TEACHING STATISTICS AND ACADEMIC LANGUAGE IN CULTURALLY DIVERSE CLASSROOMS

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ABSTRACT

The last decade has seen a substantial increase in the cultural and academic diversity of commencing tertiary education cohorts. The challenge for mathematics and statistics educators is the development of curriculum measures which address the language related difficulties of language minority students (Cocking & Mestre, 1988) and improve learning outcomes for all students. Our focus in this paper is on enhancing language and communication skills in culturally diverse undergraduate statistics cohorts. Most students have difficulty adjusting to the formal language requirements of academia. Non-English speaking background (NESB) students can have particular difficulty with the reading and assessment demands of Western universities if they are not adequately supported (e.g. Ballard & Clanchy, 1997). This is especially problematic when discrepancies between verbal and written expression and true intellectual ability result in assessment penalties. What is required are curriculum models which focus on **what students do** as opposed to deficit models which focus on **who students are** (Biggs, 1999).

We describe curriculum development in two subjects designed to teach language skills in statistics. Both subjects require students to engage with academic language and to develop statistical discourse skills relevant to modern professionals in the quantitative sciences. Methods used to encourage this include explicitly teaching academic reading techniques, and group research projects that are peer assessed. The projects are designed to develop statistical concepts within the context of professional practice and to address key competency requirements of relevant professional associations.

We will present data that suggest that NESB students have more difficulty than ESB students on "traditional" statistics assessment tasks and describe curricula interventions that assist those students to achieve their academic potential. The reaction of students to these developments has been very positive. The quality of the work is impressive and students improve both their statistical knowledge and their reading and writing skills.

Keywords: language, statistics, professional preparation

1. Introduction

Several studies have shown that students have difficulty with all forms of academic language: reading, writing, speaking and listening; and that students from a non-English speaking background (NESB) have more trouble that those from an English speaking background (ESB) (e.g. Martens, 1994). NESB students tend to have a more conserving attitude to knowledge (Ballard & Clanchy, 1997) resulting in a strong reluctance to "skim read" or "mine" articles for useful information. NESB students can also be reluctant to participate actively in class due to cultural influences which suggest that this is inappropriate behaviour (Ballard & Clanchy, 1997; Biggs, 1999). These factors are problematic when discrepancies between verbal and written expression and true intellectual ability result in assessment penalties. The drive to internationalise university curricula in Australia has created opportunities for local and international students but requires imaginative teaching solutions and sensitivity to cultural issues. In this paper we will describe work done with students studying in the English medium, though this applies to students studying in any medium that is not their home tongue.

All students, whether ESB or NESB, have to adjust to the more formal language requirements of academia. It is our thesis that these language requirements be taught explicitly rather than implicitly. We will present data that confirm that NESB students have more difficulty than ESB on "traditional" assessment tasks and describe interventions that assist those students to achieve their academic potential. It that curriculum measures for improving learning outcomes for students currently disadvantaged by language difficulties will improve outcomes for *all* students.

Two similar subjects that are designed to teach language skills in statistics will be discussed. Both subjects require students to engage with academic language and to develop statistical discourse skills (reading, writing, listening, communicating) required of globally competent professionals in the quantitative sciences. Methods used to encourage this include explicitly teaching academic reading techniques using statistical articles and independent group research projects which require students to synthesise a journal article relevant to their professional field and to present findings for peer assessment. The projects are designed to develop statistical concepts within the context of professional practice and have been popular with students. Teaching and assessment methods are also designed to address key competency requirements of relevant professional associations.

The reaction of the students has been positive. They appreciate that effort is being made, not only to improve the standard of teaching and learning, but to make what is learnt relevant to their careers ["I was surprised to see so much information about stats in the journals. Very few lecturers attempt to make the unit seem relevant to our careers but ... this is very worthwhile" and "The group project was good as it showed how statistics is applied to optometry."]. (All student quotes are reproduced here verbatim from original electronic sources.)

2. Rationale

The curriculum design for both subjects uses four theoretical frameworks. The first is a study of students' conceptions of statistics (Petocz & Reid, 2001). Petocz and Reid found that final year students who had studied statistics had three levels of conception about the subject, an *extrinsic technical* conception, *extrinsic meaning* and *intrinsic meaning*. This influenced the students' interaction with the discourse of statistics. Careful design of questions assists students to progress to higher levels of both language and statistics.

The second framework uses Systemic Functional Linguistics (Halliday, 1995). We can use Fairclough's three-dimensional conception of discourse (Fairclough, 1992:73) to design learning activities for undergraduates to help them understand:
- how the texts that they read are constructed,
- how they themselves can construct and interact with text,
- and how these constructions and interactions become the substance of that discipline.

