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THE EFFECT OF CONTEXT ON THE TEACHING OF STATISTICS AT FIRST YEAR UNIVERSITY LEVEL

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1. Introduction

Clark (1993b) has described how at Victoria University in New Zealand there are two different but essentially equivalent (with respect to level of difficulty and statistical content) first year statistics courses. These courses are: STAT131 Data and Probability – the course recommended for students majoring in mathematics, physics, chemistry, computer science and engineering; and STAT193 Statistics for the Natural and Social Sciences – suggested for those majoring in biological sciences, social sciences and medicine.

The proportion of females in STAT193 is always higher than the proportion of females in STAT131. This is unsurprising, as approximately one and a half times as many females as males study biology in their final year of high school (Ministry of Education, 1992). Less predictable is that it is easier for female students to succeed in the STAT193 course than in the STAT131 course. As shown in Table 1, they consistently take a larger proportion of the A grades than their proportion of the class while the converse is sometimes true for STAT131.

Table 1. *Participation and success for female students in first year statistics courses*

	% female		female % of A grades	
year	131	193	131	193
1987	20	44	26	62
1988	30	36	27	48
1989	21	41	25	59
1990	37	52	37	57
1991	28	54	38	60
1992	29	64	20	73

The total numbers of students in these classes (220 and 480 respectively in 1993) together with the amount of available resources

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dictates the fairly traditional lecture format of the courses with a final timed examination.

2. The final examinations

Over a three year period some patterns have emerged. In the STAT131 final examination, male students often perform better overall. The examination as a whole is usually somewhat abstract. Any non-abstract questions often (> 50%) involve machinery, manufacturing or money and it is these latter questions in which males, in general, perform better (and are more likely to choose). The questions that female students tend to prefer in this paper are questions involving standard theory or algorithms. No questions or part questions over this three year period came from what one might term the "world of women" although in 1992 'she' was used as the pronoun in two general questions.

In the STAT193 examination male and female overall scores were either the same or significantly in favour of females. There are always two or three very abstract questions, usually about finite populations, the central limit theorem, power etc., but these questions are shunned by male and female students alike, and performance is poor in them. The nonabstract questions were predominantly 'people' or 'animal' questions and sometimes (11%) related to manufacturing. In this paper males and females attempt the same questions. The most frequently attempted questions were those involving people and the environment, for example: analyses of variance on scores in psychology tests, and abilities of mentally retarded people to learn basic life skills; contingency table analyses on spouse abuse versus family type, and on vaccination levels and ethnicity; a confidence interval on foetal heart rates, a t-test on chemical residues in birds. These were the questions in which the female students did particularly well.

The majority of male students in STAT193 are not studying in technical or mathematical areas. The problems that appeal to the females in the class are, by and large, the problems that appeal to these males who have mostly rejected or not been successful in mainstream mathematics. Work with secondary school pupils in New Zealand has confirmed a liking for problems in which students can see the connection between the statistics and their lives (Purser and Wily, 1992).

The numbers of Maori (indigenous New Zealanders) in these classes are too small to draw any statistically significant conclusions but some indications exist. A regression question relating pre-historic cave art in France to incidence of mammoth bones was chosen by a greater proportion

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of Maori students than European students and some Maori students did very well in this question. It seems reasonable that there are questions that are significant and meaningful to various ethnic groups and which enable them to demonstrate their knowledge. Furthermore, of five undergraduate first year mathematics or statistics courses offered, STAT193 was the only one to have more Maori female students than Maori males.

3. Course work

Success in the final examination, however, is not entirely due to the content of the examination. The courses themselves have differences. The nature of the weekly assignment problems in these courses differs. All assignment problems for three years were categorised into three groups: firstly, abstract and traditional (urns, dice, $P(A \cup B)$, coins, ...); secondly, problems about people and animals (blood pressure, bacteria, ...); and a category of non-traditional and non-abstract problems whose content could be seen as belonging to that sphere of activity that is traditionally thought to be appropriate to males (Morse code, football matches, the stock market). Over the three years STAT131 has had up to a quarter of its assigned problems from the 'boys world' and close to a quarter framed in terms of people or animals. STAT193, however, has had less than one eighth of its problems from the 'boys world' and between fifty and eighty percent have a people or animal context; i.e. there is far more emphasis on people problems in STAT193 throughout the course.

This suggests some reasons why female students might be preferring STAT193 as there is much research to show that "the most influential factor in girls attitudes to study is whether the subject is perceived as a 'male' or 'female' subject" (The Royal Society, 1986).

Another difference is in the staffing of these courses. STAT131 has three male lecturers while STAT193 has two male lecturers and one female lecturer. An exploratory study of 102 STAT193 students in 1993 strongly suggests (89%) that the students themselves do not believe this to be a factor.

4. The exploratory study

In 1993 a sample of 102 class members participated in an exploratory study which consisted of ten pairs of statistical questions. For each pair students were asked to specify which of the two options they felt that they would prefer to answer if they were required to or if they had no preference. They were also asked if they could say why they chose

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particular options.

