SAMPLE SURVEYS AS A VEHICLE FOR INTEGRATION OF STATISTICAL CONCEPTS ®

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Taught modules on sample survey methods provide a useful means of integrating and extending a range of statistical ideas. Knowledge and expertise gained in basic Statistics modules at Levels 1 and 2 can be brought together and applied in sample surveys, and provide the platform for the development and application of more advanced concepts. This paper mainly concerns Level 3 modules in the programme of Statistics learning in the undergraduate degree(s) at The Nottingham Business School, but the principle has been applied elsewhere.

INTRODUCTION

The statistical content of the undergraduate curriculum at The Nottingham Business School reflects the School's view of the importance of the role of Statistics in the world of business, over a substantial period (first reported in Bedrock & Dixon, 1982). All first year students must complete a year-long module in Statistics (Accounting students also do some basic Mathematics) amounting to credit earned of one sixth of the year's total. The approach to teaching/learning adopted is similar to that followed in Curwin (1996), with minimal theoretical input and an emphasis on problem solving through a copious supply of practice exercises. Thereafter, students follow an option structure that allows them to select modules from Business Mathematics, Statistics and Optimisation, and Survey Research Methods at Level 2, and from Sample Surveys, Advanced Survey Methodology, Operational Research and Management Science at Level 3. In the interests of flexibility, students who omit Statistics and Optimisation and/or Survey Research Methods at Level 2 are not barred from studying the Sample Surveys and Advanced Survey Methodology modules at Level 3. The approach adopted with regard to the latter two modules is similar to that of Scheaffer et al. (1996). For clarification of some of the more technically difficult concepts in a more formal framework, Skinner et al. (1989) is a welcome source of reference. The latter provides a useful guide for students who might take a more advanced approach to studies of survey methodologies, such as is required for final year undergraduate project work.

The intention is to integrate previous knowledge in an applied setting within the Sample Surveys module, to extend knowledge and application in relation to a case study within Advanced Survey Methodology and to challenge the students intellectually, as befits study at Level 3. These two Level 3 modules provide an appropriate and useful vehicle for the integration of statistical skills in an applied setting, and for further development of statistical expertise in relation to the real world.

LEARNING / TEACHING SNAPSHOTS

In a fuller version of the paper, available from the author, a number of snapshots are presented in which some interesting teaching/learning scenarios are described, and some pedagogical tips given. Sample surveys present a welcome context for the integration of statistical ideas. The teaching technique employed is that of winning students' confidence in their ability to cope with a fairly advanced course in applied statistics by drawing out from them their basic knowledge, integrating it and applying it in a meaningful, relevant context. Then, when their confidence has been established, the way is open for introducing new ideas within the safety net of the 'meaningful, relevant context' (see Bibby & Davies, 1995). In other words, students are able to cope with an increase in the degree of difficulty of new statistical concepts provided they are reassured by the development of the concepts taking place in a recognisable, familiar subject setting. Further details on integrative approaches to statistics teaching, learning and assessment in an applied, real-world setting are to be found in Dixon (1998).

EXAMPLE OF SNAPSHOT: INTEGRATION OF PREVIOUSLY-LEARNED MATERIAL

In their core Statistics module all students are acquainted with the basic principles of sampling and key results such as the Central Limit Theorem. It is relatively easy to encourage and achieve integration and application of this knowledge within sample surveys. In what follows the problem under study is that of estimating the mean μ for a population of size N for a random variable Y from data obtained from a simple random sample of size n consisting of observations $y_1, y_2, \ldots, y_n$, and measuring the precision of the estimate.

The appropriate results are:

$$\hat{\mu} = \bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$$

$$\hat{Var}(\bar{y}) = \frac{s^2}{n}\frac{(N-n)}{N}$$

where s^2 denotes the unbiased form of the sample variance. (The notation here and in what follows is that used in Scheaffer et al. (1996).) It is relatively easy to explain to students the need for these expressions, drawing on their knowledge (just recollected at this stage!?) of sampling and persuading them of the need to compensate for a finite population size. Nicholson (1997) gives an entertaining slant on this, which can provide a useful topic for tutorials.

Students are reassured if they can see this demonstrated 'live'. Suppose N=1000 savers' records are available, a simple random sample of n=200 records is drawn and the balance y noted for each, from which $\bar{y} = £94.22$ and $s^2 = 445.21(£^2)$ can easily be computed, whence

$\hat{\mu} = £94.22$ and $\hat{Var}(\hat{\mu}) = \frac{445.21}{200}\left(\frac{1000-200}{1000}\right)(£^2) = 1.78(£^2)$.

It is easier to relate to the standard error estimate $\hat{SE} = \sqrt{Var(\hat{\mu})}$ of $\sqrt{1.78} = £1.33$.

