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Teachers' Conceptions of Teaching Service Statistics Courses

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Keywords
Statistics educators, Service teaching

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Introduction

Statistics education provides a singular and interesting context for reflection on and illumination of teaching and learning in higher education, and so the results of such studies are of interest beyond the context of statistics education. Statistics is taught as a major subject in its own right, but for the vast majority of students it is taught as a 'service' course in a wide range of disciplines including science and engineering, biomedical courses, business and economics, psychology, nursing and education. Hence, statistics students as a collective are a microcosm of the diversity in ability, motivation, academic and cultural background that Mann (2001) suggests is a hallmark of higher education today. Statistics educators, too, are diverse, practising in many disciplines and contexts and varying in professional orientations, pedagogic backgrounds and training.

Teaching statistics as a service course presents particular challenges to educators, as students who are required to enrol in a quantitative methods or statistics course do not necessarily have an interest in the subject and may not wish to engage with any study perceived as mathematical (Gordon, 2004). Indeed, it is well documented in the literature that statistics courses often generate anxiety (Onwuegbuzie & Wilson, 2003). However, there is much less data on a fundamental question: What do statistics educators understand by good teaching and how do they perceive the relationship between teaching and student learning in statistics?

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Research on teaching at the tertiary level suggests that teachers' conceptions of teaching and learning play an important role in teachers' intentions and practice of teaching (Martin, Prosser, Trigwell, Ramsden & Benjamin, 2000), the quality of their students' learning outcomes (Trigwell, Prosser & Waterhouse, 1999) and their conceptions of development as teachers (Åkerlind, 2003). Entwistle, Skinner, Entwistle and Orr (2000) synthesise research on understanding teaching and learning, affirming that: "a contrast has been drawn between teaching as teacher-centred and content-oriented (presenting syllabus content to be remembered) and teaching as student-centred and learning-oriented (stimulating students to think about the subject)" (p.6). Their research project resulted in the explication of a model representing an "expanded awareness of teaching and learning" (p.23). They report that the affective and cognitive aspects of conceptions of teaching worked in concert to inform an approach to teaching. In this instance, affect is taken to mean the expression of feeling towards the subject matter, a commitment to promote understanding and an empathic relationship with students, whilst cognitive is taken to mean a thorough knowledge of the subject matter and knowledge about how best to present the material grounded on knowledge about how students learn and develop.

For students, on the other hand, the important issue is discovering the interconnectedness of knowledge (Biggs, 1999). This idea has implications for the context of service statistics courses, and indeed service courses in general, where knowledge may be presented to students in isolation to the important constructs of their home discipline. Sowey (2006) has shown that students studying service statistics courses can pose challenging and searching questions, and that the posing of such questions helps students to understand the 'substantial' nature of statistics. However, the learning environment needs to be appropriate to encourage such questioning and the messages sent by the teacher are fundamental to the quality and tone of this social environment. Indeed, in this and other writing, Sowey articulates a coherent view of the relationship between teaching and learning in statistics.

In this paper we investigate the conceptions about teaching and learning service statistics of a group of international educators. Our aim is to explore the variation in these educators' ways of experiencing their teaching, to examine core aspects and investigate associated difficulties. Since we are focussing on the range of ways that participants experience a phenomenon—their collective awareness—phenomenography provides an appropriate research tool, and we provide a brief outline (for further information, see Marton & Booth, 1997).

Phenomenography is a qualitative research tool useful in diverse, current applications of education research. It is a method (Marton, 1986, p. 31): "for investigating the qualitatively different ways in which people experience, conceptualise, perceive and understand various aspects of, and phenomena in, the world around them".

In contemporary phenomenographic studies, data are typically collected through a series of in-depth, open-ended interviews that focus on allowing each person to fully describe their experience (Ashworth and Lucas, 2000). Unlike statistical sampling, participants are not considered to represent a particular population—rather, the aim of the interviews is to capture as much variation as possible (Åkerlind, 2005). The outcome of a phenomenographic study is a set of conceptions—logically related categories that describe the essential differences between one way of experiencing something and another. These categories and the relations between them constitute 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. The categories represent the variation found within the entire participant group. Hence the categories are illustrated

by quotations from transcripts, but do not represent a phenomenological (that is, a rich life-world) experience of a single individual.

