

## WHAT IS RESEARCH IN STATISTICS EDUCATION?

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*The history and current nature of research in statistics education are outlined and some suggestions for its future direction are made. It is claimed that research in statistics education is a research discipline in its own right.*

### RESEARCH IN STATISTICS EDUCATION

It is sometimes said that research in statistics education is not really statistics, and an unstated implication of this is that it is not really the concern of academic statisticians. Indeed some statisticians are reluctant to recognize statistics education as a field of academic research and its publication is not rated as highly as that of statistical research. On the other hand, although statisticians who are active in this field might find that they are honorary members of education departments when research assessment exercises are carried out, it is doubtful whether they would be accepted as full members of an education department unless they also have a qualification in education. The reverse of this is that those whose main discipline is education but who are interested in statistics education research are not necessarily accepted as members of a statistics department. It is therefore timely to define research in statistics education and to proclaim its existence as a research discipline. Researchers in statistics education should be eagerly sought after by both education and statistics departments, and indeed by every department where statistics is important.

One of the difficulties is of terminology and emphasis. If statistics teachers say they have research interests in statistics education or in teaching statistics it is not immediately obvious that this is any different from what teachers of statistics might do as part of their normal work in keeping up to date and reviewing their own performance. It is even less clear what a statistician without teaching responsibilities means by an expression of interest in statistics education research. There is a difference between the activity of teaching, being an active researcher into teaching and learning, and having a relatively passive interest in the research activities of others. The best teachers and researchers participate in all of these.

Another difficulty relates to the position of statistics itself, and in the context of this paper statistics should be taken to include probability. It is often coupled with

mathematics, and teaching of statistics at all educational levels is often the responsibility of a mathematics department. The theory of statistics is underpinned by mathematics but statistics is essentially an applied subject and many developments in statistics have been made by those specialising in an application area so we might ask whether statistics belongs with mathematics or with the subjects it serves (Vere-Jones 1995). Similarly statistics education falls within the wider field of mathematics education and researchers in statistics education find an outlet for their work in mathematics education publications and conferences such as the International Congresses on Mathematical Education (ICME). A recent important book focusing on probability (Kapadia and Borovcnik 1991) was ostensibly written to fill a gap in the mathematical education research literature.

Research in educational, experimental or mathematical psychology, particularly into statistical thinking and probabilistic understanding, some of which has a long history, could be said to be research in statistics education. More recently, with development of statistical software, increased dissemination and communication through electronic means, and the growth of multi-media for teaching, the distinction between statistics and computer science has become blurred. In addition, the growth in popularity of computing science as a subject to study and a decline in mathematics and statistics has meant that in some institutions both mathematics and statistics departments have been merged with, and are sometimes the smaller part of, a computing science department, providing opportunities for increased collaboration. Thus educational research activities in computing science and in learning technology provide another outlet for research in statistical education.

## HISTORY AND GROWTH OF STATISTICAL EDUCATION

As is brought out in a paper by Bibby (1987) the history of statistics teaching cannot really be separated from the history of statistics. The teaching of statistics was discussed at international meetings in the second half of the 19th century, but it is, perhaps, only since the end of the second world war that statistics has grown to become widely recognised as a subject and with this has come development of interest in statistical education issues. Some key events are (and see Vere-Jones 1995): the education committee of the International Statistical Institute (ISI) was set up in 1948 and the first round table meeting it sponsored was held in 1968, the journal "Teaching Statistics" was started in 1979, the first International Conference on Teaching Statistics (ICOTS1) was

held in 1982, the proposal to form the International Association for Statistical Education (IASE) as a section of ISI was accepted in 1991, and the first issue of the electronic Journal of Statistics Education (JSE) appeared in 1993.

The growth of interest in research in statistical education can be seen by looking at the content of the different ICOTS meetings. Both ICOTS1 and ICOTS2 had a session on the principles of learning probability and statistics. In ICOTS3 a session on psychological factors affecting the teaching of probability and statistics was combined with one on classroom research issues and a session on assessment of performance in probability and statistics was concerned mainly with research issues. In ICOTS4 the session on research on teaching and learning statistics and probabilistic concepts contained twenty-two papers. In ICOTS5 the session on research in teaching statistics has seven subdivisions and the session on the role of technology in the teaching of statistics has sections on teaching experiments and on research. Similarly there has been a change of emphasis in the papers given in other sessions. In ICOTS1 papers were mainly on what training was given to different age groups or disciplines but now there is more on how the practice of statistics can inform teaching, the integration of teaching methods, and on learning. See Garfield (1995b) for another account of these changes.

Other developments include the international study group for research on learning probability and statistics which was set up at ICOTS1, and a working group concerned with psychological aspects related to the teaching and learning of stochastics which was set up after the 1996 Psychology of Mathematics Education meeting. It is now also fairly common for national and international statistics conferences to include papers on statistical education. There are thus now many alternative and more visible means of communicating with other researchers in statistics education and with the outside world than previously.

## THE NATURE OF STATISTICS EDUCATION RESEARCH

The International Commission of Mathematical Instruction (ICMI) set up a study on the nature of research into mathematics education in 1993 and the outcome was published in a 576 page book (Sierpinska and Kilpatrick 1997). The time scale involved and the size of the publication, which leads to more questions, indicate the enormity of the task. It is no less a task to consider and make a definitive statement about the nature of statistics education research.

