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ABSTRACT

This paper describes a questionnaire for exploring university students' approaches to learning statistics and investigates the approaches of more than 200 psychology students studying statistics. The Approaches to Learning Questionnaire (ALSQ) consists of two scales indicating deep and surface approaches to learning respectively. Three underlying factors of the Deep Scale were found by factor analysis. The first related to interest in learning statistics, the second denotes how personally meaningful the students found the topic, and the third factor relates primarily to relational understanding. The Surface Scale items indicate assessment as the primary focus. The results show that most of the surveyed students tended to adopt surface approaches to learning statistics. The paper outlines the relationships between students' approaches to learning statistics and other variables such as their willingness or reluctance to study statistics and performance in assessments. Four clusters of students were identified. The cluster profiles indicate markedly different orientations to and outcomes of learning statistics. The study raises issues concerning the teaching and learning of statistics as a service course. Three appendixes contain the instrument and two factor matrices. (Contains 2 figures and 22 references.) (Author/SLD)

ED 440 142

AN INSTRUMENT FOR EXPLORING STUDENTS' APPROACHES TO LEARNING STATISTICS

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Abstract

This paper describes a questionnaire for exploring university students' approaches to learning statistics and investigates the approaches of over 200 Psychology students studying statistics. The Approaches to Learning Statistics Questionnaire (ALSQ) consists of two scales indicating deep and surface approaches to learning statistics respectively. Three underlying factors of the Deep Scale were found by factor analysis. The first relates to interest in learning statistics, the second denotes how personally meaningful the students found the topic and the third factor relates primarily to relational understanding. The Surface Scale items indicate assessment as the primary focus. The results show that most of the surveyed students tended to adopt surface approaches to learning statistics. I outline relationships between students' approaches to learning statistics and other variables such as their willingness or reluctance to study statistics and performance in assessments. I identified four clusters of students. The cluster profiles indicate markedly different orientations to and outcomes of learning statistics. The study raises issues concerning the teaching and learning of statistics as a service course.

INTRODUCTION

Statistics education at the tertiary level is undergoing major transformation and change. One of the reasons for this is the impact of technology. Another important reason is the increasing number and diversity of students studying the subject. Many of these students are studying statistics as a service course and not all of them have an intrinsic interest in the subject. Hence an important challenge to statistics educators is to enable students, in many disciplines, to gain an understanding of statistics and an appreciation of its power as a tool for analysing the "uncertainties and complexities of life and society" (Mosteller, 1989 p. ix).

Much of the topical literature addresses teaching and assessment methods in statistics — publications tend to focus on the "knowledge craft" of university educators (reviewed in Becker, 1996). My research focuses on the task of learning statistics from the perspective of the students — their activities rather than that of their teachers (Gordon, 1995, 1998; Gordon, Nicholas & Crawford, 1996). Such research is important to determine whether teaching objectives are being met. In this paper I focus on students' approaches to learning statistics as indicated by a questionnaire — the Approaches to Learning Statistics Questionnaire (ALSQ). I analyse how students' scores on the ALSQ are related to other variables, such as gender, motivation and performance on tests and examinations.

The participants of this study were second year university students studying Psychology. Statistics is introduced in first year Psychology at my university, but it is as a compulsory component in second year that it plays a major role, contributing one quarter of the final assessment mark in Psychology II.

My interest in these students arises from my work at the Mathematics Learning Centre. The Centre offers assistance to students of the university who are having difficulty with mathematics and statistics and I take personal responsibility for teaching the Psychology

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students who come to the Centre for help with their statistics. This paper extends my previous research (for example, Gordon, 1993) by investigating the statistical learning of the mainstream Psychology students rather than just those who attend the Mathematics Learning Centre.

Theoretical Framework

My perspective derives from an acknowledgement that the quality of students' learning and their emerging statistical knowledge are closely related to students' learning activities — how students engage with the task of learning statistics in the university environment. To understand student learning I draw on activity theory (Leont'ev, 1981) based on the powerful ideas of Vygotsky (1978). In this framework, learning is viewed as a human activity that occurs in a sociocultural context. As Vygotsky (1978) proposed, there is no assumption of a Cartesian duality between self and context; between thinking and acting. This view emphasises the need to shift attention away from considering learning statistics as an individual enterprise, independent of the context, to a more holistic and relational view of the students, their actions and the learning environment.

