Working Group Report on Curriculum and Research in Statistics Education

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In the working group on curriculum and research, the big question we asked ourselves was, "How does curriculum development relate to the changes in society, statistics, and theories of learning?" A few important questions related to these changes are: How is society changing, for example, due to technology? How have theories on learning and learning situations evolved? How has statistics itself changed, for example, in response to new technologies? Answers to such questions can help us theorize regarding the implications for education (including curriculum development and instructional methods), for professional development, for assessment, and for future research. The sections below present several questions and issues, relevant research, and a few recommendations related to these areas.

Implications for Education

1. How do changes in society, statistics, and learning theory influence what statistics content should be taught?
2. What knowledge and skills (fusion of mathematical, statistical, technological) do future citizens, employers, and scientists need?
   Many educators philosophize on this but mostly in the American context. See Madison & Steen (2003); Moore (1990); Noss, Pozzi, & Hoyles (1999); Scheaffer (1990, 2003); Scheaffer et al., (1998); Steen (1990, 1997, 2001); and Utts (2003).
3. What has changed in our views on how students learn and should be taught?
   See Bransford et al., (2000); Broers, Mur, & Budé (2005) in this document; Garfield (1995).
4. What affordances do new technologies offer us?
   See in this document: Finzer & Erickson (2005); Matis, Riley, & Matis (2005); and Gould & Peck (2005).

Implications for Curriculum Development

More concretely, with respect to curriculum development, a changing society suggests the need for a new curriculum. The basic question we must answer is, "*How* should *what* [content] be taught to *whom*?" (See Rossman & Chance, 2005; Harradine, 2005; Ottaviani & Luchini, 2005; Li, 2005; McGillivray 2005; and Bakker, Biehler, & Konold, 2005 in this document). If we want to foster more than "content" learning, such as aiming for statistical literacy, how do we promote and assess it? (See Schield, 2005; Reading & Reid, 2005; and Watson & Callingham, 2005 in this document).

We may want to record what the statistics curriculum looks like in different countries, beginning from a document on the IASE website (this may be a possible research project), and reporting on how curriculum is actually developed in different countries (See Begg, 2005; and Li, 2005 in this document). We need research that helps with making decisions in curricular development, taking into account all constraints (see Bakker et al., 2005), so we can begin to theorize about questions such as, "What could improve the curriculum development process?" (See Pfannkuch & Horring, 2005 in this document).

Research often only offers ideas and shows what is possible (see, in this document, Reading & Reid, 2005; and Broers et al., 2005), and is usually not about the choices that have to be made. It is clear that inter-disciplinary teams are needed to develop a sound curriculum. Members of these teams should include statisticians, researchers, educators/teachers, students, curriculum authors, software designers, and also publishers, policy makers, assessment experts.

As another working group stated, technology plays a significant role in the teaching of statistics and is changing the nature of the subject. Complex investigations, exploratory data analysis and visualization, simulation, and re-sampling are all accessible earlier in the curriculum due to technology

use. The influence of technology on statistics education can be summarized by the following statements adapted about mathematics (originally stated by Seeley, 1990) made by Engelbrecht & Harding (2001):

> Some statistics becomes more important because technology requires it;
> Some statistics becomes less important because technology replaces it;
> Some statistics becomes possible because technology allows it; and
> Some statistics can be taught using technology.

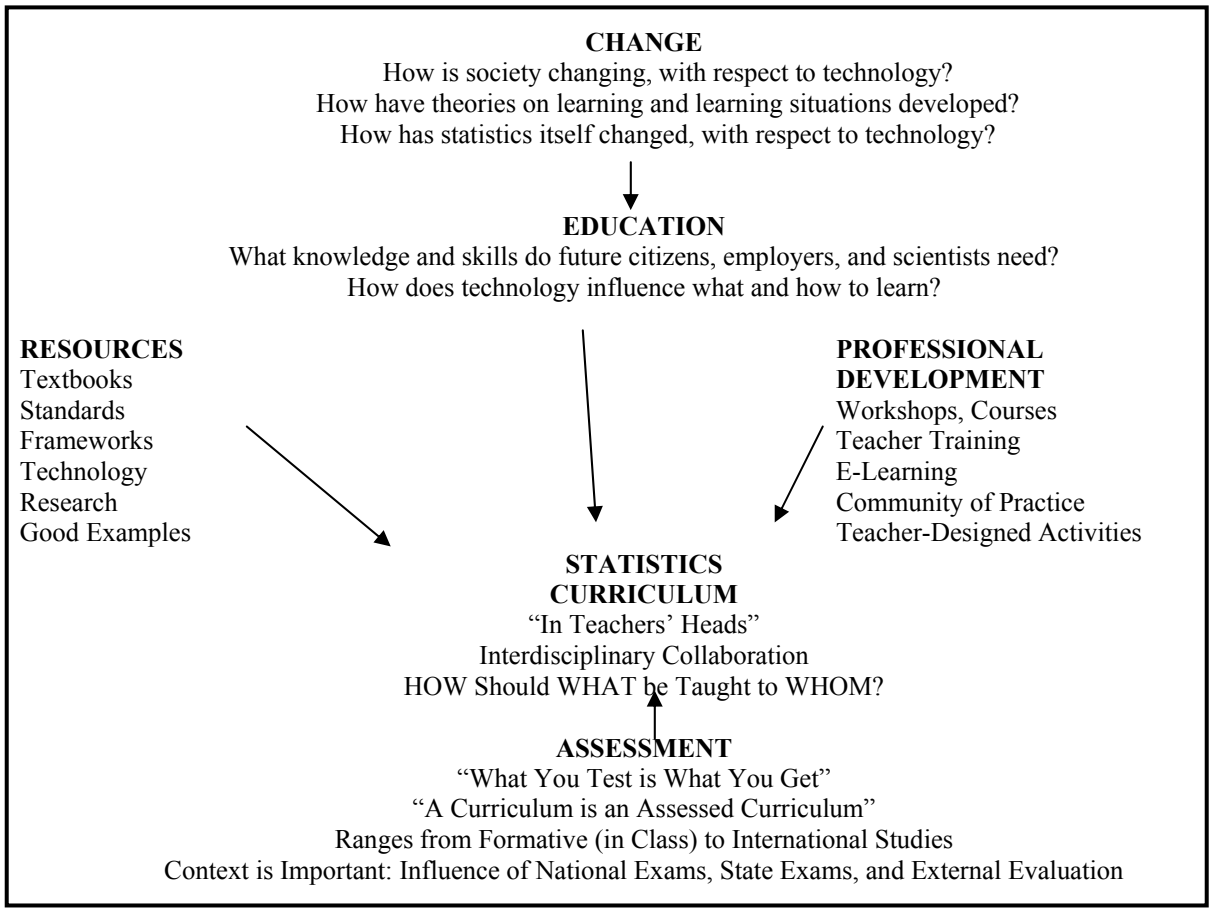
Implications for Professional Development

