® HOW IMPORTANT ARE COMMUNICATION SKILLS FOR 'GOOD' STATISTICS STUDENTS? — AN INTERNATIONAL PERSPECTIVE

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What do statistics teachers believe makes a good student of statistics? What part does the ability to communicate statistical results and ideas play in this judgement? In this paper, we investigate these questions and suggest answers based on a recent empirical study carried out by e-mail interview with IASE members from around the world. The responses alert us to the diversity of views on the relative importance of statistical communication held by statistics educators in service courses. Some teachers propose that communication skills are essential to learning statistics at university, others do not mention communication. In any discussion on statistical communication, we should be aware of the range of views held by statistics educators themselves, and the range of views that they communicate to students through their teaching.

INTRODUCTION

It is likely that most, if not all, statistics educators would agree that good communication skills are integral to teaching and learning statistics. However, when statistics teachers think about and describe 'good' statistics students do they articulate views that the ability to communicate is essential to their students' learning or report that interpreting and communicating statistical results are key components of statistical skills? We present results from an empirical study with university statistics educators from around the world that shed light on what statistics teachers appear to value in students and the role of students' communication skills in these appraisals. We conjecture that educators articulate these ideas to their own statistics students, explicitly or implicitly, and so their views impact on their students' learning.

Anecdotally, in the faculty staff room, or during the casual corridor conversation, we seem able to describe a 'good student' and the meaning of the term is implicitly understood. We may be referring to a student who shows an intuitive grasp of statistics, or we may be referring to a student who has done very well in an assessment task, or we may simply be referring to a student who works hard. Research on variation in ways of experiencing teaching suggests that the idea of 'good' may be related to a lecturer's conception of teaching and of the subject (Reid & Davies, 2003). Hence, university teachers' ideas about the nature of a good statistics student are integrally bound with their views regarding statistics. Statistics educators have traditionally talked about good students as those with a strong mathematical background, and weak students as those for whom the mathematical aspects are a challenge. This view suggests an orientation to the statistics curriculum that focuses on the mathematical "nuts and bolts" of statistics (for instance Provost, 2002) and reflects an historical view of the position of mathematics in the study and practice of statistics, although it is a view that may still be widespread amongst statistics educators. Over the last two decades, helped by the enormous increase in availability and sophistication of statistical computing, there has been a change in emphasis towards a different view of statistics as investigation, analysis and use of data (Marasinghe, 2002). Educators in the United States have referred to this change in emphasis as "statistics reform" (Garfield, Hogg, Schau & Whittinghill, 2002), but the reform is a world-wide change. Such a position implies that good students are those who can carry out "numerical detective work" (Petocz, 1998) and communicate the results of their investigations clearly and effectively. Nevertheless, empirical studies suggest that the challenge remains to statistics educators to move students from

conceptualising statistics as number crunching and application of algorithms and techniques, with or without software (MacGillivray, 1998). In some service courses, maths-phobia or a lack of interest and engagement with quantitative methods can hinder students' appreciation of statistics (Gordon, 1995; 2004).

In previous papers we have investigated the views of statistics major students about their discipline (Reid & Petocz, 2002) and their learning (Petocz & Reid, 2003), and the views of students taking 'service' statistics courses as part of their preparation as professionals in areas that will make use of statistics (Gordon, 2004; Petocz & Reid, 2004). However, there is a dearth of data on academics' experiences of teaching statistics and how these relate to student learning. In Gordon (2004), interviews with just two university teachers of a psychology statistics course indicated polarised views of perceptions of good statistics students from being mathematically competent, able to "deal with formulae", on the one hand, to being math-phobic but "very good at interpreting results ... at telling you what's actually going on", on the other. Here we take up a proposal (Reid & Petocz, 2002) to "map the differences in the ways that professional statisticians (especially academic statisticians) understand statistics and teaching/learning statistics" with a focus on university teachers' perceptions of what makes a good statistics student in a service course and the role of communication in their reports.

METHOD

The investigation consisted of a series of e-mail interviews with tertiary level statistics educators. Our aims were to explore educators' ideas on teaching and learning statistics at university and how they develop their teaching. Participation was invited through the membership list of the IASE (International Association for Statistics Education) and other electronic lists and respondents gave informed consent. This information is currently available on:

http://www.usyd.edu.au/stuserv/documents/maths_learning_centre/StatsProject.pdf .