A relational view of learning has formed the basis of much research into student learning in higher education. Early work in this field identified major qualitative differences in students' orientations to study and their approaches to study in specific contexts (Biggs, 1979; Entwistle & Ramsden 1983; Marton & Säljö, 1976a). A major difference was between approaches that focused on meaning and understanding (deep approaches) and those which focused on reproduction (surface approaches). In surface approaches to learning, the student's attention and activity is centred on reproduction of knowledge that is perceived as transmitted by experts — short term instrumental goals. Self evaluation addresses the question: How can I reproduce their knowledge under assessment conditions? In deep approaches students adopt a more global and personal perspective on learning. Learning strategies are aimed at making sense of new information in terms of existing conceptions and opinions, which may be revised if necessary. In this study I explore students' approaches to learning statistics through an instrument: the Approaches to Learning Statistics Questionnaire. My interpretation of the results emphasises that a student's approach to learning is not related solely to psychological factors, nor does it characterise that individual, but is inseparable from the social, institutional and cultural contexts surrounding the learning task.

METHOD

Psychology II students at my university were asked to complete a survey on learning statistics. The survey was completed during 20 minutes of a statistics lecture near the end of the first semester with the co-operation of the lecturer concerned and was the major source of data for this study. Other data for this study included assessment results and vignettes from interviews with selected students.

My survey included questions relating to age, gender and prior level of mathematics studied; three open ended questions and a Learning Statistics Questionnaire. The open ended questions aimed to ascertain students' feelings about learning statistics and their perceptions of the topic. The Learning Statistics Questionnaire is shown in Appendix 1. The Approaches to Learning Statistics Questionnaire (ALSQ) consists of 18 items from the Learning Statistics Questionnaire as will be explained below.

Participants

The survey was completed by 279 students most of whom were female (73%). The prior level of mathematics studied by the surveyed students was higher than is often assumed for Psychology students. Most had studied Calculus at Secondary School (over 70%) and almost one quarter of those surveyed had studied mathematics at university (68 students).

The Approaches To Learning Statistics Questionnaire (ALSQ)

Background

The Approaches to Learning Statistics Questionnaire (ALSQ) was derived from the Approaches to Learning Mathematics Questionnaire developed by colleagues and myself (Crawford, Gordon, Nicholas & Prosser, 1998). This, in turn, was a modified version of the Study Process Questionnaire (Biggs, 1987). The items of the Study Process Questionnaire (Biggs 1987) refer to approaches to academic study in general. In the Approaches to Learning Mathematics Questionnaire (Crawford et al, 1998), we modified the items to refer to students' approaches to learning mathematics, as a generic field of study. The ALSQ investigates students' approaches to learning statistics — as a particular subject studied for second year Psychology. Hence the three questionnaires: the Study Process Questionnaire (Biggs, 1987); the Approaches to Learning Mathematics Questionnaire (Crawford et al, 1998) and the ALSQ represent a progression — each focusing and particularising the constructs of interest in previous investigations.

Biggs (1987) characterises a surface approach and a deep approach to an academic task by the following.
A surface approach is distinguished by:

- a view of the task as imposed, a demand to be met;
- a fragmented view of the task — parts are unrelated to each other, the task is unrelated to other tasks;
- worries about the time taken by the task;
- a lack of recognition of any personal meaning in the task;
- reliance on memorisation and ways of reproducing the details.

A deep approach reflects:

- interest and enjoyment in the task;
- a search for underlying meaning;
- efforts to make the learning personally meaningful — relating task to personal experience or to the real world;
- holistic approach — relating parts of the task to each other and to other knowledge
- theorising about the task.

The surface approach and the deep approach, as defined by Biggs (1987), correspond closely with the surface and deep levels of processing distinguished by Marton and Säljö (1976a, 1976b). Later, Marton and Säljö (1984) referred to these as surface and deep approaches to learning. Marton and Säljö (1976a, 1976b) showed that students would adopt one of two methods of processing information according to their intentions. If their aim was merely to memorise and reproduce material, or, as Biggs (1987, p. 11) puts it: "to display the symptoms of having learned", they would adopt a surface level of processing; if they wanted to maximise their understanding of the underlying meaning, they would adopt a deep strategy. Hence Marton and Säljö (1976a, 1976b) inferred a relationship between strategy and intention. What the student intends to gain from the learning determines the strategy used.

In recent research, Marton, Watkins & Tang (1997) make the point that while a surface approach to learning is often associated with rote learning, this is not what characterises it. They maintain that:

> "Rather, a surface approach is characterised by a focus on the learning material or task in itself and not, as would be the case for the deep approach, on the meaning or purpose underlying it" (Marton, Watkins & Tang, 1997, p. 24).

