STATISTICS TEACHING FOR PROSPECTIVE TEACHERS OF MATHEMATICS: REFLECTIONS AND PERSPECTIVES

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Basic knowledge of statistics has become necessary so that people do not become hostages of data interpretation. Since 1998, in Brazil, the National Curricula Parameters suggest the incorporation of statistics content into mathematics, although a main concern is the academic background of elementary school teachers. The aim of this work is to evaluate the basic statistical background of students in the first semester of mathematics at the Federal University of Lavras, by means of interviews and workshops. Results suggest that it is possible and necessary to plan, in the short and medium term, pedagogical workshops of statistics teaching for prospective teachers of mathematics in order to motivate and qualify them.

INTRODUCTION

Nowadays our society has been demanding a better academic background for the comprehension of its own reality, by means of discussion and manipulation of a huge amount of information, which usually is presented by a statistical treatment, e.g., use of graphs and tables. In this context, statistics is a main tool, since it allows description of the observed data and development of methodologies to make decisions. Therefore, it is very important for students to have their first contact with statistics early, during basic education, and that urgent efforts are made to establish statistical literacy.

To reinforce these needs in Brazil, the National Curriculum Parameters, elaborated and published by published by the Secretaria de Educação Fundamental (Ministry of Basic Education) and the Ministério da Educação e Cultura (Ministry of Education and Culture) (SEF/MEC). SEF/MEC include themes like combinatorial analysis, probability and statistics that are recommended to be part of the "Information Treatment" content in the mathematics curriculum for elementary schools (Brazil SEF, 1998). According to Nicholson, Road and Darnton (2003) and Batanero, Godino and Roa (2004), such recommendations are already a requirement abroad. In our opinion, what seems to be the ideal process for teaching probability and statistics in elementary school is schematically represented by Figure 1.
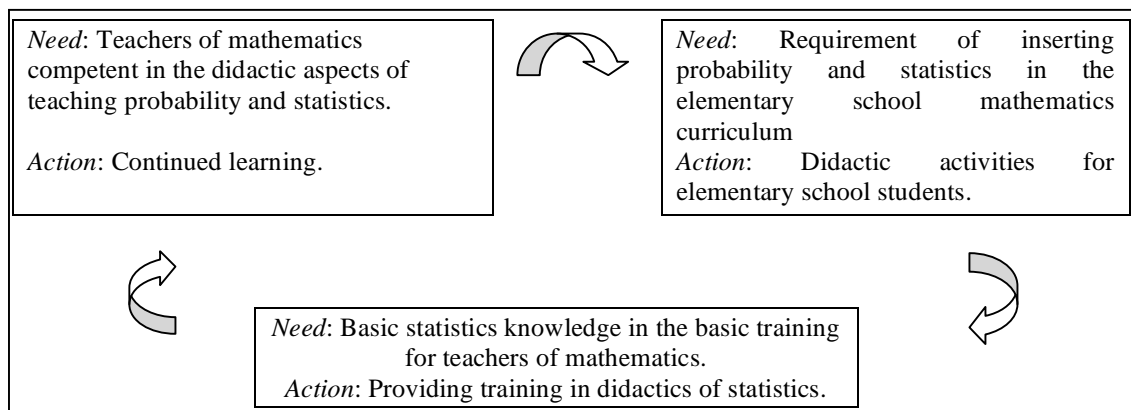

Figure 1. Scheme of needs and actions for preparing teachers of mathematics in elementary school to teach statistics and probability

In practice, researchers point out that one of the major difficulties regarding the teaching of probability and statistics in the elementary school is the poor knowledge that teachers acquire during their degree (Nicholson Road & Darnton, 2003; Batanero, Godino & Roa, 2004; Rodrigues, Oliveira, Souza, Kataoka & Oliveira, 2006). Then, the teachers usually show thinking that is too exact and determinist (given by mathematics) and have difficulties in dealing

with concepts like approximation, randomness and estimation. Such lack of experience in the statistical way of thinking seems to lead to both wrong approaches to statistical methods and little interest in statistics.

Reinforcing the idea of lack of teaching of statistics, Cordani (2001) and Boland (2006) argue that the students entering college often demonstrate insufficient (or no) knowledge of themes like probability, variability, random reasoning; an issue supported by consequent problems in understanding particular terms used in statistics. Cazorla, Silva, Vendramini and Brito (1999) have shown that students seem to have difficulties in even using the simplest data analysis tools, like graphical data representation. On the other hand, regarding the continued formation of mathematics teachers regarding didactics activities for elementary school students, we found several successful examples (Cordani, 2002; Watson, 2002; Peck & Gould, 2005; Gattuso & Pannone, 2006; Innabi, 2006; Lopes, 2006; Morin, 2006; Kataoka, Oliveira, Rodrigues, Souza & Oliveira, 2007).

