RELATIONSHIPS BETWEEN STUDENTS' EXPERIENCE OF LEARNING STATISTICS AND TEACHING STATISTICS

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SUMMARY

Students in the same statistics course learn different things, and view the role of the lecturer in different ways. We report on empirical research on students' conceptions of learning statistics, their expectations of teaching, and the relationship between them. The research is based on interviews, analysed using a qualitative methodology, with statistics students studying for a mathematics degree. Students expressed a range of conceptions of learning in statistics and a range of conceptions of their lecturers' teaching. These conceptions of learning and teaching were related, but not as closely or as exclusively as previous researchers have indicated. Looking at what students expect of teachers and their views of their own learning provides an opportunity for teachers to develop teaching practices that challenge students to move towards more integrated conceptions of statistics learning.

Keywords: Statistics education research; Learning; Teaching; Conceptual change

1. INTRODUCTION

Any teacher can tell you that it is obvious from the ways our students react in class, the sorts of questions they ask, the quality of their assessment tasks and the sorts of ways they integrate knowledge from one subject to another, that students learn in remarkably different ways. Research on learning often focuses on the ways that *teachers* understand teaching and learning (for example, Ho Yu et al., 2002; Weinberg and Abramovitz, 2000; McLean, 2000; Roiter & Petocz, 1996) based on the assumption that the teachers are best placed to make changes to the learning environment. Student evaluations of teaching, commonly undertaken by universities, quickly show that students have different expectations of what teaching should be about (Biggs, 2001). In investigating the problems of statistics education, some writers currently refer to a pedagogical 'reform' (Moore, 1997; Garfield et al., 2002) and discuss changes in content and methods of teaching, including explicit reference to the roles of assessment (Garfield & Gal, 1999) and attitudes (Gal et al., 1997). Many of these articles investigate and make comment about the teachers' perspective, implying again that changes and developments in teaching practice will result in some sort of change in learning. While these are important components, our approach has focused on investigating *students' understanding* of their own learning. Investigating the different ways that students understand learning in statistics will inform the current debate about the nature of reform in statistics

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education. We have previously reported on a study of the variety of different ways that statistics students understand learning statistics (Petocz & Reid, 2001) and teaching statistics (Petocz & Reid, 2002), and how students' epistemological beliefs about learning are related to a series of learning strategies and intended outcomes. Often, research of this kind focuses on teachers' beliefs about student learning, or students' understanding of their learning. Here we report on another component of our investigations, extending the scope of the previous discussions to explore in greater depth the relations between students' conceptions of learning statistics and their conceptions of teaching.

Kember (2001) has reported a relation between students' beliefs about learning and teaching with 'novice' and 'expert' part-time distance education students in Hong Kong. He concludes: "Overall this study has concluded that this set of beliefs about knowledge, learning and teaching is a fundamental factor in determining how well students cope with higher education and what they get out of it" (p.220). A similar relation was described by Beishuizen *et al.* (2001), who found that school-age children defined the characteristics of good teachers as personality and ability. They suggest that: "It is important to find out what students think about good teachers. Misunderstandings about mutual views of teachers and students may harm the efficacy and efficiency of teaching and learning" (p.186). Although our context is different, this study adds to these findings. We have also found a relation between students' conceptions of learning and teaching, and these conceptions of teaching (but not learning) have a strong affective component. Intriguingly, our study suggests that our statistics students consider teachers' enthusiasm for the subject and for their students to be a fundamental characteristic of good teaching. We describe the ways in which this, and students' other conceptions of teaching, are related to their understanding of learning.

Our research is based on interviews with 20 students from a first-year statistics class and a third-year class in regression analysis. All these students were studying on-campus, undertaking a degree in mathematics, with possible specialisations in statistics, finance or operations research. Each group was informed about the nature and aims of the project, and students were randomly selected from amongst those that had agreed to possible participation. The study was approved by the Human Research Ethics Committee of the University of Technology, Sydney, and the illustrative quotes that we use from the interviews are labelled with pseudonyms to avoid identification of individual students. We acknowledge the essential part played in the project by the students themselves.

These interviews showed that students expressed a range of conceptions of learning in statistics, some of them limiting, others expanding their view of statistics. It also showed that students expressed a range of ways that they experienced teaching, and that their ways of experiencing learning statistics and their expectations of teaching were related. In this paper, we summarise students' concepts of learning statistics and their conceptions of teaching statistics. We then discuss the relations between these two sets of conceptions, make comparisons with previous findings, and draw some implications for the continuing development of quality student learning environments (Reid & Petocz, 2001).