That is, it is the intention of the learner that is important.

Development of the Approaches To Learning Statistics Questionnaire (ALSQ)

The Learning Statistics Questionnaire contains 28 items on approaches to learning statistics (shown in Appendix 1). The 14 odd numbered items were modified items from the previous questionnaires (that is, Biggs, 1987; Crawford et al, 1998) indicating a surface approach to learning and the 14 even numbered items were derived from the scales denoting deep approaches to learning. For each item a choice of responses numbered 1 to 5 was provided. The lower end indicates that the student "only rarely" adopts this approach when studying statistics, while the upper end indicates that the student "almost always" does so. Hence, a student's score on each scale signifies how usual it was for her or him to adopt the specific approach (deep or surface) to learning statistics. I used the software package SPSS (Norusis, 1990) to carry out scale reliability analyses and item factor analyses in order to determine the internal consistency of the items and the structure of the questionnaire. These analyses are described below.

Firstly I examined the item inter-correlation matrices and eliminated items to obtain the maximum Cronbach alpha coefficients for the Deep and Surface scales. As a result of these analyses the ALSQ was defined as consisting of 18 items, twelve making up the Deep Scale and six items constituting the Surface Scale. The Deep Scale yielded α=0.86, indicating a high level of internal consistency. For the surface scale of the ALSQ I obtained α=0.70. This value is in the middle of the range (from 0.60 to 0.75) cited for studies on the Study Process Questionnaire (Biggs, 1987).

I then carried out a principal components factor analysis to explore the structure of the relationships among the 18 items which make up the Deep and Surface scales. This was followed by a varimax rotation. The rotated factor matrix is shown in Appendix 2. Four factors were identified with eigenvalues greater than 1. These eigenvalues are 5.34, 1.39, 1.43 and 1.26.

The aim of factor analysis is to account for as much of the variance as possible with a solution which is both interpretable and economical (Kerlinger, 1973). The four factors which I extracted account for 57.3% of the variance. The first factor links items from the Deep Scale which relate in the main to how interesting students find learning statistics. Factor 2 links items from the Deep Scale which suggest that students seek personal meaning from their learning, while items that load highly on Factor 3, again from the Deep Scale only, indicate that students adopt a cohesive approach to learning statistics, relating it to other material. I have interpreted these factors as FIND INTERESTING, SEEK PERSONAL MEANING, and RELATE TO OTHER MATERIAL. As the fourth factor links items from the Surface Scale only, I have interpreted it as ADOPT SURFACE APPROACH. Some overlap was found among the first three factors, all of which show high positive coefficients for items from the Deep Scale, but there was no overlap with items from the Surface Scale.

Since there was no overlap among the items loading positively and highly on Factor 4 (the Surface Scale items) and the items loading positively on the other three factors (the Deep Scale items) a two factor solution seems reasonable. The two factor solution after varimax rotation is shown in Appendix 3. The two factors account for 42.5% of the variance and have eigenvalues of 5.33 and 2.32. This factor solution supports the structure of the ALSQ I proposed above. That is, the six items I classified as representing surface approaches loaded positively and highly on one factor, and the twelve items classified as representing deep approaches to learning statistics loaded positively and highly on another, separate, factor.

RESULTS

Statistics for Deep and Surface Scales of the ALSQ

The mean item score for the Deep Scale was a low 2.19, compared to a mean Surface Scale item score of 3.43 — a substantial difference (paired $t=-8.66$, $p<0.001$, $N=264$). Moreover, for each of 214 students (77% of those surveyed) the mean on the Surface Scale exceeded the mean on the Deep Scale. This indicates that over three quarters of these students evidently adopted surface approaches to learning statistics more frequently than deep approaches.

The lowest average item scores were on the five items loading positively and substantially on Factor 1 of the Deep Scale — FIND INTERESTING. The mean item score on these five items was only 1.67 (with standard deviation 0.69, N=269). A few students even indicated on their survey papers that had a rating lower than 1 ("only rarely") been available for these items they would have chosen it.