To look at the specific needs of mathematics and statistics students, a research team gathered teaching and learning materials from a range of classes and video- and audio-taped several lecture and tutorial sessions. Some results were published in Wood, Smith & Baynham (1995). The team also collected examples of published work that exemplified the range of reading material that professional mathematicians and statisticians use, and the manner in which analysis is conducted and presented in professional journals.

Another framework to inform the design of curriculum is the increasing amount of work investigating graduate profiles and professional competencies. Both universities and professional societies are developing lists of graduate competencies that can be developed through degree programs. The development of academic and professional discourse skills connects well with the generic competencies needed by graduates of quantitative disciplines. These include: information retrieval; problem solving; application of knowledge; effective oral and technical communication; functioning as an individual and a member of a team; critical thinking; and lifelong learning skills. Fortunately, mathematics and statistics are two of only a small number of disciplines able to embed all the generic attributes in an integrated way (Challis & Gretton, 1997).

The final framework connects the ideas of equity, equal opportunity and non-discrimination which have become part of teaching and learning at university. For many lecturers these are principles they have adhered to throughout their lives. However, the recent changes have been in the legislative and social acceptance of these principles. Universities are no longer for the elite and importance is given to teaching and learning initiatives that are inclusive and assist students to reach their academic potential whatever their background.

Analysis of results data for a first year quantitative methods unit offered at Queensland University of Technology, Australia (see next section) suggested that NESB students performed, on average, at a level below their ESB counterparts on all five performance measures considered (see Appendix 1). There were, however, no significant differences in the level of high school achievement between the two groups. The teaching and learning strategies described here were motivated by our desire to improve the performance of NESB students who may be disadvantaged by language difficulties, while improving the discourse skills of all students by providing explicit instruction in reading, writing and presenting academic language.

3. Context

Quantitative Methods for Optometry and Health Science (QMOHS). This unit is taken exclusively by commencing students in Queensland University of Technology's Bachelor of Applied Science (Optometry) course. Teaching, learning and assessment practices place a heavy emphasis on developing statistical literacy (reading, writing and communicating statistics). Learning experiences are designed to develop students as "users of statistics" (practitioners) rather than "creators of statistical knowledge" (researchers). The competency standards of the Optometrists Association of Australia (OAA) (see Kiely *et al.*, 2000) relevant to the unit are drawn to the attention of students early in semester. These include an ability to: "read recent publications";

"undertake continuing professional education"; evaluate developments in clinical practice using "journals, videos, tapes, library, seminars, conferences"; demonstrate "independence in optometric decision-making and conduct"; and to "clearly communicate information to patients, carers, staff, colleagues and other professionals". This activity helps to set the tone for the unit and motivates the teaching and learning activities to follow.

A typical cohort has approximately 35 students, one-third of whom are from non-English speaking backgrounds. Of these, two (sometimes three) are full fee paying overseas students, usually from Singapore or Malaysia. On average, there are two mature age entry students per cohort. The majority of students (approximately two-thirds) are Anglo-Australian students entering QUT straight from high school. Students in the Optometry program are generally selected from the top 5% of high school achievers, or equivalent if overseas or mature age entry students.

Mathematical Practice. The second subject is *Mathematical Practice* taught at the University of Technology, Sydney Australia. Approximately 60 first year students study the subject each year, about 2/3 are from a NESB, half are male and all are studying statistics or operations research as a major. The subject aims to develop language and statistical skills, specifically:

- to distinguish between levels of formality used in various contexts, such as journal papers, lecture notes, seminars and discussion;

- to communicate knowledge clearly, logically and critically, in a variety of forms and levels, appropriate to the context;

- to analyse and criticise the way mathematics/statistics is used by the media;

- to judge the appropriate type and level of representation and language for a particular context.

The subject was developed because of the large number of NESB students studying mathematics majors and perceived problems with academic language related to statistics. We did not believe that NESB students should receive supplementary tuition in academic discourse but that *all* students would benefit from structured statistical language activities. This fitted well with the desire to introduce more communication skills into all degree programs.

4. Teaching and learning approaches

Quantitative Methods for Optometry and Health Science. The aim of the group reading and presentation project is to provide students with early exposure to the use of statistical techniques in *real* optometric scenarios. Students are required to select their own articles from amongst the professional optometry literature. This freedom allows students to follow up on topics of personal interest and encourages wide reading. Most importantly, the process requires students to make a substantial effort to transfer concepts from the "safety" of the classroom to the complex scenarios encountered in applied experimental design and data analysis. Students are supported by group consultations with the lecturer. During these meetings, statistical misconceptions are corrected and advice for the most effective way of presenting the material is proffered.

After gaining a basic understanding of the aims, methods and results of the study in question, students are asked to think critically about their articles. Are the techniques used appropriate? What assumptions have been made, and are they valid? What other techniques (if any) could have been used here? In some cases, students reconstruct the data sets from available information and redo the analysis as a check. At the end of their research phase student groups are asked to "distill" their articles in a form suitable for a 10 minute presentation to an audience of their peers

and interested academic staff. These presentations are peer assessed (see Section 6). The critical thinking and presentation phase of the group project take place towards the end of semester, a typical QMOHS student's first at university.

