

Statistics in Project 2061 Curriculum Development

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It is now common to hear calls for inclusion of statistics topics in science and social studies courses as well as in mathematics courses. These calls are almost always from statisticians and have seldom been realised. As David Green stated at an ICOTS 3 session regarding his own endeavour, "Cross-curriculum work is encouraged - but does not take place". I will describe here the plans of the American Association for the Advancement of Science to incorporate basic ideas of statistics into K-12 curricula that more or less integrate science, technology, and mathematics. Rather than adding simply statistics topics to the curriculum, the curriculum design involves a mapping of ideas in these fields as they interconnect and increase in sophistication.

One might characterise the history of statistics in the schools as going through several stages. The first could be called Algorithm-Driven, taking its content and form from traditional statistics courses at the university - that is, instruction in a sequence of statistical algorithms and their applications. Following that, there has been a Problem-Driven movement, in which instruction would begin with problems to be answered and the statistical techniques introduced when they are helpful. (The posing of problems, however, is ordered most often by the instructor, with full knowledge of what techniques are intended to be used.)

The Algorithm-Driven approach has found new life with the appearance of software that allows easy use of a variety of statistical techniques. Of course, convenient software also benefits the Problem-Driven approach. The widespread use of computers has also now led to the Database-Driven approach, in which one begins with a given database and wonders what questions can be asked of it.

An interesting incidence of the potential tension between approaches occurred in a recent conversation between two innovative statistics educators. One was enthusiastic about having students use a rich database. The other insisted on the importance of students collecting data themselves - "I give students problems for which they have to go out and devise means of collecting their own data." "Ah", replied the first, "but I

have the students devise their own problems!"

Different approaches do not necessarily compete. Increasing attention is being given to an elaboration of the Problem-Driven approach in which both the problems and data are devised by the students themselves: the Project-Driven approach. The touchstone here is that the students' chief motivation ought to be their actual interest in the answer to the problem - so that they will care about the quality of the data as well as about the appropriateness of the statistical techniques.

By imbedding the learning of statistics in real-world projects of real interest to students, the likelihood of understanding and remembering important statistical ideas is surely increased. But, even if highly successful, that still leaves the learning of statistics as a separate part of one's education. I would like to propose a further development in which the projects engaged in are a legitimate, indeed *necessary*, part of learning in other subjects in the curriculum: a Curriculum-Driven approach. In this approach statistics must, as Richard Sheaffer of the American Statistical Association says, "weave through" the curriculum, not just appear from time to time in isolated lessons.

Project 2061 is a long-term effort to reform education in science, mathematics, and technology. Beginning with the proposition that no idea need be included in the curriculum just because it is there now, we convened panels of scientists, engineers, and mathematicians over three years and produced the report Science for All Americans (SFAA). The report describes the basic knowledge and skills that all students should retain after leaving the secondary school.

Included in SFAA are the knowledge sections Uncertainty, Summarising Data, and Sampling, and the skills section Critical-Response skills (in interpreting media reports based on data). But statistics and probability are not limited to these fairly obvious sections. They appear as necessary parts of understanding a great variety of other core topics, including the nature of scientific inquiry, risk analysis, tradeoffs in social planning, diversity of life forms, natural selection, and health technology.

The project is now in the middle of a three-year enterprise in which teams of educators are sketching K-12 curriculum that would be likely to produce such knowledge and skill. The underlying viewpoint of the project is that far less is learned than is taught, and far less is retained than is learned - and therefore we should spend more time on fewer topics, insuring that real understanding is growing. In designing curriculum, our teams are required to think through the progression of understanding through which students would move in eventually arriving at the desired outcomes. This is done by means of progression-of-understanding maps that incorporate two kinds of considerations: (1) what are the logical underpinnings of the outcome understanding; and (2) what do we know about how students think and learn.

Because we are still in the midst of our work, I cannot present you with a complete or polished example of mapping. But I can show you what the process is like and suggest how it might look for some statistical ideas. An example of an outcome understanding is illustrated by this passage from the SFAA section Sampling:

"In drawing conclusions about all of something from samples of it, two major concerns must be taken into account. First, we must be alert to possible bias created by how the sample was selected. ... A second major concern that determines the usefulness of a sample is its size. If sampling is done without bias in the method, then the larger the sample is, the more likely it is to represent the whole accurately. This is because the larger a

sample is, the smaller the effects of purely random variations are likely to be on its summary characteristics." (p.106)

A map for a particular outcome understanding starts in the elementary school, where we imagine what the first steps toward the outcome might be, and works up to senior high school, where we imagine what the final assembly of ideas would be like. In constructing such a map, connections are made to similar ideas in all other parts of the curriculum in natural science, social science, and mathematics.

For example, children in the elementary school could begin toward understanding the prevalence of diversity - in populations of students, trees, automobiles, stars, water quality, and so on. Later, the question is raised about what can be learned about a diverse population by looking at only a small part of it, perhaps in the context of investigating the effects of fertiliser on plant growth or the opinions of different social groups. "What can be learned" implies some means of summarising diversity, hence connects to the introduction of descriptive statistics.

We hope that the result of this long-term approach to development of curriculum models will be schooling experiences for children that are truly integrative, rather than a patch-work of independent topics. We would wish, for example, that students working on a two-week investigation of the question "What kind of car do people prefer?" would not be able to say at any one moment whether they were studying social science, mathematics, social studies, or statistics. One and the same lesson or project could be serving all four.