This study clearly indicated that in some areas the students had very definite preferences (70% or more of the group) for particular contexts over others. In particular, problems involving money, the stock market, investments and any allied topic along with engine parts and other machinery oriented problems were soundly rejected by this group of students. This in part reflects the bias of these particular students who are not taking commerce courses or engineering but the strength of the reaction was a little surprising. There were further indications that no matter how relevant a question seemed on animal or botanical issues, if the question was in competition with a question involving people, then the people question would be preferred. This was highlighted when a choice between a question on soil types and one on blood glucose levels in diabetics was offered. Of those students that had a clear preference, twice as many opted for the question involving the diabetics. This was further illustrated by a question in which they had to choose between the contexts of a political opinion poll and the incidence of sheep intestinal cancer in New Zealand. These are both current and relevant issues. Forty three of the respondents would rather attempt the opinion poll question, forty three were neutral and only sixteen opted for the intestinal cancer. These results cannot be entirely explained by the relative proportions of social science to biology majors in the group (2:1). For those students able to explain their preference the criteria were clear and very similar. Those preferring the sheep cancer stated: "it's more interesting", "I'm interested in biology not politics", and "I'm not going to vote Alliance". Reasons given for preferring the opinion poll option were: "I can relate to it" (2), "I can vote so it affects me", "it's a current event" and "option B is gross". This also serves as a useful reminder that 'relevance' must not be the only consideration. Topics such as the destruction of the ozone layer may add relevance to our classes but we should be sparing in the use of such material so that statistics doesn't become irretrievably associated with the unpleasant (Clark, 1990).

This study confirmed results found by Purser and Wily (1992) with high school students. In particular that no matter how interesting an example is, if it is in competition with a standard, recognisable problem then the standard problem is preferred. The example used in the study is shown below. Students had to say whether they would prefer to do problem A or problem B or whether they had no particular preference.

A. The town of Muddleton is well known for its complicated oneway streets and complete lack of signposting. A diagram of the main routes through Muddleton is shown below.

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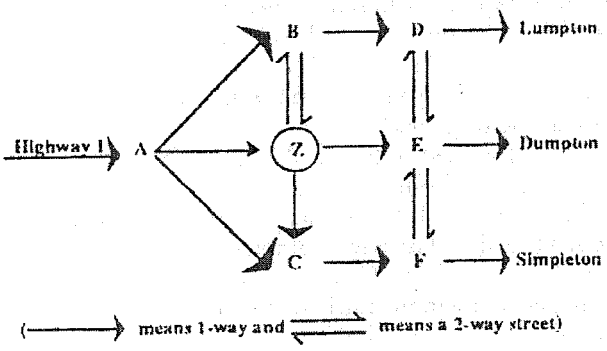
Mr V approaches Muddleton along Highway 1, and is aiming to leave it along the road to Simpleton. Each time he approaches a cross road his wife randomly selects (with equal probability) any one of the choices open to him (U-turns are not permitted). Thus, approaching S, with probability 1/3 he takes the roads to B,Z,C. Approaching B from A, he goes to D or Z with probability 1/2 each, etc.



What is the sample space associated with the "experiment" of driving through Muddleton? List out all possible points (i.e. routes) and find the probability associated with each.

B. An urn contains 4 balls coloured black (B), white (W), red (R) and green (G) respectively. Three balls are drawn, one at a time, without replacement, and their colours noted in order of selection.
Twelve of the simple events for this experiment are:
(B,W,R), (B,W,G), (B,R,W), (B,R,G), (B,G,R), (B,G,W), (W,B,R), (W,B,G), (W,R,B), (W,R,G), (W,G,B), (W,G,R).

By using trees or otherwise, list the remaining simple events and their associated probabilities.

Seventy-one of the 101 respondents to this question were clear that they preferred option B, sixteen had no preference and only fourteen expressed a wish to do option A. Many of the comments were quite revealing: "I like the urn problem, it reminds me of junior school", "seems simpler", "more like what's been taught", "more concise", "clearer", "easier", "less problem solving", "looks familiar", "tree diagram process is much more familiar than following the highway and road diagram", "cliched".

However one of the few Maori students in the class when opting for A stated: "related to everyday life" and another student stated that: "B is

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pointless".

This is not a simple situation however. It might be argued that the male driver and topic of vehicle routes would deter many female students from option A but the proportions of males and females choosing option B (and the other options) were not significantly different. Furthermore, this problem is rather typical of many spurious problems that ostensibly provide a relevant context. Option A is presented with a diagram, which to a few (4) seemed helpful but to some other students (4) in this class it was clearly perceived as a hindrance and reasons given for not preferring this option were:
"diagram"; "less words and I wouldn't need to take time in figuring out a diagram"; "look at the diagrams!".

A number of students (8) indicated that the comparative brevity of option B was the deciding factor.

