# RECOGNISING AND DEVELOPING GOOD STATISTICS TEACHERS

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*In this paper, we examine some results from a series of interviews carried out by e-mail with an international group of statistics educators, all of them members of the International Association for Statistical Education (IASE). We asked for their ideas on the qualities of 'good' statistics teachers and ways in which they could develop as statistics educators. Follow-up questions explored their answers in depth. The responses highlight the diversity of views about recognising and developing good statistics teachers at tertiary level, an important consideration for any discussion on professional practice and certification in statistics education.*

INTRODUCTION

What makes a 'good' statistics teacher at tertiary level? How can teachers of statistics develop their professional expertise in statistics pedagogy? How can ideas about good practice in teaching statistics be shared with other teachers? In this paper, we investigate these questions and suggest answers based on a recent empirical study carried out with IASE members. Initial interview questions asked university statistics lecturers for their ideas about the attributes of a 'good' statistics teacher. We also invited suggestions from participants on approaches that would help them develop as statistics teachers. Further questions, based on respondents' initial answers, enabled us to explore these topics in depth

Parallel to the idea of 'good teaching' is the assumption that good teaching leads to quality learning. Indeed, the very word 'good' indicates that there is also an objective 'bad' (or perhaps 'not so good') as well as an affective 'rightness' about the very notion of good. Studies of good teaching have shown that different orientations towards students, the subject being taught, ideas about the profession, and beliefs about teaching practice are related to different learning and teaching outcomes (Prosser, Trigwell and Taylor, 1994; Kember, Kwan and Ledesma, 2001). Kember (1997) observed that in studies explaining teacher activities and beliefs a contrast could be made between conceptions of teaching as teacher centred/content focused and student centred /learning focused. Entwistle, Skinner, Entwistle and Orr (2000) represented the relationships between those broad teaching/learning orientations and their epistemological roots as in Figure 1.

This diagram presents us with a potentially important diagnostic tool for the development of competency standards for good teaching that go beyond affective notions of good or bad. Using this tool, we could decide that a reasonable goal is for teachers to demonstrate student-centred conceptions of teaching that facilitate student understanding or conceptual change, and provide evidence that students can reason alternative interpretations (of something) or are committed to a personal reasoned interpretation (of something). Lesser competence would be characterised by a teacher who merely structured knowledge and expected students to demonstrate multiple, equal viewpoints. Figure 1 was constructed from a general review of studies on conceptions of teaching undertaken across a range of disciplines. But what is the viewpoint of educators themselves in a discipline such as statistics, and are there discipline-specific attributes of being a good teacher of statistics?

Kreber (2002) suggests that teaching can be qualified by recognising the distinctions between teaching excellence, teaching expertise, and the scholarship of teaching. From a statistical perspective, Sowey (1995) draws on his teaching excellence and expertise and holds this up to critique based on student learning outcomes and broader pedagogical literatures. He suggests that a good teacher is one who makes statistics memorable, a goal that is attainable if the pedagogic focus is on the structure and the perceived worth of the subject (comprising intellectual excitement, resilience and practical use).
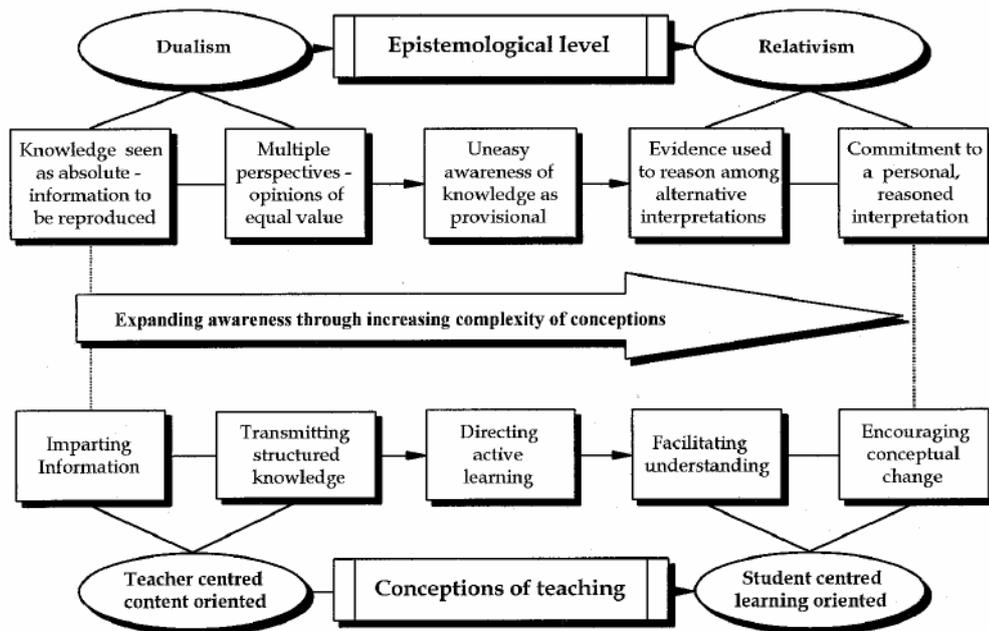
Figure 1: Relations between epistemology and conceptions, from Entwistle *et al.* (2000), p.3