Using knowledge of interval estimation, it is an easy step to say that an approximate 95% confidence interval estimate for the mean is

$$\hat{\mu} = £94.22 \pm 1.96 \times \sqrt{1.78} = £94.22 \pm £2.62$$

The £2.62 term is often referred to as the *bound* on the error of estimation. We can be reasonably sure that the mean balance of savers' accounts is within £2.62 of £94.22.

This is a stage-setting segment of work in which the students draw on familiar knowledge and experience and reapply it in a new but 'reachable' context. Some useful ground has been gained here in establishing the important concepts of estimation and precision of estimation in survey work, integrating previous and new knowledge. If the actual value of μ is known, a measure of the accuracy of the estimate may be obtained. It is useful to help explain the point that accuracy and precision are not the same thing. A tutorial exercise on sampling that might benefit students' revision/learning in the early stages of teaching this material is suggested in Smart (1999).

ASSESSMENT

Assessment is by phase test, assignment and examination across the two modules. The formative purpose of the phase test is to lead students to focus on and consolidate the knowledge imparted in the early stages of study, thereby allowing students to be better equipped to integrate and apply their knowledge.

The assignment, presented by students in report form, gives students an opportunity to demonstrate the extent to which they are able to apply their new technical knowledge of sampling methods in a practical context. There is ample room for students to display initiative and

creativity in this work. The purpose of the examination is to measure summatively in a controlled manner the extent to which students are able to integrate knowledge and application together in a logical, creative way within short, structured problem-scenarios.

STUDENT FEEDBACK

Student feedback on the Sample Surveys module and its delivery was obtained via a standard questionnaire for the 2000-01 cohort. The module was taught in the first half-year. A summary of the results is presented in Table 1.

Table 1
Summary of Student Feedback on Sample Survey Module

	Very poor	Poor	Satisfactory	Good	Very good
Teaching			2	8	11
Subject organisation			1	9	11
Aids, handouts, etc.			5	12	6
Availability of help		2	5	9	5
Suitability of problems			6	8	7

The results indicate a degree of success in the teaching and the students' learning but the 2 students who were dissatisfied with *Availability of help* present a cause for concern. However, a few students did not respond well to the expectation on them of independent study, and it is supposed that they fed back accordingly. The results of the feedback for The Advanced Survey Methodology, a subject taught in the second half-year, are presented in Table 2.

Table 2
Summary of Student Feedback on The Advanced Survey Methodology Subject

	Very poor	Poor	Satisfactory	Good	Very good
Teaching			1	11	8
Subject organisation			3	9	8
Aids, handouts, etc.			4	11	5
Availability of help			7	11	2
Suitability of problems			3	12	5

This shows a similar pattern to that of the previous summary. It was pleasing to note that *Availability of help* had no ticks in the 'Poor' category!

COMMENTS

There is some indication from the results of assessment and from feedback that the modules have been reasonably successful in integrating previous knowledge, new knowledge and application. In particular, all students were able to attain the learning outcomes for the two modules to a greater or lesser extent. However, these outcomes are fairly typical of those which occur following delivery of a final year option module, given that the students have *chosen* to study the module; they are mostly subject enthusiasts who have good basic skills in numeracy and logical thought. It will be of great interest to attempt to carry the module to a wider audience within the core curriculum, though this is not feasible at the moment. The modules appear to support the general curriculum well, with students from a wide range of 'pathways' within the business programme electing to study the modules.

As intended, the modules provided a useful framework for integrating and extending a range of statistical ideas, showing that knowledge and expertise gained in basic Statistics modules at Levels 1 and 2 can be brought together and applied in a sample surveys context, and providing the platform for the development and application of more advanced concepts. The teaching/learning approach was through minimal theoretical input and an emphasis on problem solving, consolidated via a copious supply of practice exercises. Integration of previous knowledge in an applied setting was well-achieved and the development of new material in a case

study setting proved a welcome opportunity to demonstrate an appropriate and useful vehicle for the further development of statistical expertise in relation to the real world.

The snapshot of teaching material gives an indication of the content and style, which can be received and understood by students at this level, with the backgrounds indicated. Previous knowledge and expertise were integrated in a meaningful, practical context, enabling students to use their previously-acquired skills with confidence, rendering them in a state of readiness to receive further instruction. Some of the ideas received by students were quite sophisticated. Much recognition must go to the student audience for their keen, positive interest and cooperation during the modules' delivery and assessment. The snapshots available in the fuller version of the paper present instructors with some ideas for teaching topics in sample survey**.**

Many of the points made above relate to statements on teaching, learning and assessment in applied statistics made in Dixon (1998), Bibby and Davies (1995).

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