How Can IASE have an Impact on Statistics Education in Schools?

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Abstract

The ICOTS conferences and ISI/IASE Satellite meetings provide valuable printed resources on modern trends in statistics education. Activists in the schools can make use of these to modernize and improve their teaching, but the demands of school curricula are constraining. Both curricula and teachers of school statistics will not reform soon without reform at the tertiary level. But there are constraints to tertiary reform as well: textbook publisher conservatism and the priority of research in tertiary career progress. In this paper, we propose a way to overcome the inertia in tertiary curriculum reform: include more guided experiential learning and less technique-oriented lecturing, more projects and extended applications, and less text-book coverage. To facilitate transfer to the schools, IASE needs to sell this tertiary reform to the school activists.

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Background:

The ICOTS conferences begun in 1982 initiated a serious attempt at improvement and reform of statistical education at all levels: primary, secondary, and tertiary. (See for 1986 and following the link http://www.stat.auckland.ac.nz/~iase/publications.php) The IASE has been created in 1993 as a product of this activity and is now its primary sponsor. In this paper I will discuss the impact of IASE on statistics education in the schools. I need to begin by explaining why, in my view, the instruction of statistics in secondary schools has been made difficult by unintended institutional constraints.

I hasten to add that my comments are not guided by a firsthand knowledge of statistics education in the schools, but rather by firsthand knowledge of the training that statistics teachers in the schools have received from tertiary institutions. Changes in the statistics curricula at the primary and secondary level include selections of ideas taught at the tertiary level. Consequently, for a topic in statistics to be taught in the schools, it must be taught at the tertiary level, and it must be deemed acceptable and appropriate for the schools. IASE sponsored conferences have included many presentations relating to both these selection processes.

Consider the material most often taught in the first year or two of tertiary education. A common focus of these courses is the logic of inference for means, proportions, and sometimes contingency tables including the normal theory as required. Many courses

will also include some descriptive statistics. Courses for the math-facile will likely include some probability and combinatorics. Courses that have been inspired by IASE conferences may include modern elements such as individual and team data analysis projects, student presentations and writing projects, use of statistical packages for simulation and associated graphics, hands-on activities, and analysis of "live" data sets. In fact there will be a wide variety of tertiary courses reflecting various degrees of modernization over the pre-computer "math-stat" course or early calculation-based "service" course. The designers of secondary statistics curricula must choose from this spectrum of tertiary topics.

A fact of life in secondary schools is that a "Statistics Department" seldom exists. Statistics instruction in secondary schools is usually housed in Mathematics departments. Statistics topics to be included in secondary school courses will be taught by teachers with qualifications in mathematics. The topics that tend to be selected for secondary schools are topics that are understood by math teachers. Topics often chosen for these secondary school statistics courses, or parts of courses, include combinatorics, descriptive statistics, and calculation procedures for confidence intervals and hypothesis tests. Note that modern aspects such as writing projects, student presentations, "live" data sets, simulation and associated graphics, and "hands-on" activities, tend not to be considered a natural part of a "math" program. Only a few high school math teachers will have experienced a modern education in statistics, either because they have not studied enough statistics, or because they have studied statistics from an old-fashioned statistics program. The fact that the old-fashioned statistics courses are the easiest for constructing tests and exams is an additional disincentive to reform.

Why is statistics training in an old-fashioned statistics program so unhelpful for the secondary school teacher? It is because the old-fashioned programs taught statistics as a specialization of mathematics, or even as an application of calculus. It is several decades since academics interested in statistics education have been trying to change this trend – see, for example Tukey(1977), Zidek(1986), Weldon (1986). An early response to the realization that math-stat from the fifties was not usable by the vast majority of potential data-based researchers was the creation of the statistics "service course". These courses had minimal algebra and no calculus, but also had very little of the logic of statistics as well. It was not that the logic required mathematics, but rather that the difficulty with the statistical ideas was deemed to be difficulty with mathematics, and it was concluded that the only way to teach mathophobes statistics was to turn it into a course of calculation rituals. It did turn out that mathophobes could often handle the arithmetic of the calculations, but it eventually became clear that this was not a useful skill in practice, especially when all the calculations could be done by statistical software. What was needed was a course in statistics that immersed the student in the entire process of data-based research, keeping the actual analysis fairly simple mathematically but ensuring that most important aspects of statistical analysis were discussed, such as:

What question might be answered with data?
What data is needed?
How is the data screened and explored?

What software is needed?
How can we protect ourselves from jumping to conclusions?
How can we justify our chosen methods of analysis? And,
How can the whole process, including the conclusions, be described in words and graphs?

Many math teachers would find most of these questions to be outside of secondary school mathematics, and they would be correct in that assessment. There will be very little attraction of this expanded statistics curriculum for the math teacher. As a compromise, and in view of the pressure from tertiary institutions to include statistics in the secondary school curriculum, a math teacher might decide to teach some descriptive statistics (means, standard deviations, histograms, scatter diagrams), some combinatorics, and some basic probability calculus (Venn diagrams, independence, mutual exclusive rule). But these topics do not prepare the student for statistics at the tertiary level. Instead the student gets the impression that statistics is simple math in an uninteresting abstract context!

Teachers attracted to mathematics enjoy the power of abstraction and the absence of ambiguity from symbolic manipulation. How often will these teachers be attracted to the discipline whose principal focus is uncertainty, and for which the crucial details of an investigation often depend on an intimate knowledge of the context of the data? These questions suggest we should look for a different group than math teachers to teach statistics in secondary schools. However, this is likely to be considered unrealistic, and so a more near-term solution might be to obtain enhanced recognition at the secondary school level for those mathematics teachers that have a genuine interest in statistics. This attitude and capability needs to be recognized as a value-added feature. If the conferences and teaching materials produced by IASE over the years contribute to this recognition, then IASE will have had a great influence on secondary education in statistics.

