USING EXCEL TO TEACH STATISTICS IN NEW ZEALAND SECONDARY SCHOOLS ®

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This paper explores the reasons why technology has not been used extensively in New Zealand secondary schools and why changes are now starting to take place. It discusses why Microsoft Excel is a useful tool in the solution of statistical problems and why it is the ideal tool to use in secondary school statistics. A software package, written in Visual Basic, has been developed to augment the teaching of Year 13 Mathematics with Statistics. This software package, called OG Statistics, interacts with Microsoft Office and is designed to encourage the use of Excel in solving statistics problems. A number of worked examples are given that show students how to solve a problem and encourages them to experiment. Practice problems are then provided with worked solutions. When students feel ready to work independently they can attempt the self-assessment modules. This also indicates whether they have reached a reasonable level of competency. The package can be incorporated into a lesson or used as a revision aid for the self-paced learner. The software package also incorporates a number of educational principles including constructivism and scaffolded learning.

STATUS OF TECHNOLOGY IN NEW ZEALAND SCHOOLS

"The rate of technological change in the computer field is breathtaking. The rate of change in the way we teach, however, is much slower"(Ferris & Hardaway, 1994).

One area where this notion is very apparent is in the use of technology to teach statistics. A number of factors have contributed to this slow rate of change in New Zealand schools. Firstly, schools rely largely on community support to fund the purchase of computers. Consequently, there is considerable inequity in the ratio of computers to students. Moreover, computer facilities are at such a premium in schools that it is often not possible to accommodate mathematics classes when required.

A survey, carried out in 1998 by the Information Technology Advisory Group (ITAG), asked New Zealand principals what they believed were the two most important factors reducing the value their school got from its investment in information technology. The factors most commonly cited were the cost of equipment, teacher knowledge of equipment, and teacher understanding regarding the value of technology use. Furthermore, there is a particular concern about the qualifications, and therefore the statistical understanding and confidence, of many teachers of statistics (Franklin, 2000). Teachers often struggle with the content and must rely on the work of others if they are to do justice to the subject (Cobb, 1993). Understandably, such teachers often lack innovation in their teaching of statistics, or in the use of technology.

There have been a number of positive developments which auger well for the future. In 1998 for example, the government allocated $50 million to schools as part of a technology drive. The amount of money was inadequate but the initiative indicated a political will for the introduction of technology into New Zealand classrooms. Moreover, in 2001 the Government initiated the Catching the Knowledge Wave Conference, which recommended developing a superlative education system that respects, rewards and develops technology teaching. In addition, today's students do not know a world without the computer. Consequently, they are more confident in the use of computers and teachers no longer have to teach computer basics before using them as a teaching aid. This computer literate generation will also become tomorrow's teachers and will be more receptive to the use of computers than many of their older counterparts.

USING EXCEL TO TEACH STATISTICS

Statistics software packages, such as Minitab, are generally user friendly to the statistician because they are designed primarily as statistical data analysis tools. However, all individuals doing statistical analysis will not have access to such software packages. When using

these software packages in statistics courses there is a stipulation for students doing the course to have access to the software package. This can have cost implications for students and institutions, as well as strategic implications if the course is to be taught at different institutions, as is the case with Mathematics with Statistics taught in New Zealand secondary schools. There is often debate in most university statistics departments regarding which statistical package is best for different courses. It can be hard to get consistency within the same institution. Often the solution depends on the person in charge of the course and as personnel change so can the packages used.

We believe there are a number of compelling reasons to consider using Excel as an integrated part of statistics courses in secondary schools. Waltner (2000) estimated that Microsoft had almost 95% of the spreadsheet market share in 1999. He observes that analysts do not see this changing in the near future. Furthermore, the survey carried out by ITAG found that of the New Zealand secondary schools surveyed, 90% had Microsoft Office running on at least one computer, and a high ratio of homes had access to Microsoft products including Excel or Works. In addition, statistics software packages tend to produce results such as p-values, whereas students must construct their solution when using Excel, hence, encouraging a constructivist approach to learning.

In the early 1990s a number of statisticians started to see the advantages of using Excel as tool for a teaching statistics. Hunt (1996) argues that Excel 5.0 has a great deal to offer at the elementary level. As Microsoft introduces regular updates to its products, we would argue that the current version, Excel 2000, has even more to offer at the elementary level, although it is of limited use to tertiary students who require sophisticated software packages such as Minitab, SAS and Splus.

This paper reviews the development of a computer software package, *OG Statistics*, developed to augment the teaching of the Mathematics with Statistics course offered at Year 13 in New Zealand secondary schools. Moreover, *OG Statistics* was designed to encourage teachers and students to consider the use of Excel in the solution of statistical problems.