The Investigation

The focus of this study is the experience of teaching service statistics as reported by the participants. Our primary research question was formulated as: What range of ideas or conceptions do statistics educators have about the phenomenon of teaching service statistics? The investigation consisted of a three-phase series of e-mail interviews with statistics educators around the world. Participation was invited through an electronic request to members of the International Association for Statistics Education (IASE) and Australian bulletin boards. Approval was obtained from appropriate ethics committees and participants gave informed consent. In this paper we confine our report to findings from the 36 IASE participants—extensive interviews totalling over 70,000 words. These participants were from many countries: Argentina, Australia, Belgium, Brazil, Estonia, Israel, Italy, The Netherlands, New Zealand, Poland, Slovenia, Spain, Uganda and the USA. Most interviews were conducted in English (one was bilingual with English questions and Spanish responses). Pseudonyms were chosen by the participants themselves and quotes in this paper are under these pseudonyms.

The interview protocol consisted of an initial series of six questions:

Q0) First, some background information please: What country do you work in? What type of institution do you teach in? What level of students do you teach statistics? What discipline areas do you teach statistics in?
Q1) Tell us some more about the context in which you teach statistics.
Q2) What do you consider to be the most important aspects of statistics for your teaching?
Q3) What do you think makes a good statistics student?
Q4) What are the attributes of a good statistics teacher at university?
Q5) What approach or approaches would help you develop as a statistics teacher at university?

A further two rounds of questions followed, each question individually tailored to elicit clarification and in-depth explanations of the participant's previous responses. Hence, the interview process was a written version of the usual face-to-face interview, but the respondent always had a record of all previous communications. Both interviewers and respondents could continue the dialogue in their own time and respondents could reflect on and expand their initial responses to questions.

Our participants taught statistics at universities in a range of contexts: from pre-degree and first year to postgraduate, while teaching methods included large-group lecturing, small research groups, problem-based learning and distance education. Serviced courses ranged from traditional areas such as health, business, engineering and psychology, through to less common areas such as theology and liberal arts. We are confident, therefore, that these interviews enabled us to access an extensive range of ideas on teaching service statistics.

Our analytic process aimed to develop categories for conceptions of teaching service statistics. The e-mail interview records were read several times by all three authors, categories were suggested, refined and checked by repeated reading, and the final categories were confirmed by identification of appropriate quotes in the transcripts. In forming these categories, personal and idiosyncratic differences were ignored: instead, we focused on commonalities in the narratives to highlight the core features characterising a conception and differentiating it from other categories. Once the

categories were identified, we used the qualitative analysis software NVivo (QSR International, 2002) to keep a record of our decisions regarding the interpretation of the interview records. This process enabled us to establish a rigour in our analytic protocol.

Findings: The Outcome Space

We will present our overall results first, followed by a detailed justification of the findings. Analysis of the transcripts provided evidence of three qualitatively different ways that teachers experience the phenomenon of teaching service statistics. These three conceptions are summarised according to their centrality or focus on 'Teacher', 'Subject' or 'Student'. The transcripts also suggested that teachers experienced different sorts of tensions associated with their work. These tensions were oriented firstly around the participants in the learning environment (the teachers and the students), and then around the enterprise in which the teachers were engaged, in particular, the relationship between statistics and the serviced discipline. The overall outcome space is summarised in Table 1, representing the range of variation (or difference) in the way that teaching statistics as a service subject is experienced by teachers. The horizontal dimension shows the conceptions, organised by their centrality or focus. The vertical dimension shows the tensions—views expressed about the roles of teachers and students (the participants) and about teaching statistics within a serviced discipline (the enterprise).

Centrality → ↓ Tensions	A. Teacher	B. Subject	C. Student
Participants:			
Teacher	Focus on self as teacher	Illuminates material	Teacher in background
Students	Students acted upon	Students' work facilitated	Students' world most important
Enterprise:			
Serviced discipline (SD)	SD peripheral	SD gives relevance	SD as a profession, including …
Statistics	Stats as techniques	Stats illuminates SD	Stats as an approach, way of thinking

Table 1. Conceptions of teaching service statistics

In common with other phenomenographic outcome spaces, we found that the structure of the conceptions seems to be hierarchical, from the narrowest 'Teacher' to the broadest 'Student' conception. That is, expressions of the 'broader' (more expansive) conception categories include expressions relating to the 'narrower' conceptions. This hierarchy arose from the respondents' reports rather than from an imposed or predetermined taxonomy, and it was checked by confirming that some transcript data classified in the 'broader' categories indicated awareness of ideas from the narrower conceptions but not vice versa. This empirical hierarchy of conceptions is the reason for the labels 'broader' and 'narrower', and for our inherent preference for the 'broader' conceptions over the 'narrower'.

