Mathematics and Statistics Skills in the Social Sciences

Graham R Gibbs

Abstract

The issues concerning numeracy and quantitative skills that exist for social scientists are somewhat different from those affecting many within the natural sciences and technology-related disciplines. In general students do not need to model systems algebraically or symbolically although they do need a good sense of number (scale, size, etc.) and an understanding of some of the logical principles and thinking that underlie mathematical proofs. The main area of application of these skills is in research methods and statistics.

Quality Assurance Agency (QAA) benchmarks and the Economic and Social Research Council (ESRC) Training Guidelines for postgraduates are very clear about the importance of methods and statistics in the social science disciplines. However, key surveys suggest that there is 'a crisis of numeracy' in social science disciplines. Many students are ill equipped to undertake quantitative work and there is a shortage of suitably qualified teachers. The response by academics has been, in part, to provide a range of mathematics support for students who need it. Alongside this, teachers have adopted a range of approaches to teaching quantitative methods including teaching statistics using formulae, teaching statistics using step-by-step instructions, and even teaching statistics without either calculations or formulae.

Mathematics in the Social Science Curriculum

The social sciences constitute a broad range of disciplines and not surprisingly there is considerable variation in the degree to which quantitative approaches are used. Many social science disciplines' mathematical concerns focus primarily on numeracy and mathematics within research methods and statistics: this is reflected in the QAA benchmark statements for these disciplines (QAA, 2007). These benchmarks represent each discipline's own perception of curriculum content at undergraduate level. (Although there might be sophisticated use of mathematics and quantitative methods at postgraduate or research level, many take the view that it is not necessary for all undergraduates to be proficient in these approaches.)

The reference to quantitative work within the benchmark statements falls into three groups. For some disciplines, for instance Politics, Education, Social Anthropology and Area Studies, there is little mention of research methods and no reference to quantitative methods. The majority of disciplines, for instance Human Geography, Sociology, Social Policy, Social Work, Biological Anthropology, Business and Management, Criminology and Linguistics, adopt what might be called a 'Basic Research Methods' approach: students are expected to study both qualitative and quantitative research methods as well as some basic statistics. For example the Education benchmark statement suggests students should "*have an ability to interpret simple graphical and tabular presentation of data and to collect and present numerical data*".

Two disciplines expect greater mathematical competence and address both numerical skills and quantitative techniques more explicitly and in greater detail in their benchmark statements. The first is Economics where proficiency in quantitative methods and econometrics, including knowledge of appropriate techniques for structuring, representing and analysing data, is central. The second discipline to adopt this 'maximal approach' is Psychology. The benchmark document states clearly that students should "develop an understanding of the role of empirical evidence in the creation and constraint of theory and also in how theory guides the collection and interpretation of empirical data" and that they should acquire "knowledge of a range of research skills and methods for investigating experience and behaviour, culminating in an ability to conduct research independently". At the modal level, a student should be able to "demonstrate a systematic knowledge of a range of research paradigms, research methods and measurement techniques, including statistical analysis, and be aware of their limitations".

At the level of postgraduate teaching, a good indication of the centrality of quantitative methods can be seen in the Research Methods Training Guidelines produced by the Economic and Social Research Council (ESRC 2005). These all include reference to quantitative methods and statistics and they specify the content of MSc training which is compulsory for all ESRC funded students.

What is the Problem?

The centrality of quantitative methods and numeracy and its compulsory status in much of the social sciences presents particular problems. Put simply, research methods (and especially quantitative methods) are typically unpopular with students – and indeed with many members of academic staff! Although some quantitative methods are compulsory within most of the social sciences, many students will avoid them if given the opportunity, especially in the second and third year of undergraduate degrees when they are given flexibility. Moreover, when taking compulsory quantitative elements of their courses, many students experience anxiety, and demonstrate a lack of arithmetic ability or sense of number skills, as well as poor probabilistic thinking and logic skills.

In addition to knowledge and understanding of statistical techniques, the mathematical skills that social scientists might be required to demonstrate fall into three broad categories:

- numeracy, including a familiarity with numbers, a sense of size and scale, and the ability to undertake simple calculations;
- symbolism and algebra, including the ability to substitute numeric values into algebraic expressions and hence evaluate them;
- logic and argument including probabilistic thinking and other forms of logical reasoning.

With the possible exception of Economics, most social sciences do not require students to possess a full range of mathematical skills. Whilst numeracy, sense of number, and logical thinking are generally considered to be important skills for any quantitative work, in general, social sciences students are expected to have no more than limited skills in algebra. Unfortunately, there is evidence in many disciplines that students are ill-equipped in all three respects.

