THE TEACHING OF STATISTICS AND PROBABILITY IN MATHEMATICS UNDERGRADUATE COURSES

Prof. Lorí Viali
Department of Statistics, PUCRS/UFRGS, Brasil
Viale@pucrs.br

In Brazil the basic system of Education is divided in Elementary School I (ages 6 or 7 to 9 or 10 with a generalist teacher, usually a pedagogy undergraduate) involving the grades 1 to 4 and Elementary School II (ages 11 to 13 with a specialist teacher) including the grades 5 to 8 and a 3 and in some cases 4 years of high school involving, also, a specialist teacher. The faculties who teach Statistics courses in universities come from a number of areas such as Statistics, Mathematics, Economics, etc. However, in Elementary II and High school, teachers with a degree in Mathematics teach the Statistics courses. The promulgation of the 1996 LDB (Brazilian Education Basic Tenets Law) has made Statistics and Probability part of the content of the curriculum of Elementary (I and II) and High school. This study analyzed the curriculums of Mathematics undergraduates programs in Brazil.

INTRODUCTION

People have to deal with technology now more than ever because new advancements are constantly having us faces new challenges. Access to the WWW through the Internet makes more information available to us than we can process in a lifetime. The knowledge of mathematics, statistics and probability provides us with tools to adapt and understand the world and the information available in it. According to Hacking (1990), "the most decisive conceptual event of the twentieth century has been the discovery that the world is not deterministic".

Even if a little late, the NCP (National Curriculum Parameters) have captured these changes and highlighted the importance of the teaching of statistics and probability in Elementary II and High School. The university and higher education courses in general should prepare students for this rapidly changing society where science is constantly presenting something new. In an attempt to adjust the curriculum and the university programs to these rapid changes, the NEC (National Education Council), in the 1996 reform allowed a reduction of the minimum coursework hours of the majority of the university programs and eliminated a number of barriers so that universities can have greater flexibility to adapt their curriculum and programs to this ever more dynamic reality.

The NCPs state that the treatment of information and uncertainties should be presented starting in the first years of schooling. In elementary and high school, the math teacher will undertake this task. However, after taking a closer look at the NCG (National Curricular Guidelines) for the undergraduate programs in Mathematics, we find that there is no mention of this type of content. The NCG is a set of rules similar to the NCP but for undergraduate courses instead of regulations to elementary and high school.

Bayer et al., 2005 interviewed 80 majors in Mathematics. These are some of results they found:

- 49% of majors had no knowledge that statistics had been included in the teaching of mathematics;
- 52% of majors state that the course did not prepare them well enough to teach statistics;
- 96% of majors believe that the teaching of statistics plays an important role in the development of students.

OVERVIEW

This article analyzes the Mathematics undergraduate programs curriculums to verify whether future teachers are acquiring the minimum knowledge required to be in accordance with the NCPs for the teaching of statistics and probability for elementary II and high schools.

In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8, July, 2010), Ljubljana, Slovenia*. Voorburg, The Netherlands: International Statistical Institute. www.stat.auckland.ac.nz/~iase/publications.php

Official data from CEM's (Culture and Education Ministry) electronic database for the year 2007 was analyzed. There were 23,488 undergraduate courses in Brazil in 2007. These 6,403 were teaching degrees, that is, 27.3% of the total. Five hundred and sixty four were teaching degrees in Mathematics (8.8%), which represents 2.4 % of the total number of undergraduate courses.

In 2007, 756,799 students acquired an undergraduate degree. Almost nine percent (8.8%) of these students graduated in Pedagogy (mainly teachers of Elementary I schools), which represents 38.6% of the 171,806 students having a teaching degree. Math teachers represent 1.3% of the students who graduated and 5.6% of the undergraduates with teaching degrees.

Out of the 644 existing courses, 87.6% are teaching degrees. Unlike trends observed in other areas, fifty percent of the slots (50.0%) are offered in public institutions. This discrepancy becomes more evident when we examine the types of courses. Therefore, out of the 564 teaching degrees, 52.1% are private and this proportion goes down to 35.0% among the B.A. courses.

