

6. DISCUSSION: HOW TECHNOLOGY IS CHANGING THE TEACHING AND LEARNING OF STATISTICS IN SECONDARY SCHOOLS

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SUMMARY OF DISCUSSIONS FOLLOWING PAPER PRESENTATIONS

The conference demonstrated that technology can have a profound impact on teaching and learning statistics. Discussions of the working group throughout the presentation of papers raised a variety of issues related to this impact. Anne Hawkins positioned the entire discussion with the questions "What makes a good teacher and what makes good technology?" A good teacher knows how to not just "use" technology but to make it an effective part of the teaching and learning process. The group was reminded that probability and statistics requires a different sort of thinking and that many teachers do not think in probabilistic and statistical terms. A different premise was suggested, in light of rapidly changing technology; there is a real need to define the statistics curriculum so that it is independent of technology and courses do not focus on the use of one particular technology but rather the concept. Participants noted that in some countries students bring virtually no formal statistics knowledge to a course, and the aim of teachers is to get statistics more situated in the curriculum. Both the need for the professional development of teachers in order for them to effectively teach statistics and use technology to teach statistics, as well as the need to have a clearly defined statistics curriculum were underlying themes of the rest of the discussion.

Good technology helps students learn. After several of the papers were presented, this relation between technology and learning was addressed. The question was raised about what sequence of activities will lead to understanding. One comment, regarding an activity involving graphing calculators, suggested that the focus of the activity was on the statistical process, but technology aided in calculations and the investigation. In the discussion following a presentation on Tabletop Software, it was suggested that the dynamics of the software allowed students to build a continuity from their understanding of properties of single cases to the more abstract statistical features that emerge when multiple cases are arranged in statistical displays. Another comment was made that perhaps the use of colors adds a third variable that supports student reasoning about more than one or two variables at a time, demonstrating how computers allow us to help students build understandings of aspects of uncertainty and how variables behave, which are both essential to understanding statistics. One participant added that computers gave students opportunities to look at an entire process and confront misconceptions right from the start.

Discussion about the relation between technology and teaching was primarily on the actual use of technology in teaching. In response to a question about difficulties students have with software, one participant indicated that group activities often engage students but they may not focus their attention on conceptual issues. One advantage of a single computer setup is that the teacher can use it to focus class

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discussion on important statistical concepts. An issue was raised about the time it takes to become acquainted with new technology and whether it takes more time to teach statistics this way. One respondent stated that students are often willing to spend time on their own because of their interest in doing the computer investigations. It was suggested that teachers need to use "myth-conceptions" as a source of intuitive guidance in the development of educational technology.

Assessment issues were also part of the discussion. One participant indicated that current assessment objectives in the United Kingdom guided their work, but if the instruction succeeds in promoting understanding, students should do well on a variety of assessment items. In another country, students appear to respond well to multiple assessments in their project, which included an emphasis on self-assessment.

WORKING GROUP DISCUSSIONS

The working group followed these discussions with a summary session where they synthesized the issues and then looked to the future. The issues encompassed professional development, curriculum, materials, assessment, research, and communication. Their suggestions for a vision of the future for teaching statistics included new data sources, more collaboration (across students, classes, schools, and borders), multimedia and video conferencing, more personal technology for teachers, and continued change in the nature of statistics. Based on the issues and the vision, and mindful of Anne Hawkins' questions about what makes a good teacher and what makes good technology, the group offered the following recommendations:

There is a need on behalf of those in statistics education to promote research on student learning and the role of technology. What is the relationship among student understanding, statistical reasoning, and the role of technology? How can technology (including forms that are not yet developed but are possible) be used to enhance the development of statistical understanding as well as to carry out the actual processes of statistics? The discussion suggested some possible links, but clearly opened the way for more work.

Identify critical issues around student understanding of statistical topics. Careful analysis of these issues will provide the information necessary to develop a sequence of activities, both within a lesson and throughout a broad development of statistics, that will enable students to build on what they have learned and in the process put the issues in perspective. Misconceptions as well as a sequence for learning were part of the discussion in this respect.

Create an international center for sharing ideas, research findings, materials, and resources. There is a need to synthesize and disseminate the results of implementation and research to prevent reinventing the wheel. There is currently no formal mechanism for sharing the results of research on effective ways to teach a concept or on the ways students come to understand a statistical idea. Even sharing professional development models can be beneficial to those in the field. The conference itself was a good illustration of the benefits of sharing.

Develop different models of professional development, in particular ones to help address issues of scaling. There are large numbers of existing teachers with little statistical background on which to build, yet most current professional development strategies involve small cadres of teachers. There is a need to find

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efficient and effective ways to reach teachers and to provide continuing support for them as they both learn statistics and how to use technology to teach statistics.

Create networks among teachers in elementary, secondary schools, and universities. Bringing together those with different perspectives about teaching statistics will enable discussions to take place about content and pedagogy. It will also encourage teachers to become researchers and to reflect with others about what works and what does not and why.

Design activities to measure where students are in their statistical understanding - at all levels including secondary school. There is a need to build continuity into the curriculum so concepts are not developed anew at each grade level but rather that increased understanding is part of the design. This includes thinking about the appropriate place in the curriculum in which to teach the "big ideas" of statistics, about statistics as a cross-curricular subject and as a part of a core curriculum. It also includes recognition that students come to statistics with knowledge from other disciplines, knowledge that should be integrated not separated.

Create flexible learning environments in which teachers and students are ready to adapt to new and different technology, recognizing that it will continue to improve and become more available. Promote more and better use of the World Wide Web in the statistics classroom as well as other forms of technology and be thinking about other forms of technology, such as interactive voice, that are not yet on the market. This will affect curriculum design and materials; care should be taken to isolate the important statistical ideas in ways independent of technology. Sharing data among classrooms and countries can become commonplace.

Increase awareness and professional development about the changing nature of statistics. Statistics is not a fixed subject, but one that is growing and changing as demand for its application becomes stronger and as technology enables us to think of new and more revealing ways to process information and use the results to make decisions. Teachers will need help in accepting and incorporating into their classroom these new ideas and ways to think.

Develop curricula that has statistics for everyone and statistics for future statisticians. There is already a tension between the statistics needed for literate citizenry versus the statistics needed for a university core curriculum versus statistics needed for a profession.

Work towards changes in assessments that will include alternative ways to assess students on what they know about statistics. Technology can be useful in recording and reporting the statistical processes students use as well as the results. The role of statistics in matriculation exams at the end of high school and in other compulsory exams can have a major impact on the acceptance, and on the level of statistics, that is taught in the curriculum.

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As these recommendations are considered, two underlying concerns should be addressed. There will be increasing tension between those who are comfortable using technology and those who are not. This may have a negative impact on students in two ways. First, teachers who are adept with technology may give their students an advantage over students whose teachers avoid technology. Second, students who are not comfortable with technology or who do not have access to technology may avoid using it and, thus, find the subject much more difficult than it should be. The second tension may arise from the process of communication, necessary in order to make any of these recommendations a reality. Even within countries, but particularly across countries, there is not necessarily a clear and common interpretation of words such as proportion, project, or data analysis. As we strive to reach our common goals, it is imperative that we recognize that our language may lead to different understandings. Thus, we must be as clear and concise as possible in our discussions.