Females had statistically significant, higher scores, on average, than males on the Surface Scale of the ALSQ. ($t=2.98$, $p<0.01$). The item mean for females on this scale was 3.53 (standard deviation 0.76, N=196) while males attained an average of 3.18 (standard deviation 0.90, N=73). On further analysis I found that while the mean item scores were higher for females than for males on all six items of the Surface Scale, these gender differences were greatest (at least 0.5) and statistically significant ($p<0.01$) on items 5, 13 and 27 (see Appendix 1 for items). This suggests more concern about assessment and a greater reliance on the authoritative view of statistics by females than by males. Average scores on the Deep Scale did not differ significantly for males and females. However, on two items of the Deep Scale: item 20 and item 22, differences were statistically significant ($p<0.05$). Both of these items are concerned with the level of interest in statistics. On these two items males scored on average somewhat higher (at most 0.3 higher) than females although the means for both sexes were low on these two items — not more than 1.8.

Approaches to Learning Statistics and Willingness to Do So

The teachers of this topic have an unenviable task. Most of the surveyed students (73%) reported in response to an open-ended survey question that they would not have studied statistics, had they been given a choice. For students who expressed willingness to study statistics the reasons most frequently reported concerned the perceived usefulness of statistics — for the study of Psychology or other subjects or higher degrees, for research or for general "real world" applications. On the other hand, students who were reluctant to study statistics reported their reasons for this in terms of its lack of appeal — to them the subject was boring and hard and they did not enjoy it. Hence, rather than reflecting opposite sides of the same coin, the reasons given by students willing to study statistics related to extrinsic factors, while the reasons given by the reluctant majority related to personal or intrinsic considerations.

On average, the students reporting that they were willing to study statistics scored substantially higher on the Deep Scale and substantially lower on the Surface scale of the ALSQ than those expressing reluctance to learn statistics ($t>5.6$, $p<0.001$ in each case). This indicates that motivation is integral to the ways in which students approach learning statistics.

Relation of Scores on the ALSQ to Performance on Tests and Examinations

Students were assessed by means of open-book quizzes and multiple-choice examinations. My qualitative investigations (interviews and responses to open ended questions) suggested four different profiles of achievement and approaches. These were identified by cluster analysis using the SPSS procedure QUICK CLUSTER (Norusis, 1990). This procedure is an agglomerative hierarchical method which is efficient in producing a solution once the number of clusters has been determined. Cluster analysis is a way of identifying subgroups of students on the basis of similarity of scores on chosen variables. Clusters are determined so that the members of each cluster are closer to each other than to members outside the cluster with respect to the chosen clustering variables. The final cluster centroids (vector means) describe the profile for each cluster.

In order to relate students' performances on assessments and their approaches to learning statistics, clustering was done on the standardised variables (Z-scores) for students' assessment marks and their scores on the Deep and Surface scales of the ALSQ. Differences between the means for the four groups were considerable on the clustering variables. Table 1 below, shows the standardised means (Z-scores) for final marks in statistics (MARK) and approaches to learning it (DEEP; SURFACE) for the four clusters.

TABLE 1

STANDARDISED AND #RAW MEANS OF FINAL STATISTICS MARKS AND ITEM SCORES ON DEEP AND SURFACE SCALES FOR FOUR CLUSTERS

MEANS	CLUSTER 1 (N=47) Higher Achievers; Above Average on Deep Scale	CLUSTER 2 (N=61) Higher Achievers; Above Average on Surface Scale	CLUSTER 3 (N=43) Lower Achievers; Above Average on Deep Scale	CLUSTER 4 (N=60) Lower Achievers; Above Average on Surface Scale
MARK	1.03 (77%)	0.62 (70%)	-0.37 (52%)	-1.1 (37%)
DEEP	0.98 (2.85)	-0.41 (1.91)	0.16 (2.30)	-0.4 (1.91)
SURFACE	-1.06 (2.57)	0.38 (3.75)	-0.50 (3.02)	0.7 (4.01)

#Raw means are shown in brackets.

Figure 1 and Figure 2, below, depict graphically the profiles for the four clusters.