However, the problems that students prefer as test items are not necessarily the same as the illustrative examples that they would prefer in class or the ones that they actually opt to attempt as was seen in the discussion of student choice in the final examination.

The indications at secondary school are that female students are doing better at problems that have "meaning and significance" (Howson and Mellin-Olsen, 1986) for them (Clark, 1993a). Purser and Wily (1992) in their work with high school students comment on "how much the students, particularly girls, were influenced by the gender orientation of the context of the question". We should probably proceed on the assumption that the situation is no different for university students. The exploratory study suggests that for straight from school students, the young women are less likely to have no preference among the options than young males tending to confirm the suggestion that context matters more to them ($t_{67} = 1.988$). This implies that we should present problems that make all groups feel at home in their statistics classes.

When the students were asked which they would prefer of an analysis of variance involving psychological test scores or one involving strengths of concrete mixes, 41% chose the test scores, 47% were neutral and only 12% opted for the concrete mixes. This was consistent with results from 1991 when students were required to choose one of these two as an assignment problem. Then 64% chose the psychological test scores and 36% the concrete mixes. In 1991, women were more likely to take the second option if the first was about concrete and overall 73% females took the psychological test score option and 53% of the males. In 1993, of the non-neutral responses, 74% of females and 84% of the males chose the test score option while males were more likely to be neutral (51% versus 44%) than females.

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5. *Assessment types*

Not a great deal of work has been done so far with student preference and performance in different assessment modes. Until this year the STAT131 course has had no internally assessed component. However, the STAT193 course has a large internally assessed component: the Data Assignments. These consist of five linked assignments throughout the year all performed on a single data set. These data sets are specific to an individual student and consist of data on a set of hypothetical mothers and newborns from a region in a year and includes information on gender, weights of mother and baby, mothers' smoking habits and socio-economic group. Throughout the year the students investigate this data set. While some specific questions have to be answered these assignments are much more open ended than a traditional assignment, the student has much more control over what they decide to do, the material of the assignments is all ostensibly within a relevant social context and collaboration on the work is possible and appropriate up to a certain point. Furthermore, the results of these investigations have to be written up clearly. Thus these assignments can be seen as not as competitive as the final examination questions and much less threatening. If a student gets a very low score in one of these, there are four more in which to recover a respectable grade. These qualities are all qualities that the literature (Ministry of Education, 1992; Everybody Counts, 1989) describes as "girl friendly" and this proves to be the case. In STAT193 females do significantly better than males in both the traditional timed examination questions and in these Data Assignments, but they do 'more better' in this investigational, open ended setting as shown in Fig. 1.

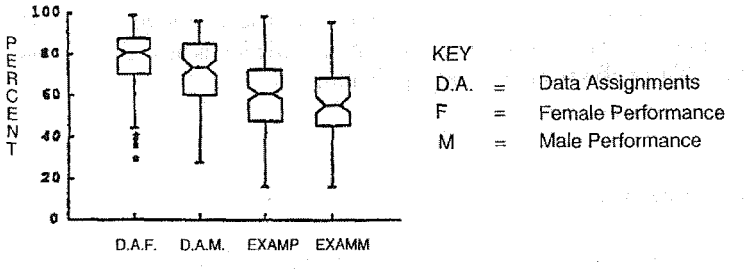

Figure 1. *Performance in examination and data assignments by gender*

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The language of examples and problems makes problems more or less accessible to the student. Given the problem in terms of people, animals and everyday reality, female students and non-technical males appear to achieve better than when attempting the same material couched in the abstract or in terms traditionally associated with industry and manufacturing.

Underachieving in mathematics has been associated with female students for a long time and they may now perceive being good at mathematics as being unfeminine (Sherman, 1987). Now statistics is not mathematics, and there does seem to be a difference in its perception by young women, at least in New Zealand (Forbes *et al.*, 1990). We must be careful not to lose this advantage by mathematicising statistics unnecessarily and too soon. In particular we should be holding on to the data for as long as we can. Some of the ways we currently ask questions and assess work may be implicitly asking young women to opt out of belonging to the group of feminine women - an untenable demand for any educator to make. It is important to set work that supports the notion that statistics is a discipline that is entirely appropriate for women.

A characteristic of female students is their avoidance of risk taking (Murphy, 1980). Lorcher (1989) describes how economically and ethnically disadvantaged girls in Germany were less inclined to attempt questions than boys and middle class white girls. Avoidance of risk taking appears to be taken to extreme lengths in the former group of students. It is imperative that we make the situation appear to be less risky, something not done conspicuously well at the moment. One way to do this is to make the questions set for examination and in class more comfortable and less threatening than at present. Negative attitudes to study are consistently related to poor academic performance (Watkins, 1982), thus university study in statistics needs to be a more comfortable and equitable experience for all students.

Since over 50% of New Zealanders in paid employment use statistics (Knight *et al.*, 1993) - it is vital that statistics is made as accessible as possible to all sectors of the population.

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