SAMPLE CHARACTERIZATION

The objective of the study was to verify whether the curriculums of the teaching programs included probability and statistics courses and to observe how many credits they offered, that is, if the institutions agreed, not only with the NCPs, but also with the modern world and the market. After all, the undergraduate student will need statistics as part of the knowledge necessary to perform his or her job and, according to the NCPs, for "describing and analyzing a large number of data, making inferences and predictions based on a sample of the population, apply the notions of probability and combinatorics to natural phenomena and everyday life...statistical and probabilistic techniques are tools of the natural sciences as well as the social sciences. Therefore, a careful approach of the counting, statistics and probability content in secondary education is imperative because it broadens the interface between learning mathematics and other sciences and areas." (NCP–High School, Part III).

A random sample of 125 institutions was taken out of a total of 564 teaching undergraduate degree courses, which represents 22.2% of the existing programs. Eighteen (14.4%) of the 125 curriculums investigated were university centers, 31 (34.8%) were isolated colleges and the remaining 76 (60.8%) were universities.

Eighty-five (68.0%) courses were private and the remaining ones were public. Among the public courses, 9 or 7.2% of the total belong to the state, 24 or 19.2% belong to the federal domain and six or 4.8% belong to the municipal domain. It is important to point out that São Paulo participates with more than 40% of the institutions since it is the state with the greatest number of courses. It was not possible to do an exact stratified sample with the existing courses because, at this time, not all the courses maintain all the information needed available.

RESULTS

Four percent of the courses investigated presented instruction hours below the legal limit, that is, 2400 hours. It was also noted that 2.4% of the courses presented instruction hours over 3600 hours, that is, 50% over the legal limit. The majority of the courses, 53.6% of them presented instruction hours that varied between 2700 and 3000 hours. It is important to note that one credit equals 15 instruction hours. However, the concept of an instructional hour is quite elastic, usually meaning 50 minutes for daytime courses and 45 minutes for night courses.

The main aim of the study was to verify the instruction hours of the probability and statistics courses and what they represent out of the total number of hours of the course. It was also important to identify whether the courses in the curriculums being analyzed were given importance proportional to the requirements of the NCPs. We can look at a sample of the NCPs for secondary school as an example:

> ... the three following focal points or base themes must be developed concomitantly in the three grades of secondary school: (1) algebra: numbers and functions; (2) geometry and measures and (3) data analysis.

The data analysis is detailed as follows: “a third focal point for the base theme is proposed. This theme can be organized in three thematic units: statistics, counting and probability.”

As a product of these contents, “it is expected that the students at this level of education go beyond reading information and critically think about meaning. Therefore, the theme proposed must go beyond simple description and data representation, achieving data investigation and decision making.”

It is important for the teacher to master these courses for these objectives to be met. Unfortunately, this will only be able to be possible if undergraduate students are exposed to more than what is being offered in the higher education curriculum today. It is evident that unless there is an adequate investigation, it will not be possible to determine the number of credits the curriculums should present. They should at least reflect the proportion in which they are presented in the curriculums of primary and secondary education. According to Batanero, Godino and Roa (2004) “In primary and secondary school levels, probability and statistics is part of the mathematics curriculum and mathematics teachers frequently lack specific preparation in statistics education.”

It was observed that the average number of credits in statistics or probability was 4.7. If we include the courses of combinatorics, this number goes to 5.2. If we take into consideration that each credit corresponds to 15 instructional hours, we can conclude that each course dedicates an average of 70.9 hours to statistics or probability and 78.7 if we add combinatorics. Furthermore, if we consider that the average instructional hour of the undergraduate courses found in the sample investigated was of 2964 instructional hours we could calculate the percentage that each curriculum dedicates to these contents. Considering only statistics or probability, this number amounts to 2.4% and if we add combinatorics, this rate goes up to 2.7%.

Therefore, the findings of Bayer, et al are at not at all surprising. After interviewing 80 prospective teachers in 2005, they found that 49% of them were unaware that statistics and probability were part of the contents to be taught in primary and secondary education and 52% stated that the degree did not prepare them enough to teach these courses.