2. METHOD

Our choice of methodology – phenomenography – looks at how people experience, understand and ascribe meaning to a specific situation or phenomenon (Marton & Booth, 1997). Phenomenography can provide a rich description of an object of study through an emphasis on describing the variation in the meaning that is found in the participants' experience of the phenomenon. The outcome of a phenomenographic study is a set of logically related categories. These categories and the relations between them provide the *outcome space* for the research. The categories are usually reported in order of their

inclusivity and sophistication, and they are defined by their qualitative difference from the other categories. However, it is the structure of the variation across the *group* that emerges through iterative readings of descriptions of the experience.

Data are typically collected through a series of in-depth, open-ended interviews that focus on allowing each person to fully describe their experience (Bowden, 1996; Ashworth & Lucas, 2000; Dortins, 2002). Questions are designed to encourage the participants to think about why they experience the phenomenon in certain ways and how they themselves constitute meaning of the phenomenon. In this case, students responded to questions on learning statistics: "What do you aim to achieve when you learn about statistics?", "What would you say learning in statistics was about?", "What do you do when you learn statistics?", "How do you know when you have learned something in statistics?". They were also asked questions about their perceptions of teaching: "What are your teacher's responsibilities?" and "How does your lecturer's teaching affect your learning?".

The questions were designed to focus students' awareness on different aspects of their experiences of learning and expectations of teaching, and were followed by responsive probing questions. The categories of description were developed on the basis of the range of responses. Interview transcripts were read by both authors, categories were suggested, refined and checked by repeated reading, and the final categories were confirmed by identification of appropriate quotes in the transcripts.

It is important to be aware of two important points when using this method for investigating people's experience of a certain phenomenon. Firstly, the outcome space describes a distillation of the *group's* experience and does not seek to describe one single person's experience. Secondly, this description of experience is situated; the participants are encouraged to focus their responses in relation to the specific investigative context. Hence, the categories describing variation in conceptions of the phenomenon represent a 'snapshot in time' in a specific context and do not represent a static view of any single individual.

Finally, for the purposes of this paper, we returned to our original transcripts once the initial categories had been obtained, and reanalysed each of them with the phenomenographic outcomes as the 'unit of analysis'. This process, which is an extension from the primary methodology, enabled us to consider the relations between a student's most integrated and sophisticated conception of learning statistics and their broadest conception of teaching statistics. It is *very important*, however, to recognise that these transcripts – and our decisions about them – only represent students' responses *at the time of interview*, and may not now represent the current state (and certainly not the permanent state) of any individual student's understanding of learning or teaching statistics. In fact, we would expect that, through the students' learning and our best teaching methods, they would develop their approach to learning, and maybe change their conceptions of teaching from time to time.

3. CATEGORIES DESCRIBING STUDENTS' CONCEPTIONS OF LEARNING STATISTICS

We have previously described students' conceptions of learning statistics in Petocz and Reid (2001). It is important to note that these categories are inclusive and hierarchical; they move from the most limited (Conception A) to the broadest (Conception F). Students who typically describe the more inclusive conceptions can use characteristics of the less inclusive conceptions if their perception of the situation demands; the reverse, however, is not generally true (Reid, 1997). Each conception is a complex relation between students' ideas about the subject, and their learning intentions and approaches. (A more detailed description of students' conceptions of *Statistics* appears in Reid and Petocz, 2002.) With each

conception we have provided succinct quotes from the students' transcripts to illustrate the main characteristics of the category; these quotes are given verbatim and where interview questions are included, they are given in square brackets. Table 1 (below) shows these categories as one dimension of a table showing joint conceptions of learning and teaching.

3.1. CONCEPTION A– DOING: LEARNING IN STATISTICS IS DOING REQUIRED ACTIVITIES IN ORDER TO PASS OR DO WELL IN ASSESSMENTS OR EXAMS

Here, students focus on activities they have to do as part of their subject, which they think is sufficient to pass. They approach their study by attending lectures, reading, doing labs, repeating questions or examples until there are no mistakes, or doing previous exam papers. They aim simply to do well in assessment tasks and the exam.

Anne: *Well I think that the way in which they structure the course usually what happens is they have the revision before the exam, which is a good thing because most of the time it reinforces ideas and the main point that you are supposed to learn and also it forces you to study before the exam, and I think that is a very good thing for my case. … The truth is, I just learn what they teach me and I am not really sure about how broad statistics is yet.*

Hung: [How do you know you have learnt something in statistics?] *By doing different questions relating to the same problems over and over again without having to look back or getting any mistakes in them. … If they are going to cover a lot of the course in the final exam then it is probably better if they give out points relating to that at the beginning of the course.*

3.2. CONCEPTION B– COLLECTING: LEARNING IN STATISTICS IS COLLECTING METHODS AND INFORMATION FOR LATER USE

Here, students focus on gathering information, absorbing methods, increasing knowledge, and stockpiling examples or ideas. Students with this conception understand statistics to be about a group of techniques that need to be acquired in order to be used 'later'.

