A COMPUTER-AIDED LEARNING PACKAGE FOR HYPOTHESIS TESTING

Michelle McDougall, Jamie Mustard and Glenn Ridley, Deakin University, Australia

Hypothesis testing is an integral part of most first year undergraduate statistical courses. Unfortunately students find this area confusing and don't fully grasp some of the subtle concepts involved. At the same time, there is an increasing demand on both academics' and students' time availability. A Computer-Aided Learning (CAL) package has been designed specifically to aid students' understanding of this area in an effective and efficient manner. It will be shown that such programs should be viewed as complementary rather than a replacement of traditional teaching methods.

INTRODUCTION

Computer-Aided Learning (CAL) programs have been identified as an effective means of presenting disciplinary knowledge to a student via a computer. Moreover, in some cases they provide students with a way in which they can apply knowledge learnt in the classroom. CAL programs have been successfully implemented in disciplines such as accounting (Holt *et al*.) and engineering (Woolf) and in other areas that involve tasks that are procedural.

In statistics, teaching concepts such as sampling distributions and the theory of hypothesis testing which includes some quite subtle concepts, is probably best done by traditional means such as lectures or possibly even some multi-media presentation. However, solving hypothesis testing questions is somewhat procedural and as such CAL programs are best suited to giving students detailed feedback at the different stages (from stating the null and alternative hypothesis through to drawing the correct conclusion). Used in this way, CAL programs can be viewed as complementary rather than a replacement of traditional teaching methods. In this paper, HypoTest, a CAL package for hypothesis testing will be discussed.

HypoTest should not be confused with other statistical or spreadsheet packages commonly found in introductory statistics courses. Such programs are generally used as a means of applying knowledge students have learnt in the classroom to generate statistical results. In their own right they are important to the overall educational experience of a student. HypoTest, on the other hand, is intended to be used as a precursor to improve the learning process so students can gain an in-depth knowledge of inferential statistics.

The rest of this monograph is devoted to the description of the HypoTest program including the design considerations taken. Educational benefits of CAL programs in general will also be discussed.

DESIGN PHILOSOPHY

HypoTest is a completely closed system, by this we mean that all sentences and data are generated within the program. Because of this, checks are in place to make sure that the data generated is not only statistically sound, but real world parameters in questions have valid ranges. For example questions about blood pressure have patients' blood pressure in the range 70 to 150 mmHg and not between 2000 and 3000 mmHg! Data cannot be imported into HypoTest, but questions that are generated can be exported with either a worked solution (in point form) or without.

Another advantage of the closed system is that because the computer has generated all the intermediate calculations it can give specific feedback for all the steps needed to solve a hypothesis question and not just the final result. A good example of this is that the 'tables' are actually looked up to determine the values needed, this means that the computer knows which area of the table the student should 'click on' to indicate the value being looked-up.

The package has been designed with two major stages: Classifying the question; and solving the hypothesis. The first thing the student must do before proceeding to solve a hypothesis is to correctly classify the question. The student cannot proceed to solve the hypothesis test question until they have either classified it correctly, or had the computer classify the question for them (see Figure 1).

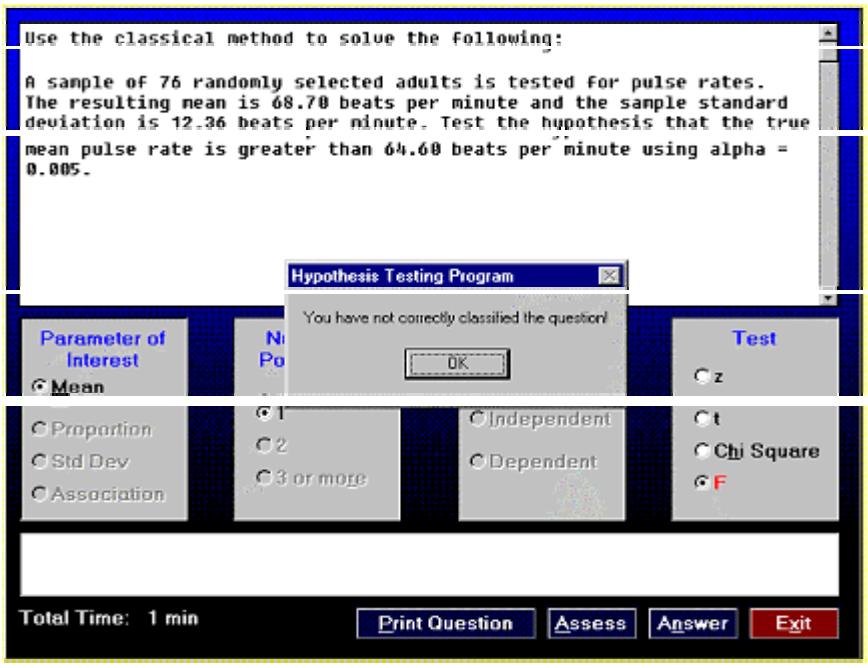

Figure 1. A student has incorrectly classified a question

Once the student enters the solving phase of the exercise they must identify the statistics, parameters, formulae, table, and indicate on the table the values that are being used (see tabs on right hand side of Figure 2). The student must then select either 'Reject Ho' or 'Fail to Reject Ho' and choose the correct conclusion from the two given possible conclusions (in sentence format).