Taking another personal viewpoint, Yilmaz (1996) describes the specific challenge of working with non-specialist students of statistics. For such students, he suggests three essential competencies – to link statistics to real world situations, to demonstrate knowledge of basic statistics, and to understand and communicate statistical results. His implicit notion of good statistics teaching is encapsulated in a sequence of topics that could develop these competencies for business students.

From our small sample of two statistics educators, above, it seems that their ideas about pedagogy are not incongruent with those of educators in general. So, is there something unique about the way statisticians think about teaching and learning? Can we use our collective experience in teaching statistics to develop our continuing practice as scholarly teachers?

METHOD

This project is an extension of our previous investigations into students' ideas of statistics and learning statistics in a tertiary environment and about their teachers' roles (Reid and Petocz, 2002; Petocz and Reid, 2003; Gordon, 2004). Here we focus on the views of statistics educators, specifically those teaching in 'service' statistics courses, their roles in the pedagogical process and the ways in which they define competence and excellence in their profession. We sought volunteers using a notice sent out to IASE members, and carried out interviews by e-mail with 36 educators from August 2004 to February 2005. Respondents came from 13 different countries, and all interviews were carried out in English (except for one in Spanish). Despite this, there was no intention to investigate possible geographic differences (nor was the participant group large enough to do so). The study was approved by the appropriate ethics committee and all participants gave informed consent.

The interviews were carried out using a three-stage process. In the first stage, a uniform set of questions was sent to each participant. These questions included two key ones for the present discussion: (1) *What are the attributes of a good statistics teacher at university?* and (2) *What approach or approaches would help you develop as a statistics teacher at university?* (A complementary question previously discussed was: *What do you think makes a good statistics student?* – Gordon, Reid and Petocz, 2005.) The first round of questions was followed by up to two further rounds that probed the responses. Although follow-up questions were individually tailored to participants' responses, a question that often seemed appropriate was: (3) *What advice would you give a junior colleague just starting to teach a service course in statistics?*. We report responses to these three questions in answer to the questions posed at the beginning of this paper.

The resulting interview transcripts of over 70,000 words formed the raw material of our study. We carried out a content analysis of the themes relevant to recognising and developing good statistics teachers and we summarise the results below. Participants chose their own pseudonyms, and these are used in the verbatim quotes reported in this paper.

HOW CAN WE RECOGNISE A GOOD TEACHER OF STATISTICS?

We address this question by looking at responses to one of our initial questions: *What are the attributes of a good statistics teacher at university?* CÉSAR highlighted the personal nature of the question, and how this makes it difficult to answer, when he wrote: *Bueno, ¡qué problema esta pregunta! en tanto tengo que construir el 'espejo' en el que, inevitablemente, me veré reflejado posteriormente.* [Well, what a problem this question is, to construct this 'mirror' in which I will inevitably be reflected later!]