Emma: *It is furthering your knowledge, increasing what you know or coming across something you haven't thought of before. And remembering it for the future, putting it away somewhere. … I do all the examples, I think I learn by example, I read through the theory but I find that doing as many different types of problems as possible especially in statistics, like every different problem seems to pose a different way of doing it. I just try to do as many different problems as I can and I think I usually feel most confident when I have been able to do all the problems that I have been able to find if we were given past papers, or if we were given examples all through the book. If I can do all of them, then I am happy.*

Natasha: *What's learning?* (long gap) *Learning how to… hmmm…Going through the process of doing that, gathering… going through the… using stats, using your lecturer, that's learning. It's collecting information that in the end after you've absorbed everything you are able to use whatever you need to… It is very abstract.*

3.3. CONCEPTION C– APPLYING: LEARNING IN STATISTICS IS ABOUT APPLYING STATISTICAL METHODS IN ORDER TO UNDERSTAND STATISTICS

Here, students believe that actually carrying out the statistical activities provided will enable them to understand the subject of Statistics. They focus on doing practical things like examples, checking results and getting problems correct. In this regard their *approach* looks

similar to Conceptions A and B: it is different, however, as their intention for their learning is to understand the subject Statistics.

Danny: *I try to focus on giving something a practical example in my own mind so that I can understand it. I can't, I would love to be able to rote learn things but I can't do it, I have to actually understand the concept to, get some sort of example or some kind of visualisation of it.*

Anne: *It was regression where it showed me the whole picture and that is when I understood that is what I was learning, and it is like oh that is how I use it. That's what I think every subject should have, to show how it is used in practice rather than just the theory.*

3.4. CONCEPTION D– LINKING: LEARNING IN STATISTICS IS LINKING STATISTICAL THEORY AND PRACTICE IN ORDER TO UNDERSTAND STATISTICS

This conception focuses on linking theory with practice. Students intend to find out how the practical exercises can inform their understanding of statistical theory, and vice versa. Students describe an intention to use statistics in 'real life' situations and they enjoy trying out their ideas on 'real' data.

Joe: *It is very important to be able to perform well in the laboratories side of things because if you only have an elementary understanding of the theory, of how it will work, it is actually the doing of the problems in regression analysis that is really important than understanding the theory behind it. The theory is important, it lays the foundation for the actual real world problems. You are not going to make money in the real world as a stats consultant or as an analyst knowing the theory behind the work. Whereas if you can solve a business's problems, that is more important I feel.*

Lucia: *Do the lab sheets, read text book and lecture notes. I think that helps me understand more by reading the text book and lecture notes, by doing the lab. It helps me understand more deeply about the information that I have read from the text and the lecture notes, in other words, reading gives more knowledge about statistics, doing labs gives more practice.*

3.5. CONCEPTION E– EXPANDING: LEARNING IN STATISTICS IS USING STATISTICAL CONCEPTS IN ORDER TO UNDERSTAND AREAS BEYOND STATISTICS

Here, students intend to connect statistical concepts with other areas. They aim to understand what they are doing, the meaning of data summaries, the broad subject area, and the real world meaning of what they are doing with numbers. They can see how statistics can be used outside the subject area or even outside the university context.

Paul: *I want to achieve understanding of what statistics actually means and how you interpret statistics in the real world and what is the value of statistics. … All I want to achieve is how to get in-depth understanding of what statistics is. … What I try to do is I try to apply the academic theory or concept into work and see if it is helpful or if it makes sense at work too.*

Jessica: *I guess, basically, by getting an answer right in the textbook or something, but also, like, when you do the work and also when you discuss with the lecturer, like, if you've got any problems you can go to the lecturer and you can ask them, and if you're on the right track then you know you're learning, I guess, and also just when you can find…, like, you can always get an answer from the textbook, but it's only when you start to understand it that you*

appreciate something, I guess, like…, I don't know… it's just like understanding the whole concept surrounding it, and things like that, and you're able to connect things with other things, like connect… just different aspects of what you're learning to something else and eventually figuring it out by yourself, and whatever…, something like that.