Findings: Categories Describing Teachers' Conceptions

In this section we discuss the characteristics of each conception, illustrated by short quotes from the interviews. It is important to keep in mind that we are not categorising participants. In phenomenographic analysis individuals are seen as the "bearers of

fragments" (Marton & Booth, 1997, p.114) of differing ways of experiencing the phenomenon.

Conception A – Teacher
The focus in this conception is on the qualities, expertise, resources and strategies brought by the teacher into the classroom. Teaching is the explanation for learning and, by extension, it is the voice and perspective of the teacher that assumes the foreground. The students' roles are to carry out the tasks given to them in the ways prescribed by the teacher. The meaning of learning is constructed by the teacher using his/her perceptions of what students need to know. Where the dynamic shifts from the participants to the enterprise, statistics is viewed as a body of concepts, skills and techniques—underpinning the teacher's perceptions of what is essential statistical knowledge—while the serviced discipline is placed on the periphery.

The following passages illustrate the conception of the teaching-learning experience as highlighting the teacher as actor, with the students being acted upon.

John: [How do you go about teaching students to communicate statistics?] *This is important, you can't assume that they know how or what to write or talk about. Initially, you need to be quite explicit about teaching this, you need to almost give them a template: you need to list for them the things to look for, and in what order, in plots, e.g., what to look for in a scatter plot or in a plot comparing groups; you need to give them a word-template for interpreting a CI or interpreting a test result.*

Joyce: [What are the attributes of a good statistics teacher at university?] *Able to explain concepts in more than one way. Can give a variety of almost real-world examples. Knowledgeable of software. Willingness to help students outside of class.*

Where the focus is on the enterprise, educators view statistics as a discipline to be learned independently of the context in which it will be used. Statistical concepts, skills and techniques are emphasised, while the specific serviced discipline is in the background or not mentioned at all. This is illustrated in the two following quotes.

Reginald: [What do you consider to be the most important aspects of statistics for your teaching?] *Exploratory data analysis and the probabilistic aspects of sampling, errors involved, etc. The concept of inference, in particular estimation and significance. /…/* [What are the attributes of a good statistics teacher at university?] *A sound knowledge of statistics. Ability to show the basic statistics ideas and concepts without resorting to complicated maths.*

Joyce: [What do you think is essential for an introductory statistics student to take away from his or her course?] *Nothing is essential. Super-important are: some knowledge of descriptive statistics and how to make good graphics, logic of hypothesis testing, and p-value.* [Could you give some examples of what is important for classes from particular majors?] *See the previous response. This goes for all majors.*

Taken together, the passages quoted in this section illustrate a conception of teaching service statistics which is focused on the contributions of the teacher and on the particular characteristics of statistics as a discipline, irrespective of the particular discipline in which it is applied.

Conception B – Subject
In this category the focus moves from the teacher as the central component of the teaching/learning experience to the course content or subject matter itself. The role of the teacher shifts to providing illumination of the statistical material and facilitating students' understanding of that material. The serviced discipline is the context for the

statistics and provides the relevance of the enterprise, while statistics is viewed as a body of knowledge that illuminates the serviced discipline.

There are many ways of illuminating material and helping students to understand it. Horace uses vivid graphics to illuminate statistics: the first part of his quote could illustrate the 'Teacher' conception A, but then it broadens to focus on illuminating the material for students, an immediate illustration of the hierarchical nature of the conceptions. QMmale explains how he facilitates his students' work in a problem-based learning (pbl) context.

Horace: *I give lectures that are in some ways traditional in that I introduce topics, give definitions, work through examples, and try to justify and motivate everything. But I also often use my own software, which is intended to provide vivid graphical representations of concepts, multiple representations, interactivity, and in some cases simulations. For any key concept, e.g. standard error, I aim to give a take-home vivid image – the mean heap* [the empirical sampling distribution of sample means] *– that is linked to the definition, a formula, explanations, and examples. I hope the image will be the anchor for understanding. /…/ I hope students come to think more conceptually, to use the images and labels I introduce, and to feel more confident about stats and their stats knowledge.*