OG STATISTICS AND ASSOCIATED EDUCATIONAL PRINCIPLES

OG Statistics is a package written in Visual Basic that interacts with Microsoft Office. The user is given worked examples they can step through at a pace that suits them. The explanations include how Excel can be used to solve the problems and the user can load Excel templates to help solve the problem. Exercises can be loaded and printed using Microsoft Word. The Excel templates can be used to solve these problems and full worked Excel solutions can be loaded and printed. When users feel confident in their knowledge of a topic, they can attempt an on-line test. However, if they do not have the desired level of success they can return to the worked examples and review the problems. As all variables are randomly generated, the user can use any component several times without repetition. The package covers the following topics of the Mathematics with Statistics syllabus taught in New Zealand secondary schools:

1. Venn diagrams, tree diagrams, and related formulae
2. Conditional probability
3. Mean and variance of a linear function of a random variable
4. Mean and variance of the sum of independent random variables
5. Binomial, Poisson, and Normal Distributions

As mentioned earlier, statistics is often taught by teachers who have limited statistical knowledge, and as a result they tend to rely on the transmission model of teaching. This involves the teacher as an authoritative source of knowledge who transmits the required information to students (Good & Brophy, 1995). Furthermore, the students mostly work alone to memorize this information and reproduce it on demand in tests and examinations. This often leads to a surface approach to learning (Biggs, 1999) rather than developing sound statistical problem-solving techniques.

OG Statistics is a teaching tool that can be used by students for revision or it can be incorporated by teachers into statistics lessons. The latter is recommended initially to aid the student in developing independent statistical thinking and reasoning. To this end the software package is based on a number of educational principles, which include constructivism, social interaction, modelling, and scaffolded learning.

The constructivist view describes learning as an active process. As Sheull (1986) states, "what the student does is actually more important in determining what is learned than what the teacher does" (p.429). Therefore, it is important that students are not just passive receivers of information but engage in active or "minds on" instructional activities. Good and Brophy (1995) argue that unless this happens, knowledge will only be recallable for tests and examinations with similar wording to practice exercises. Furthermore, students will not be able to access and apply their knowledge in real life situations.

According to Sivan, Wong Leung, Woon and Kember (2000) the basic elements of active learning include talking, listening and reflecting. To encourage these, *OG Statistics* includes suggestions for students to work together to discuss their solutions to problems and to think about or reflect on what they have learned. There is strong evidence that this approach promotes deeper, more effective learning. "Increasingly, cognitive psychologists are realising that thinking is not just an "in-the-head" thing and that the development of knowledge depends heavily on social interactions" (Pressley & McCormick, 1995, p.82). Moreover, through increased interaction and involvement, students are able to extend themselves to higher levels of cognition.

Students also need to develop the learning strategies and skills required to think independently and reason logically. These skills need to be taught as part of the learning process; therefore, it is recommended that teachers use modelling or think-aloud techniques. This involves teachers verbalising their thought processes and strategies when they are solving a problem. Students can base their own similar problem-solving attempts on the teacher's modelling, either on their own or in groups (Short & Weissberg-Benchell, 1989). Furthermore, repair strategies can be demonstrated to show students that not all problems are solved on the first attempt or by using the first strategy considered. In addition, this technique allows students to draw upon the understanding of teachers and other students.

Vygotsky (Guerra, 2001) developed the idea of the "zone of proximal development" which suggests that students can attain higher levels of thinking when guided by a more capable and competent person. This is the difference between what a student can do with help and what they can do without guidance (Berk & Winsler, 1995). Scaffolded learning developed from this idea. Wood, Bruner and Ross (1976) coined the term scaffolding to describe the process that enables a student "to solve a problem, carry out a task, or achieve a goal that would be beyond the unassisted efforts" (p.90). The scaffolds or supports are only temporary and are slowly removed as the student becomes proficient and is able to work independently.

The principle of scaffolded learning is incorporated into *OG Statistics* in a number of ways. The worked examples provide scaffolding in that students step through a full worked solution to a problem at their own pace. Having seen how the problem is done, they can attempt the same problem again with different values, or a similar problem. Having attempted and/or discussed their solution students can compare their solution to the full worked solution. The teacher can also use the worked examples for modelling or thinking aloud.

The problem sheets are similar to traditional exercises in written texts and can be printed using *OG Statistics*. The questions are similar to the problems in the worked examples. Students are encouraged to use the spreadsheet to solve the problem. At this stage, the scaffolding is partially removed. Furthermore, since students do not automatically transfer the thinking skills they have learnt to other problems it is important that they are given many opportunities to apply these skills to a wide range of course-related problems. The scaffolding is faded at the testing stage when students feel confident in their knowledge of the topic.

OG Statistics can be used by individual students to consolidate learning. However, it is recommended that the software package be used by teachers in a classroom situation with students working in groups. This approach is believed to promote understanding and more effective learning of statistical principles.

CONCLUSION

We believe that (computer) technology has not been well integrated into the teaching of statistics at high schools. This paper was a result of a project to develop a software package that

integrated technology into teaching the statistics component of the Mathematics with Statistics course in New Zealand secondary schools. From the initial impressions of *OG Statistics*, we are satisfied that it proved the philosophy and the methods involved were legitimate, giving an exciting and valid alternative method of using Excel to teach statistics at introductory level. It must be regarded as a prototype and is not necessarily error free. Further development remains to be carried out for it is to be developed into a true "off the shelf" package that could be used universally by any teacher and/or student regardless of their computing skills. It should be emphasized that secondary schools are operated under a completely different environment to tertiary institutions as far as expertise and resources are concerned. While, often expensive, statistical software packages such as Minitab, SAS and Splus are utilized to learn statistics (and analyze data) at universities, tools such as Excel is a very valuable teaching tool at Secondary Schools. *OG Statistics* aims at providing teachers with a framework to utilize Excel in teaching basic Statistics.

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