Chris: *With statistics, … it also helps me understand more in some of the financial models that are being used nowadays, whereas they don't teach it in business subjects. They might give you a brief explanation, 'blah, blah, blah', what it is, but they don't go in depth, and when they don't go in depth you don't get such a great understanding of what it is all about, and because I have done stats subjects it helps me understand a lot more. Even though the lecturer might not teach it, when I do my own reading, it actually helps me understand the context of that business subject, so it ties in with business and finance related subjects, so that's good for me.*

3.6. CONCEPTION F– CHANGING: LEARNING IN STATISTICS IS ABOUT USING STATISTICAL CONCEPTS IN ORDER TO CHANGE YOUR VIEWS

This is the most expansive and inclusive conception. Students focus on the changing quality of their own understanding of the broad idea of statistics and of the world. They see statistics as an intellectual tool that can be used to inform their understanding of many other areas, or to solve problems in other areas. They believe that their study of Statistics pushes them to change the way they view the world.

Lily: *I guess, you look at things differently when you have learned something. Like you know, this is totally non statistically based but if you learn about photography or light or stuff like that and how light focuses, I guess you'll always look at light differently. So whenever you see data and whenever you see graphs and things like that then you can look at them a little more critically. Then you look at tricks people use to change data and manipulate data.*

4. CATEGORIES DESCRIBING STUDENTS' CONCEPTIONS OF TEACHING STATISTICS

Our analysis of the transcripts identifies five qualitatively different ways in which students understand teaching in statistics. We have previously described these conceptions in Petocz and Reid (2002). As for the conceptions of learning statistics, they are presented here in an inclusive hierarchy from the most limited (Conception 1) to the most expansive (Conception 5). Table 1 (below) shows these categories as one dimension of a table showing joint conceptions of learning and teaching.

In the first conception, the focus is on the organisation and conditions for successful study.

4.1. CONCEPTION 1– PROVIDING MATERIALS, MOTIVATION, STRUCTURE

Here, students expect lecturers to provide them with good quality materials (e.g., course guides or lecture notes), motivation (e.g., interact, be enthusiastic, not boring); or structure (e.g., lectures for theory and labs for practice).

Jessica: *If you have any problems, even at the last minute, he'll always help you out, like, he'll tell you what to learn or what to do, so it's also like a personal kind of interaction with the students, not only just like a lecturer standing up there and teaching, or whatever, and like just… Obviously, he helps with the lecture notes and stuff like that, which is good, and*

then just when we get into the labs, he's always around and he helps around there. Like, he comes up and helps; it's personal, so it's no…, you're not so detached from your work and you feel like getting into it. I think it's good when you've got a lecturer that gives you motivation, and gives the interesting side to the subject…, basically, what I've said, it's just a personal thing.

Lily: *I guess they should turn up and have an air of approachability. If they are not approachable if you have a problem then you won't approach them. I think that's pretty important. We have had a fair few lecturers, and some of them are kind of egotistical and you just can't approach them and if you do ask them a question you feel that they are looking down at you in a very stupid way, which is pretty bad. And they are very intelligent people so maybe it all comes naturally to them. I think social skills should be part of it.*

Melissa: *For regression analysis last semester we actually had lab times, so we'd have our lecture and then we would actually go into a lab and apply that straight away, so we would know what is actually going on. We would see the link between theory and practice. And also in Maths because it is such a small group we do have the one to one part as well in the labs and lectures. They even know your name, which is nice; you are not just a body. They actually do seem like they are willing to help and they actually care about your education. And they present things well. They have little booklets and things like that; you don't just learn from a textbook.*

In the next two categories, the focus is on the actual content of the course, and successful student learning within that course.

4.2. CONCEPTION 2– EXPLAINING MATERIAL AND HELPING WITH STUDENT WORK

In this conception, students expect that their lecturers will explain material coherently, providing clear guides for student work, assessment tasks, and ways of working. Lecturers should be able to deal with student problems, provide them with solutions, and review material at appropriate stages.

Anne: *He actually made a booklet so that we could read before we came to the lecture and so during the lecture he didn't actually go through each section of the book, rather he talked about tutorials in a lot of depth and he explained practical examples, so it was like if you went to the lecturer and read the book it is not the same content. So you feel you are not bored for one thing and you are getting two different sides of the same topic and it reinforces everything and you have the flexibility to read beforehand so you understand what he is talking about and I think that is one of the best ways.*

Melissa: *To actually teach things that you can apply in the real world and things like computer programs. Because you are not going to do it all by hand these days, so they have got to not only teach you the theoretical side but also the practical side, so that you can go out and actually get somewhere in your job. You know a lot of theory but you just can't apply it, or because you maybe have so many variables you can't do it by hand; it is impossible. They really have to show you how to use programs and what sort of things to look for in a program and commands.*

4.3. CONCEPTION 3– LINKING STATISTICAL CONCEPTS AND GUIDING LEARNING

In this conception students expect that lecturers will link statistical concepts by clarifying, explaining, elaborating on ideas, especially in unusual or different situations, and making connections between areas of the course.

