® SERVICING STUDENTS COMMUNICATING IDEAS ABOUT STATISTICS

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Statistical communication has become a larger part of statistics pedagogy during the previous decade, particularly for those students who are majoring in the discipline. Students in servicing courses may have less opportunity to develop statistical communication skills, as they usually take only a small number of statistics subjects: it is this group that forms the basis of our present study. Based on analysis of the discourse in interview transcripts, we highlight an interesting disjunction: many students seem to be able to communicate their understanding of statistics to the interviewer, but their statements about their statistical communication imply that they are unaware that they are communicating statistically during this process. We briefly explore the pedagogical implications of our findings.

INTRODUCTION

The majority of students studying statistics are taking a 'servicing' course in preparation for a career where statistics will be a professional tool rather than a central skill. Such students come from a wide variety of disciplines: business, tourism, psychology, engineering, dentistry and even archaeology. For many of them, statistics represents a completely new way of thinking and an unexpected component of their studies and their future profession. But how do such students communicate statistically, how do they explain the statistical work that they have done, and how do they communicate using statistics with colleagues or clients who do not have any background in statistics? In this paper, we try to provide answers to these questions based on an analysis of transcripts of interviews carried out with students who had undertaken servicing statistics courses. We focus our discussion on two specific transcripts (due to limitations of space) but they are broadly representative of the collection of interviews in our study.

For statistics major students, statistical communication has become a focus of pedagogy during the previous decade, in part due to the increasing recognition that professionals need to adapt their modes of communication to their clients, rather than vice versa (Fairclough, 1995). For instance, statistics major students in Australia commonly have access during their degrees to courses in graphical techniques and statistical consulting (Mackisack & Petocz, 2002) and their syllabuses include an emphasis on communicating with non-statistical clients. Several such courses for statistics majors and/or postgraduate students in general have been described in recent articles from the US (Spurrier, 2001; Schafer & Ramsey, 2003).

Students in servicing courses may have fewer opportunities for developing statistical communication skills during their degrees (they may only take one or two statistics subjects), although many modern courses include components of communication, particularly as part of assessment tasks (Keeler & Steinhorst, 2001; MacGillivray, 2002). The American Statistical Association's (ASA) recent guidelines for teaching undergraduate statistics courses mention that students should know that communication of results is one of the last steps in the statistical process, but do not include any aspect of communication in their recommendations (ASA, 2004). The Royal Statistical Society's new online certificate course in Teaching Statistics in Higher Education makes no explicit mention of problems of statistical communication, although it may be discussed in the detail of the syllabus (Davies & Gilchrist, 2003). A recent international interview study of the views of statistics educators involved in service teaching found that two-thirds of them did not mention communication skills in their discussion of good statistics students and good statistics teaching (Gordon et al., 2005).

Perhaps statistical communication for servicing students is seen as one component of a general concept of statistical literacy and statistical thinking skills (Wild & Pfannkuch, 1999; Ben-Zvi & Garfield, 2004) or in the context of professional competencies and generic skills (Bowden & Marton, 1998; Barrie, 2004).

BACKGROUND TO THE STUDY

We have previously investigated and reported statistics major students' conceptions of statistics (Reid & Petocz, 2002) and learning statistics (Petocz & Reid, 2001, 2003). Our research approach – phenomenography (Marton & Booth, 1997) – uses in-depth interviews to enable participants to explore and explain their understanding of the topic under discussion.

We identified six qualitatively distinct conceptions of statistics, which can be grouped into three levels from the most limiting (1) to the most expansive (6). We also identified six qualitatively distinct conceptions of learning in statistics, which can also be grouped into three levels, from the most limiting (A) to the most expansive (F). These conceptions are shown in Table 1 below:

Table 1 *Students' Conceptions of Statistics and Learning Statistics*

Conceptions of Statistics	Conceptions of Learning in Statistics
Focus on techniques: (1) individual numerical activities, (2) using individual statistical techniques, (3) collection of statistical techniques.	*Focus on techniques:* (A) doing required activities in order to do well in assessment, (B) collecting methods and information for later use.
Focus on using data: (4) analysis and interpretation of data, (5) understanding real life using statistical models.	*Focus on subject:* (C) applying statistical methods in order to understand statistics, (D) linking statistical theory and practice in order to understand statistics, (E) using statistical concepts to understand areas beyond statistics.
Focus on meaning: (6) an inclusive tool to make sense of the world and develop personal meanings.	*Focus on student:* (F) using statistical concepts to change your views.

We have also carried out a series of (30) interviews with second to fourth-year students from servicing courses in tourism, sports science and engineering: additionally, we obtained further information using open-ended questionnaires completed by a larger group of students in sports science, nutrition and orthodontics. Although we expected, *a priori*, to find different conceptions in this group, our preliminary analysis of this rich source of data indicates that students in servicing courses show the same range of variation in their ideas about statistics and learning statistics as do the statistics major students (Petocz & Reid, 2004). Here, we focus on students' views about their statistical communication, and their actual communication as demonstrated in a subset of the interview transcripts.

