HOW FAR CAN WE GO IN THE STATISTICS CURRICULUM DEVELOPMENT AT THE SECONDARY SCHOOL LEVEL TO REACH SUCCESSFULLY THE OBJECTIVE?

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In most countries at the secondary school level, the statistics curriculum is a part of the mathematics curriculum. If we have a look at the papers on statistical education at the college or at the university published ten years ago, we can see that the requirements are practically adaptable to the actual secondary level. With the changes occurring in mathematical education at the secondary school level, with the development of interdisciplinary class projects especially for higher grades (9-12), with the increasing availability of computers at school, the teaching of statistics has changed. But first, we have to define the objective or more precisely the objectives, then the ways to get them and conclude with the limits and their reasons of the approach.

INTRODUCTION

In most countries, the past decade witnessed a great effort to improve statistics curriculum and teaching at all levels of the academic educational system. At the secondary school level, the statistics curriculum remains a part of the mathematics one. But things seem to have changed. We are now in the context of democratisation of mathematics as called by David Vere-Jones in 1995. Teaching means content and pedagogy. But first, what are the objectives of statistical education at the secondary school level? Clearly, they are not the same at the college and at the university. I see at least two goals: general education of all citizens and scientific education. In the first paragraph, we will define precisely the objectives of a statistics course. The second part of the article will deal with the reasons why, in spite of the recommended reforms, it is quite hard to make significant progress.

WHY DO WE TEACH STATISTICS?

The teaching of statistics is not only the learning of formulas and graphics. It is the teaching of a way of thinking, a way to deal with data and to learn how to take decisions. Gras (2000) says that probabilities and statistics have three essential functions:

1. A sociocultural function which gives a greater place to the citizen,
2. An epistemological function emphasising the difference between a deterministic way of reasoning and a non deterministic one, between deductive and inductive reasoning,
3. A didactical function: a non-dogmatic teaching of probabilities and statistics will provide to the students rich interdisciplinary situations.

We must remember that we have two different objectives, the first one is the general; education of citizens (for everybody, and this the minimum), meanwhile the second one is mainly concerned with scientific education. Whatever the objectives are and whatever the students are, we must keep in mind that a sensible curriculum must have these three previous functions. To reach the objectives, we have to define the content, the pedagogy and the use of technology as defined by Moore (2001) for undergraduate students. It is amazing to see that we are introducing at the secondary school level the proposals that were made ten years ago for the students at the university. But, things are not exactly the same: more powerful technology, different students and contents to be adapted.

First, introductory courses must place greater emphasis on data collection, understanding and modelling variation, graphical display of data etc., and less emphasis on mathematical and probabilistic concepts (Snee, 1990). Moore (1992) suggested that only the necessary probabilistic concepts required for further statistical thinking should be thought. In her article, Ballman (1997) provides some suggestions to develop a sound intuition for the characteristics of random variation. At this level, the curriculum must include data collection, management of data, organisation and summarisation of data and perception of variability and the learning must be active. The goal is to provide quantitative skills to people. Even if at the secondary school level, it

could be hard to settle, we could use small group co-operative-learning as defined by Garlfield (1993).

On the other hand, the available material to help teachers is very rich; they can use any magazine with statistics. And some courses such as Chance (http://www.dartmouth.edu/~chance/) or publications such as Pénombre (http://www.unil.ch/penombre/) give them the elements to discuss articles, and teach their students. Neither Chance, nor Pénombre can replace a statistics or a probability course but both will make students and teachers more rational and informed readers of the press. At this step, any practical work with the computer can help the understanding whether to process real-world data sets or to work on simulation datasets. And don't forget that written and oral reports of the results are very important and helpful to develop statistical reasoning (Smith, 1998). The contents and the steps of scientific education are more or less the same as the previous ones except that in that case, students need more time to conduct a scientific approach to solve a problem and construct their own knowledge.

CONSTRAINTS

Even if most of the educational actors agree on the need of change, things don't change so fast (McAveley, 2001). Why?

1. Lack of Implication of Academic and Professional Statisticians

Statistics is taught by mathematics teachers meanwhile at the university, there are academics that are also statisticians. The absence of statisticians (academics or not) in the secondary schools and their absence also in the thought groups about the evolution of statistical education at this level is a major problem. In most of the countries, a huge portion of beginning statistics introduction is in the hands of mathematicians. We need statisticians to communicate with other people and to promote their domain.