Given the need for a community of practice (as described by Pfannkuch & Horring, 2005; and Li, 2005), "What statistical, technological, and content-pedagogical (didactical) knowledge do teachers need?" (See Rossman & Chance, 2005 for some ideas). In addition, "How can we use new courses and new technologies to support (mathematics) teachers' efforts to teach statistics?" (Gould & Peck, 2005).

Assessment

Given the motto, "What you test is what you get", it is crucial to develop assessments that test what we want to get. This a great challenge (as discussed by Ridgway, McCusker, & Nicholson, 2005; and Watson & Callingham, 2005), whether related to formative assessment in the classroom or through large-scale international comparisons. Political issues play a large role in both the challenges and in the resulting assessment (see Begg, 2005).

More diagrammatically, our line of reasoning can be displayed as follows.



Note that in the diagram, the statistics curriculum is in the central position. The curriculum, as what is "in teachers' heads", is influenced by the resources (such as standards, textbooks) as well as by teachers' professional development activities, and the assessments that are used to judge teaching and learning success. Which factor among these has the greatest influence on the curriculum seems to depend on the context of the country, for example the structure of its school system, the presence or absence of state or national exams, and the general culture. Issues that influence how strongly resources (versus, say, assessments) affect the statistics curriculum include examples such as:

- the fact that there are no state exams in Queensland, Australia, or
- that 80 percent of assessments in New Zealand are externally evaluated, or
- the presence and role of national exams (such as in China, UK, NL, etc.), or
- the social fact that, in some countries, such as New Zealand, teachers value high levels of autonomy.

Implications and Recommendations for Future Research

Based on the discussion during the conference, many important topics of research arose, but several particular topics arose repeatedly. As a result, we became convinced that research is needed in the following areas:

1. We seem to know more about student learning than about teacher learning, which implies that research into professional development should be a high priority.
2. We need better models or examples than RDD (research, development, and dissemination). The relationship between resources, professional development, and assessment is interactive, so collaboration among interdisciplinary teams is needed.
3. If assessment is as influential as it seems to be, and we really want to promote statistical literacy, then more appropriate assessment tools are needed.
4. We need research that helps curriculum developers make concrete decisions about *when* in the curriculum to teach *what* content, and *how* to best teach that content to the learners of focus.
5. It would be nice if comparative studies of statistics education in different countries could be carried out, so that we could learn more about the influences of the context and culture.

Methodologies

To be considered scientifically sound and potentially useful, research must meet several criteria (some of which may seem trivial, but are critical nonetheless). We highlight four such criteria.

1. All research should be embedded in what is already known about the topic. We recommend that authors of papers relate their own research to the research literature (or other resources) where appropriate. The papers should provide more than description and opinion. A good theoretical framework or background theory can help strengthen both statistics education research and teacher education research.
2. Research should provide evidence or empirical support, not mere rhetoric. By these terms we want to avoid the connotations of "evidence-based research," which sometimes means just randomized experiments. Different forms of evaluation can help to convince readers and interested parties.
3. Research should follow a sound methodology. It is not always possible or desirable to do a randomized experiment as in medical or agricultural research. Observational studies or quasi-experimental designs can be informative and convincing as well, as long as the conditions are made explicit. Yet it is often very difficult to obtain ethics approval for such designs. Qualitative

research methodologies can also yield insights that are empirically grounded (e.g. Miles & Huberman, 1994; Kelly & Lesh, 2000). Triangulation plays an important part in qualitative studies.

4. Which methodology is most appropriate? This depends on the research question. Research in the strict sense is, of course, not the only way to gain new knowledge. As Begg points out, we also need more informal research, such as that which can be carried out by teachers and curriculum authors. The practice of curriculum development shows that research in the strict sense is only one of the many resources from which curriculum developers can profit. Sharing informal experiences of what works and what does not is also needed, as happened during this IASE Roundtable.

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