

Ongoing Individualised Student Assessment using the Internet

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1 Introduction

The potential of computer technology to enhance the student's learning experience is being increasingly recognized and utilized. Many, many interactive, dynamic software packages have been developed which allow students to explore complex statistics concepts in new and exciting ways, with the goal of enhancing understanding. There are, however, other roles for the technology which allow us to enrich the students experience in ways which are not only educationally defensible, but also efficient and economical. This paper describes an internet based assessment tool which has been developed and successfully utilized in an Introductory Statistics course taught at tertiary level to a group of about 800 undergraduate students each year.

2 Issues of Assessment

It is well recognized by many educators and researchers that students are able to successfully complete certain mathematical tasks but at the same time demonstrate no real understanding of the concepts and rules inherent in these tasks. Cognitive psychologists (for example Hiebert & Carpenter, 1992) have coined the terms *procedural* and *conceptual* understanding to describe this phenomenon. Procedural understanding describes the student's ability to carry out routine tasks successfully, whereas conceptual understanding implies knowledge on the student's behalf of what they are doing and why they are doing it. Nowhere is this dichotomy between procedural and conceptual understanding more evident than in statistics. Whilst many students are able to solve routine problems, or perform complex calculations using standard formulae, statistical educators have no doubt that many students have little understanding of the concepts involved (Garfield & Ahlgren, 1988).

Mastery of a set of calculations and procedures, together with the relevant statistical vocabulary, has formed the basis of much assessment in statistics (Hawkins, Jolliffe & Glickman, 1992). However, it has been shown that students who are able to correctly solve a standard statistical problem may not understand either the question or the solution produced (Jolliffe, 1990, Lipson, 2000). Thus, it is important that students be exposed to a variety of assessment instruments, which over their range cover not only the content of the course but also assess both procedural and conceptual understanding. As well as addressing issues of content and form of understanding, it is also desirable that the assessment program provides tasks which are both *formative* as well as *summative*. Whilst summative assessment is designed to provide a measure of student achievement, formative assessment encompasses activities which provide students with timely feedback on their progress in the subject, drawing attention to the concepts with which they are having difficulty. Such an assessment program can be demanding of both teachers and students alike, in terms of both time and energy. The possibility of developing a component of the assessment which is automated is attractive, particularly if it includes the additional feature that it can be attempted by students via the internet any place, any time, with no teacher intervention or involvement required. If the more procedural aspects of the subject can be assessed in this way, then the energy of the teacher can be directed to more conceptually challenging assessment tasks.

In the past, most online testing packages have suffered from severe limitations, for both the student and the teacher. These include:

- The necessity to include only multiple choice or true/false type questions.
- Limited range of graphics available for inclusion in the questions (if any).
- Difficulty in maintaining the integrity of the assessment, so that the result for each student is a valid measure of their knowledge and ability at that time.

Thus, it was determined that we would develop a purpose built program which overcame these difficulties, as well as addressed the assessment objectives which have been outlined earlier in this section, known as the Online Workbook. The Online Workbook is an interactive assessment instrument which provides students with an opportunity to obtain feedback on their progress in statistics at several stages throughout the semester. It contributes 20% to the total assessment for the subject. The other assessments for the subject are a mid-semester test or assignment worth 30%, and a final examination worth 50%. In both of these assessments students are required to demonstrate both procedural and conceptual understanding of the various statistical analyses included.

3 The Online Workbook

The Workbook consists of seven related tasks. In the first task, the students are asked to complete a questionnaire about themselves, answering questions such as “How many hours per week do you spend in paid employment?”, “How long does it take you to travel to university?” and the like. This information is recorded into a database for future reference. The second task is merely the submission of a request by the student for a dataset which is a random sample of 30 questionnaires. In fact, the sampling process is not dynamic, and the database has already stored 1000 random samples of 30 questionnaire results, one of which is allocated to each student. This dataset forms the basis of the student’s analyses for the remainder of the tasks, and is unique to that student during the conduct of the subject. This means that, even if students choose to work in groups when completing subsequent tasks, answers need to be calculated separately for each dataset. A sample question from the Online Workbook is shown in Figure 1.