BASIC TRAINING FOR MATHEMATICS TEACHERS

Facing such evidence, it seems clear there is a need to include probability and statistical concepts during the basic education of elementary school mathematics teachers. It is worth noting that, in Brazil, there is no statistics education as a subject for prospective mathematics teachers yet. Moreover, in a previous investigation of mathematics licenciature degrees in Brazil, it was possible to detect that currently there are 37 degrees at federal universities and many more in private institutions that offer only one course in basic statistics, with one that offers no statistics, and another that offers two courses: Probability and statistics; and statistical inference. It is worth noting that, in Brazil, there was only one licenciature degree in statistics that was cancelled in 1997. Further worrisome data are that, in the curricular guidelines for mathematics from the Brazilian Ministry of Education (Brazil CNEC, 2002), the subject *Probability and Statistics* is required only for the licenciature degree. There is no mention of statistics for the mathematics degree.

Therefore, we realize that teaching basic statistical concepts is not a concern when training prospective teachers for elementary school. There are no courses or programmes providing pedagogic actions that can reinforce teachers' statistical reasoning. Cazorla (2006) says that the same happens when analyzing the curricular form of the courses in areas related to statistics. The mastering of the content is a must for teaching, but if the teacher is not able to teach the content clearly, the learning process can fail.

Changing the research focus back to our local reality, the mathematics degree at the Federal University of Lavras (UFLA), settled in 2007, initially provides only one course in statistics, but it is still possible to have an optional course in statistics education. However, while Brazilian mathematics degrees do not update their curriculum, small and medium interim actions could be taken to improve basic training in probability and statistics for teachers of elementary school mathematics. In order to address this, we prepared a survey and a workshop for students who had just entered the mathematics degree at UFLA, Minas Gerais. The aim was to briefly investigate how they learned probability and statistics at secondary school and what their knowledge level in some basic statistical topics was. Contextual and interdisciplinary situations were explored in the workshop, rather than providing lots of formulas and formalisms.

A PRIORI ANALYSIS: INTERVIEW
Methods

We initially investigated 34 volunteer students from the first semester in the mathematics degree at UFLA. Questionnaires with 15 objective and subjective questions were answered individually to collect information about the students' schooling background, their statistics and probability knowledge acquired during secondary school and the resources offered by the schools. Questions were classified into two groups: *objective questions*, referring to some aspects of their scholar lives and the teaching of statistics, with answers being yes or no, which were transformed into ratios; and *subjective questions*, about the importance of statistics teaching.

Results

Only 14.7% of the interviewed students concluded high school before 1998, the period when the National Curriculum Parameters (PCNs) first suggested the teaching of statistics and probability at the basic education level. Some students (13.8%) argued that statistical themes were not taught during their basic foundation. Students who had contact with statistics (86.2%) enjoyed the discipline, and the didactic books they used had some kind of statistical themes. However, 50% suggested that their teachers had difficulty in teaching such content. This result suggests that problems in teaching statistics may be due to the lack of motivation and knowledge of the teachers. More than 80% of the students considered the teaching of statistics at the elementary school level important, since it can be done in an interdisciplinary way and help develop critical thinking. Moreover, considering that not all students who conclude high school will engage in a university degree, a previous critical statistical foundation will certainly favour their entrance into the work market and the development of their citizenship. Some responses suggest the need for further didactic-pedagogic investigations related to probability and statistics teaching in elementary schools, as well as for developing projects that enable the students to contact both mathematics and statistical themes during their education.

WORKSHOP

A pedagogical workshop on *"Adequacy of statistical reasoning for interdisciplinary work"* was conducted in the same way as previous workshops for mathematics teachers of elementary education II (Kataoka et al., 2007). From the 34 respondents, 22 attended the workshop as volunteers, and 12 could not attend the workshop. Two four-hour meetings were held, divided into theoretical parts and didactic practices that were intended to improve the knowledge and relationships among the participants.

First meeting – Exploring estimators

The first meeting started with a parallel comparison between the determinism of mathematics and the uncertainty of statistics. Some basic concepts of sampling were given, highlighting the importance of a representative sample in order to obtain a precise estimate. In the didactic practices, nine activities showing research published in magazines or newspapers that presented problems of sampling and doubtful inferences or without a scientific base, were given to the participants, who were challenged to identify errors and important omissions, as for example, the research represented in Figure 2.

SUPERenquete

ARMA NA MÃO

Mudar a atual lei brasileira sobre quem pode andar armado não é uma idéia que agrada aos leitores que participaram de nossa enquete.

A VENDA DE ARMAS DE FOGO PARA CIVIS DEVE SER PROIBIDA?

| Não | 75,6 |
| Sim | 24,4 |

Figure 2. Voting through web site www.superinteressante.com.br
(Super Interessante Magazine, ed. 202 (07/2004)]

As a second step, we presented the concepts of descriptive statistics, the main measures of central tendency and measures of dispersion, which can be used as estimates of some population parameters. We not only discussed with the teachers the ways of calculating but also the interpretation of each of these measures, showing that each one of them can be better used in specific situations, depending on the problem. As a didactic practice, we estimated the mean height of students attending the workshop in order to highlight the sampling technique used,

avoid bias in the selection and also to notice that the larger the sample size, the more accurate the estimate.