FIGURE 1
MARKS AND APPROACHES FOR THE TWO HIGHER ACHIEVING CLUSTER GROUPS

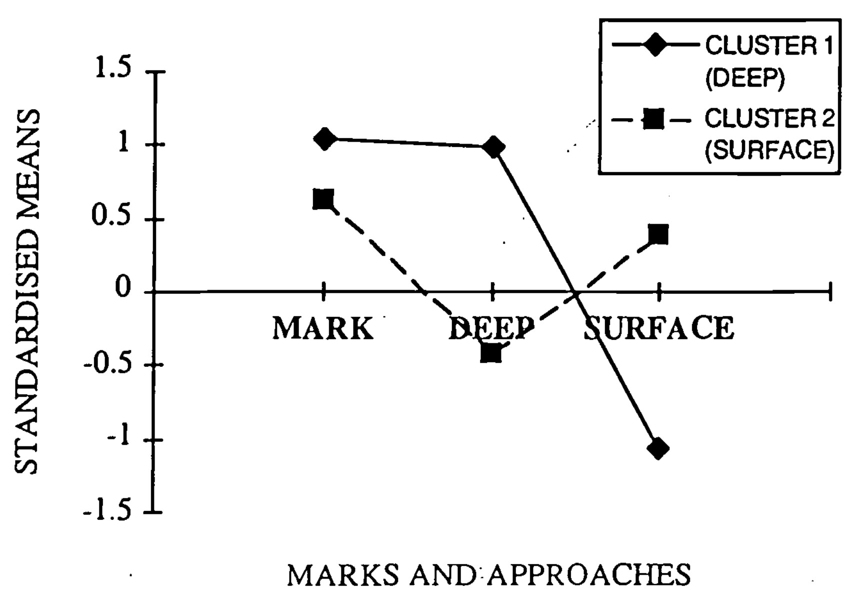

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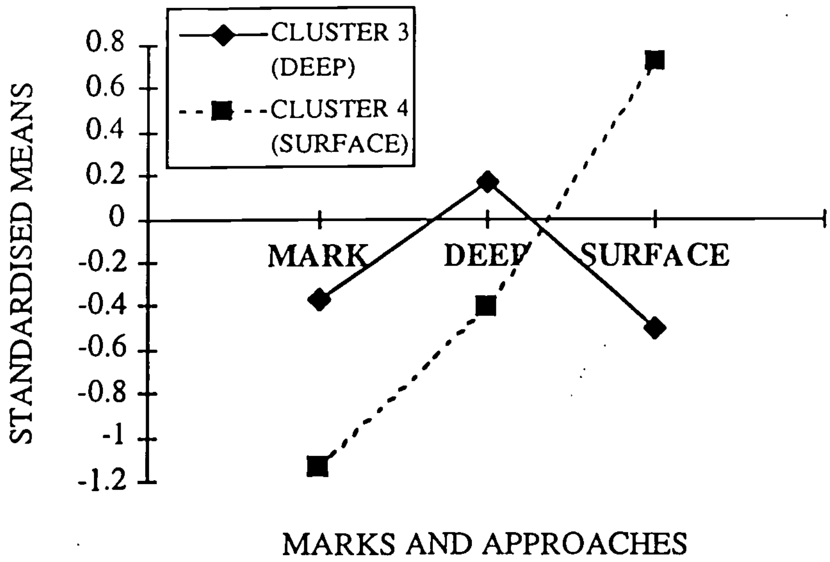
FIGURE 2
MARKS AND APPROACHES FOR THE TWO LOWER ACHIEVING CLUSTER GROUPS



The profiles of the first two clusters are particularly interesting. While both these groups of students achieved relatively high marks in statistics, attaining averages of 77% and 70% respectively, their characteristic approaches to learning were very different (see Figure 1). Cluster 1 is characterised by students who, on average, reported adopting primarily deep approaches to learning statistics, rather than surface approaches. Unlike the other three clusters, most (54%) of the students in this group expressed willingness to learn statistics. On average, the students classified in Cluster 2 evidently had a facility for learning statistics, while lacking the deep approach to learning it of their colleagues in Cluster 1. Most (77%) of them reported reluctance to study statistics.

Cluster 3 and Cluster 4 students performed, on average, at a much lower level than the first two groups, attaining averages of 52% and 38% respectively (see Figure 2). The profile of the Cluster 4 students is particularly dismal with 93% reporting that they would not have studied statistics given a choice. These students, on average, reported adopting primarily surface approaches to their learning.

Most of the males were in clusters 2 and 1 (38% and 30% of them, respectively) while females fell mainly into clusters 4 and 2 (33%, 26%).

Vignettes From Student Interviews

The profiles described above are of clusters, not individuals. Hence any individual learner may fit some but not necessarily all the characteristics of the cluster group into which she or he has been placed. The following excerpts are from interviews with students from each of the four clusters. Tilly (Cluster 1) and Ben (Cluster 2) both achieved very good results in statistics. Tilly achieved a final mark of 87.5% on statistics, while Ben attained 95%. As the extracts show, these two students had, however, quite different approaches to learning.