QMmale: *So our system is strongly based on pbl principles (and therefore: mostly learning without teaching, since most of the learning takes place outside class, with our problems, textbooks and electronic tools as learning devices). /…/* [What are the attributes of a good statistics teacher at university?] *Besides the required domain knowledge and traditional 'teaching assets': has a good knowledge of a wide range from learning tools and learning contexts so as to be able to create good learning conditions for different students. /…/ Once such an* [pbl] *approach is adapted, the role of the teacher is changed into that of 'facilitator': more in search for tools that might help specific students in their learning process, than being a tool yourself. I regard that last change as stimulating.*

Where the focus is on the enterprise itself, the quotes from Reginald and Lizzie show how the serviced discipline provides the relevance for the study of statistics; the quote from Sjefke shows how, in turn, statistics illuminates the serviced discipline. The quote from Reginald, below, also illustrates how some transcripts providing evidence of the 'Subject' conception include data (quoted in A) illustrating the 'Teacher' conception; an example of the empirically hierarchical nature of these two categories.

Reginald: [What is it about taking part in research projects that helps students appreciate statistics?] *I have had the experience of co-supervising medical students in research projects proposed to them by medical researchers in which real data had to be analysed. They were somehow surprised to see that statistics really mattered in helping the researchers making decisions (inter-observer variability, design effects, etc.). Students tend not to believe that statistics is so helpful when they do not see it applied to REAL data in REAL situations.*

Lizzie: *The main assignment I use is based on a real article from a nursing journal. The students have the article for many weeks and it is discussed in tutorials. Then I lead them through an evaluation of the statistical aspects of the article with leading questions like: what hypothesis test was used? Was it appropriate? Explain. Do the conclusions follow from the results? Really very searching questions asking them to justify their statements.*

Sjefke: A good statistics teacher has to bridge the gap between the psychological content and the statistical concise summary of that psychological content. Statistics is a

way of describing psychology in another language; it is not performing calculations at all! On the other hand, we – the statistics teachers – have to convince the psychological professors/teachers that they cannot 'skip' the empirical foundations of their theories and their statements about reality. It is a well-known fact that many (psychological) theorists skip the 'results section' in scientific articles when they discuss these articles.

The totality of passages quoted in this section illustrates a conception of teaching service statistics which is focused on the teacher as a facilitator of learning statistics firmly in the context of the serviced discipline.

Conception C – Student

In the final and broadest category, students are placed in the foreground, highlighting their voices, perspectives and concerns. The teacher is seen as part of the overall teaching context but is not the privileged aspect of the teaching/learning experience. Where reports emphasise the enterprise, the discussion is about the serviced discipline as a profession, with statistics viewed as an approach and a way of thinking for the use of a professional in the serviced discipline.

Maybe the best description in our interviews of the student focus comes from Heintje, who works in a problem-based, distance-learning environment. We include one excerpt from Heintje's interview below: more expansive excerpts from her interview follow in the next section. The quote from Margaret focuses specifically on the benefits of group work, initially in terms of helping students with their learning (as in the 'Subject' conception B) and then explicitly from the students' point of view (another illustration of the empirical hierarchy of the conceptions).

Heintje: *Thanks to communication media, our (distance learning) students now are able to work on group assignments and tasks, a social construction of knowledge. /…/ Instead of individual learning our participants will experience a zone of proximal development in which they'll generate more ideas and are stimulated to (self-) reflection. All these (virtual) experiences will stimulate the development of competencies (the combination of knowledge, skills and attitudes) that are important for their future jobs.*

Margaret: [What approach or approaches would help you develop as a statistics teacher at university?] *I think that it would be useful to learn how to effectively get students to work in small groups. To know how to develop good case examples for students to work on so that they develop their skills in a step by step fashion. To learn how to guide students and keep their interest as they go from simplistic examples to more complicated ones. /…/ If done well, small group work can help both strong and weak students: (1) stronger students get the benefit of "teaching" which makes them have to rethink a concept and figure out different ways of explaining it. This is good because it reinforces the concept for themselves, while (2) weaker students benefit because they are getting additional assistance and review. They can ask questions in a more comfortable environment than a full classroom.*

In terms of the enterprise itself, the focus is very much on the serviced discipline as a profession—medicine in the quotes from Henry VIII below—including the statistical way of thinking as an approach to professional problems.

Henry VIII: *What I try to show medical students is that, even if they don't ever intend to do any research, they still need some basic knowledge of stats in order to be able to fully understand the concepts of "statistical patterns" and "typical values", and the probabilistic nature of the decisions they have to make every moment during their practice. I try to do this by highlighting, through examples, the probabilistic nature of the patterns and decisions, and by trying to steer them away from the sort of*

deterministic thinking they are exposed to during most of the other courses they attend at college.

