HOW STUDENTS EXPERIENCE LEARNING STATISTICS AND TEACHING ®

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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 views of their lecturers' teaching. 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.

INTRODUCTION

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. It is equally obvious that our students have different expectations of what teaching should be about. Investigating the problems of statistics education, some writers currently refer to a pedagogical 'reform' (Moore, 1997), 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). While these are important components, our approach has focused on investigating students' understanding of their own learning. We have previously reported on a study of the variety of different ways that statistics students understand learning statistics (Petocz & Reid, 2001) and how students' epistemological beliefs about learning are related to a series of learning strategies and intended outcomes. The research reported in this paper extends the scope of the initial paper to explore 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.

Our research is based on twenty interviews, analysed using a qualitative methodology, with first and third-year statistics students studying on-campus for a mathematics degree. The choice of methodology – phenomenography – supports a relational view of teaching and learning (Prosser & Trigwell, 1999) where conceptions of learning and teaching are described as an internal relation between the participants and the phenomenon. The object of the research is to describe the qualitatively *different* ways that students experience the phenomena of learning and teaching statistics. 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 (Petocz & Reid, 2001) and then describe their conceptions of teaching. We will also discuss the relations between these two sets of conceptions and draw some implications for the continuing development of quality student learning environments (Reid & Petocz, 2001).

METHOD

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). Questions are designed to encourage the participants to think about why they experience the phenomenon in certain ways and how they 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.

CATEGORIES DESCRIBING STUDENTS' CONCEPTIONS OF LEARNING STATISTICS

Students' conceptions of learning statistics have already been described in Petocz and Reid (2001). For this reason, we give a summary of the categories but not quotes from the student transcripts to support them. It is important to note that these categories are inclusive and hierarchical: they move from the most limited to the broadest. 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).

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.

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'.

Conception C – Applying: learning in statistics is about applying statistical methods in order to understand Statistics. Here, students believe that doing practical 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. The students' intention for their learning is to understand of the subject Statistics.

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.

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.

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.

CATEGORIES DESCRIBING STUDENTS' CONCEPTIONS OF TEACHING STATISTICS

Our analysis of the transcripts identifies five qualitatively different ways in which students understand teaching in statistics. They are presented here in a hierarchy from the most limited to the most expansive. In the first conception, the focus is on the organisation and conditions for successful study.

1. Providing materials, motivation, structure. Here, students expect lecturers to provide them with good quality materials such as course guides or lecture notes; interaction, motivation (be enthusiastic, not boring); or structure (eg lectures for theory and labs for practice).

Tran: "Give us a lot of tutorial work and mark them. If you ask questions the lecturer will tell you how to solve the problem. A good lecturer should give us more work before the exam like sample papers. The problem often occurs in the exam and they should give us this to 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.

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.

Pat: "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 text book does it because it is just another version and could make it clearer."

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."

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 point key 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. 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 and 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 power point 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 is 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 are 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."

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.

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 is come to be what it is. That really is how the lecturer's learning does seep into everyday life."

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 view point, expanding my knowledge."

Each of these conceptions has been defined in terms of their *difference* from each other. However it is important to understand that there are also commonalities. Students' conceptions of teaching statistics are inclusive and hierarchical. Students showing the broadest conceptions suggest that teaching is about focusing on their learning needs or helping them change their world view, but they will also appreciate clear course notes, links between areas of the course and enthusiasm. The hierarchical nature is shown, for example, in the quotes from Helen in categories 3 and 5. Students showing the most limited conception, who suggest that good teaching is simply about the provision of materials and motivation, will be happy with clear course notes 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' (as shown in detail in another subject area in Reid, 1997).

LINKS BETWEEN LEARNING, TEACHING AND CURRICULUM

If we look at the broad areas of variation described in both sets of categories we can see that there are three main groupings in each: (AB, 1) which focuses on techniques of learning and teaching and emphasises these techniques as isolated activities, (CDE, 23) which focuses on Statistics as a defined knowledge object, and (F, 45) which 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. The conclusions from our research are broadly similar: our descriptive categories indicate that there is a relation between conceptions of learning and teaching. However, some individual students seem to show less consistency in their ideas: for instance, Tran, Pat and Helen show consistent views on learning and teaching, but Emma and Lily do not (quotes from their transcripts related to learning statistics are included in Petocz & Reid, 2001). Reid (1995, 1999) previously identified this inconsistency and postulated that students with a sophisticated view of learning can view teaching as only a single component of their learning environment.

Another area of difference between the conceptions of learning and of teaching is the affective component. Almost all students in our sample indicated that an important component of 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). However, this affective component did not appear in students' experience of their own learning.

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 & 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 toward the most inclusive levels.

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'. Rather, 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 the most inclusive views of their own learning.

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