USING THE TI-83 GRAPHICS CALCULATOR IN A LIBERAL ARTS STATISTICS COURSE

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Many statistics educators find themselves in a dilemma when teaching large introductory statistics courses. Whilst they would like to be able to teach a course which fully integrates up to date technology, the facilities available at many campuses are not adequate for large number of students to have sufficient computer laboratory access. One solution involves rethinking the type of technology that could be used. The TI-83 graphics calculator has been equipped with all of the computations, plots and statistical inference techniques required for most introductory statistics courses. This paper reports on the introduction in 1997 of the TI-83 calculator into an introductory statistics subject, taught to an extremely varied group of more than 600 students majoring in Business, Applied Science, Tourism and Social Science.

INTRODUCTION

In 1996 Swinburne University of Technology opened a new regional campus of the university. While the main campus of the university has a technological focus, this campus was to be styled both philosophically and operationally on the liberal arts colleges that are so successful in the United States. Australia has no traditional of liberal arts colleges, and so the challenge for the staff was to develop the liberal arts theme, whilst remaining under the banner of the technological institution for which Swinburne is known locally and internationally.

In order to embrace the philosophy of a broad based education, a decision was made early in the planning stage of the new campus that all students would be required to take four core subjects in their first year. One of the subjects chosen to be studied was *Statistics and Research Methods*. This was to be an introductory course, covering the basics of one and two variable descriptive statistics, some principles of data collection and experimental design, as well as the more difficult ideas of hypothesis testing and confidence intervals. The students in the course would ultimately qualify for a Bachelor's degree in one of Applied Science, Business, Social Science or Tourism. No prior knowledge of statistics could be assumed.

The challenges afforded to the statistical educator when planning a course such as this are immense. Many of these students would have no real appreciation for the need for such a course, and be fairly unwilling participants. Others, whilst recognising its purpose, would feel extremely apprehensive, unsure of their abilities to be successful in

such a subject. Some of the students would have studied quite high level mathematics in the previous year, including some statistics, whilst others would not. Furthermore, the student body of this campus would include a large proportion of mature age students returning to study, meaning some students would not have studied a mathematical subject for more than twenty years, and have *never* owned a calculator!

THE ROLE OF TECHNOLOGY

A major dilemma faced in planning the implementation *of Statistics and Research Methods* concerned the place of technology in the course. As a University of Technology the inclusion of state-of-the-art technology in the teaching program was seen as a high priority. However, there were strong reasons why a computer based statistics package could not be included in the course. Apart from having to spend time learning such a package, there was not enough computer availability to make this possible, given the anticipated enrolment of more than 600 students.

One possible solution involved rethinking the type of technology that could be used. The TI-83 graphics calculator had recently been released. This calculator had been equipped with all of the computations, plots and statistical inference techniques required for the course. Previously, these features were only available in specialist statistics computer packages such as Minitab or SPSS. Using the TI-83 calculator seemed like a possible solution, but many questions were raised concerning their introduction. The dilemmas involved in introducing the TI-83 calculator can be summarised as follows:

- Cost: *These calculators are quite expensive, and the students would only use them for one semester. Would the students actually purchase the calculator if requested? Would there be an equity problem, with some students unable to purchase the calculator on financial grounds?*
- *Ease of use:* Whilst quite simple to use, some time needed to be spent in lectures and in the students' own time learning to use the calculator. Would all the students, especially those without much prior experience with technology, be able to use the calculator correctly and efficiently?
- *Implications for teaching and learning:* Would students become focussed on the use of the technology, and see this as the main purpose of the course. Or, would the fact that the use of the calculator removed most of the routine and meaningless calculation from the course mean that students would concentrate

more on the concepts, developing conceptual as well as procedural understanding? That is, would the adoption of the calculator enhance or impede student learning, or would very little difference be noted?