Mulhearn and Wylie (2005) have undertaken a detailed survey of the level of mathematical ability amongst entrants to Psychology degrees. In this study a mathematics test was given to students in eight British universities (including both pre and post-92 institutions). The test examined the mathematical ability expected of a student with an A-Level in Psychology. Mulhearn and Wylie found a mean correct score of only 13.75 out of 32 (43%) with female students consistently performing significantly worse than males; an important finding as 80% of Psychology students are female. Common errors included mistakes in dealing with decimals, problems with simple algebra, inaccurate graphical interpretations and false probabilistic thinking. Figure 1 shows a table of responses to four questions set by Mulhearn and Wylie. The test was the same as one used in previous studies undertaken in 1984 and, hence, the authors were able to compare the results found in 2004 with those found twenty years earlier. They concluded that the results suggested a marked decline in mathematical and numerical competence amongst A-Level Psychology students.

Table 4	
Calculate each of the following:	
√ 0.09	
Answers	%
.03	43
.3	17
.81	2
Other	12
No answer	26
0.02 x 0.12	
Answers	%
.0024	28
.24	27
.024	14
.06	3
Other	12
No answer	15
40 ÷ 0.8	
Answers	%
50	43
.5	10
320	3
.1	2
Other	24
No answer	19
Note: highlighted item is the correct answer	

Figure 1. Answers given to four questions in the maths test for psychology students.

A similar situation can be found in other social science disciplines. For instance, Williams (2002) reports a study of teaching staff in Sociology which was undertaken by surveying departments, delegates at a British Sociology Association (BSA) conference, and attendees at consultation days. Williams found that all the departments surveyed offered at least some quantitative methods and that this constituted between 5 and 15% of the degree. However, staff felt that there was a crisis of numbers in British Sociology, with students unenthusiastic about quantitative methods and with many barriers to effective teaching. 75% of Sociology staff surveyed at the British Sociological Association conference thought that students chose a degree in Sociology in order to avoid having to deal with numbers and two thirds thought Sociology students were not numerate. The staff consultation days, undertaken later, reinforced the view that students perceived quantitative work negatively. Many staff indicated that this perception was often perpetuated by colleagues: those teaching qualitative methods might typically begin their sessions with a diatribe against quantitative methods. Participants also identified a shortage of qualified and motivated staff. Whilst one has to be cautious about responses from a consultation of this kind, which would clearly attract teachers supportive of quantitative approaches, the view that there is a shortage of staff able to teach quantitative methods is shared by the ESRC, which in the last few years has operated various schemes aimed at increasing the number of postgraduate research students undertaking quantitative projects.

Students' negative views about quantitative methods and about their own mathematical abilities have been found by other studies and in other coutries. For example, Murtonen and Lehtinen (2003) examined education and sociology students in Finland and found that statistics and quantitative work were perceived as more difficult than other topics. They found some evidence for a correlation between perceived difficulty and how abstract the student thought the subject to be, with statistics and mathematics seen as difficult and abstract whereas the students' own degree subject and language modules were both perceived as relatively easier and more concrete.

The Response by Academic Staff

Academics in the social sciences have responded to these problems in two ways. The first is the approach, familiar in many disciplines, which addresses the students' deficits and needs directly with additional support. This is provided by academic members of staff who re-assure students, improve their confidence and give individual tutorial support. In addition, much support is now given through specialist units (as discussed in other papers in this volume) based in schools, departments, faculties or at the university level.

The second approach has been to teach quantitative techniques, and statistics in particular with significantly reduced emphasis and minimal reliance upon mathematical skills, thereby reducing the amount of calculation, arithmetic, and manipulation of algebraic formulae expected of students. This approach has been propagated by the widespread use of statistical software (usually SPSS) so that a 'Black Box' attitude can be adopted: the software does the calculation and academic staff focus upon teaching the appropriate choice of statistical tests and the interpretation of results. Examples of both approaches appear in current textbooks. For instance, as illustrated in Figure 2, Howitt and Cramer (2005) adopt the traditional approach demonstrating how to substitute values into appropriate algebraic formulae. An example of the 'Black Box' approach is illustrated in Figure 3 in an excerpt from *Statistics without Maths for Psychology* Dancey and Reidy (2004). Actually the title is misleading: it does not mean "without maths" but rather "without calculation and algebraic expressions" as students still need to understand some simple mathematical concepts.