Helen: *No matter how well read or intelligent that the lecturer may presume or the audience of students is really, the harsh reality of it is that the students, most of them are there to learn really a concept for the first time and really because they had a bit of background in the subject they don't really have any great idea about what the subject may be about. There may be some grey areas in that subject but simply the lecturer would need to go back on, elaborate on… and being able to make a smoother transition from one concept in a subject to another concept in the subject is really the key point to learning for students. Being able to relate one concept or idea closely to another is what really weaves all the different subjects together. … To me, the important thing is that the lecturer can bind them altogether and show how one relates to the other, why this is important, why that goes hand in hand with the other and so forth.*

Chris: *I believe that their responsibility is to communicate the subject matter to us. They have to be able to communicate well, and basically teach us what the subject is about. They need to teach us the theory bit first, and then teach us how it's applied, and walk us through different examples and situations that we might get, and also you know how in some situations you can apply a certain theory, but then there's always a 'but' to it. I think they need to show us a few of the 'but' examples. So, basically, I believe that their main role is to communicate the point to us and help us to understand the subject matter, that's what I think the lecturers are there for.*

The next two conceptions have a focus on the students themselves that goes beyond their learning in a specific course or subject.

4.4. CONCEPTION 4– ANTICIPATING STUDENT LEARNING NEEDS

In this conception students expect that the lecturers will focus on the learning characteristics of each student in order to provide materials and methods that will best suit their learning needs. Students expect their lecturers to be teaching professionals, know the best methods to teach certain concepts and know what to do when students don't understand certain ideas.

Chris: *Some lecturers are incredibly passionate, like some of our stats lecturers in the maths faculty, they're really passionate about what they do. And because of that, they really help us to get the point across. They get the point across really well because first of all they know what they're talking about, and second of all they're very experienced, so they probably know what goes through a student's mind. They probably know how the students react to different subject matter. So powerpoint presentations do help, also the lecturer's tone, and I guess to me that's just about it; how the lecturers feel about their subject matter does help as well.*

Emma: *I think a teacher's responsibility is to have some idea of your capability and, even though I know it's sometimes impossible in a class of 200, in a small class, just what your students' strengths are, to know how best they respond to… if you're teaching a class in regression, knowing the best way to teach that subject. So, know the subject well enough to know the best way to teach it and the best way it should be learned, so whether it is by example to… to have the material well thought out, to just to be good at what they do, but to*

know it well enough to know the best way to get it across to a group of people. ... Going through the examples and not getting stuck on the finer points, leaving that up to the student to do their own reading, but ramming home the important points in the topic. What makes the topic different.

4.5. CONCEPTION 5– BEING A CATALYST FOR 'OPEN MINDEDNESS'

In this conception students have an integrated view of a lecturer's responsibilities. They expect that lecturers will be a catalyst for their learning by showing them the importance of Statistics for general living, helping students change their view of the world, and opening the students' minds to new possibilities. This conception of teaching is different from the previous conceptions as it focuses on helping students develop high level understanding of Statistics.

Natasha: *Well, OK, different ways of looking at… well you are given data, different ways of looking at it and also helping you understand concepts and just opening your mind to… sometimes I have a one track mind so I wouldn't see a different scenario with some of the labs, different viewpoint, expanding my knowledge.*

5. LINKS BETWEEN STUDENTS' IDEAS ABOUT TEACHING AND LEARNING

Each of these conceptions of teaching or learning has been defined in terms of their qualitative *difference* from each other. However it is important to understand that there are also commonalities. Students' conceptions of both teaching and of learning statistics are inclusive and hierarchical. Students showing the broadest conceptions of teaching suggest that it is about focusing on their learning needs or helping them change their world view, but they also appreciate clear course notes, links between areas of the course and enthusiasm.