And, finally, César describes his approach towards making students aware of the ethical responsibilities of professionals in disciplines that make use of statistics.

César: *Nuestra disciplina se presta a muchas formas de malos usos: la muestra y los datos obtenidos de manera no rigurosa, una prueba de hipótesis realizada por la distribución normal cuando las condiciones del problema no son las indicadas, etc. /…/ Siempre les señalo a mis alumnos que 'la mentira de por sí es mala pero cuando está basada en la estadística es doblemente mala porque tiene el poder de convicción de los números y de los métodos sofisticados (esotéricos-misteriosos para el común de la gente) en los que se sustenta'. La idea es fomentar en los estudiantes el compromiso ético que requiere el quehacer estadístico.*
Our discipline is subject to many forms of misuse: collecting samples and data in a non-rigorous way, hypothesis tests carried out using the normal distribution when the conditions of the problem are not the indicated ones, etc. /…/ I always indicate to my students that 'lies are bad in themselves, but when they are based on statistics they are doubly bad, because they carry the power of conviction of numbers and sophisticated methods (which are esoteric and mysterious for many people).' The idea is to provoke in students the ethical commitment that the statistical task requires. [Our translation.]

Taken together, the passages quoted in this section illustrate a conception of teaching service statistics that is focused on the students themselves and their future profession, with the statistical approach and way of thinking seen as an essential component of that profession. This is the broadest of the three conceptions.

Findings: Illuminating the Conceptions and Hierarchy

The three conceptions: 'Teacher', 'Subject' and 'Students', described above, are a distillation of participants' collective experiences. We now focus in more detail on two specific interviews to illustrate these conceptions and how they unfold in personal narratives about teaching and learning service statistics. The more extended quotes from these interviews also support our earlier claim concerning the hierarchical nature of the conceptions. The excerpts from Andrew's interview show that much of the time his focus is on illuminating the subject statistics within the disciplines he is teaching it, such as pharmacy and medicine, illustrating the 'Subject' conception. However at other times his focus shifts to his role as instructor, taking responsibility for students' learning, and exemplifying a narrower 'Teacher' conception. We then consider excerpts from Heintje's interview. These demonstrate her primary concern with students' worlds, and a focus on students' learning from their perspectives, portraying the 'Student' conception. However, some excerpts indicate understandings in keeping with the two narrower conceptions: illuminating the subject and even occasionally foregrounding the teacher as instructor.

The excerpts illustrate the broadening of awareness through the three conception categories. They also demonstrate that an individual's understanding of a phenomenon, in this case, the experience of teaching service statistics, is not stable, internal knowledge but dynamic—playing out at different levels and different times, as expressed in the interview discourses.

Andrew's Interview: Illuminating the Subject Conception

Andrew reported teaching diverse groups of students including a *"huge first year class of 1100 students intending to enter the schools of medicine, dentistry, pharmacy and physiotherapy."* He considered the most important aspects of statistics for his teaching to be: *"an ability to call on current data sets which have been generated from local*

research or from recently published papers. Even at first year level students are surprised at the wide level of application of statistics. I believe that these applications should not be remote case studies from other sources. It is hard getting examples which are appropriate but this is where local consulting can generate interesting examples. I have recently called on examples from marine science, human nutrition and epidemiology. A guest lecture or two from scientists and others who are generating data for analysis helps make statistics interesting. /…/ It is important to convey to students the view that what they learn in a preparatory course on statistics is going to be essential for their future work in their major subject, something that many first year students do not appreciate. It is essential to cultivate the support of all staff in the departments which apply statistics and ensure they show how statistics relates to their field."

The previous extracts convey Andrew's mission to relate statistics to the serviced discipline and to enable students to appreciate the relevance and usefulness of the statistical knowledge to their future work. Rather than working in isolation, Andrew draws on expertise in the community as well as emphasising collegial support.

He went on to discuss how he used medical reports to reinforce statistical concepts taught in lectures.

"Two weeks ago the lectures introduced issues of selection and information bias, confounding and external validity. This was followed up by a class exercise which required the students to read a three page paper from the New Zealand Medical Journal on attitudes to sun exposure, tanning and melanoma among New Zealanders of all ages and ethnicity with a view to establishing opinions in the community. This study was part of a health dept funded research project. /…/ Such examples abound but they must be chosen very carefully. They must not be artificial class exercises in my view."