The most commonly mentioned requirement was an obvious one – solid knowledge of statistical theory and practice. ANETTE wrote: *I am absolutely sure that good statistics teacher should have at least some practical experience – I mean she has to be involved in real research projects as a data analysis expert.* MARIA believed that: *Her/his background should be related to the statistics subjects she/he teaches. She/he should be involved in research about this subject.* And SAMUEL put it this way: *Sound background, the teacher needs to see the material being taught in the context of the wider picture of statistical theory and practice.* FORD PREFECT gave more justification of this view: *Statistics has its own issues in that it is a subject that is taught in a variety of contexts and disciplines, each of which has its own complexity. This forms part of our problem, because approaches we take in business are different to psychology and are different to mathematics. We need to have a good understanding of our own discipline area.*

The next theme was the importance of a range of personal attributes. JOHN put it dramatically as: *Enthusiasm, enthusiasm, enthusiasm!!!* ROSE mentioned: *Willingness to learn (imperative!!!), ability to listen, excellent communication skills, capacity to respond with rather than react to, flexibility, sense of humour, healthy sense of self.* And CÉSAR talked of: *Capacidad para comprender los códigos culturales de los jóvenes que ingresan a la universidad. Es decir, la habilidad de relacionarse positivamente con los estudiantes.* [Capacity to understand the cultural codes of the young people who enter university. That is, the ability to relate well to students.] RON FISHER linked this to the previous theme: *Curiosity about the world around them; knowledge of what is current in work on statistics and data analysis (including related fields such as data mining); familiarity with at least one general-purpose statistical package; and perhaps most importantly, enthusiasm about the field.*

Personal qualities are extended to the notion of a professional approach to the task of teaching. ANDREW stated that: *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.*

JANET COLE described the results of her own research: *I looked at experts in the field of statistics education and identified a kind of 'magic' that each of them had in the classroom. I am not sure how to qualify this 'magic' in any other word. Passion and enthusiasm are a must. A good statistics teacher is not someone who is teaching only so that s/he can do research or just as a job – a good statistics teacher wants her/his students to learn and be excited about learning.*

A final theme that was mentioned by many respondents is the importance of pedagogical knowledge and interest. MARGARET wrote: *A good teacher needs to know how to test well and how to provide useful assignments that will help students learn.* JAZMIN focused on another aspect: *I think it is difficult for students to communicate their statistical ideas. To help them to develop this ability they should write a project involving collecting and analysing data and interpreting the results or review a paper and present a report orally in class.* And HORACE listed these ideas: *Recognition of students' attitudes, cares, motivation. Sensitivity to students' conceptions, misconceptions, practical needs for stats. Commitment to keep working hard on good communication of basic ideas. Use of, and development of, examples, tricks, techniques, tools, to help students understand, and develop positive attitudes and confidence.*

HEINTJE summarised: *A good statistics teacher will stimulate students to take their own initiative, 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.*

WHAT APPROACHES CAN HELP US TO DEVELOP AS STATISTICS TEACHERS?

We investigate this question by looking at responses to the question: *What approach or approaches would help you develop as a statistics teacher at university?* This question focuses on participants' ideas for self-development as university statistics educators. There were several themes here, the first to do with the importance of pedagogical training or guidance.

CARA wrote: *I'd be more than happy if I were given at least some basic pedagogic training at the beginning of my academic career. I had to figure it out myself. … I'd be very happy if somebody made me aware of a huge difference between teaching a group of 300 vs. 30 people in advance. If I was shown how to structure a lecture for different kind of audiences.* The theme was echoed by MARGARET: *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.* And KAY had an interesting suggestion: *What would help me be a better teacher would probably be the opportunity to observe master teachers presenting material that I also teach. I learn a lot by example.*

This last quote leads into the next theme, the importance of learning from colleagues. GLEE stated this as: *Find out how other colleagues are doing it and incorporate any innovations into your teaching.* SAMUEL suggested: *Practical experience in the real world working on real-life problems. More time to interact with other teachers of statistics i.e., ICOTS, read journals i.e., JSE, and reflect on what others are doing.* RON FISHER added: *I enjoy learning about activities that people use to keep students engaged in a statistics class. I am also a firm believer that current research should be incorporated in statistics classes as quickly as possible.*

JOHN described the benefits of a collaborative approach: *I think that we have been reasonably successful in our suite of intro stats courses by using a team approach (provided there is a safe/non threatening environment). It has certainly lifted my performance level. We discuss ideas/approaches, share resource production, use common materials, and are fortunate to appear to be all working towards the same goal.* And HEINTJE's comment is particularly important for service statistics teaching: *And it would help when statistics and psychology teachers at the university should cooperate and work together in a multidisciplinary team, to integrate psychological subjects more and more in statistics courses and research projects, and statistics and methodology in psychological courses.*