TILLY (Cluster 1)

> When I'm trying to summarise my lecture notes I try to integrate all the information I have on each set topic. And understand that and therefore know how to apply it. What we're doing this semester is a lot more real statistics,

how you really apply statistics to what you're doing. I think that's how psychologists would go about testing and researching these things. I want to learn it because I'm going to need the knowledge. And also — in a lot of ways it overcomes my frustration I had with maths last year. So it's a triumph, almost, to have overcome that big barrier to statistics that I had built up last year.

BEN (Cluster 2)

It doesn't so much interest me, but its easy going. You don't have to muck 'round doing reports and stuff. You can just learn it. And it's sort of half relevant to what I'm doing, and that's fine. It doesn't bother me a great deal if I don't understand, say, the exact theory behind different distributions and stuff like that. It doesn't really concern me a great deal. As long as I understand the basics and be able to just get through the questions.

Tessa (Cluster 3) despite taking the highest level of mathematics at school, achieved only 47.5% for statistics. This was mainly due to her poor performance in the multiple choice examination in first semester, where she attained only 20%. In her survey she indicated a high level of engagement with learning statistics and insight into statistical knowledge. Tessa's interview responses confirmed that she was an exceptional student.

TESSA (Cluster 3)

It's very interesting — how statistics moulds itself into psychology. Right now I think psychology's trying to become a science because of the emphasis that people put on science being the main area of knowledge. The way statistics moulds itself into psychology kinda gives psychology a basis. Like — how would you put it — like raw facts that can be analysed scientifically, I guess. In 4 Unit Maths (at school) there wasn't that much application to things in real life. A lot of it was just formula based, following the formulas, plugging in the numbers. With statistics, however, you've got an aim. In a real life situation, in society — statistics is like a tool to analyse whatever happens when you do experiments. ... It's helped me think more logically. Like inductive reasoning. It's a lot like inductive reasoning. You come up with a hypothesis and you have to follow through in order to get an answer. ... I guess that's one of the main reasons I chose psychology and philosophy. I wanted a broader view of life. Science and maths in high school was more a regurgitation of theories. I just thought that in psychology and philosophy I might be able to contribute some new ideas.

Hence, despite her low mark in statistics, Tessa seemed to have orientations to learning statistics that most educators would find highly commendable. Her approach to learning statistics seemed to have all the hallmarks of the deep approach — interest, personal engagement and relational understanding.

Narelle was classified into Cluster 4. She attained 50% for statistics, well below the 58% average for the surveyed students. Her score on the Surface Scale of the ALSQ was almost one standard deviation above the mean (Z=0.9) while on the Deep Scale she was well below the average (Z=-0.65). In her interview, Narelle indicated a preoccupation with mechanical procedures. Narelle had completed the subject General Statistical Methods in her first year of university. However, her lack of relational understanding meant that her previous knowledge of statistics was confusing to her, rather than helpful. An excerpt follows.

NARELLE (Cluster 4):

> I usually come home and have a look at what we've done in class and hope I understand it. If I don't then I'll perhaps contact my tutor, which I've only done once, or just keep doing the exercises until I work out what's going on. ... I want to be able to do it automatically rather than it be such a difficult process. ... I'd find what I need out of the problem, the mean and whatever, and then work through that — rather than read so much into the problem; what's going on with the rats or whatever. ... I'm trying to get the relevant information from the problem without being distracted by so much to think about, like the whole experiment. ... I found it just a little bit confusing because sometimes we have been doing the same sort of problem (as General Statistical Methods last year) but doing it round a different way. I found that a little bit confusing. I mean, if I'm confused then those that didn't do as General Statistical Methods last year must be really confused.
>
> I don't enjoy it particularly. I enjoy it once I get an answer out I guess, but the working out is just not my thing. I'm not a very mathematical person.

Narelle, it seems, endured, rather than experienced, learning Statistics.

DISCUSSION

On average, the participants of this study reported an overwhelming preference for surface approaches to learning statistics — for gaining an inventory of routine skills and operations at the minimum personal cost. Some of these students may have believed that surface approaches to learning statistics were expedient. Such beliefs may not be without grounds, as a comparison of the Cluster 2 profile with that of Cluster 3 indicates (shown in Figures 1 and 2). Clusters are not indicative of causes. However, they suggest a link between surface approaches to learning and success in assessments for students who have a facility for the procedures. Ben's experience attests to the success of such strategies for some. However, students who are diverted from a preferred path of deep approaches to learning toward surface approaches, perceived as strategic, are likely to feel disappointed or frustrated.