The above excerpts primarily exemplify the conception we have termed 'Subject'. We now quote data from Andrew's interview that fit with the 'Teacher' conception—foregrounding the teacher as instructor and his role in managing and directing the learning.

"There is a need to give the students clear and concise notes and be well prepared. Never think that you can just pick up last year's notes and present these. This usually displays a lack of interest in the subject which is easily noted by the students. Also, if very detailed notes are handed out at the start of the semester for the whole semester you must be prepared to add to these notes otherwise the feeling of disinterest can be present again. It can be good to ask questions in the lectures even in the large classes. Personally, I do not use PowerPoint in lectures but instead use two overhead projectors with pre-typed notes containing gaps handed out to the students at the start of each lecture. Students then complete the gaps during the lecture.

Almost every morning in the media there is some mention of an application of statistics, whether it be to an opinion poll or political survey (not particularly interesting) or to some health issue (more interesting). It is very good to draw attention to these reports. Recent ones which I have used relate to meningitis, screening for cervical and prostate cancer, increased incidence of diabetes and a possible relationship with breast feeding (highly controversial but interesting), folate levels in mothers of child bearing age and dolphin habitat selection and behaviour problems."

The final paragraph, above, while teacher centred, clearly indicates Andrew's broader aim of relating statistics to medical and scientific data and publications. The interview excerpts indicate the dynamic and contextual nature of awareness. As Andrew's focus

shifts to and from the subject and serviced discipline to the teacher's instructive role, different centralities of his experience are communicated.

Heintje's Interview: Focus on Students' Worlds

Heintje described her teaching as follows: *"I am supporting students in computer supported collaborative (distance) courses statistics and methodology, which are joint in special research projects."* When asked about differences between CSCL courses and face-to-face teaching of psychology statistics her response immediately demonstrated an appreciation of students' perspectives on learning, communicating and social relations.

"Most of all the explicitness of the communication and the challenge to verbally communicate and formulate everything. That means that every participant is challenged to formulate his or her messages exactly, to reflect critically on his or her own assumptions and reasoning, before sending a message to the group. The critical discourse between students about statistical and methodological issues and assumptions, and the challenge to create a (distance) community of inquiry. To build on relations with colleague students you hardly know (in real life) and with whom you're only virtually related. Because of the lack of visual cues, it is harder to express feelings that are consistent with one's intentions. Each community member has the responsibility to contribute to a body of student- knowledge, in research, as the synergetic result of virtual group work. So CSCL is a challenge in critical thinking (and reflecting) and a social challenge. /…/

The most important aspect of statistics is that students become aware of the fact that statistics and methodology actually are the origin and ground for every psychological theory they're interested in. From that point we start motivating and stimulating them in researching literature, gathering data, exploring and analyzing data and interpreting data. In this way students get familiar with all the requirements and prerequisites of a real research project and each time the student is involved in a new project, the level of his or her research project will be more challenging and higher."

These paragraphs illustrate the tension outlined in Table 1, between participants and enterprise. In the first paragraph, students' perspectives are reported as central, the focus is on their communications and interpersonal relationships. In the second, the focus is on the role of statistics and methodology in underpinning psychological theory.

In the following excerpt Heintje explicitly acknowledges and confronts this tension. She talks about challenging students' understanding and knowledge by 'embedding' statistics in research in psychology, aiming to motivate students' interest in research and develop their capabilities for 'profound' academic and methodological knowledge and professional awareness.

"Actually we don't have the goal or intention to make our Psychology students researchers, that wouldn't be very realistic. Our program has to do with presentation. Our object is to present statistics to our students embedded in research-programs and research tasks. This kind of presentation has several advantages. We use our students interests and motivation in Psychology to foster their familiarity with methodology and statistics. Our students are confronted with tasks in which they actively have to 'construct their own knowledge', supported by guidelines, resources and study paths. /…/ Linking statistics to everyday practices of psychologists makes students aware of the importance of empirical evidence and its instruments, statistics and methodology. /…/ Without this profound academic knowledge, one could also diagnose or assess with astrology or using one's intuition and make use of alternative treatments. This general awareness is an important epistemological fundament for the program."

At one point in the interview, Heintje briefly alludes to the instructors' role, but this focus on the teacher as instructor almost immediately broadens to foreground students' experiences.