Some highlights of IASE-sponsored conferences.

A good summary of progress up to 1996 is given in the Phillips (1996) summary of the ICME 8 Presidential address of David Moore. David Moore was the first IASE President and has been an influential advocate of education reform in statistics education.

In discussing what helps students learn, [David Moore] listed the following:

Hands-on activities
Working in small groups
Frequent and rapid feedback
Communicating results
Explaining reasoning
Computer simulations
Open questions real settings
Learning to work co-operatively

One has to wonder how many mathematicians in the schools would be willing and able to integrate these aspects into their teaching of statistics.

The issue of the various levels of statistics to be presented at various levels of student – elementary, secondary, post-secondary, and continuing education – is discussed by Schaeffer (1998) in the ICOTS 5 conference. He discusses the increasing sophistication required through the levels, and the need to consider practical use of statistics even at the post-secondary stage. It may be that for pedagogy, approaching statistical theory through practical examples is the only way to succeed for the vast majority of students. The future statisticians taking graduate work may be the only exception, in that a presentation of mathematical statistics at that level may be appropriate. This issue is discussed in more detail in Weldon (2008).

Since 1996, the ICOTS conferences in Singapore (ICOTS 5), Capetown (ICOTS 6) and Salvador (ICOTS 7) have continued to inform teachers of statistics on the latest developments. The four-year intervals between the ICOTS conferences is long enough that the primary focus of research in statistical education changes between conferences. At the risk of oversimplifying the differences, there does seem to be an emphasis on technology in ICOTS 5, literacy in ICOTS 6, and interpersonal strategies (e.g teamwork) in ICOTS 7. All the papers from ICOTS 5,6 and 7 are freely available from the IASE website - http://www.stat.auckland.ac.nz/~iase/publications.php. In fact this website includes access to earlier ICOTS papers, stat ed papers from ISI conferences since 1999, papers from the ISI/IASE Satellite conferences since 1993, IASE Round Table conferences since 1996, and ICME conferences since 1996. Also freely available on this same website are papers from SERJ-the Statistics Education Research Journal, the IASE Review, the International Statistical Review, the ISI Newsletter with its IASE insert, and IASE Matters that appears in Teaching Statistics.

In other words, hundreds of articles aimed directly at improvement of statistics education are freely available to the public. This wonderful resource includes advice on presentation of particular topics, novel applications to use in presenting statistical teachniques, software to make the calculations easy for students or to demonstrate statistical phenomena, recommendations on how to teach students to verbalize their knowledge of statistics, results of psychological research on what does and does not work in presenting theory in statistics and probability, and suggestions for how to motivate students with hands-on activities.

How can these resources be influential in advancing the teaching of statistics in the schools? The easy availability of advice on statistics education is only a first step. A further requirement is that the receiving institutions – the universities and colleges – need to encourage curriculum reform in statistics so that the secondary schools will also allocate scarce resources to the reform. . Of course, secondary schools prepare students for life other than through colleges and universities, but the traditional math-based selections are even less useful for this group – broadening the statistics curriculum would be useful for this group as well. What motivates school teachers to reform secondary

school curriculum in statistics? A clear signal is needed from universities and colleges that the broad view of statistics is the target, in spite of the math base at the schools.

A cursory review of courses provided at universities and colleges suggests that the broad view of statistics will be slow in gaining a foothold. This is in spite of the fact that there is wide agreement among IASE members concerning the need for reform and even concerning the nature of the reform that is needed. IASE sponsored conferences bring together professionals with a keen interest in improving the effectiveness of statistics education, and the remedies for current problems in the area involve more of the things David Moore listed in 1996. Perhaps IASE is at the stage now where the result of 25 years of deliberations needs to be transmitted more forcefully to university and college administrations. There is a political aspect to this that needs to be addressed, and perhaps a committee of the IASE should prepare a strategy for directly influencing post-secondary curricula in statistics.

Until the reform of post-secondary curricula is accomplished, the reform at the secondary level will be limited. At the schools, it may be necessary to integrate statistics instruction with science instruction or even social science instruction. As long as statistics is considered a kind of math, there will be little progress with the broader view of the discipline. Of course, some math teachers do have the interest and ability to move into the applicable statistics area, but they are rare, and the current math culture does not give them the prestige they deserve to influence others. IASE has the research experience to make a strong case for reform at all levels, and it is time this case is made directly to the education administrators rather than merely to other researchers.

References

Phillips, Brian (1996) Plenary Lecture Given By David S. Moore (USA) "New pedagogy and new content: The case of statistics". Proceedings of ICME 8, Seville, Spain.

Phillips, Brian (2002). The IASE: Background, Activities, and Future. Proceedings of ICOTS6, Capetown, South Africa. Available through www.stat.auckland.ac.nz/~iase.

Schaeffer, Richard L. (1998) Statistics Education – Bridging the Gaps Among School, Colleg and the Workplace. Proceedings ICOTS 5, Singapore. Also available through www.stat.auckland.ac.nz/~iase

Tukey, J.W. (1977) *Exploratory Data Analysis*. Addison-Wesley. New York.

Weldon K.L. (1986) Statistics: Mathematical Specialty or Separate Discipline? Liaison V1 No 1. Also available through www.stat.sfu.ca/~weldon.

Weldon, K.L. (2008) Experience Early, Logic Later. Proceedings of OZCOTS 2008. Melbourne, Australia.

Zidek, James V. (1986) Statistication: The Quest for a Curriculum. ICOTS 2 pp 1-17, Victoria, BC. Available through www.stat.auckland.ac.nz/~iase.