provides flexible learning opportunities for students, particularly external and research students. Flexible learning offers many advantages over the more traditional face-to-face only method of teaching (Collis & Moonen, 2001). Students can gain access to the program anywhere and anytime so long as they have access to the internet.
Data capacity	Handles large data sources and performs all standard and commonly used statistical procedures.
User friendly	Can be easily used by people with a minimal knowledge of statistics or computing by providing detailed and comprehensive documentation of the program and statistical procedures via the web.
Easily accessible	Enables users to perform statistical analyses and to manage large data sets through a browser using either their local data or data on the web server.
Encourages deep approach to learning	By utilizing the learning tools in WebStat, students are given the opportunity to be responsible for, monitor and assess their own learning. This will be beneficial for them in acquiring a deeper approach (Biggs 2003, p.82) to their learning by enabling them <i>to learn how to learn</i> .

One main criticism of WebStat is its inability for users to analyse their data without uploading them to the WebStat system (or server). This will be addressed in our further development plan for WebStat.

Discussions and Conclusion

WebStat provides web-based learning with ease of access and flexibility and hence provides students with ample opportunity to practise the methods to which they have been introduced. Oliver et al (2005) reported a favorable response to web-based statistical tools in learning bioinformatics statistics. Their students, from a post graduate course, found the web-based tools useful and thought they had great potential as a learning tool. McNaught's study (1999) of students in science and engineering suggested that web-based learning provides flexibility for students, avoiding access restrictions due to time and space.

By using WebStat, students are not only able to use the knowledge they have learnt in lectures but also reinforce this knowledge from the information provided by WebStat. This makes it unique, a truly statistical learning system.

Our students can take advantage of WebStat, applying knowledge they have gained at university to statistical problems they encounter in the workplace. This may impact on the perception and understanding that employers and colleagues may have about statistics. In the long term, this could encourage the establishment of links between universities and industry and may eventuate in collaborative research projects, a major goal of universities today.

White (2000) suggested that the flexibility of access to the internet is positively associated with the use of computers by students. Since WebStat will be available through the internet, it could encourage students to practise statistical techniques when access through other means is not readily available.

Studies have found that there is no difference in students' grasp of fundamental statistical concepts between those who study via e-learning (fully online) and those who use face-to-face methods of study (Meletiou-Mavrotheris et al 2007). However, Summers et al (2005) showed that satisfaction of students enrolled in fully online courses were significantly less than those enrolled in face-to-face courses. It is important to support student learning through additional resources such as WebStat, which can be used as a resource for either a fully online course or to support a traditional face-to-face delivery course.

Future developments will take place in stages. The first stage will make the current version available to all users in our division (faculty). The second stage will introduce an improved version with complete online documentation incorporating feedback from users. This version will be available to all Macquarie University staff and students. In the final stage, a more updated version will be available to a wider audience.

While developing WebStat, we are undertaking research to investigate the quality of our teaching and students' learning before and after implementation of WebStat into our statistics curriculum. The findings of this research will guide us in further development of WebStat in a direction that will be beneficial to both students and teachers.

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