Mathematical Practice. The teaching and learning approach is to use *real* materials. Starting at the lowest level of conception, we examine how texts are constructed. This is the extrinsic technical level of students' ideas of statistics. Students are encouraged to read widely in a range of genres, from informal newspaper articles and web sites, to research papers. The tasks lead them through structured reading activities. At this level of skill, students are technically proficient at statistics and reading.

	Fairclough (1992)	Petocz and Reid (2001)
Level 1	How texts are constructed	Extrinsic technical concept of statistics
Level 2	Construct and interact with text themselves	Extrinsic meaning
Level 3	How this all fits into their discipline	Intrinsic meaning

Table 1. Teaching approach

The next level is for students to start to construct and interact critically with texts. They are still looking at the learning process as outsiders, with the meaning external to themselves. At level 3 students have internalised the meaning. They become part of the discipline and see how the statistics and discourse fit together to communicate ideas. An example of a Level 1 and 2 learning task is listed in Appendix 2. In this task students are asked to find a recent article that uses statistics. The publications suggested are general science publications and this reflects the student body who are first year undergraduates. For a post-graduate group, I would ask them to find a professional journal in their discipline area. Section 1 of the assignment takes students through the development of reading and summarising skills. First they write down the aim of the article in one sentence, then summarise it in 3 points, then in 100 words. The 100-word summary is done for two different audiences to sensitise students to the idea that writing is for your audience. Section 2 of the assignment looks at oral presentation and so asks students to take essentially the same material and change to form of the summary for oral presentation. Again this is done for 2 different groups to encourage students to think about audience. The presentations for senior high school students have been particularly imaginative and reflect the fact that this group is close to the current age of the students so they are able to identify with the audience.

5. Outcomes

Quantitative Methods for Optometry and Health Science. The group reading and presentation projects have been popular with students since their inception in 1999. Their popularity stems from the exposure students gain to *real* applications of statistics ["the group reading project was useful both as an insight into the practical use of stats that otherwise seem fairly obscure in their application (in the field of optometry anyway). Also gives us a view into the "world of optometry" from a quite different point of view"]. They also give NESB students an opportunity, and the necessary encouragement, to contribute verbally in class. Previous research has suggested that NESB students studying in western universities tend to take on the role of passive learner, looking to the teacher for "direction, authority, and control" (Ballard & Clanchy, 1997). NESB

students in QMOHS had similar reservations initially ["Most of the non-English back ground student will not ask question in the class. I think the reason is they afraid to speak out. We rarely speak out loud in the class during our high school"] but all participated enthusiastically in the end-of-semester presentations.

One of the most important outcomes of the reading and presentation projects has been a perception amongst students that group discussion of concepts aids understanding ["It was good to have a different way to help consolidate concepts learnt in class - through discussion with other group members."]. It is well recognised that the process of explaining concepts verbally is an important aid to developing higher order cognitive strategies (e.g. Rosenshine & Meister, 1992) especially when preparing students to tackle unfamiliar problems and when teaching students with a diversity of cultural attitudes towards reading and knowledge (Ballard & Clanchy, 1997). This was reflected in student surveys.

Giving students responsibility for preparing and communicating syllabus sections to other students can also engender a sense of "ownership" of the material and a perception of improved understanding and confidence (Coutis *et al.*, 2001) ["The group project was useful as [it] ensures you have a full understanding of the statistical methods used"]. These benefits were enjoyed by NESB students also ["Group reading is useful that we can discuss our problems and I think I understand more of the statistic after the group project!"].

Mathematical Practice. The *Mathematical Practice* subject has been running for 8 years. Surveys of students show that they perceive that their reading and writing skills have improved. The historical content of the subject is not popular with about a third of the students. For the oral component, the quality of the presentations is excellent and students feel more confident with public speaking. The written examinations demonstrate that students reach good levels of reading, comprehension and writing. The main presentation task is structured like a mini-conference. Students choose a theme and write papers to that theme (this year the theme is based on *The Code Book* by Simon Singh). The papers are refereed by fellow students and a book of proceedings is produced. Students appoint an editorial team who decide on the editorial guidelines and format for the proceedings. During the mini-conference, students are very supportive of their peers and particularly encourage students with poor spoken English.

Lecturers in subsequent subjects make use of the skills developed in the first year subject and require students to write and make presentations about the technical content of their areas. There is evidence that many students are reaching a Level 2 conception of statistics but few students reach Level 3 (Petocz & Reid, 2001). This is not surprising as the Level 3 conception is a professional level and we may expect to see this in final year students or graduates. We are investigating these conceptions with graduates.

