STATISTICAL LITERACY IN BRAZIL IN HIGH AND MIDDLE SCHOOL: AN ANALYSIS OF OFFICIAL DOCUMENTS

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In order that students become able to exercise their full rights of citizenship, they need to develop abilities and competencies related to statistical literacy at compulsory school levels. These include being able to read, interpret and criticize media information and take conscious decisions in the face of these readings. In Brazil, in 1998, it was suggested that, in the middle school, the study of statistics be incorporated into the mathematics curriculum, and in 2002 the same was prescribed for the high school level. In this context, the aim of this paper is to identify the institutional practices of statistical literacy as specified by the Education Ministry in their official documents and to analyse in the pedagogical orientations, also supplied by the Ministry, the expected levels of statistical literacy levels. Results show that there have been great improvements in relation to statistical literacy, but much has yet to be done in the compulsory school.

INTRODUCTION

The Brazilian National Curricular Parameters (PCN) for compulsory school levels are guides for quality that aim to guarantee the population the right to know a set of knowledge recognized as essential to the full exercise of citizenship in a society marked by social inequalities, fast improvement of science and technology, and changes of paradigms. The PCN aims to create new bonds between teaching and society, searching for a 'citizen-school', a school that prepares individuals to be effective members of society. To this end, the guidelines present the content to be taught as well as discussing the reasons and methods by which this should be achieved, valuing collaborative work above all. In order for individuals to fully develop their citizenship, they have to be able to read and write to face the needs of their social context and to use their abilities to keep learning and developing throughout their lifetime (IPM, 2005). To do so, it is not enough to grasp school knowledge; it is also necessary to know how to mobilize this knowledge in order to solve daily life problems (Carvalho, 2006).

Functional Literacy Rates–INAF (IPM, 2005) evaluate the mathematics abilities of 15 to 64 year-old adult Brazilians, where the full literacy level means being capable of elaborating and/or choosing a solving strategy for problems that demand the execution of a series of operations. This includes demands related to statistical literacy, particularly about reading and comprehending data in the media using graphs and tables representations. Related to these abilities, Lopes (2004) explains that in the 2002 INAF, the highest rate of right answers (57%) was on a question that asked for the reading of the values corresponding to the maximum point of a bar graph and the lowest rate of right answers (9%) was in identifying the interval of highest growth on a line graph. This low level of performance in reading tables and graphs, an informal statistical literacy level as presented by Watson and Callinghan (2003), was repeated in the 2004 Mathematics INAF in which rates of correct answers varied from 8% to 41%.

These results show how work at the compulsory school levels needs to be dedicated to elementary statistical concepts and their various representations as strategies for accessing information for democratization and resources and procedures to organize and analyse it. Our current society requires that citizens be able to read, to understand statistics, mathematics and their contextual concepts, and also to have a questioning attitude in the face of information; this is what Gal (2002) terms statistical literacy. Also, statistics being the language of the scientific method makes it possible for individuals to formulate hypotheses, direct the process of collection of empirical evidence, search for tools to treat data and raise the need to communicate results–that is, what Rumsey (2002) calls statistical competency.

In this context, acknowledging the importance of statistical thinking to promote the required abilities and competencies for citizenship, PCN have incorporated the elementary statistics and probability concepts in the Mathematics Syllabus, in a strand named Treatment of

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Information, in the case of the middle school (Brasil, 1998) and Data Analysis in the case of high school (Brasil, 2002, 2006). Each of these is one part of the four strands that comprise the mathematics curriculum at each of these school levels.

However, much of the information that reaches citizens employs increasingly sophisticated statistical concepts and procedures, such as confidence level and error margin, content currently restricted to undergraduate courses. In countries like Brazil, most of the population does not reach the undergraduate level of education. Therefore, it is the duty of the compulsory school to ensure that citizens will grasp concepts and procedures that are involved in their daily life, and it is the duty of the mathematics teacher to develop statistical abilities.

In this sense, this paper aims to analyse the mathematics curricular policy, explicit in the official documents for compulsory school, with regard to statistics and probability and their potential contribution to the production of citizens capable of understanding and interpreting the world around them enabling them to take conscious decisions in the perspective of the statistical literacy (Gal, 2002; Watson, 2003) and promoting scientific spirit, in the perspective of statistics competence. In other words, the aim of this paper is to study the objects of statistical literacy as specified by the Education Ministry in the PCN. These are considered as institutional objects in the sense of Godino and Batanero, (1994, p. 11), objects that emerge from systems of social practices linked with a problem field.

STATISTICAL LITERACY

Gal (2002) proposes a model of statistical literacy composed of five cognitive elements, related to one's competencies to critically understand, interpret and evaluate statistical information and a dispositional component, regarding the active attitude towards statistic information (critical stance and attitudes):

> a) one's competence to critically interpret and evaluate statistical information, the arguments related to data or to a stochastic phenomena, that can be presented in any context and, when relevant, b) one's competencies to discuss and communicate relations to such statistical information, such as one's understanding of the meaning of the information, one's opinions about the implications of this information, or the considerations about the acceptance of given conclusions (p.2-3).

For Gal (2002), basic statistical knowledge comprises knowledge of the reasons and ways that data collection have been carried out; familiarity with basic ideas and terms related to descriptive statistics; familiarity with basic ideas and terms related to graph and table representations; understanding the basic notions of probability; and knowledge about how statistical conclusions and inferences are made.