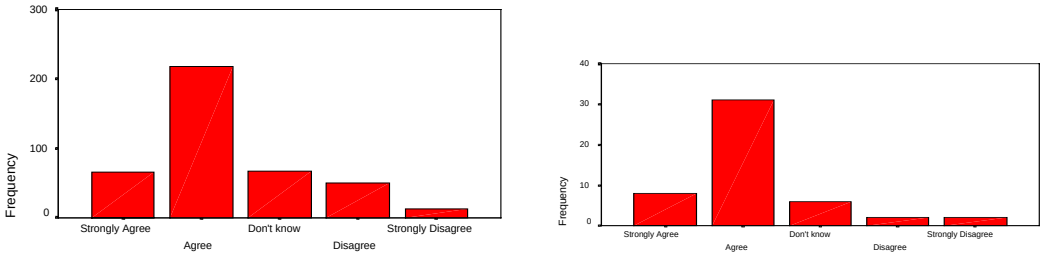
In spite of the potential difficulties, the decision was made to adopt the TI-83. Some decisions were made in the planning stage of the course, in an attempt to eliminate or minimise problems we anticipated. This included the production of a calculator guidebook written specifically to address the types of problems students would encounter in the course (Lipson and Jones, 1997). However, having no real idea of the impact of the TI-83 there were bound to be many problems we did not anticipate! Data was collected during and at the end of the course, in order to evaluate the success of the implementation, and in an attempt to provide some of the answers to the questions raised earlier in this paper.

ISSUES OF COST

It was proposed that the purchase of the calculator be made optional, and a much cheaper non-graphics calculator given as an alternative (the TI36X). This is a simple calculator with bivariate statistical capabilities. As well, forty TI-83 calculators were purchased and made available in the library. By the end of the semester, 350 students had purchased their own TI-83, far exceeding expectations. Many of those who did not purchase their own TI-83 took advantage of those in the library. In the final examination, the vast majority of students (78.3%) had a TI-83 calculator with them, indicating that cost was not a prohibitive factor for the demographic group with which we are dealing and that students are prepared to adopt the calculator.

EASE OF USE

Students were asked at the end of the semester to respond to the statement "I feel confident in using my calculator". Figure 1 shows their responses for the both the graphics TI-83 and the non-graphics TI-36X. In summary, at the end of the thirteen week semester a total of 68.4% of the students using the TI-83 responded either "Agree" or "Strongly Agree" compared to 79.6% of those who used the TI-36X. These results are quite similar, and in fact there is not a significant difference between the two groups, $\chi^2(2)=2.758$, $p = 0.252$.



(a) TI-83 *(b) TI-36X*

Figure 1. *Bar chart of student reponses to the the question "I feel confident using my calculator".*

A further question of interest concerns the appeal of the calculator to the mature age student, and those with little calculator experience. Results showed, however, that there was no relationship between these variables, with all groups equally likely to adopt the TI-83. Table 1 shows a crosstabulation of the highest level of mathematics previously studied with the type of calculator chosen, showing almost identical percentages.

Table 1. Percentage of students choosing each calculator by prior mathematical experience.

Highest level of mathematics studied	TI-83	TI-36X
Year 7-8	2.2%	1.9%
Year 9-10	10.1%	10.1%
Year 11-12	79.6%	79.2%
Other	8.2%	8.8%

What then would be the most powerful explanatory variable of whether or not a student felt confident in using the calculator? Perhaps not unexpectedly, further analysis of the data revealed a strong relationship between the student's level of confidence and how long they have owned the calculator. Those students who felt confident in using their calculator were generally those who had started using their calculator early in the semester (85.8%), compared to those who had delayed this until the middle of semester (49.7%) and end of semester (33.3%). This relationship was significant, $\chi^2(3)=72.275$, $p < 0.0005$.

COMPARISON OF STUDENT LEARNING BETWEEN CALCULATORS

What was the relationship between the type of calculator chosen and the student's result? Summary statistics for the final examination result for the two calculator groups are given in Table 2.

Table 2. Means and standard deviations for the final results by calculator group.