6. Problems

The main problem encountered concerned the peer-assessed component of the subjects. A comparison of peer assessment marks for the QMOHS group projects in 2000 revealed that NESB students faired significantly worse in the eyes of their peers (Appendix 1). This is interesting when considered in tandem with student responses to the Likert scale item "The group reading project and presentation was a worthwhile learning experience" which suggested that the views of ESB and NESB students were comparable (p = 0.58). In hindsight the marking criteria used (see Appendix 3) may have disadvantaged NESB students who were self conscious about their spoken English ["We (non English background student) have problem while speaking to friends using

English, it's even worst when we need to talk out loud in the class. We'll get nervous and sometimes I'm not sure what I'm talking out there"].

In response to these findings, a 5-point Likert scale will be trialed this semester in place of the current criteria-based system, which requires students to give a numerical rating based on their own interpretation of the various grading criteria. MacAlpine (1999) found that this significantly improved consistency and discrimination amongst ratings given by final year Electrical Engineering students at the Hong Kong Polytechnic University because it gives more explicit guidance on relationships between level of performance and grade. Class time will also be set aside for groups to practice their presentations prior to their graded performance, and for misconceptions concerning the grading criteria to be addressed.

Our observations also suggest that students tend to avoid working in culturally mixed groups, limiting opportunities for cross-cultural perspectives (Volet & Ang, 1998). However, recent student discussions have encouraged us to experiment with mixed groups in the future ["Grouping with Australian student of course is an advantage because its help to improve our English by more frequent conversation using English. … if we were grouped and not chose the group member ourselves, it will forced us to use English, that's better."]

7. Conclusion

The types of learning experiences described here develop discourse skills in statistics. More than that, they develop skills required for professional practice in disciplines that need the communication of technical information. They encourage deep learning by requiring students to internalise concepts, and to *explain*. It is a teaching and learning strategy that is appropriate for students studying mathematics majors as well as students studying statistics as part of another degree program. Students believe that the approach is relevant to their future work and study needs and there is evidence that the skills are transferable to other subject areas.

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APPENDIX 1

Comparison of ESB and NESB student performance in the unit Quantitative Methods for Optometry and Health Science (2000).

Item	NESB mean	ESB mean	p-value
Final Result (/100)	71.0	79.7	0.055
Final Exam (/100)	65.2	75.7	0.057
Group Presentation (/10)	9.06	9.46	0.0001
Class Tests (/30)	22.5	24.5	0.10
Group Assignment (/100)	95.1	95.6	.30

APPENDIX 2

Assessment task for Mathematical Practice

Aim: To develop skills in summarising information from mathematical/statistical writing.

Section 1: For this task you may choose an article from a recent edition of *New Scientist* or similar scientific, computing or financial journal. Only read the parts of the article that each question requires you to.

(a)   Clearly reference the article

(b)   Read the title, abstract (if any) and the first and last paragraph. Write down the aim of the article in one sentence.

(c)   Now skim-read the article. Write down the three main points of the article in three dot points.

(d)   Now read the article in detail. Write a summary of the article for your peers in about 100 words.

(e)   Imagine that you are writing for students who are about to start university. Write a summary of the article for these students in about 100 words.

Section 2: Using the same article, this task requires you to prepare for an oral presentation of information.

(a)   You are to deliver a 5 minute talk that summarises the article for your peers. List the points you would make and design three overhead transparencies to accompany the talk.

(b)   Again, you are to deliver a 5 minute talk but this time it is to senior high school students. You will also prepare an A4 page handout to accompany your talk. Here the emphasis is on how to present the material in a way that the students will grasp the ideas. Write down how you would deliver the talk, what you would say and design the 1 page handout.

Marking:

0	1					1(a)	The aim is correct
0	1	2				1(b)	The three dot points summarise the content accurately
0	1	2	3	4		1(c)	The content and language of the summary are accurate, clear and appropriate for the required audience
0	1	2	3	4		1(d)	The content and language of the summary are accurate, clear and appropriate for the required audience
0	1	2	3	4		2(a)	Your content and overhead transparencies show accurate, clear and appropriate preparation for the required audience
0	1	2	3	4	5	2(b)	Your method of presentation, content and handout show accurate, clear and appropriate preparation for the required audience

APPENDIX 3

Previous peer assessment criteria for QMOHS group presentations.

Group Presentation Peer Assessment Form

Notes:

1) Content marks (/5) should be awarded on the basis of:

    i)   quality of background information / introduction
    ii)   demonstrated understanding of techniques discussed
    iii)   quality of overview: the bigger picture?

2) Presentation mark (/5) should be awarded on the basis of:

    i)   clarity of explanations
    ii)   conciseness of summary/conclusion: take home message?
    iii)   overall presentation quality
    iv)   accurate citation details