A problem of concern, both to academic institutions and to organisations which employ graduates, is what Billet (1996, p. 263) calls the: "paucity of transfer from the education setting to other situations". Billett explains this by the embedding of problem solving in the setting. The perceived context of an activity determines how it is construed. If students view learning statistics as an enterprise for gaining examination marks then the process of learning is directed towards that end. Statistics, as interpreted by the participants of this study, appeared to be overwhelmingly concerned with mastering concepts, techniques and skills in order to do classroom exercises. A lack of awareness of the functionality of these skills and processes made it difficult for the students to experience statistical thinking as personally meaningful. Within this context, statistical meaning is reduced to performance on assessment tasks. Furthermore, assessments of the sort written by these students measure a product — what students "know" as indicated by written tests and examinations. This knowledge product may not reflect a student's ability to communicate the knowledge, apply it in different situations or even remember it the following year.

The survey and interview data from this project indicate the heterogeneity of perceptions of statistics and orientations to learning it of students. However, there are tensions within the system of higher education that are more deep-seated than those presented by individual diversity. Three such tensions which seem to me particularly pertinent to statistics education are discussed below.

The first tension is between what students perceive as theoretical knowledge presented to them in the academic context and knowledge situated in statistical practice. For example, research by Martin (1997, p. 339) suggests that in a vocational setting, the factors important for success in learning statistics include:

- relating existing knowledge to the project on hand;
- drawing on knowledge from as many sources as possible via project teams;
- placing theoretical statistical ideas into the realm of "shop-floor" experience;
- relating and distinguishing between evidence (data) and argument.

These capabilities are not necessarily stressed in undergraduate statistics courses.

The second tension is between the deep approach to learning that is a goal of university education and the current conditions surrounding higher education in many countries including Australia. These conditions of dwindling resources and increasing demands on both students and staff can lead to expectations of what Grace (1997) terms "the pizza delivery model" of education. That is, conditions can lead to demands for the economical transmission of information, efficiently delivered and in a form that is easy to consume — if not to digest.

The third tension concerns the gap between the complexity and changeable nature of statistics itself in our information rich and technologically advanced era, and the less flexible resources and pedagogy on which teaching is based. Although the use of computers and other electronic and multimedia resources is prevalent in teaching statistics, these can be expensive permutations of lectures and tutorials, based on the information transmission model.

This research suggests that we need to take a systemic view of the learning environment. That is, we should consider not only the content and the presentation of statistics, but also the students' activities and the context in which statistics is taught. The aim of statistics education at university is surely high quality learning. Such learning, however, depends on students' perceptions of the task rather than just the intentions of their lecturers. Moreover, long term research is needed to explore the effect of students' approaches to learning statistics in undergraduate years on their further study or vocational practice.

CONCLUSION

My investigation raises questions about the central premises behind teaching and learning statistics at university. That is, what statistics should be taught and how is it experienced by students in an era when the rapid advance of technology is outstripping progress in solving escalating social and environmental problems? One student expressed her political awareness about the use of statistics as follows:

> "When I see a normal distribution I become a little concerned for its use. Who's fitting what into it for what purposes? Who benefits?"

Unless statistics can be more successfully embedded in the human problems that concern students — the "personal" plane — the importance of a deep approach to learning it will not be recognised and the power of statistics for solving these problems will not be appreciated.

ACKNOWLEDGEMENTS

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APPENDICES

APPENDIX 1

Learning Statistics Questionnaire

Below are a number of questions about your ways of studying statistics this year.

For each item there is a row of numbers (1 - 5) corresponding to a five point scale. A response for an item is shown by circling one of the five numbers. The numbers stand for the following responses:

1 . . .	this item is only rarely true of me when I study statistics
2 . . .	this item is sometimes true of me when I study statistics
3 . . .	this item is true of me about half the time when I study statistics
4 . . .	this item is frequently true of me when I study statistics
5 . . .	this item is almost always true of me when I study statistics

Please answer each item. Do not spend a long time on each item; your first reaction is probably the best one. Do not worry about projecting a good image. Your answers are CONFIDENTIAL, and will not be divulged to anyone teaching this course.
Thank you for your co-operation

(Note: * indicates that this item was included in the Approaches to Learning Statistics Questionnaire.)