An example of this hierarchical nature is shown in the quotes from Melissa in Conceptions 1 and 2. Although she is aware of and appreciative of the materials and structure that her teachers provide, she also expects them to explain and help her with the computer programs that she uses; however, she did not make any comments about teaching that could be put into Conceptions 3, 4 or 5. In the context of her whole transcript, she was classed in Conception 2. Students showing the broadest conceptions of learning describe using statistics to change their views, but they are also able to discuss learning to apply statistical ideas and even learning basic statistical techniques. As another example, Anne describes understanding statistics by looking at practical examples in regression (quoted in Conception C) but also talks about learning by doing the required revision (Conception A); her views of learning statistics, taking her whole transcript into account, were classed under Conception C. Students showing the most limited conceptions, who suggest that good teaching is simply about the provision of materials and motivation and learning is focused on individual statistical techniques, will be happy with clear course notes describing these techniques, worked examples and lecturer enthusiasm. However, they seem to find it much harder to broaden their view to the more inclusive conceptions, to view teaching as a catalyst for 'open-mindedness' or learning as a way of changing their view of the world. Reid (1997) has demonstrated this inclusivity of conceptions in detail in another subject area (music), and it is also discussed by Prosser and Trigwell (1999, pp.108 -136).

If we look at the broad range of variation described in both sets of categories we can see that there are three main groupings in each. The two narrowest categories in learning and the narrowest in teaching form a group (AB, 1) that focuses on techniques of learning and teaching and emphasises these techniques as isolated activities; the mid-level categories

represent a group (CDE, 23) that focuses on Statistics as a defined knowledge object; and the broadest categories in learning and in teaching form a group (F, 45) that focuses on the students and beyond the subject area of Statistics. These broad groupings show that the students in this study see that there are important areas of overlap between learning and teaching: (a) a focus on techniques, (b) a focus on the subject, and (c) a focus on the student. Kember (2001) suggested that students see learning and teaching as a coherent set of activities such that if a student's study focused on acquisition of techniques then their view of effective teaching would be supplying these specific techniques.

In some aspects, the conclusions from our research are broadly similar to Kember's ideas, but in other aspects they are quite different. Our descriptive categories indicate that there is a relation between conceptions of learning and teaching. Many students, such as Tran, Pat and Helen, show broadly consistent views on learning and teaching, as shown by the following excerpts.

Tran: *I think stats is not related to any other maths subject, or any other finance subject, just find out the relation between the independent variable and the dependent variable. ... I think I still need to learn the more basic things in stats.* [What are some of the more basic things?] *Hmm, it's very hard to think, because I'm not quite get to the point. ...* [What do you think your lecturers' responsibilities are?] *They give us a lot of tutorial work and mark them. If you ask questions the lecturer will tell you how to solve the problem.* [Are there any other things a good lecturer should do?] *Give us more work before the exam like sample papers. Some problems often occur in the exam: they should give us this to practice.*

These quotes, taken in the context of the whole transcript, suggest that Tran can be grouped as A1.

Pat: [What have you found is the most important area of statistics to learn?] *Understanding where it is coming from and how to see all the problems and how to apply it to things is important. Knowing how to do examples ...* [How do you go about learning statistics?] *I learn by doing it, doing all the examples. If you do enough, like, there is no point in me reading something because I won't understand it, to apply it ...* [What do you think your lecturers' responsibilities are?] *I don't know. Some of the lecturers, they basically just read out of a book, and it can't be just that, I think it is more than that, because a lot of them what they are saying you can read it out and it is no more clearer than the text book is, they have a slightly different thing to what the book says and add to it, and answer questions. I think that is important, someone that you can like ask questions and they make everything clearer, maybe it's a bit different to the way the textbook does it because it is just another version and could make it clearer.*

Pat's quotes suggest a grouping in C2.

Helen: *I think, to be able to sum it up in one sentence, it would be that it has changed to some effect the way I am viewing the world around me. I am finding that a lot of what I do learn in lectures with whatever subject does change the way I see things and the really effective lecturers will make sure that once you have left that room where the lecture has taken place to the real world you start to see things a lot differently, you start to understand how these figures apply, because we are talking about maths here, how different equations will apply, how this changing world has come to be what it is and why it has come to be what it is.*

This single quote (which we used in our previous writing about learning statistics, Petocz & Reid, 2001, and about teaching statistics, Petocz & Reid, 2002) shows that Helen holds the most inclusive conceptions of both learning and teaching, F5.

However, some individual students seem to show less consistency in their ideas. Maybe the most extreme example is Julie.

Julie: [How do you think learning about statistics will help you in your future career?] *Err, I know I can use it for… like, particularly jobs and things like that, and sometimes I get my neighbours and so forth asking me about it, and stuff, and just general use.* [What do you mean by 'general use'?] *Sometimes, I don't know, to work out my own percentages and so forth, and statistics has helped me with that, like the probability of this happening, and so forth.* [So your own world view?] *Yeah! It changes, like, sometimes, like, like I thought always studying was about just studying to get a job, and so forth, but it changes the way you view things, and so forth; I think of things differently! ...* [What do you think your teacher's responsibilities are?] *Err, to be there when they're needed, to make sure you understand, like if they get asked. My teacher's taught me how; he's very nice, he's always concerned, and he always makes time, and that's very important. Our tutes* [tutorials] *and so forth are very interesting, yeah, I guess that's what it turned out, kind of making maths fun and statistics fun.*

These quotes, and Julie's whole transcript, show that she holds the most inclusive conception of learning in statistics, but the least inclusive conception of teaching, F1.