Many of the points made about mathematics education research apply equally to statistics education research. For example it appears that mathematics education researchers have been unsure as to their identity. Similarly a glance at ICOTS proceedings or at the contents of *Teaching Statistics* or the *JSE* suggests that even statistics education researchers might be unsure as to exactly what research in statistics education is, though to be fair the conferences and journals are concerned with wider issues than statistics education research in its narrowest sense. The role of IASE is still emerging and it is not yet clear whether it is primarily a research or a professional organisation and whether its purpose is to advance statistical education as a scholarly discipline in its own right (Vere-Jones 1995).

Research in statistics education could be classified by the aims and objectives of the research, the disciplinary approach used in the research, statistical topic, interaction with an area of application, methods of teaching or learning or assessment, and characteristics of those being educated. The research study might be empirical, observational, experimental, a review of others' work, or theoretical. Shaughnessy (1992) gives an overview of research in learning and teaching probability and statistics, and Hawkins et al (1992, chapter 6) give examples of a number of research studies to illustrate the nature of statistics education research.

Statisticians should be expert at conducting and analysing research studies, consulting with experts in the area of study when appropriate, but little is known about or has been published on the methodology of statistical education research. As is the case in social and medical research, it is often not practical to experiment in educational research and it is not always ethical to do so. Controlled experiments are particularly difficult to do (Hawkins et al 1992, pp.96-9).

We might have a gut feeling that a different syllabus or teaching method is better, but the support of colleagues could be needed in order to try it, even within one's own courses, and in some cases constraints imposed by a curriculum or assessment can effectively rule out any changes. Even when a method or course appears to be successful it cannot be said for certain that it is any better than any other unless a proper comparison with alternatives has been made. It could well be that almost anything would have been successful. Continuing as previously can also be considered to be an experiment in some sense as external circumstances outside the teacher's control might have changed,

especially the nature of the students. In any case what has worked well in the past sometimes goes wrong (see Tanur 1997).

The success of a statistics course, content and objectives as well as the method of delivery, tends to be measured by assessing student performance, understanding and retention, and asking students about what is sometimes referred to as the “student experience”. However, assessment in statistics presents challenges (Gal and Garfield 1997) and few would claim that there are perfect instruments for assessment. Research into methods of assessing statistics is part of research in statistical education. More is known about ways of asking students about their experiences of a course, including their attitudes, as survey research is well established as a discipline. Researchers could also survey teachers and employers as part of the research into the effectiveness of an approach and whether needs are being met.

#### THE FUTURE OF STATISTICS EDUCATION RESEARCH

It is useful to think about the purpose of statistics education research. It is likely that one of the chief aims is that research findings would be used to improve teaching practice and students’ understanding of statistics and performance in it, and associated research might concentrate on the teaching and the learning of statistics and the relation between them and statistical knowledge. Another aim might be connected with how to further statistical literacy in the world at large - the best way of educating both those who present statistical facts to the public and the consumers of statistics. There is still plenty of research which might be done in these areas. Other suggestions for research in statistics education can be found in Garfield (1995a) and Shaughnessy (1992).

As those involved in the ICMI study found in the case of mathematics education research (Sierpiska and Kilpatrick 1997), asking what research in statistics education is leads immediately to a number of supplementary questions, and further thought about these leads to yet more questions. Some of the general questions are: “Is there a unity to the different activities which take place under the heading of research in statistics education?”, “What are the research questions in statistics education?”, “Are there research questions which are specific to statistics education?”, “What are the results of research in statistics education?”, “What criteria should be used to evaluate research in statistics education?”. Questions more directly concerned with teachers of statistics are: “How many teachers have access to research results and how many read these?”, “Do

research results influence training in the teaching of statistics?”, “Are statistics teachers competent to do research in statistics education?”, and “Does research positively inform practice?”. Each of these questions defines a topic of research and answering them will keep statistics education researchers occupied for some time to come.

## REFERENCES

- Bibby, J. (1987). 1786-1986: Two centuries of teaching statistics. Proceedings, 2<sup>nd</sup> International Conference on Teaching Statistics, pp.478-493. Eds. R.Davidson and J.Swift. University of Victoria, Victoria B.C.
- Gal, I. and Garfield, J. (Eds.) (1997). The assessment challenge in statistics education. IOS Press.
- Garfield, J. (1995a). How students learn statistics. *International Statistical Review*, 63,1, 25-34.
- Garfield, J. (1995b). Reflections on the past 15 years. *Teaching Statistics*, 17,2, 77-8.
- Hawkins, A., Jolliffe, F. and Glickman, L.(1992). *Teaching statistical concepts*. Longman.
- Kapadia, R. and Borovcnik, M. (1991). *Chance encounters: probability in education*. Kluwer Academic Publishers.
- Shaughnessy, J. M. (1992). Research in probability and statistics: reflections and directions. In *Handbook of research on mathematics teaching and learning*, ed. D.A.Grouws, pp.465-94. Macmillan.
- Sierpinska, A. and Kilpatrick, J. (Eds.) (1997). *Mathematics education as a research domain: a search for identity. An ICMI study*. Kluwer Academic Publishers.
- Tanur, J. M. (1997) Leading horses to water. *International Statistical Review*, 65(2), 159-61.
- Vere-Jones, D. (1995) The coming of age of statistical education. *International Statistical Review*, 63(1), 3-23.