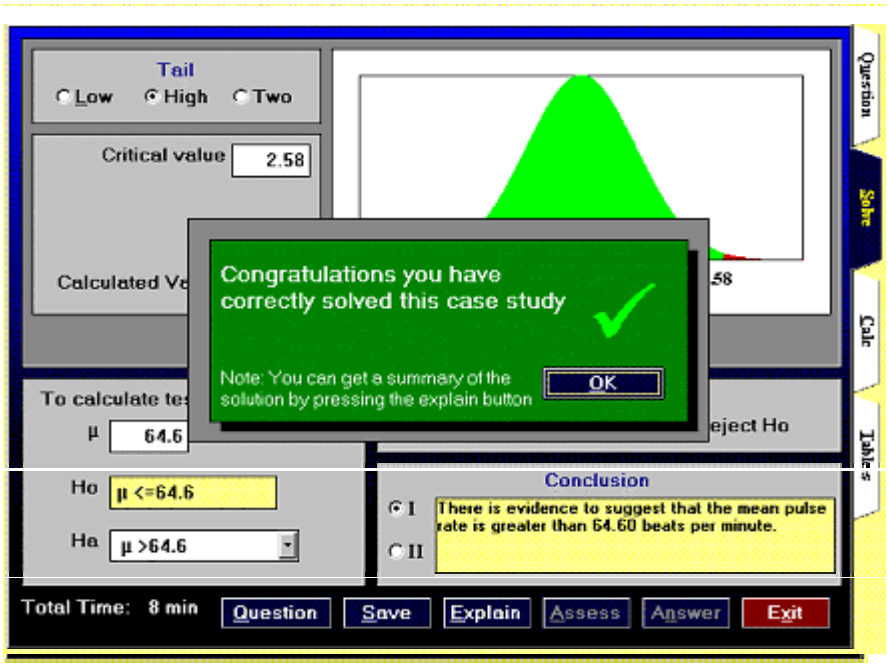

Figure 2. The student has correctly solved the case study

The sentence templates and the two possible conclusion templates for each question have been generated and cross checked by staff in different faculties to ensure that wording is not misleading or too discipline specific.

There are many differences in ideas, approaches to teaching and subject content in various discipline areas. For hypothesis testing, there are differences between lecturers, textbooks, and faculties within a university and different universities in terms of many topics and the notation used. For example, some books include matched pairs tests in two population dependent means while others consider these tests as part of one population means. For matched pairs, one text uses $\bar{x}$ and another $\bar{d}$ for the mean of the sample differences. HypoTest has successfully accommodated these different approaches and notation in a number of ways. In being able to choose the types of questions that the package will generate, only those types appropriate to the student's studies can be chosen. Also, the software will accept alternative solutions, if for example one student uses a t-test for a large sample size, and another uses z. Although some formulae may appear different between texts, the student is only required to enter the relevant statistics and the software does the required calculations. Therefore, the student does not have to write down or work closely with a rule that is unfamiliar to them.

EDUCATIONAL BENEFITS

HypoTest responds to the needs of students studying first year statistics who are having some difficulty with one of the crucial areas of their course – hypothesis tests. The majority of students lack confidence or ability in the initial classification of hypothesis test questions, particularly when all of the topics have been covered and they know a given question may be one of a number of types. The most common hypothesis tests learnt in first year involve single proportions, single means, two independent means, two independent proportions and two dependent means. If the initial classification is incorrect, then obviously the subsequent choice of test statistic formula and final solution most likely will be incorrect as well. HypoTest provides the opportunity for students to practice the initial classification, with questions presented at random, or on a given type of question. Some students can easily solve hypothesis test questions once they know what type of question it is, so may just use the classification part of the program. Other students also have difficulty solving the problem, even when they have correctly classified the question. These students can then choose to solve the problem using

HypoTest in a similar manner to a manual solution. Thus, the package addresses the needs of students who have difficulties with hypothesis test questions in terms of correctly identifying which type of test it is in the first place and/or going on to correctly solve the problem.