1	I concentrate on studying statistics largely with a view to the job situation in the future rather than because of how much it interests me.	1	2	3	4	5
*2	I find that studying statistics gives me a feeling of deep personal satisfaction.	1	2	3	4	5
3	I think browsing around is waste of time, so I only study seriously the statistics that's given out in class or in the course outline.	1	2	3	4	5
*4	While I am studying statistics I think of real life situations in which the material that I am learning would be useful.	1	2	3	4	5
*5	I am worried about how my performance in statistics will affect my overall assessment.	1	2	3	4	5
6	While I realise that ideas in statistics are forever changing and knowledge is increasing, I need to discover what is meaningful for me.	1	2	3	4	5
*7	I learn some things in statistics by rote, going over and over them until I know them by heart.	1	2	3	4	5
*8	In reading new material in statistics I find that I'm continually reminded of material I already know, and see the latter in new light.	1	2	3	4	5
9	Whether I like it or not, I can see that doing well in statistics is a way for me to get a good result in second year Psychology.	1	2	3	4	5
*10	I feel that statistics becomes interesting once I become involved in studying it:	1	2	3	4	5
11	In studying statistics I am focusing more on the examples than the theoretical material.	1	2	3	4	5
12	Before I am satisfied, I find that I have to do enough work on statistics until I personally understand the material.	1	2	3	4	5

*13	I worry that even if I work hard in statistics the assessment might not reflect this.	1	2	3	4	5
*14	I find that studying statistics is as interesting as a good novel or movie.	1	2	3	4	5
15	I restrict my study of statistics to what is specifically set, as I think it is unnecessary to do anything extra.	1	2	3	4	5
*16	I try to relate what I have learned in statistics to material in other subjects.	1	2	3	4	5
17	I think it's only worth studying the statistics that I know will be examined.	1	2	3	4	5
*18	I become increasingly absorbed in statistics the more I do.	1	2	3	4	5
19	I learn statistics best from teacher(s) who work from carefully prepared notes and outline the major points clearly for me.	1	2	3	4	5
*20	I find most aspects of statistics interesting and spend extra time trying to obtain more information about them.	1	2	3	4	5
*21	I almost resent having to study statistics but feel that the end result will make it all worthwhile.	1	2	3	4	5
*22	I spend a lot of my free time finding out more about interesting aspects of statistics.	1	2	3	4	5
*23	I find it best to accept the mathematical statements and ideas of my teacher(s) and question them only under special circumstances.	1	2	3	4	5
*24	I believe strongly that my aim in studying statistics is to understand it for my own satisfaction.	1	2	3	4	5
25	I am prepared to work hard in statistics because I feel it will contribute to my employment prospects.	1	2	3	4	5
*26	Studying statistics challenges my views on how the world works.	1	2	3	4	5
*27	I am very aware that teachers know a lot more statistics than I do, so I concentrate on what they say, rather than rely on my own judgement.	1	2	3	4	5
*28	I try to relate new statistics material, as I am reading it, to what I already know.	1	2	3	4	5

Date:...............

Thank you for completing the survey.

APPENDIX 2

ROTATED FACTOR MATRIX ON ITEMS OF THE ALSQ

Note: I have ordered the items so that the six items which make up the Surface Scale are shown first, followed by the twelve items which make up the Deep Scale. Coefficients smaller than 0.44 and negative coefficients are omitted in the table in order to clarify the structure.

Decimals are correct to two places with decimal points omitted.

ITEM	Factor 1: FIND INTERESTING	Factor 2: SEEK PERSONAL MEANING	Factor 3: RELATE TO OTHER MATERIAL	Factor 4: ADOPT SURFACE APPROACH
5				62
7				62
13				59
21				44
23				57
27				79
2		75		
4			80	
8		44	46	
10		71		
14	77			
16			64	
18	47	62		
20	79			
22	85			
24		48		
26	56			
28			74	

APPENDIX 3
PRINCIPLE COMPONENT FACTOR ANALYSIS WITH TWO FACTORS, USING VARIMAX ROTATION

ITEM	Factor 1: DEEP APPROACH	Factor 2: SURFACE APPROACH
5		70
7		55
13		68
21		54
23		48
27		66
2	61	
4	48	
8	45	
10	61	
14	76	
16	64	
18	76	
20	74	
22	65	
24	67	
26	68	
28	46	

Decimals are correct to two places with decimal points omitted.
Negative coefficients and coefficients smaller than 0.2 are omitted in the table.

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