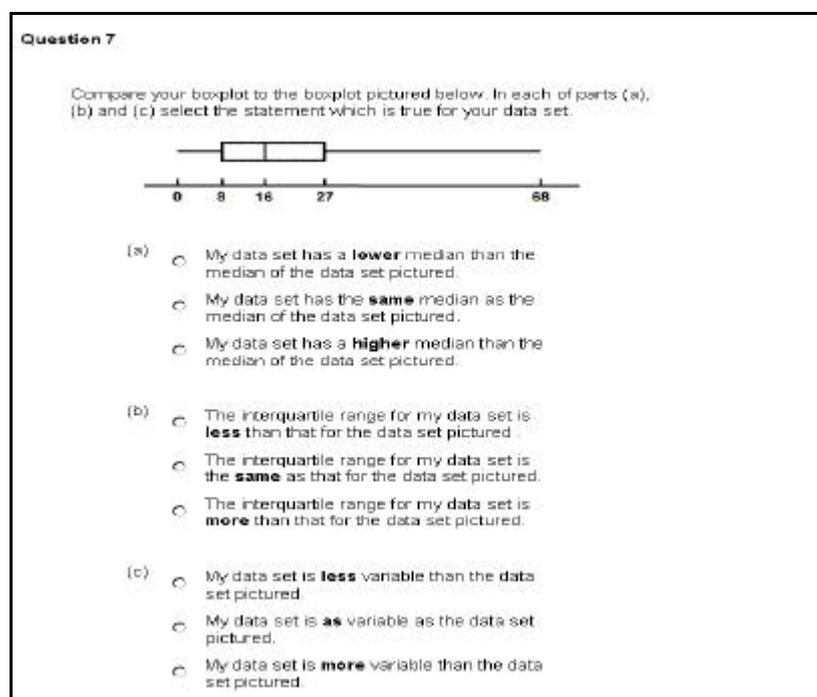


Figure 1 Sample question from the Online Workbook

Tasks 3, 4, 5 and 6 are concerned with Univariate Data Analysis, Bivariate Data Analysis, One Variable Inference and Two Variable Inference respectively. The questions in each task are framed in general terms, and since they relate to the student and his or her peers, are readily interpretable

within the student's own experience. Some of the questions are constructed response, in that they require the student to perform a calculation and enter a numerical value in a field, whilst others are multiple choice. Whilst most of the questions are concerned with assessing students procedural knowledge, some attempt has been made to encourage the students to think more deeply about the statistic which they have calculated. For example, after constructing a boxplot of the data collected in response to the question "How far do you travel to university each day?" the students are asked to compare the distribution of their sample data to the distribution of another set of sample data visually by comparing the boxplots (see Figure 1).

After all questions have been answered the student submits their Task electronically. The student's answers are matched with the correct responses been previously calculated and stored in the database, and the student receives immediately a receipt giving their answer, the correct answer, the mark available for that section of the question and the mark obtained (see Figure 2). As well as returning this information to the student the information is stored in the database for future reference. The student's total mark for the tasks is also stored, so that at the end of the semester the teacher can download the marks obtained by individual students for this component of the assessment.

Question	Correct answer	Student answer	Tolerance	Student mark	Maximum mark
q_1_a_1_1	0.83	.83	0.02	1	1
q_2_a_1_1	2	2		1	1
q_2_a_1_2	0.7	.7	0.02	1	1
q_2_a_2_1	3	3		1	1
q_2_a_2_2	0.7	.7	0.02	1	1
q_2_a_3_1	0.83	.83	0.02	1	1
q_2_a_4_1	0.08	0.08	0.02	1	1

Figure 2 Example of Student Receipt returned after submitting a Task from the Online Workbook

In order to enhance the capability of the Online Workbook as a formative assessment instrument, a practice task has been incorporated into the design. A hypothetical student (Joe Bloggs) has been included into the database, and each student is encouraged to attempt the Workbook Tasks as this student, using the dataset belonging to this student, before completing their own Workbook Task. In this way, the students are able to evaluate their understanding of the concept in question before submitting their own answer. Students are able to submit the task as Joe Bloggs as many times as they like, but they are able to submit their own task only once.

Task 7 is a questionnaire, asking for some general feedback on the subject and in particular on the On-line Workbook

4 Limitations and Future Developments

The Online Workbook has been in use now for three years, and has been completed by about 2500 students over that time period. The students who use the Online Workbook are both on-campus and distance students. The major difficulties experienced would have to be described as external to the design and programming of the workbook. These have been largely network and log-in problems, and perhaps ignorance on the part of system administrators as to the difficulties

presented to students when web pages are moved to different addresses!! From an educator's point of view, the Online Workbook could be improved by building into it extra pedagogical features, in particular follow up for students who submit an incorrect answer. This could take the one of all of the following forms:

- Reference to sections of the student materials where the concept being addressed in the Workbook is discussed.
- Web based linking to an online exposition/demonstration of the concept.
- Recommendations for further exercises in the student materials which could be attempted.
- Online exercises of the same form which could be completed online and again submitted for evaluation online.

Inclusion of these extra facilities would increase the value of the Workbook as a formative assessment instrument, increasing its potential to support the development of both procedural and conceptual understanding in the students.

5 Conclusion

The development and implementation of an online assessment instrument was both expensive and time consuming. However, given the large numbers of students participating in the subject, the requirement for continuous assessment with timely feedback to students, and the move to teach the subject both on and off campus, the investment has proved to be worthwhile from both the teacher and student perspectives. Certainly, the gains made so far would justify supporting further investigation into the potential of the web to facilitate more and varied assessment instruments in the future.

References:

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Resume:

This paper describes a web-based assessment instrument developed to contribute to both summative and formative assessment for a first year introductory statistics subject. This subject is undertaken each semester by a large group of students, some of whom are entirely off-campus. The assessment instrument was developed so that students could receive regular, timely feedback on their progress, while at the same time an offer individualized tasks which could validly contribute to a student's final mark in the subject.