2. Teachers' Education

Besides, we cannot wait for a new generation of teachers to boost statistical education. We also have to provide teachers with appropriate teaching resources. The need of curricular resources is particularly acute. But to understand statistical thinking, teachers have to practise statistics by themselves, to understand the methodology and manage the data. This implies a good background in applied mathematics, computing, probability and statistics. Unfortunately, the need of more statisticians in the services and in the industry and the appeal of these new jobs don't allow us to increase the number of well-trained teachers.

3.The Problem of Assessment

Third, a last but important problem at the end of the secondary is the assessment in statistics and probability. In the absence of evaluation, teachers will not be motivated to teach probability and statistics. Some experiences must be mentioned (Chance, 1997).

4. The Great Variability among World Educational Systems

There is a great variability in the situations among the countries: in the United States, we can see the increased cooperation between the MAA and the ASA; in France, the birth of a new curriculum is a little bit more painful. The situation depends highly on the collaboration of statistical societies and their involvement in academic changes. Besides, the research on statistical education makes available a great variety of innovative techniques such as collaborative learning, active learning, computer integration and use of real data.

CONCLUSION

The use and application of cognitive theory to statistics instruction are very insufficient. In their paper, Lovett and Greenhouse (2000) present five principles of learning that are derived from cognitive theory and they develop and illustrate each of them in the context of statistical education:

- Students learn best what they practice and perform on their own.
- Knowledge tends to be specific to the context in which it is learned.

- Learning is more efficient when the students receive real-time feedback on errors.
- Learning involves integrating new knowledge with existing knowledge.
- Learning becomes less efficient as the mental load students must carry increases.

The authors provide also guidelines for instructional design in parallel with the principles of learning.

In spite of thinking and research on the improvement of statistical educational, we can be a little bit pessimistic. The situation at the secondary school level is not so different as it is at the college or university levels; the contents are not different; we just have to be a little bit more modest. For instance, the description of the situation in business statistics is not comforting.

To achieve, we can have a look at Cobb's article (1993). Cobb gave four approaches to rethinking a beginning course in statistics (we summarise here the main points):

- Questioning the standard assumptions:
  - Introductory statistics need not to be taught as a survey course.
  - A first course need not be organised by statistical topic.
  - A first course need not present topics in the standard order.
  - A course need not rely on lectures to present material.
- Anticipating resistances to change (Cobb said that generally resistances to innovation are symptoms of other problems).
- Total quality management which, from Cobb, leads to two principles that govern the student-teacher relationship:
  - Student and teacher share the responsibility for the quality of a process.
  - The core motivation for both student and teacher must be the satisfaction that derives from improving the quality of the student's learning.
- Educational assessment.

Cobb develops each of the points with persuasive arguments.

We can improve the pedagogy taking into account the changes in education in general. For the content, we have reached the limit point and the best thing we can do now, is to use the researches in cognition and psychology to improve the perception the students have of our field.

REFERENCES

Ballman, K. (1997). Greater emphasis on variation in an introductory statistics course. *Journal of Statistics Education, 5(2)*.

Chance, B.L. (1997). Experiences with authentic assessment techniques in an introductory statistics course. *Journal of Statistics Education, 5(3).*

Cobb, G.W. (1993). Reconsidering statistics education: a national science foundation conference. *Journal of Statistics Education, 1(1)*.

Garlfield, J. (1993). Teaching statistics using small-group co-operative learning. *Journal of Statistics Education, 1(1)*.

Gras, R. (2000). Quelques principes majeurs pour l'élaboration d'un programme de mathématiques dans le second cycle. *Bulletin de l'A.P.M.E.P., 429,* 522-527.

Lovett, M.C., & Greenhouse, J.B. (2000). Applying cognitive theory to statistics instruction. *The American Statistician, 54(3),* 196-206.

McAveley L., Everett, A.M., and Sullivan C. (2001). Evolution in business statistics curricula learning for the 'Making statistics more effective in schools of business' conference. *The Statistician, 50(3)*, 321-333.

Moore, D. (1992). Teaching statistics as a respectable subject. In F. Gordon and S. Gordon (Eds.), *Statistics for the Twenty-first Century*, *MAA Notes (26)* (pp. 14-25). Washington.

Moore, D. (2001). Undergraduate programs and the future of academic statistics. *The American Statistician, 55(1)*, 1-6.

Smith, G. (1998). Learning statistics by doing statistics. *Journal of Statistics Education 6(3*),

Snee, R. (1990). Statistical thinking and its contribution to quality. *The American Statistician*, *44(2),* 116-121.

Vere-Jones, D. (1995). The coming of age of statistical education. *International Statistical Review, 63(1)*, 3-23.