"When students start with these research programs, support of their instructor is intensive, guidelines are completely provided and resources delivered. After a few different research cycles, with different accents in the research program, the need for support will decrease and student's autonomy will progress. /…/ I already explained how we connected statistics with psychological theory and translated statistics into an instrument to provide psychological insights. That corresponds to the instrumental value our students apply to statistics. But on top of that we explain them that understanding and applying statistics is a way of higher order thinking, a problem solving technique, which is essential for being a professional psychologist. In this way we have the opportunity to connect statistics with personal meaning, their future jobs, or academic skills in general, which is essential for a deeper motivation."

Summary

We have now described the outcome space for teachers' conceptions, illustrated the conceptions with short examples from various transcripts and provided two narratives indicating individual ways of experiencing teaching service statistics. We conclude the findings with data that perhaps summarise the hierarchical nature of the conceptions most simply. These data are responses to one of our interview questions: *What are the attributes of a good statistics teacher at university?* In illustrating Conception A we quoted responses to this question as being able to "*explain*" well. An illustration of Conception B was supplied by QMmale who proposed that *"creating good learning conditions"* and tools was the key. Heintje's response to this question exemplifies the significant elements of Conception C:

"A good statistics teacher will stimulate students to take their own initiatives, to become confident about themselves in doing statistics, exploring data, discussing subjects with other students or teachers. A good statistics teacher will help students to overcome their statistics anxiety and will take care for the process that they get familiar with the discipline step-by-step, embedded in a psychological context. A good teacher will also be a good listener and will seriously consider student evaluations as a means to improve the educational design." [In your teaching how do you stimulate students to "take their own initiatives"?] *"By progressively decreasing support, instructional guidelines and providing resources in the sequence of research cycles and making use of their experiences in researching and applying methods and statistics."*

Discussion and Implications

The first point, one that often arises from phenomenographic studies, is a deceptively simple one: educators—even those who are good at teaching and interested in pedagogy, as our participants undoubtedly are—have different views about their teaching. By reading through the results, individual teachers can see a range of views and can consider alternatives that they may not have been aware of previously. Further, the range of conceptions that we have found in this context of teaching service statistics is in agreement with conceptions of teaching that have been explicated in more general contexts (see, for example, Kember, 1997) on scales from 'teacher focussed' to 'student focussed'. The conceptions that we have identified in this particular context move from the teacher's focus on herself or himself, to include the subject of study, and then to include the student and their arenas.

We emphasise that we are reporting the range of conceptions rather than categorising individuals or developing criticisms of particular approaches. For one thing we

acknowledge the diversity of contexts, cultures, values, resources and constraints surrounding the teaching of our international participants. Teaching and learning are socially situated and teachers' understandings of teaching service statistics are related to their aims, experiences and positions within the arenas in which their teaching is organised. Different teaching contexts may favour different approaches. Further, the very identity of a teacher is contextual (Gordon & Fittler, 2004). It is a manifestation of cultural and historical influences at many levels and from many sources and emerges through experience and participation in specific, teaching activities.

Nevertheless, we have expressed a preference for the broader conceptions and suggest that our outcome space could provoke reflection and self-evaluation through examining the inclusiveness of the perspectives presented. Could it be that teachers who focus on a teacher-centred pedagogy have some difficulty appreciating the 'Student' or even the 'Subject' conceptions? In illustrating the 'Teacher' conception, we have quoted Joyce as talking about giving *"almost real-world examples"* and her proposal that what is important statistical knowledge: "*goes for all majors*". This contrasts sharply with insights illustrating the 'Subject' conception, such as Andrew's assertion that examples: *"must not be artificial class exercises in my view"*, or Sjefke's point that: *"A good statistics teacher has to bridge the gap between the psychological content and the statistical concise summary of that psychological content".*

According to Devlin (2002, p.135), many students believe that: "learning is a quantitative exercise in accumulating facts and knowledge to be remembered and used in 'practice'." Research into students' conceptions of statistics is in accord, showing that many students who are learning statistics focus on mastering techniques or else they view statistics as information to be accumulated and stored in order to meet the demands of assessments (Reid & Petocz, 2002; Gordon, 2004). If statistics educators convey, albeit inadvertently, a matching awareness of learning-as-accumulation of decontextualised concepts, skills and techniques, students' beliefs may remain unquestioned and unchallenged. In contrast, our interview data provide examples of how more expansive insights into teaching and learning statistics are related to teaching strategies that consciously aim to enhance students' critical thinking and to support students' professional capabilities within their chosen disciplines. Further, Summers and colleagues have shown that teaching strategies promoting group work and collaborative learning are related to the development of community in the undergraduate classroom and to students' feelings of social connectedness (Summers, Beretvas, Svinicki & Gorin, 2005). Hence, teachers who attend to and foreground students' perspectives may be able to tap into important tools and strategies for enhancing students' motivation and engaging them with challenging tasks.