Initially, interviews were sent to all respondents and the 36 IASE members who participated were from many countries including Argentina, Australia, Belgium, Brazil, Israel, Italy, Netherlands, New Zealand, Slovenia, Spain, Uganda and the USA. Most interviews were conducted in English (one was bilingual with English questions and Spanish responses). The interview protocol consisted of an initial series of five questions, followed by up to two rounds of further questions which explored participants' responses in depth. Pseudonyms were chosen by the participants themselves and brief excerpts from interviews in this paper, are reported under these pseudonyms.

One of the initial questions asked *What do you think makes a good statistics student?*. This question was posed in a deliberately open way to enable the participants to explore their own ideas rather than we, the researchers, eliciting responses in a specified direction. The follow-up questions explored the thread of thought that was prompted by the original question and so depended on the individual response, for example: *Are there qualities specific to a good student in statistics? What do you feel you can do with a student or a group of students who don't display these qualities? Can you explain how mathematical ability can help students but can also blinker them? How do you go about teaching students to communicate statistics?* The follow up questions also generated discussion on how to encourage those students who were not 'good' to achieve the desired qualities.

In this paper we will focus on three research themes that emerged in response to the interview questions on 'good' students:

- What are the qualities of good students expressed by the participants?
- What are the participants' perceptions of the role of mathematics in statistical learning?
- What part do communication skills play in the educators' evaluations of good students?

QUALITIES OF GOOD STUDENTS

Many participants interpreted the notion of a 'good' student in terms of personal qualities. The attributes of good students commonly mentioned included critical thinking, curiosity or an active mind, a preparedness to work hard and to understand, willingness to

overcome maths phobia and more individualistic ideas such as a sense of humour, willingness to take responsibility or to play with abstraction.

Critical thinking is described by CARA as: *Simply the ability to ask all the relevant questions (that are usually not asked by the general public): what's the sample size, what kind of sample are we dealing with here, is it representative of the population, what are the observed variables and how many observations do we have; are we dealing with repeated observations, who funded the research and what could he/she gain by favourable results, etc?*

SAMUEL explained his view of curiosity as essential to good students in the context of learning statistics. *Curiosity. A student who asks why, what is the connection to the context, have I met a problem like this before? … A student who is systematic, who begins in an orderly way, asks the right questions and applies the appropriate techniques. A person who is self critical, always questioning them self and checking their conclusions.*

ROSE expressed the view that a good student was the same *as a good student anywhere I guess*, listing qualities as: *good sense of humour, open, sense of wonder about the world, appreciation of the beauty, of the inter-connectedness of things in general (and ideas specifically), grounded in the world but also willing to 'play' in the world of abstractions.*

HENRY VIII summed up the views of many when he said: *The good student is the one who is curious to see what statistics has to offer, and how it relates to their careers (whatever their backgrounds, and their knowledge of maths). The bad student (by far, the majority), is the one who wonders how he can pass the examinations with the least effort and the least pain.*

THE ROLE OF MATHEMATICS

This theme is important as we did not ask specifically about mathematics, yet it was given a priority in the responses of many of the participants. The participants were almost equally divided on their views of mathematics as shown in the following excerpts.

HENRY VIII reported that little mathematics was needed for the courses he taught: *They are not courses on 'mathematical statistics', but rather introductory courses in applied univariate statistics, relying heavily on computers for the actual calculations. We usually avoid doing mathematical demos of theorems and properties.*

LEIGH's response indicated agreement with the above view, terming it *a mistake to call the subject mathematics, at least the way we teach at this level*. She explained why: *Because so many students walk into a maths class and say "I'm hopeless at maths"! In this class we are addressing questions about the real world through collecting and looking at data.*

In contrast, ANDREW endorsed mathematical skills as needed for statistics specialists saying: *The specialist statistician must have an overall ability at mathematics and be able to reason quantitatively. … Over and above all these qualities, the statistics specialist must be able to work with mathematics and enjoy the mathematics. And enjoy the sort of detective work you get involved in with complicated data.*

DARIA's report suggested that the need for mathematics was not confined to statistics specialists. *Every 'scientist' should have a minimum knowledge of calculus. The mathematical background helps in developing the ability to solve problems and in the process of generalization.*

The ambivalent attitude of the participant group can be summed up by the quotes below.

