WOULD YOU ALLOW YOUR ACCOUNTANT TO PERFORM SURGERY? IMPLICATIONS FOR EDUCATION OF PRIMARY TEACHERS

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One important part of statistical education is the training of teachers. It would seem to the author that while most teacher education programmes for primary teachers include mathematics education courses, they do not specifically address statistical education. In addition, teachers who enter these programmes would have taken mathematics in school and possibly at post-secondary institutions, but their exposure to statistics would have been limited. Since statistical thinking is different from other forms of thinking, the situation seems to have implications for teacher training. Reasoning under uncertainty is a different way of looking at the world. An accountant may be very good at what he or she does, but the author, for one, would not like an accountant to perform surgery. This paper will raise some questions associated with statistical knowledge as it applies to primary teachers.

INTRODUCTION

The approach to this paper will be different from that usually presented at conferences. Rather than reporting on research, a specific curriculum, activities, or any of the multitude of other topics that often form the basis of a contribution, this paper focuses on some questions associated with statistical knowledge and asks the reader to think about the questions with a view to possibly setting a focus for research in the future; time and interest will determine if this is viable. Given this approach there is no attempt to include a review of the current literature in the area.

In an article by Rothstein (2001) in The New York Times titled "Statistics, a Tool for Life, Is Getting Short Shrift" he argues that present programmes leave too little room for statistics. While he illustrates examples of statistics being used in the classroom the title and introduction to his article imply that there is insufficient statistics integrated into the curriculum.

It would not be difficult to find articles that support statistical education as part of the curriculum. Most curriculum documents suggest that statistics be an integral part of the curriculum. The *Curriculum and evaluation standards for school mathematics* (National Council of Teachers of Mathematics, 1989) and *A national statement on mathematics for Australian schools* (Australian Education Council, 1991) are just two examples. Therefore, the issue facing statistics educators is not one of convincing educational organisations that statistics should be included in the curriculum, but issues associated with implementation.

There is a large amount of literature on misconceptions in statistics and this is not reviewed here. Suffice it to say that there is considerable evidence that people at all levels, from primary school to adults, have misconceptions associated with statistical concepts. These misconceptions develop based on experiences both inside and outside the classroom. They develop even when students or adults have had no formal exposure to statistics in the curriculum.

There are also a large number of books of activities for students designed to develop statistical concepts. There are computer programmes to help represent data, analyse data and simulate statistical situations. Textbooks have activities within the programmes designed to help students develop statistical ideas. So, although statistical education is a relatively new discipline, there is a body of knowledge that should help inform educational practice. However, there is limited knowledge of teachers' statistical knowledge and, in particular, what the knowledge is that primary teachers should have.

ISSUES: MATHEMATICAL VERSUS STATISTICAL KNOWLEDGE

As stated in the abstract, teachers have limited exposure to statistics in their formal education. Primary school teachers have been exposed to considerable mathematics in school (and may also have taken some mathematics as part of their university or college education) and their teacher training usually includes some mathematics education which may have, as a small

segment, topics associated with teaching statistics. The author is aware that the present school curriculum does include statistics, particularly through a data handling approach, but most of the present teaching force does not have this background. It is an open question as to whether this will have a significant impact on future teachers' ability to teach statistics.

What do students learn from their exposure to mathematics? The author is not concerned with the topics, per se, but rather what do they learn about the nature of mathematical thinking? This is a large question and cannot be realistically addressed in a short paper such as this. However, the author would like to argue that one thing they learn is that mathematical reasoning follows a logical approach to obtain answers to problems, even in situations where there are multiple solutions. Conclusions are drawn from logical arguments and, based on this reasoning and provided there are no errors in the reasoning or incorrect assumptions, students can conclude that their answers are valid. This will be called *reasoning under certainty.*

Statistical reasoning is fundamentally different. It involves *reasoning under uncertainty.* Even if one applies the procedures, formulas, etc. correctly and the assumptions are valid, the conclusions are "uncertain". One is interpreting data in a world where uncertainty rules. Yet teachers (and students) exposure to statistics is often through the mathematics curriculum. The underlying understanding they develop of the nature of mathematical reasoning would seem to be inconsistent with the nature of statistical reasoning. This apparent contradiction, together with other aspects of statistics such as its particular interdisciplinary nature, raises questions regarding the statistical education of teachers. The author presents some of these questions, draws some personal conclusions and then leaves the debate to the reader.