JANET COLE continued and expanded on this theme with these suggestions: *I personally feel that I need more experience learning about the technology that exists to teach statistics. I highly underutilize technology in my classroom. ... I need opportunities to interact with others who are passionate about teaching statistics. I need to continue to attend conferences and be active in the statistics education community. 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.*

Some participants talked about access to good teaching resources. NATALIE wrote: *Would be good to have access to some more good stories about real-life data analyses – things that went wrong, issues that arose, findings that have come out.*

A final theme was the importance of administrative and material support from the institution, and valuing of the work of teaching. ANETTE stated this as: *Less administrative obligations and more time for preparing the lectures and seminars (mainly for finding interesting databases and preparing interesting examples for students).* HENRY VIII wrote: *I think what I would need mostly is more support from the school – more computers (we haven't got enough machines yet), more software, and more assistants.* ROSE expressed a (thankfully rare) view that: *For me, the biggest barrier I face is the culture in the department here – they neither value nor appreciate the relevance of statistics education and their recognition of the importance of teaching is purely a 'politically correct' statement – it has no substance in practice.*

HOW CAN GOOD TEACHING PRACTICE BE TRANSFERRED TO OTHERS?

We address this question by looking at responses to the follow-up question: *What advice would you give a junior colleague just starting to teach a service course in statistics?* Transferring good teaching practice to others is possibly most important for junior colleagues without (much) experience. The advice given is mostly fairly straightforward: know your material and your students; talk to and learn from colleagues; use student feedback processes and take account of the results; make use of your university's professional development opportunities; participate in conferences, read journals and try to apply the research that is reported.

ALICE suggests: *Read up, know your stuff, try and find out the students' points of reference, i.e., what they understand and what they don't (by asking questions) and try and meet them at this level.* ANETTE recommends that you should: *Ask yourself if you really understand the essence of the concepts you are teaching or have you some doubts – if you have, then do not hesitate to ask or discuss it with your colleagues! Do not hesitate to admit that you do not know everything about statistics – believe nobody does! But make sure you know the topic you are going to teach!* She adds: *Try to get involved in real data analysis projects! – it's where the experience and understanding of statistics comes from!*

LIZZIE's advice is brief but practical: *Listen to the students and start your explanations from where they are at; keep jargon to a minimum; try to be very consistent and explicit.* JOYCE calls on her own experience to make these suggestions: *Prepare your lectures carefully and continually update them based on feedback from your students and their mistakes on examinations. Read Journal of Statistics Education. Talk to colleagues who also teach or have taught the same courses at your institution or elsewhere.*

ANDREW gives a comprehensive range of advice, including: *I would say the young colleague should prepare well for lectures, should talk to those who have taught similar courses before, possibly develop a style which may have been present in the person they admired most as a lecturer, be available to students through office hours, carry out teaching evaluations and ask students what can be done to improve their teaching.* He adds that: *The new staff member should also take advantage of any teaching development centre which a particular university may have. There are new ideas from such help groups in a university and some of the good practice ideas may not have been thought of.* However, he warns his junior colleagues that: *Given the emphasis on research now in most universities there is little incentive to spend time developing good teaching practice even though university administrations say teaching is important. I would first have to say that the new person would need to spend most time developing a research programme in their area, which could of course be in the area of statistics education.*

CONCLUSION

The interviews are an indication of collective wisdom about good teaching in the community of statistics educators. Most participants showed that they had a clear intuitive idea of a 'good university statistics teacher.' They would recognise such a teacher by his or her sound discipline knowledge, personal attributes – particularly enthusiasm and ability to communicate with students – and interest in pedagogy. At the broadest level, participants identified an important characteristic common to good teachers — to be focused on their students, over and above their own discipline knowledge and their own personal qualities. Heintje's (first) quote shows this clearly, as does this one from HENRY VIII: *I think the good teacher is the one who is able to show the students that statistics is the science that provides the researchers with tools for dealing with the uncertainties of the real world, and not just a set of boring formulas and procedures. … I think the good teacher is the one more concerned with showing the students WHY and WHEN to use statistics, rather than HOW.*

In terms of developing and sharing professional expertise in statistics pedagogy, participants had a range of suggestions. These include further study of statistics itself; using pedagogical guidance, both formal and informal; interacting and collaborating with colleagues, in statistics and from the disciplines that are being 'serviced'; participating in professional exchanges, attending conferences and reading journals, pedagogical and statistical; and utilising feedback from students, particularly for less experienced teachers. They also pointed out that developing good teaching takes time and resources and needs to be valued.