Table 2. Credits for the Combinatorics, Statistics or Probability courses in Mathematics teaching degree courses–Brazil–2007

Credits (*)	0	2	3	4	6	7	8	10	12	Total
Stat. or Prob.	6.4	4.8	4.0	52.0	12.0	0.0	19.2	0.8	0.8	100.0
Combinatorics, Stat. or Prob.	6.4	4.0	4.0	40.0	16.0	0.8	24.0	3.2	1.6	100.0

(*) One credit = 15 teaching hours

Table 2 details the number of credit hours the teaching degree courses in the sample present. The first row presents only statistics or probability while in the second row Combinatorics is added. It had been previously observed that the average credit hours corresponded to 4.7% and 5.2% respectively. Table 2 shows that not only the modal number of credit hours, but also the median number of credit hours in any of the cases, that is, including Combinatorics or not, are four. Therefore, it can be concluded that the modal value as well as the median of hours dedicated to these courses is 4.15 = 60. If this value were divided not for the modal or median number of hours in the courses, but for the minimum legal number of 2400 instructional hours we obtain a rate of 60/2400 = 2.5% of the hours in the curriculum dedicated to these three courses.

The fact that 84.8% of courses are taught at night calls our attention because it reflects on their quality and consequently the proper training of teachers. Even public institutions, where day courses are available, follow this pattern. Thirty or 76.9% out of the 39 institutions in the sample work at night. It is important to highlight that many public institutions offer the options of day or night courses.

The duration of the courses is also an important factor that will reflect on the quality of the teacher. This duration varied from a minimum of six semesters to a maximum of 10 semesters. A little over half of the courses (51%) presented durations of 4 years (8 semesters) and practically 40% of the courses presented durations of 3 years (6 semesters).

THE TYPICAL COURSE

As or even more critical than a low number of instructional hours is the quality and the manner in which the teaching is given to the future mathematics teachers. A typical course is of four credits, that is, 60 instructional hours and it includes statistics and probability. It would not be as bad if the course included the teaching of a methodological approach with the appropriate didactics, that is, Statistics Education. However, the fact is that the course is shared with other programs in the area, typically, Engineering. The Mathematics majors, usually in lower numbers, fight for a slot with a large number of students from other programs. Therefore, the future teacher is exposed to an essentially algorithmic approach to education and with examples too distant from his or her interests and with little or no relation to what he or she will teach in the future. These courses usually present outdated methodology based on statistics as a Mathematics course and not a methodological approach that presents the stochastics as a resource for empirical analysis and the testing of models, which serves as support to all sciences.

In undergraduate Math curriculum the typical Statistics or Probability course includes the following contents: Concepts and fundamental theorems of probability; Aleatory variables; Probability distributions; Descriptive Statistics; Sampling; Estimation and hypothesis testing; and Simple linear correlation and regression. There are cases where a topic of one-way ANOVA was found.

CONCLUSION

It can be seen that the problem of training the mathematics teacher to teach statistics as well as probability in elementary and high education is not specific to a country or region. While other countries are, developing programs and trying to find a solution, in Brazil it will take a while. It is clear that undergraduate students are far from receiving the appropriate and necessary training and thus, they do not feel ready to teach the courses. The majority of the curriculums have been recently reformulated to meet the LDB standards. However, there is a flaw in the legislation itself, which states that statistics and probability should be taught in elementary and high schools but does not guarantee that undergraduates' courses at high educational institutions of all kinds have these contents included in their curriculums.

On the one hand, the NCPs foresee that statistics and probability be a part of primary education right from the start. On the other hand, the curricular guidelines of the undergraduate courses fail to reflect these demands. Thus, the opportunity has been missed and there is no appropriate solution to the problem in sight.

REFERENCES

Bayer, A. et al. (2005). Preparação do formando em matemática-licenciatura para lecionar estatística no ensino fundamental e médio (Preparation of last-years undergraduate students in mathmatics to teach Statistics in fundamental and high school classes). *V ENPEC (Encontro Nacional de Pesquisa em Educação em Ciências)*. From November 28 to December 3. Bauru, SP, Brazil. (pp. 1-11).

Batanero, C., Godino, J. D., & Roa, R. (2004). Training teachers to teach probability. *Journal of Statistics Education, 12*(1). Online: www.amstat.org/publications/jse/v12n1/batanero.html.

CNE/MEC. (2001). Diretrizes curriculares nacionais para os cursos de matemática, bacharelado e licenciatura (National curricular guidelines for the Mathematics courses). Parecer CNE/CES 1.302/2001. DOU 5/3/2002.

Hacking, I. (1990). *The taming of chance.* Cambridge (MA): Cambridge University Press.

Kader, G., & Perry, D. M. (2006). A framework for teaching statistics within the K-12 mathematics curriculum. In A. Rossman & B. Chance (Eds.), *Proceedings of the Seventh International Conference on Teaching Statistics.* Salvador, Brazil: International Association for Statistical Education.