The software does not replace the learning of the material through traditional means, but tests the students' knowledge of the content through timely feedback. The multi-layered feedback mechanism provides reinforcement of students' progress throughout the various stages of their solution to the problem. Initially, if the classification is correct, a green tick and a congratulatory remark are displayed, whereas incorrect choices are shown in red when the 'Assess' button is pressed. Students then can change these selections before another assessment. Alternatively, they can press 'Answer' to see the correct selections. As they work through the solution part of the problem, at any stage they can 'assess' their work (with incorrect answers highlighted in red) or see the correct solution. Furthermore, the full worked solution can be generated and printed as required. The immediate feedback with the red or green displays serves to provide positive reinforcement and confidence building to the student, particularly when their answers are rewarded with the green tick, which acts as an intrinsic reward. The incorrect red sections appear to provide stimulation and motivation to continue with the problem, gain the correct answer and, in effect, 'beat' the computer. Some students have been observed to jubilantly clench their fists, say 'yes!' or brag to nearby students when they 'get the green tick' (see Figure 2). Their sense of personal accomplishment and therefore enthusiasm for continuing is heightened.

HypoTest provides an efficient means of practicing hypothesis test questions, as there is potentially an infinite source of questions due to the use of the templates and randomised approach by the software of generating the data. The time needed for students to attempt a number of original questions is much shorter than it would be, had the student been required to find relevant questions in textbooks. The feedback and solutions provided by HypoTest provide greater detail than 'back of the book' textbook solutions. Also, since the package does the required calculations, the students are not bogged down by 'number crunching', further adding to the efficiency of this method of learning.

The students, in many senses, are in control of their own learning as there a number of options they have regarding the use of the package. They can work at their own pace, either at home or in the university laboratories. Within the package, apart from

being able to choose when to request feedback, they can choose only a particular type of question(s) and whether to solve them by the p-value method or the classical approach (See Figure 3). Thus students can customise their learning by practicing only the types of questions they need to, at times and locations that suit them.

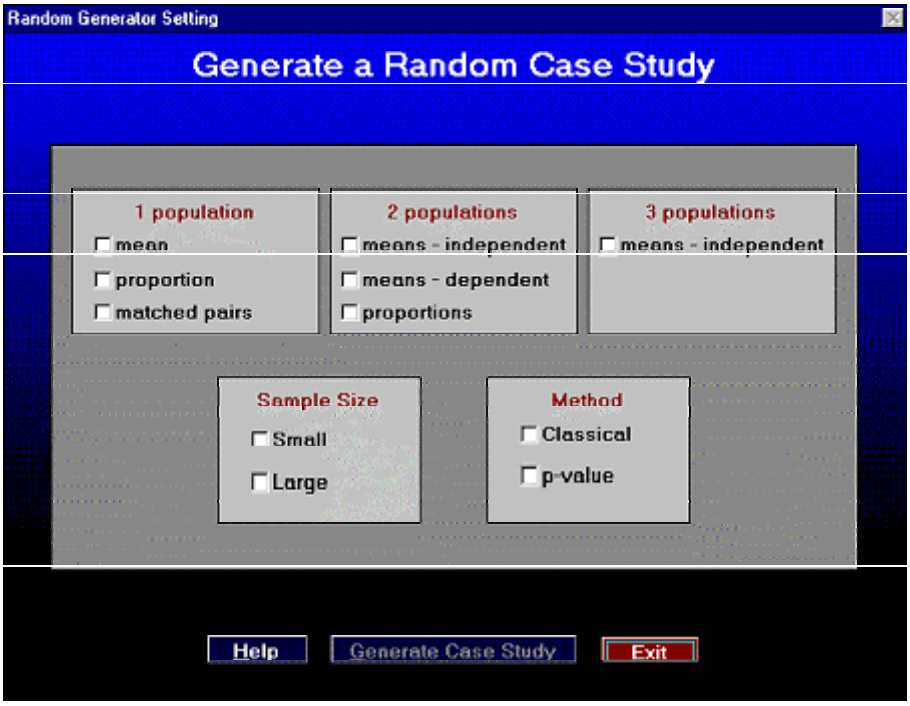

Figure 3. Menu for choosing question type

The fact that their progress is being monitored by the computer may suit the learning styles of many students as this is a relaxing, non-threatening environment in which to work for those students comfortable using a computer. If so desired, there is no need to find and discuss solutions with a lecturer, as the software provides all necessary feedback and solutions. Of course, any problems and solutions may be printed off to be discussed with the lecturer if a student would like to.

REFERENCES

Deakin University (1997). *Flexible Teaching and Learning at Deakin University: A Guide to Development and Delivery*, Deakin Centre for Academic Development, Geelong.

Holt, D., Boyce, G., Carnegie, G., Lourens, J. and Bigelow, A. (1995), *Intelligent Computer-Assisted Learning, Australian Society of CPAs*, Melbourne.

Rogers, C. (1975). Freedom to Learn. In N. Entwistle and D. Hounsell (Eds), *How Students Learn*, University of Lancaster, Lancaster, pp. 149 - 158.

Woolf, B. P. (1996). *Intelligent Mutimedia Tutoring Systems*, Communications of the *ACM, 39, No. 4*, 30 - 31.