THE INTERVIEWS

The study was approved by the appropriate ethics committee; participants were volunteers from classes in tourism, sports science and engineering and each gave informed consent. Participants were asked about their understanding of statistics (and mathematics), the use of these areas in their future professional work, and their own communication of statistics. The initial interview questions included the following: *What is statistics? What role do you see statistics playing in your future profession? Has your study of statistics and mathematics changed the way you communicate?* Further questions were posed to explore students' responses in depth and to allow them to expand their answers, for example, general questions such as *Can you give an example of that?* and specific questions such as *How does statistics help you determine the risk professionally?*

The interviewer was 'naïve' in the world of statistics, but she was an expert at developing participants' capacity to explore and explain their experience using sequences of carefully constructed questions. She told respondents that she didn't know much about statistics, and hence they were encouraged to explain and communicate their statistical ideas to her. Thus, in terms of communication, the transcripts of the interviews can be looked at from (at least) two different viewpoints: what the students actually say about their communication and how their study of statistics has changed this, and how they actually communicate statistical ideas to the interviewer, who has told them that she has no expertise in statistics. The examples that we analyse later show

that there can be a large disjunction between what students say about their communication of statistics and their actual ability to communicate statistically. In the interpretation of the interviews we have used a discourse analytic approach, exploring the intersections between critical reflection (Brookfield, 1995) and narrative inquiry (Polkinghorne, 1995) whilst maintaining a focus on the primary research questions. In this manner we hope to address the 'trustworthiness' concerns expounded by Moss (2004). The participants' views are represented through the discourse analysis in relation to our views as analysts and our previous research findings, acknowledging that all participants are part of a community of practice.

ANALYSIS OF STUDENTS' DISCOURSE AROUND STATISTICS

In the analysis that follows, we explore two students' (Zhen and John) experiences of communicating statistics. Having determined that the servicing students showed the same range of variation as the statistics majors, we analysed their transcripts against the categories described in Table 1. We determined the overriding conceptual categories contained within each transcript, and selected a subset for further discourse analysis. We used fragments from two interviews as representative of the transcript group. Our discourse analysis focused on the communication aspects contained within those transcripts. Zhen's transcript represents students whose transcripts implied a 5E approach to statistics and learning statistics. This means that the transcript gives indications of 'understanding real life using statistical models' and 'using statistical concepts to understand areas beyond statistics'. By contrast, John's transcript represents a qualitatively different experience of statistics and learning statistics. Within that transcript we can see the 'use of individual statistical techniques' and 'collecting methods and information for later use', representing level 2B. In the discourse analysis we see that both students are able to communicate their core understanding of statistics to the interviewer. The extreme left and right columns in the examples (below) summarise our interpretations as researchers of the linguistic event in the context of the previously derived categories.

Zhen is a second-year student in Human Movement and International Studies. During these two years, she has undertaken one statistics course and one mathematics course. Relative to many other students, she seems to have fairly broad conceptions of statistics and learning.

Example 1: Zhen

	Interviewer	Zhen	
Question intent			*Response orientation*
General opening – non specific.	Ok, then can you tell me what you understand statistics to be about?		
		In one word? Or two words… measuring trends.	*Clarification seeking, definitional response.*
Encouraging amplification.	Can you explain that a little bit more?		
		So it is about studying the collective pattern of a sample size or a population group.	*Use of statistical terms, using statistics for understanding general trends.*
		It is not about worrying about the individual stuff,	*Confirming previous ideas.*
		it is more about worrying about the overall trend and the overall pattern of a particular sub-section.	*Recognises specificity of sample in relation to generalisations.*
Seeking to relate ideas presented to an example that makes sense to the participant.	Do you have an example that might explain what you mean?		
		So let's say school kids, and their levels of activity in school,	*Discipline context.*
		then you study a whole bunch of kids and then you work out, you know, what age groups are more	*Use of simple language for explanation. Identifies some common aspects for*

		active and what age groups aren't, different genders, different activity levels,	*data collection.*
		so you then measure the level of participation in sports let's say with kids as a collective group, you wouldn't say pick on every single year 7 and 8 kids, even though you do have to measure them by recording information of each of them.	*Stats as measurement – recognition of human individuality (discipline concern), return to formality of statistics.*
		So stats would be about measuring the general trends of activity levels of these kids.	*Summary statement.*
		Numerical sociology maybe?	*Explicit linking with discipline.*
A new idea – seeking clarification.	Wow, what's that?		
		Well, I have just come out of a sociology tute so it is just looking at society but in a numerical form.	*Explicit linking with discipline.*
		I guess?	*Tentative confirmation.*
		That is one way of looking at it.	*Confirmation.*
Linking example with new idea – seeking clarification using participant's language.	Do you think the example you gave me about school children is an example of numerical sociology?		
		Yes, I would say so, yeh.	*Confirmation.*
		Because you do have to find out about the each and every individual,	*Discipline orientation.*
		but at the end of the day it is all about the collective group and what the collective group is doing.	*Statistics orientation.*
... break in transcript ...			
Links previous dialogue with planned communication question.	By covering these components of maths and stats in your course, have you changed how you communicate this knowledge?		
		If there is material being presented, then yeah I definitely look at it from a different point of view from now on.	*Agreement with idea of 'change'.*
		Whereas before I remember, like last year for instance we had one biomechanics subject and we had to do a literature review and we did come up with a lot of numbers everywhere, from past journal entries and past literature reviews.	*Clarification with discipline specific example.*
		And we just didn't know what the hell we were looking at.	*Indicates early unease with statistics.*
		Had no idea!	*Emphasis.*
		Whereas now I would say if I went back to it, it would sink in a bit more.	*Admits new level of understanding at a superficial level, cautious.*
		It's a deeper level of appreciation for stats and maths.	*Strong acknowledgement of learning, implication of stats communicating through written accounts.*