The narratives from which we have quoted in this paper suggest a relationship between self-efficacy (Bandura, 1994), defined as perceived control over one's own functioning and the teaching environment, and conception of a teacher's role. This self-efficacy or agency appears to increase as the focus moves away from the teacher (teacher-as-director) as central to the teaching experience towards a focus on illuminating the subject and then on students' ways of learning. The responsibility for learning shifts towards the student and the teacher's role changes from instructor to facilitator, or even to co-learner. QMmale expressed explicitly an increased sense of fulfilment in changing his role from instructive "*tool*" to "*facilitator"* in the pbl-system, reporting: *"I regard that last change as stimulating."*

Bandura (1994) posits that an increased sense of self-efficacy leads individuals to approach difficult tasks as challenges to be mastered rather than as threats to be avoided. Heintje demonstrated this assurance in tackling the challenging task of *"stimulating students to take their own initiatives"* by *"progressively decreasing support, instructional guidelines"*.

Edwards & D'arcy (2004) extend the idea of agency, or self-efficacy in Bandura's (1994) term, to 'relational agency' meaning a capacity to both give and seek support—to work towards shared goals. They suggest that relational agency in students is likely to be enhanced by teachers who themselves experience it and call for support for the development of relational agency, not only during periods of teachers' training, but throughout practitioners' working lives, in their institutions. Andrew showed this emphasis on working collectively, saying that he sought to: *"cultivate the support of all staff in the departments which apply statistics".* Such institutional and collegial interaction and support could be a useful way to extend teachers' experiences and expand their conceptions about teaching and learning in service courses.

There are two important characteristics of the broadest, 'Student' conception: an explicit connection with the students' world, and an explicit link to the serviced discipline and recognition of this as an area of future professionalism. Our results show that teachers are well aware of the need to know their students and the world they live in, but that they associate different levels of importance to this idea. It is clear from our findings that statistics educators are required to transcend the boundaries created by different disciplinary contexts and that their levels of engagement with the serviced discipline are associated with their preferences for different ways of working with their students. There is evidence from previous studies that teachers can modify their approaches to include the broader, more holistic conceptions (Reid & Petocz, 2003). Teachers can use the outcome space of conception categories as a means of critiquing their own experience, developing "alternative perspectives on teaching" (Entwistle *et al.*, 2000, p. 24), becoming aware of and consciously considering the relationship between teaching and learning and so being alert to diverse ways of improving practice in their own disciplines.

The findings of this study suggest challenges in training and developing statistics teachers: how to promote the relationship between statistical knowledge and the professional and societal context of that knowledge; how to support teachers in the task of recognising and promoting all statistics students as active and responsible learners.

Our data show that individual awareness is contextual and dynamic, rather than internal and crystallized. The inference from this is that awareness about teaching and learning is developmental. Hence we suggest that a significant contribution of this research is the opportunity it provides to reflect on the factors impacting on our ways of experiencing teaching, particularly in a service context—how we constitute these understandings—and how we can develop our awareness of the associated challenges.

Conclusion

Our study builds on research on teaching and learning in higher education and connects it to a specific domain of pedagogy—teaching service statistics courses—that is a microcosm of the modern higher education system. The findings provide insights into the context of teaching a service course in general, and they provide a framework for understanding statistics pedagogy in particular, thus extending personal, individualistic views on teaching statistics and revealing possibilities for developing our perspectives and, with this, extending our usual repertoires of teaching strategies.

We suggest that international research, such as this, provides rich opportunities for re-thinking assumptions about teaching and learning and creates possibilities for reconceptualizing educational practices. Taken-for-granted ideas about teaching may be revealed, on reflection, as embedded in cultural or social norms and amenable to change and innovation. Further, the goal of supporting learning underpins educational practice in

any context and achieving this goal is facilitated by debate and scholarship. As a participant of this study summarised:

"One thing that I have been thinking about recently is that I would really like to see (in person) how people from across the world teach statistics and to interact more with people teaching statistics in other countries. I would love to work on research with people in other countries ... to compare how we teach large classes. I feel that we have so much to offer each other in terms of ideas."

Such communication and interaction, in person or through scholarship, helps us build an international community of practice.

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