FORD PREFECT commented: *Mathematical ability helps, but can also blinker the students.* He elaborated: *In stats there is no guarantee that they get the right answer even if they do the right calculations and use the best method. That is a super tough concept to overcome. Part of the problem with teaching statistics in a traditional form is we sometimes don't get that concept across.*

HORACE argued passionately for ways: *to find easy tools to make our prac work understandable, easy, successful. Don't believe any folks who claim it's a weird inaccessible mathematical religion. All the rumours are wrong!*

COMMUNICATION SKILLS

It may be surprising that over two-thirds of the participants did not mention communication at all in relation to the question on 'good' statistics students. Of course, we cannot conclude from this that two-thirds of participants do *not* think that communication skills are an

important part of being a 'good statistics student', but we can say that communication skills were not a focus for the reports of the majority of participants. The responses of those teachers who did express ideas about students' abilities to communicate indicated that this dimension was an important part of students' statistical learning and fulfilled the diverse roles outlined below.

1) SUFFICIENT COMMAND OF LANGUAGE TO EXPRESS THEMSELVES

The first idea that emerged from the responses was that a basic level of literacy and ability to use language underpinned learning statistics.

JOHN: *Just as enthusiasm alone will not do it for the teacher, motivation alone will not be the making of a good student. A good statistics student needs to have reasonable levels of numeracy/ literacy skills, comprehension, interpretation and writing skills.*

ANDREW: *A good student must have quite a high level of ability or intelligence, however that is measured, must be able to write well, must be able to express themselves clearly, must be able to assess new ideas, must be receptive to new ideas, must relate well to other people, must be versatile, must be hard working, should have new ideas to be investigated, should be able to work on their own.*

SAMUEL: *I work hard on questioning, this is possible in our small classes, but is also difficult as many do not have good English to express the subtle concepts that we are discussing. Many ideas are difficult for good kiwi* [local New Zealand] *kids to express well, so are very hard for overseas students.*

2) TALKING TO PEERS TO DEVELOP OWN UNDERSTANDING

A further perception of our respondents was that discussing statistical concepts with colleagues or teachers helped students develop their own thinking and understanding.

JANET COLE: *A good statistics student will talk with her/his peers about the concepts in order to 'teach' the basic concepts to help her/himself to develop a deeper understanding of the concept.*

KAY: *Students who are struggling get paired up with a group of other students, so they have peers to talk to about statistics who can help them. These students also get direction to plan on spending more time on the course than their friends might - and to spend some time each week with the instructor or the graduate teaching assistant. These students gets extra worksheets with examples, they get extra help.*

3) COMMUNICATING STATISTICAL IDEAS FOR ALL TO UNDERSTAND

The ability to convey statistical ideas in everyday language was expressed as important by a few participants.

LIZZIE: *When working one-to-one with students like this I often say "what do you think - use your own words?" I think students are often worried about not using the 'right' words and "why do you say that?" this challenges and clarifies their thinking. Early in the semester I accept shorter responses and try to be very encouraging, focusing on what they have right. Later in the semester I am looking for more detailed and correct responses with more correct language.*

ANETTE: *so that those people who have never heard special terminology would also understand what you have found out and what you want to say about your results. ... I just use examples from (imaginary or real) situations and try to explain the meaning of concepts using only these words which we use in our everyday conversation. And I ask students to do the same - to interpret the statistical results using the words "which people who have never learned statistics would also understand".*

4) COMMUNICATION TO AMELIORATE DIFFICULTIES WITH MATHEMATICS

An important corollary to the above idea was that the use of readily understood, everyday language assisted students who were not confident or skilled in mathematics.

COACH: *So first we examine a concept such as variance as an idea, and then we develop a definition in words of variance and then from the words we develop the algebraic equation. So, instead of starting with the equation and then working back to show where it came from, I start with the abstract concept and work forward. This is essential since most of the students in my*

classes are not well-grounded in mathematics at the beginning. Then I use 'writing to learn' exercises frequently through the course to keep the students working with the words and then interpreting the words. ... Mathematics and math ability are still very important. The distinction is that in my classes we develop the math from the words. The working definition of statistics I use with the students is "Statistics is philosophy with numbers to help the words."