Type of calculator	*Sample size*	*Mean*	*Stand dev*
TI-83	*418*	*62.5*	*1.09*
TI-36X	*50*	*60.4*	*3.24*

Whilst in this sample the students using the TI-83 calculator had a slightly higher mean mark than the students using the TI-36X (62.5 compared to 60.4), this difference was not statistically significant, t(466) = 0.629, p = 0.530.

Was the use of the TI-83 calculator associated with a different level of conceptual understanding? As a part of the students' assessment, three questions on the final examination were designed to test conceptual rather than procedural understanding, and did not require the use of any technology. The mean score for these questions are given for both the graphics calculator users and the non-graphics calculator users was 7.9 marks, indicating no difference between the two groups.

Finally, it would be important to determine whether or not, for those students who chose to use the TI-83 calculator, there was a relationship between the final scores, and the student's prior level of experience. That is, although the students from non-mathematical backgrounds had embraced the calculator, had they been able to use it as successfully as those with better mathematical background? Table 3 shows the means and standard deviations of the TI-83 users, grouped by mathematical background

Table 3: Means and standard deviations for the final results by mathematics level for TI-83 users.

Level	Sample size	Mean	Std Dev
Years 7-8	9	61.3	29.3
Years 9-10	42	59.1	27.0
Years 11-12	332	61.7	21.6
other	34	73.9	16.9

From the table we can see very similar mean scores for all groups, except the other *group which has a higher mean score of 73.9. Since many of the students in this category have studied previously at a tertiary level, this is not surprising. Further analyses showed there was no significant difference between the means of the three school level groups,*

indicating that the move to a more sophisticated technology had not disadvantaged those with less that year 11 or 12 mathematics as had been suggested.

DISCUSSION AND CONCLUSION

The results of this study show that most students enrolled in a liberal arts college are prepared to adopt a sophisticated graphics calculator such as the TI-83, and are capable of learning to use it efficiently whatever their previous mathematical experience. They also show that time can be devoted to developing the ability to use the calculator without detriment to the students' development of both procedural and conceptual knowledge in statistics. The importance of purchasing the calculator early in the semester has been shown, and students will certainly be made aware of this result next semester.

How do we interpret the impact of the introduction of the TI-83 on student performance? Many educators are of the belief that students are only capable of understanding sophisticated concepts when they have a strong procedural knowledge of them. That is, that students require experience of first principle calculation with statistical problems before adopting the technology. This belief has not been confirmed by this study.

However, the adoption of the graphics calculator has relieved the students of the burden of a lot of tedious and confusing work. Why hasn't this resulted in improved student performance? Several issues are worthy of discussion here, although each may be mentioned only briefly. Firstly, we did not attempt to measure that effect of the TI-83 on affective factors such as student confidence and enthusiasm for the subject. Positive changes in this area would be benefit enough in itself. Secondly, we are yet to see if there is a difference noted as the students proceed into second year, where students use sophisticated statistical software for all analyses. It will be of interest to determine if this transition is smoother for those students who are experienced with the TI-83 graphics calculator.

Finally, and clearly most importantly, the use of the TI-83 graphics calculator in this course in 1997 was optional. This meant that staff were required to teach parallel methods for most topics. That is, both traditional statistical techniques requiring first principles calculation and the use of statistical tables, as well as the TI-83 techniques were taught. In essence, we were using a new technology to teach an old course. This proved to be somewhat confusing for some students, and meant that many topics were

rushed because of a shortage of time. The need to tailor the course to complement the technology, together with the general level of student acceptance of the calculator, has led to a decision to use only the TI-83 in 1998. As a consequence, all teaching materials have been rewritten around the TI-83, with any reference to the manual calculation and the use of statistical tables removed (Lipson and Jones, 1998). The materials now clearly emphasise concepts, and encourage the development of a deeper level of understanding. How this impacts on student learning remains to be seen, and the effect of this decision will be the focus question for a further study in 1998.

REFERENCES

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