Another example of this type is Jessica (E1); her earlier quotes show a sophisticated understanding of learning as understanding a whole concept and making connections with other areas, but she views her lecturer's role as providing motivation, interest and personal interaction. Reid (1995, 1999) previously identified this type of "inconsistency" and postulated that students with a sophisticated view of learning can view teaching as only a single component of their learning environment. This leads to the hypothesis that students will tend to have conceptions of teaching that are at the level of their conceptions of learning, or possibly at a lower level. An examination and categorisation of all 20 transcripts, shown in Table 1, lends some general support to this hypothesis, although the sample size is too small to draw definite conclusions (nor was this the original aim of the study). Almost all the classifications are on or above the 'diagonal' (interpreted in this case as the cells A1, A2, B2, C2, D2, E3, E4, E5 and F5). The obvious exception is Emma, classified as B4: her quotes (given earlier) show that she sees learning in statistics as collecting techniques and materials for future use, but she views her teachers' responsibilities as anticipating their students' learning needs.

Table 1. Students' Conceptions of Learning and Teaching in Statistics

Learning / Teaching	A. Doing	B. Collecting	C. Applying	D. Linking	E. Expanding	F. Changing
1.Providing essentials	3		1		2	2
2. Explaining ideas	3	1	1	2		
3. Linking concepts					1	
4.Anticipating learning needs		1			1	
5. Catalyst for open-mindedness					1	1

Interestingly, a significant area of difference between the conceptions of learning and of teaching is shown in the affective component. Almost all students in our sample indicated that an important component of good teaching was enthusiasm, interest and motivation. Beishuizen et al. (2001) have also found that students see this as an important feature of teaching, and it seems to be one component in the 'attitudes and beliefs' discussed by Gal et al. (1997). Student feedback on teaching (such as the Course Experience Questionnaire in Australia) consistently indicates that students rate lecturers' enthusiasm as very important to

good teaching; however, scores on that scale are consistently independent of other aspects, such as teachers' knowledge of the subject (Ainley, 2001). This affective component seemed to be completely missing in students' discussions of their own learning. It seems that students value enthusiasm and motivation, but they believe that it is an aspect of their studies that comes from outside themselves rather than from within.

6. IMPLICATIONS FOR RESEARCH AND APPLICATION IN STATISTICS PEDAGOGY

Although our conclusions are based on interviews with only 20 students, they are supported by our broadly parallel findings in several other areas including design education (Davies & Reid, 2000) and accounting education (Jebeili & Reid, 2002), and also by the findings of other research (for example, Crawford et al., 1994, in mathematics education). Moreover, they are congruent with more general ideas about conceptions of learning such as those shown in the classic report of Marton et al. (1993) and with various aspects of the 'reform' movement in statistics education (Garfield et al., 2002). Our (and others') further research can investigate whether our broad categories remain valid in other statistics learning situations, and to what extent pedagogy utilising our findings can be effective in enhancing student learning during the course of a unit of study, or even of a whole degree.

These findings are important for the development of learning environments that can engage students' interest, broaden their understanding of statistics and enrich their own lives. Previously we have suggested that the development of learning environments must be 'total' (Reid and Petocz, 2001). Sustained change and development can only take place if there is alignment between intentions and actions of students, tutors and lecturers taking account of all teaching and learning activities, assessment tasks, and understandings about content.

The current study reveals a new dimension worth consideration; the different ways that students understand teaching and learning. The categories described show that this variation plays an important role in the way students approach their learning and their expectations for the lecturer's role. If we take these categories into account, then the development of the total learning environment will acknowledge the variation and seek to provide solutions that will enable students to change their ways of thinking about learning and teaching statistics towards the more inclusive levels. There are several things that we as statistics educators can do in response to these findings.

Firstly, we can help students become aware of the range of variation in conceptions of learning and conceptions of teaching. This may be enough in itself to encourage some students towards broader views. Any activity that allows students to explore the nature of their own learning and compare it to others in the same situation can form the basis of discussion. For instance, the 'usual' discussion surrounding assessment tasks can be directed towards an exploration of the different ways that students may tackle such tasks. Research on using phenomenographic outcomes, such as those presented in this study, has shown that simple awareness of difference can be a catalyst for change (Reid, 2002).