5) OTHER

ANETTE commented ironically on students' willingness to communicate – but not about statistics. She stated that a good student should have: *Motivation to learn, active mind and a bit of decency and politeness (to understand when it is expected that students talk and discuss things and when it will disturb others if you chat or say whatever is on you mind).*

DISCUSSION

Despite the variation in the teaching contexts of our international participants – their diverse cultures, multiplicity of discipline areas and differing student groups as users of statistics, as dissimilar as nursing and engineering students – there was agreement on at least some aspects of good statistics students, qualities that were deemed important. On the other hand some responses were contradictory. The responses about mathematics are particularly interesting, and the relationships demonstrated between statistics and mathematics education will be explored in a further paper (Gordon, Nicholas, Petocz & Reid, in preparation).

Opinions on what makes a good statistics student were explicitly articulated by respondents in our interviews, and it is likely that such opinions would also be implicitly conveyed to students during teaching. Hence the findings presented in this paper have practical, pedagogical implications as well as highlighting fruitful areas for future research in statistics education. Although the focus of the initial question was on 'good' statistics students, follow-up questions encouraged many respondents to discuss what they felt could be done with students who were not so 'good'. One debate that arose was whether all students can be taught to be good learners of statistics. While some participants expressed opinions that there was little that could be done with unmotivated or weaker students, others postulated that any student has the potential to be a good statistics student: *it is our job to motivate a desire to learn and to provide an environment that is conducive to learning and that is an environment where safety and respect for all are cherished.*

Further, as our respondents pointed out, there is no single recipe for an approach, nor is there only one type of good student. Different skills and talents might be of great importance for different tasks in statistics: for example, a less competent student with creative and strong writing skills could make a valuable contribution to group projects. Teachers felt they could help students develop communication abilities by giving writing skills tips like: *make one point per sentence*, or pointing out the language structure of some common templates, such as that used in writing about confidence intervals. Participants' suggestions on activities which promote communication skills included students making oral presentations on statistical analyses, reading statistical information such as articles on statistical investigations, and writing *small reports that account for the most significant conclusions of an investigation*, giving students *absolute freedom as to how they carried out this writing*.

CESAR wrote about his students' reactions to class activities that emphasised the importance of statistical communication: *Nuestra experiencia es que los estudiantes responden de manera favorable a estas actividades porque: intuitivamente comprenden la meta u horizonte de los aprendizajes que tendrán que abordar a lo largo del curso; perciben la utilidad de estos aprendizajes; los colocan ante el desafío de ser ellos los autores de un 'buen informe' de conclusiones.* [Our experience is that the students respond in a favourable way to these activities because: they intuitively understand the goal or horizon of the learning that they will undertake throughout their course; they perceive the utility of the learning; they respond to the challenge of being authors of a 'good report' of their conclusions. *Our translation*.]

CONCLUSION

Our interview questions did not explicitly ask about communication skills and the majority of respondents did not mention communication in relation to good statistics students. Could this mean that while the rhetoric emphasises communication skills as underpinning desirable attributes of all graduates, in statistics education it is not at the forefront of the skills explicitly endorsed and promoted by statistics educators at university? We will leave the last word with a participant who strongly endorsed communication in statistics education.

JANE JOHNSON: *Communication is VITAL, the central element in effective teaching and learning. I think it was Dewey who described education as a "communication between the generations". I don't think statistics is special in this regard, except that until recently it might have been an area in which communication was limited to formal disciplinary conventions and somewhat ineffective.*

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APPENDIX: INITIAL INTERVIEW SENT BY EMAIL TO CONSENTING PARTICIPANTS

Dear ..
Thank you for agreeing to participate in the research project on teaching statistics. Please make up a false name (pseudonym) for yourself that indicates your gender but conceals your identity.

Pseudonym .....

We would like to interview you by email. The initial interview questions are below and are marked Q0, Q1, Q2, ...Q5. Please write your responses under each question and label them R0, R1, R2, ...R5.

Write as much or little as you like. There are no right answers. We are very interested in what you think and can tell us.

Q0) To start, would you like to tell us a little about yourself and your statistics teaching?
What country do you teach in and in what discipline or disciplines do you teach statistics?
Are your statistics students undergraduate and/or postgraduate?
What would you like to tell us about yourself and your background in teaching statistics?
R0:.....

Q1) Describe the context in which you teach statistics.
R1)

Q2) What do you consider to be the most important aspects of statistics for your teaching?
R2:....

Q3) What do you think makes a good statistics student?
R3:...

Q4) What are the attributes of a good statistics teacher at university?
R4:.....

Q5) What approach or approaches would help you develop as a statistics teacher at university?
R5:....