Zhen is able to demonstrate an understanding of statistics in relation to her core discipline. She neatly describes disciplinary contexts to the interviewer and then adapts statistical ideas to amplify that context. She shows an awareness of the potential of statistics for developing her thinking and understanding of her own discipline. In this transcript, she acknowledges that the communication element of statistics is what statistics communicates to *her* when she encounters it in research articles.

John is a student in 4th year undertaking studies in Telecommunications Engineering. He has previously taken two statistics courses and one mathematics course, in addition to another two courses that contained some statistics. Relative to other students, he shows more limited views of statistics and learning.

Example 2: John

	Interviewer	John	
Question intent			*Response orientation*
General opening – non specific.	Ok, well then if I can just start by asking you what you think statistics is about?		
		Collecting data and then using it for further analysis to use for later purposes.	*Definitional statement, two components of stats identified (collecting, using).*
	When you say that, do you have an example of how you see statistics working?		
		In mobile communications we use it because they have used statistics in the last 50 years to research mobile stations and how they transmit,	*Sees stats as a component of his core discipline.*
		and then they make them into graphs and then from there we can just see what the power might be to the noise or something. Without doing calculations you just look at the statistics.	*Use of 'they' indicates someone else uses the statistics – expresses distance.*
Seeking clarification – mentions discipline context.	So when you say things like 'doing further analysis for later purposes', how would that work in that context of mobile communications?		
		I guess with time the systems would degrade so you could see how you mix statistics up to time and see how they compare to previous ones to see what time does.	*Statistics as an investigative method related to a complex discipline problem. Uses 'they' to imply a personal distance from statistics.*
... break in transcript ...			
Targeted communication question.	And what about communicating statistics?		
		Show a table and point and show why I chose that number instead of something else.	*Confidence in the interpretation of statistical material. Uses 'I' instead of 'they'. Use of graphics for communication*
General open summary question.	Ok, well then just in summary if I can ask you what would you say will be the main things you will take away with you from your learning here in maths and stats?		

		The normal distribution, because that is used for theoretical applications of signal to noise ratio of probability bit error, that is all theoretical based on the non-distribution of noise. Um, that is probably one important thing for stats.	*Identification of specific statistical techniques suitable for use within the disciplinary context.*

This brief fragment shows that John is able to describe several statistical ideas and is familiar with statistical terms. His final statement shows how, despite four courses in statistics, he has determined that one idea (the normal distribution) is of most importance for the work of a telecommunications professional. As in Zhen's transcript, John is well able to describe the use of some statistical ideas within a discipline context to the interviewer. However, when asked explicitly about the idea of communicating statistics, John indicates a willingness to be involved in statistically supported decision making when he says 'Show a table and point and show why I chose that number instead of something else'.

CONCLUSION

In this paper we only have room for two examples. However, we have carried out similar analyses for other transcripts in our series. In each case, we can examine the transcript from the viewpoint of what the respondent is actually communicating about their knowledge of statistics – usually quite effectively – and what they say when they are asked explicitly about statistical communication – usually a bit more tentative. The discourse analysis highlights the disjunction between these two aspects of each transcript, and in particular, the fact that students may not realise that they are actually communicating statistically in *informal* situations.

The analyses we have presented indicate the pedagogical importance of giving our students informal opportunities to discuss the statistical ideas that they are studying in a discipline context. Students should be encouraged to practice explaining their statistical explorations to each other, maybe in the context of group work, and the link between this and communicating statistics in a professional sense should be made explicit. Such informal discussion can encourage them to constitute the meaning and usefulness of statistics for their discipline and their profession. It can also be a precursor to more formal communication in the form of presentations and reports, and discussion of the importance of professional demands for effective communication.

Major students of statistics usually get such opportunities in the form of case studies and reports undertaken as part of their assessment in various statistics courses, and also by taking whole courses which focus on statistical graphics or consulting. Servicing statistics students are less likely to have such opportunities, although they are usually very positive about them when they do occur. For example, the success of the projects described by MacGillivray (2002) in the context of statistics education for engineers seems to depend on a mixture of the "self-selection" of the topics of the projects (some professional, others based on hobbies or interests), the informal communication afforded by working in a group, and the formal communication that takes place in the presentation and the final report of the project. Our critical analysis of interview transcripts indicates how such communication can contribute to student learning and provides justification for current changes to include aspects of communication in statistics pedagogy.

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