Secondly, we can provide activities and assessment that encourage students towards the broadest levels of learning. It is easy to construct classroom activities and assessment tasks that cater for the lower levels of learning statistics and that sit well within the realm of the lowest level of teaching statistics. For instance, a series of numbers and a request to find the mean, median and standard deviation will appear to satisfy everyone. The students have learned definitions and the technical processes to extract such information from data, the lecturer will find such a question quick and easy to mark, and the department will be likely to have a high pass rate. (Although this example may seem trivial, we observed exactly this in a

recent examination question in a servicing statistics course.) However, the same question set in a specific situation where students are asked to explain the *meaning* of these observations and summary statistics for the *people* involved (such as a client or a colleague) immediately shifts students' focus. This sort of question also implies a more reflective style of teaching rather than the provision of simple definitions and worked solutions in class, and technically-focused assessment questions that are so often the result of time pressures, constraints in content, and ease of marking. Our findings imply that to change the total learning environment teachers need also to focus on the meaningfulness of statistics, and to constantly provide a variety of tasks that relate to real, important, interesting, messy, and complex data. If there is a consistency (or alignment, Biggs, 1999) between learning and teaching intentions and activities, students are more able to change their own thinking about learning, teaching, and statistics.

To encourage the highest levels of learning, a teacher can influence students' conceptions of teaching by moving the focus of their teaching from the provision of certain essentials, to the subject itself, and most importantly to the students' own learning. While acknowledging the importance of components of learning such as assessment (Garfield & Gal, 1999) or the technology of learning (Moore, 1997), this implies less focus on the curriculum itself, and certainly less focus on the traditional concern of material to be 'covered' or 'examined'. These research outcomes are critically important for the development of effective learning materials. For example, the laboratory exercises in Petocz (1998), which invite students to engage with the meaning of the data that they are analysing using a computer package, and to communicate this meaning in a variety of specific situations, or the book 'Reading Statistics' (described by Wood and Petocz, 2002), which encourages students to 'read' statistical papers, articles, and research in a variety of areas of application, with the aim of looking beyond the data to the 'real life' meanings. Now, the focus moves towards supporting students in their own learning, holistically, and beyond the arbitrary boundaries of the subject. This, in turn, can encourage students towards more inclusive views of their own learning.

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IASE 2004 Research Round Table on Curricular Development in Statistics Education, Lund, Sweden, June 28 - July 3, 2004

The Round Table dates coordinate with those of the Tenth International Congress on Mathematical Education, which takes place in Copenhagen, Denmark 4-11 July 2004. Lena Zetterqvist (lena@maths.lth.se) and Ulla Holt will be local organisers. **Those interested** can contact Gail Burrill, Division of Science and Mathematics Education, College of Natural Science, Michigan State University, 116 North Kedzie, East Lansing MI 48824, USA, E-mail: (burrill@msu.edu).

IASE Activities at the 55th Session of the ISI, Sydney, Australia, April 5-12, 2005

Chris Wild is the IASE representative at the ISI Programme Co-ordinating Committee for ISI-55th Session, to be held in Sydney, Australia, April 5-12, 2005. As such he also is Chair of the IASE Programme Committee, which is in charge of preparing a list of Invited Paper Meetings to be organised by the IASE alone or in co-operation with other ISI Sections, Committees and sister societies. The committee will pay special attention to new topics that have been not discussed at the previous ISI Session. There is still time for you to propose a session theme for the IASE sessions for ISI55 in Sydney in 2005. Sessions that are of joint interest to IASE and another ISI section are also sought. Suggestions should normally include the name of the session organiser, a short description of the theme and an indicative list of possible speakers. Please email your proposals to Chris Wild at c.wild@auckland.ac.nz.

ICOTS-7, Working Cooperatively in Statistics Education, Brazil, 2006

We are also glad to announce that the IASE Executive accepted the proposal made by the Brazilian Statistical Association to hold ICOTS-7 in 2006 in Brazil. The proposal is also supported by the statistical associations in Argentina and Chile. Pedro Morettin <pam@ime.usp.br> is the Chair of the Local Organising Committee and Lisbeth Cordani <lisbeth@maua.br> is acting as a link between the IASE Executive and the local organisers. Scientific Committee IPC: Carmen Batanero (Chair), Susan Starkings (Chair Scientific Programme), John Harraway (Scientific Secretary), Allan Rossman and Beth Chance (Editors of Proceedings). More information from Carmen Batanero (batanero@ugr.es).