For the most part, our participants believed that good statistics teaching was not discipline specific. MARGARET spoke for the majority when she wrote: *On one level, the answer should be no different than attributes of a good teacher at university – for any subject. One needs to be devoted, knowledgeable, organized, hard working.* However, several educators pointed out the particular problems of 'service' teaching, where statistics is embedded in another discipline, and where best results seem to be achieved with close collaboration in a multi-disciplinary team consisting of statisticians and other professionals (eg psychologists). This seems to be an area that could be highlighted in any formal courses in statistics pedagogy, such as the *Royal Statistical Society Certificate in Teaching Statistics in Higher Education* (see Davies and Barnett, 2005).

Returning to the diagram of Entwistle, *et al*. (2000) shown in Figure 1, we see that participants in this study showed a wide range of conceptions of teaching in their discussions of what makes a good statistics teacher at tertiary level. The teacher-centred/content-focused views were represented by the importance that many placed on sound discipline content knowledge and experience, and its role in structuring knowledge. However, this was seen by most as a first step in good teaching rather than an end in itself. The student-centred/learning-oriented views were also represented by many participants who talked about directing students' active learning and helping them to understand the nature and the role of statistics, often in relation to their major area of study. Interestingly, the notion of 'encouraging conceptual change' in students was not mentioned by any participant, possibly due to the way our questions were focused. For the most part, the various epistemological positions that correspond to the conceptions of teaching are only implicit in the quotes we have given: this is another area where further reflection could be useful.

REFERENCES
Entwistle, N., Skinner, D., Entwistle, D. and Orr, S. (2000). Conceptions and beliefs about 'good teaching': An integration of contrasting research areas. *Higher Education Research and Development*, 19(1), 5–26.
Davies, N. and Barnett, V. (2005). Learning statistics teaching in higher education using online and distance methods. *Proceedings of ISI 55th session*, Sydney, Australia. http://www.stat.auckland.ac.nz/~iase/publications/13/Davies-Barnett.pdf.
Gordon, S. (2004). Understanding students' experiences of statistics in a service course. *Statistics Education Research Journal*, 3(1), 40–59.
Gordon, S., Reid, A. and Petocz, P. (2005). How important are communication skills for 'good' statistics students? – An international perspective. In L. Weldon and B. Phillips (Eds.), *IASE Satellite on Statistics Education and the Communication of Statistics*, Sydney. http://www.stat.auckland.ac.nz/~iase/publications/14/gordon.pdf.
Kember, D. (1997). A reconceptualisation of the research into university academics' conceptions of teaching. *Learning and Instruction*, 7, 255–275.
Kember, D. and Kwan, K. P. (2000). Lecturers' approaches to teaching and their relationship to conceptions of good teaching. *Instructional Science*, 28, 469–490.
Kember, D., Kwan, K. P. and Ledesma, J. (2001). Conceptions of good teaching and how they influence the way adults and school leavers are taught. *International Journal of Lifelong Education*, 20(5), 393–404.
Kreber, C. (2002). Teaching excellence, teaching expertise, and the scholarship of teaching. *Innovative Higher Education*, 27(1), 5–23.
Petocz, P. and Reid, A. (2003). Relationships between students' experience of learning statistics and teaching statistics. *Statistics Education Research Journal*, 2(1), 39–53, http://www.stat.auckland.ac.nz/~iase/serj/SERJ2(1).pdf.
Prosser, M., Trigwell, K. and Taylor, P. (1994). A phenomenographic study of academics' conceptions of science learning and teaching. *Learning and Instruction*, 4, 217–232.
Reid, A. and Petocz, P. (2002). Students' conceptions of statistics: A phenomenographic study. *Journal of Statistics Education*, 10(2), www.amstat.org/publications/jse/v10n2/reid.html.
Sowey, E. (1995). Teaching statistics: making it memorable. *Journal of Statistics Education*, 3(2), www.amstat.org/publications/jse/v3n2/sowey.html.
Yilmaz, M. (1996). The challenge of teaching statistics to non-specialists. *Journal of Statistics Education*, 4(1), www.amstat.org/publications/jse/v4n1/yilmaz.html.