Calculation 5.1 continued

Table 5.1 Steps in the calculation of the standard deviation

Scores (X) (age in years)	**Scores squared (X^2)**
20	400
25	625
19	361
35	1225
19	361
17	289
15	225
30	900
27	729
$\Sigma X = 207$	$\Sigma X^2 = 5115$

Table 5.1 lists the ages of nine students (N = number of scores = 9) and shows steps in calculating the standard deviation. Substituting these values in the standard deviation formula:

$$\text{standard deviation} = \sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{N}}{N}}$$

$$= \sqrt{\frac{5115 - \frac{(207)^2}{9}}{9}}$$

$$= \sqrt{\frac{5115 - 4761}{9}}$$

$$= \sqrt{\frac{354}{9}}$$

$$= \sqrt{39.333}$$

$$= 6.27 \text{ years}$$

(You may have spotted that the standard deviation is simply the square root of the variance.)

Figure 2. The traditional approach to teaching statistics in Howitt, D and Cramer, D. (2005).

The 'group' row is the between-groups statistics, and is the row of interest. Our analysis shows us $F(2,33) = 9.92$, $p < 0.001$. Remember in Chapter 5 we explained that a correlation coefficient could be squared in order to show the percentage of variation in scores on *y* accounted for by scores on *x*? Well, partial η^2 is a correlation coefficient that has already been squared. So in this case, we can simply read the number in the 'eta squared' column. The interpretation in the case of partial η^2 in this ANOVA is to say that 37.5% of the variation in driving ability is accounted for by which alcohol condition the participants were in

Tests of Between-Subjects Effects
Dependent Variable: driving ability score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Corrected Model	145.167[a]	2	72.583	9.915	.000	.375
Intercept	1980.250	1	1980.250	270.500	.000	.891
GROUP	**145.167**	**2**	**72.583**	**9.915**	**.000**	**.375**
Error	**241.583**	**33**	7.321			
Total	2367.000	36				
Corrected Total	386.750	35				

a. R Squared = .375 (Adjusted R Squared = .337).

The 'error' row contains the figures relating to the within-participants variation

Levene's Test of Equality of Error Variances[a]
Dependent Variable: driving ability score

F	df1	df2	Sig.
.215	2	33	.808

Shows that the variances of the three groups are not significantly different from each other, therefore we have met the assumption of homogeneity of variance

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.
a. Design: Intercept+GROUP

Figure 3. The 'Black Box' approach adopted by Dancey and Reidy (2004).

Possible Future Developments

There are competing pressures concerning the place of quantitative skills in the social sciences. On the one hand, the ESRC is clearly pushing to ensure that sufficient numbers of the next generation of social scientists are trained in quantitative methods. On the other hand, there has been significant growth in interest in qualitative methods in the social sciences in the last 20 years, especially reflecting the 'turn to language' with increased research interest in rhetoric, narrative, discourse and representations of identity. Additionally, the social sciences face the dual challenges of students lacking (and being resistant to the acquisition of) essential mathematical and statistical skills coupled with insufficient numbers of suitably qualified academic staff to teach these skills.

To address these tensions, two developments are key: first, the expansion of central mathematics support facilities to help social science students, and second, the development of better materials and resources for such students.

There is great potential for e-learning to respond to this second need. It is vital that these new resources do not simply replicate the kinds of classroom experience that some students find so intimidating and demotivating. Rather, they should embed conceptual learning in relevant, interesting and concrete models as illustrated in Figure 4.

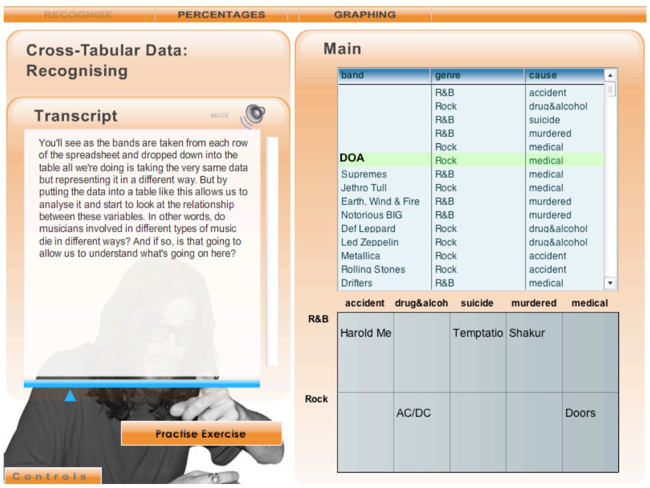

Figure 4. Reusable Learning Object on how to convert survey or experimental data into cross-tabular data (http://www.ucel.ac.uk/rlos/cross_tab_data/main.html)

To conclude on a more positive note: whilst the concerns regarding quantitative skills amongst social science undergraduate students are keenly felt, there is some indication that, at least at the research level, the growing interest in mixed methods might ameliorate the all to frequent antagonism between qualitative and quantitative methods.

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