Numeracy Counts in the Statistical Reasoning Equation

Therese Wilson and Helen MacGillivray
School of Mathematical Sciences, Queensland University of Technology,
Gardens Point Campus, Brisbane, 4001, Australia.
Email: tm.wilson@qut.edu.au

1. Introduction

The relationship between mathematics and statistical reasoning frequently receives comment (Vere-Jones 1995, Moore 1997); however most of the research into the area tends to focus on maths anxiety. Gnaldi (Gnaldi 2003) showed that in a statistics course for psychologists, the statistical understanding of students at the end of the course depended on students' basic numeracy, rather than the number or level of previous mathematics courses the student had undertaken.

As part of a study into the development of statistical thinking at the interface between secondary and tertiary education, students enrolled in an introductory data analysis subject were assessed regarding their statistical reasoning ability, basic numeracy skills and attitudes towards statistics. This work reports on the relationships between these factors and in particular the importance of numeracy to statistical reasoning.

2. Methods

Students involved in this study were enrolled at the Queensland University of Technology in the subject "Statistical Data Analysis 1" during the first or second semester of 2004. The study involved 394 students in semester 1 and 110 in semester 2, with not all students completing all instruments of the study. Approximately 30% of the students were enrolled in an Applied Science degree (most in Life Sciences), 13% in a Mathematics degree and 9% in an Education degree.

Background information was supplied by the students regarding previous mathematics subjects studied (at high-school or elsewhere), the results obtained in these and also their tertiary entrance score.

A twenty item, multiple-choice and short answer Statistical Reasoning Questionnaire was designed for the study. This questionnaire was informed by the Statistical Reasoning Assessment (SRA) (Garfield 2003) and the work by Jane Watson in Australian schools (see, for example (Watson and Callingham 2003)). Questions were developed and selected to reflect the statistical thinking appropriate at the Australian school/tertiary interface and needed for development in a wide range of disciplines. A few questions on particular aspects of the high-school curriculum were included on the questionnaire but not in the analyses reported here.

Students' numeracy was assessed by a questionnaire consisting of 21 multiple-choice items, designed around those aspects of numeracy commonly assumed in an introductory data analysis subject, such as: manipulation and understanding of fractions, decimals and percentages; substitution of numerical values to evaluate simple expressions; and rearranging simple equations and inequalities. So as to enable very simple questions to be asked, students were asked not to use calculators. As the items on this questionnaire assess skills at or below a standard relevant to approximately 14 to 15 year olds in Queensland, and the stated assumed knowledge for the data analysis subject is an algebra and function-based core senior secondary maths course, the results of incoming students on this questionnaire are of interest in themselves.

Students' attitudes towards statistics and their self-efficacy in the area of mathematics and statistics were measured via a Likert scale. Items from the survey were grouped to measure attitudes in relation to: affect (feelings engendered by statistics); value in the subject; motivation to study statistics; links perceived between mathematics and statistics; use in society; difficulty of the subject; self-efficacy (perception of own ability).

3. Results

General linear models with backwards elimination were used to determine variables which influenced scores on the Statistical Reasoning Questionnaire. In the initial analysis, all students were included with a factor allowing for whether or not the student could be considered a maths student (maths degree, science degree majoring in maths or an education degree with maths as a chosen discipline). For the whole group, the numeracy score was a highly significant predictor of statistical reasoning ($p<0.001$) after allowing for all other possible affects, with other significant predictors being gender, tertiary entrance score, years since school, whether they were a "maths" student and motivation, with significant interactions between "maths" and tertiary entrance score, and tertiary entrance score and motivation. Because of the strength of the interaction between the student's tertiary entrance score and whether or not they were a "maths" student, with these interactions being present in both numeracy and statistical reasoning scores, it was felt that additional understanding of the relationships between variables would be reached by considering "maths" and "non-maths" students separately.

For "non-maths" students, statistical reasoning depended heavily on numeracy skills ($p=0.001$) which in turn depended on the overall level of achievement at high school and a student's confidence in their own ability in the area.

For "maths" students, it was found that tertiary entrance score and self-efficacy were not useful predictors of numeracy. It is suspected that, for students whose prime area of interest is mathematics, the overall high-school achievement is not necessarily indicative of their numeric ability and any deficiency in self-efficacy is counter-balanced by a genuine interest in the area. For these students, modelling of statistical reasoning was far more complex, demonstrating the variety of individuals who are drawn to mathematics and who have already developed statistical thinking appropriate for ongoing learning.

REFERENCES

Garfield, J. (2003). Assessing Statistical Reasoning. Statistics Education Research Journal, 2, 22-38.

Gnaldi, M. (2003). Students' Numeracy and Their Achievement of Learning Outcomes in a Statistics Course for Psychologists. Unpublished M.Sc, University of Glasgow, Faculty of Statistics.

Moore, D. (1997). New Pedagogy and New Content: The Case of Statistics (with Discussion). International Statistical Review, 65, 123-137.

Vere-Jones, D. (1995). The Coming of Age of Statistical Education. International Statistical Review, 63, 3-23.

Watson, J., and Callingham, R. (2003). Statistical Literacy: A Complex Hierarchical Construct. Statistics Education Research Journal, 2, 3-46.

RÉSUMÉ

Fréquemment, la relation entre les mathématiques et la raisonnement statistique a été discuté dans la littérature (Vere-Jones 1995, Moore 1997), mais la plupart de la recherche examine le phénomène de "maths anxiety". Dans un cours statistique pour les psychologistes, Gnaldi (2003) a montré que la compréhension statistique des étudiants à la fin du cours, dépendais de leurs habiletés mathématiques basique par rapport le nombre ou niveau des cours mathématiques entrepris par l'étudiant.

Pour une étude sur le développement de la réflexion statistique entre l'éducation au lycée et à l'université, les étudiants qui se sont inscrit dans un cours des analyses statistiques élémentaire, étaient analysés en ce qui concerne leur capacité du raisonnement statistique, habiletés mathématiques et aussi leurs attitudes pour statistiques. Ici, on rapport sur les relations entre ces facteurs et en particulier, l'importance des mathématiques pour la raisonnement statistique.