The first meeting finished with the third didactic practice, where we introduced the process of capture and recapture to estimate a population size, using balls in an opaque bin. In this practice it was possible to explore concepts such as population, sampling, estimate, randomness, relative frequency. Students felt exited during the activity. Many said they could verify some theoretical concepts in a practical way and suggested that the activity could be explored in an interdisciplinary way.

Second meeting – Making the right decisions: a statistical issue

In the second meeting we held discussions about estimates, introducing the idea of interval estimate. First, the definition of sampling error was introduced, making it possible to show its random characteristic. However, for most students the definition of randomness was not natural. In this context, topics such as confidence degree, sample representativity and methods for deciding the sample size based on a maximum error pre-established by the researcher were debated. At the end, we showed that it is possible to determine the confidence intervals from the estimate of the error. To exemplify the mentioned concepts, a didactic practice was suggested, in which the students were asked to determine the confidence intervals for the average height (data of the 2nd practice of the 1st meeting) with different confidence degrees: 0%, 5%, 50%, 95% and 100%. Therefore, it was possible to discuss with the students the characterization and interpretation of the confidence interval.

During the discussion on how to make a decision, the logic of the formulation of statistical hypothesis was introduced. After that, we presented the procedure to accept a hypothesis, stressing the importance of having a good basis to avoid committing an error that could lead to impairment. Then, a didactic practice was presented in order to discuss some research found in magazines with the objective of checking the sample size and whether it was possible to make a decision on the basis of the confidence interval.

To finish the meeting, a last didactic practice was suggested to solve and estimate the value of π by means of the classic Buffon's Needle problem. In this practice the idea of geometrical probability was introduced and was compared with the frequentist probability.

Analysis of the Workshop

At the beginning of the workshop an exploratory test was given to the participants comprised of two written questions, and the same test was repeated at the end of the workshop in order to verify whether there was difference in resolution strategies. The first question presented the results of a sample survey but will not be discussed here.

The second question presented results of two surveys performed by IBOPE (The Brazilian Institute of Statistics and Public Opinion) in the Presidential Election in Brazil (Table 1) and Governor of Rio de Janeiro Election (Table 2). Both surveys presented error margins of two percentage points, considering a 99% confidence degree. We expected that teachers would be able to observe that in both surveys, some intervals overlapped, and it would not be possible to draw any conclusion from them (a technical tie).

Table 1. Survey: Presidential Election in Brazil

Candidate[1]	(%)
Lula	50
Geraldo Alckiman	38
Others	12

[1]Sample: 60 300 were surveyed in 445 Brazilian cities.

"Based on this survey, can we affirm that Lula will be elected on the first round (50% + 1 of the votes) or will face Geraldo Alckiman on the second round?"

Table 2. Survey: Governor of Rio de Janeiro Election

Candidate[1]	(%)
Sérgio Cabral	41
Denise Frossard	23
Marcelo Crivella	21
Others	15

[1] Sample: 6 000 were surveyed in 26 cities.

"Based on the survey, can you tell who will face Sérgio Cabral on the second round?"

From Table 3 it can be observed that the students' answers to the first and second tests improved after the course, because most of them drew a correct answer for both questions, "cannot be affirmed". We also observed that on the first test many students gave "unsatisfactory answers", that is, answers that are not related to the presented survey, revealing that most of them have difficulties interpreting surveys.

Table 3. Result of the first question of the exploration test

Answers	First Test (%)	Second Test (%)
Elected in the first round	19	0
Goes to second round	29	31
Not able to affirm	14	63
Unsatisfactory answers	38	6

At the end of the workshop the students were asked to answer a questionnaire assessing the performance of some pedagogical aspects of the workshop and of the lecturers. In this assessment more than 75% of the students were satisfied with what they learned during the workshop and also gave some suggestions such as organizing other statistics courses, prioritizing the interdisciplinary character, thus reinforcing the necessity of updating and building the capacity of the mathematics teachers to teach statistics. An example of the testimonies:

The workshop was great and I've got a better idea of what the subject of statistics really is supposed to deal with and its value applicable to society (A.M.Costa, 2007)

CONCLUSION

In our experience we observed that the students were not too familiar with the basic concepts of statistics due to the lack of, or little contact, with statistics during their elementary education. During the workshops we noticed an improvement in the participants' statistical reasoning and an increasing motivation towards knowing statistics better.

We consider this work a first project, with possibilities of expansion to other cities to the south of Minas. We hope that this initiative can represent a guideline for researchers in other countries. It is necessary for more actions to be implemented in order to provide students (prospective teachers) with an introduction to statistics, allowing them to enter the work market with a different view of the importance of teaching statistics in elementary schools and, therefore, improving the continued learning process for teachers of mathematics, since today they attend such courses to learn, not to update themselves.

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