(a) Does a primary teacher's extensive experience with mathematics impact on their ability to teach statistics?

This author would argue yes and, in fact, it has a *"major negative impact"*. Primary teachers' experiences with mathematical reasoning lead to an understanding that correctly formulated arguments lead to valid conclusions, often a single conclusion. The parallel type of argument in statistics leads to uncertain results and this is in conflict with their "understanding" of the nature of mathematical reasoning - yet statistics is taught as part of the mathematics curriculum and any exposure they have had to statistics/statistics education at the university level has probably been within the context of mathematics education, and is likely to have reinforced their association of mathematics and statistics. Consequently, primary teachers' experience with mathematics *inhibits* their development of statistical knowledge and their ability to teach statistics effectively. (As an aside it is worth noting that the situation for secondary teachers is likely to be slightly better since they would, hopefully, have taken some statistics courses. However, for many of these teachers their experience with statistics would still be very limited)

(b) Do primary teachers have the statistical knowledge to teach statistics in the primary school?

The author would argue no, and this has implications for how our present students are prepared. In addition to the problems that derive directly from their mathematical experiences, there is limited statistical exposure, per se, for primary teachers. Let me state that I am not criticising the effort primary teachers are making. They are asked to teach "everything" and given their knowledge of the many subjects they teach most teachers provide the best professional teaching they can. However, we are asking them to teach in an area where they lack the necessary knowledge. Certainly they know how to calculate the mean, median and mode, but do they fully comprehend the situations where each of these statistics might be most appropriate? Without this, students are likely to be taught only the calculation algorithms. Do they fully comprehend the nature of the distribution in tossing coins and what this means in a situation where a coin is tossed many times? You might like to think about the following. I tell you that I am tossing a fair coin. I toss it 15 times and get 15 heads. What do you conclude about the possibility of a head or tail next time?

(c) Does the interdisciplinary nature of statistics in the schools impact on teachers' ability to teach statistics?

The answer is yes. Statistics is used in science, social studies and other areas of the curriculum. Consequently, while taught as a topic within the mathematics curriculum it is

"uniquely" seen as a tool for applications in other curriculum areas. This means that a teacher's perspectives on statistics might be different from that in other subjects.

IMPLICATIONS

What are the implications of the answers to these questions for the training of primary teachers? The author believes that these questions pose some serious questions for statistics educators regarding the nature of teacher training.

The present curriculum is increasing the statistics within its boundaries. We are asking primary teachers to do more and more with data. There are many excellent activities included in different curricula, resource books available with statistical activities and computer programmes to help support statistical activities. The issue is not resources, but teacher training. If the teacher is a key to curriculum implementation, a statement that very few would argue with, then it is necessary that the teacher be given the tools needed to meet societies expectations.

The following are a series of questions that can be discussed at the presentation.

- Can the current primary teaching force do an effective job of teaching statistics in the primary school?
- Should the present emphasis on statistics in the primary school be increased or decreased?
- Should the statistics education of primary teachers be separated from the mathematics education of these teachers?
- Will the new teachers entering primary teacher training programmes be better prepared for teaching statistics than those who have be trained previously?
- What should we do about the statistical education of primary teachers? The answer to this question clearly depends on your answers to the previous questions.

The title of the paper was "Would you allow your accountant to perform surgery? Implications for education of primary teachers." It could be reformulated as "Would you want you mathematics teacher teaching statistics?"

REFERENCES

Australian Education Council. (1991). *A national statement on mathematics for Australian schools.* Carlton, VIC: Author

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: The Council.

Rothstein, R. (2001). Statistics: A tool for life. *The New York Times (November 28, 2001)*.