Concerned about the role of school in promoting statistical literacy, Watson and Callingham (2003) developed and validated an instrument to identify hierarchical levels for these complex constructs (Table 1), in which the knowledge of randomness and sampling, central tendency measures, dispersion, and graphs were obtained at the most advanced levels of understanding. Taking the sampling concept as an example, at the idiosyncratic level, a student makes judgments based on a non-representative sample; passes to the inconsistent level when he/she understands the sampling process; passes to the critical level when he/she perceives random and representative samples; and reaches the critical mathematical level when identifying differences and questions the sampling process when reading papers.

Based on the concept of statistical literacy, Rumsey (2002) proposes a model also composed of five components of statistical competence, which is the basis for statistical reasoning and thinking needed for the development of inherent abilities to do scientific research: capability to elaborate hypothesis; collect empirical evidence; search and find tools to treat data; explain, judge, evaluate; and make decisions based on these data. Although this proposal is evident in undergraduate courses such as Introduction to Statistics, we believe that this way of presenting elementary statistical concepts can significantly contribute to the growth of the scientific spirit in compulsory school, avoiding the instrumental only role of 'statistical research' and stepping forward towards the development of statistical literacy.

Table 1. Statistic literacy levels (Watson, & Callingham, 2003, p. 14)

Level	Brief characterization of step levels of tasks
1. Idiosyncratic	Task-steps at this level suggest idiosyncratic engagement with context, tautological use of terminology, and basic mathematical skills associated with one-to-one counting and reading cell values in tables.
2. Informal	Task-steps at this level require only colloquial or informal engagement with context often reflecting intuitive non-statistical beliefs, single elements of complex terminology and setting, and basic one-step straightforward table, graph, and chance calculation.
3. Inconsistent	Task-steps at this level, often in supportive formats, expect selective engagement with context, appropriate recognition of conclusions but without justification, and qualitative rather than quantitative use of statistical ideas.
4. Consistent Non-critical	Task-steps require appropriate but non-critical engagement with context, multiple aspects of terminology usage, appreciation of variation in chance settings only, and statistical skills associated with the mean, simple probabilities, and graph characteristics.
5. Critical	Task-steps require critical, questioning engagement in familiar and unfamiliar contexts that do not involve proportional reasoning but which do involve appropriate use of terminology, qualitative interpretation of chance, and appreciation of variation.
6. Critical Mathematical	Task-steps at this level demand critical, questioning engagement with context, using proportional reasoning particularly in media or chance contexts, showing appreciation of the need for uncertainty in making predictions, and interpreting subtle aspects of language.

PCN FOR MATHEMATICS IN MIDDLE SCHOOL

The analysis of the curricular documents aimed to identify statistical competency and, where possible, relate them to the statistical literacy levels proposed by Watson (2003) and Watson and Callingham (2003). The goal of the strand Treatment of Information as specified in the PCN for middle schools goal:

> To help students construct procedures to collect, organize, communicate data, using tables, graphs and representations that frequently show up in daily life. In addition, to calculate some of statistical measures, such as mean, median and mode, aiming to give new elements to interpret statistical data (p. 52).

Considering that it is the mathematics teacher who will conduct work in the classroom, it is expected that the curricular policy present pedagogical orientations related to this kind of activity. PCN proposes that, using a theme of interest for the student, a data collection with the "rare and precise definition of the research problem, the sample, the involved variables, the obtained information preliminary analysis to make an adequate organization of the data, the observing of the relevant aspects and the calculation" should be planned and executed (p. 135).

PCN include suggestions about the development of mathematical content emphasizing the use of graphs and tables to analyse the collected data, leaving central tendency measures aside. This can be observed when "it is expected that students (from 5th and 6th grades) should know how to construct, read and interpret tables and graphs, and to choose the most adequate kind of representation to express statistical data" (p. 77). This limitation is surpassed in 7th and 8th grades, as it is expected that "the student make some predictions from the calculation of the research central tendency measures" (p. 93).

Although there is this strong tendency towards graphical exploration, there are no pedagogical orientations that make it possible for mathematics teachers to choose the best representation related to the nature of the variables. Consequently, one can observe a strong tendency to work with qualitative variables, restricted to construction of simple bar charts and sector graphs (Silva, 2007), allowing reading and interpreting with a simpler level of statistical literacy.

Related to the central tendency measures, recent research studies show the complexity of teaching these concepts (Batanero, 2000; Cai & Gorowara, 2002; Cazorla, 2003). If their teaching is restricted to algorithms, the literacy level can be restricted to consistent understanding without reaching the critical level as presented by Watson and Callinghan (2003). In this sense, the PCN didactic orientations present an example of the effect of a discrepant value in the arithmetic mean that may allow the mathematics teacher to think of activities that make the development of the critical mathematical level of statistical literacy possible (Watson, 2003).

At this teaching level, some of the statistical literacy key concepts such as sampling and variation are not considered in a more consistent way. The only recommendation presented is: "in a research in which all students of the classroom take part, the group of students in the classroom can be considered a representative sample (as regards the school) if the variable under investigation is the students' kind of residence, but will not be representative if the variable is, for instance, the students' height" (p. 135). Nevertheless, to affirm this PCN should present pedagogical orientations about a sample's representativeness aspects as randomness and variation, in order to prepare mathematics teachers to discuss these aspects with their students. These key statistical concepts are not part of the content in this school level, not even in an intuitive form.

The PCN pedagogical orientations suggest the use of spreadsheets "to make relative the importance of mechanical calculation and simple symbolic manipulation, once that, by means of instruments, these calculations can be done in a quicker and more efficient way" (p. 43). One can observe that this recommendation emphasises the use of software as tools and not as educational resources, such as *Fathom* or similar computer environment, as suggested by delMas and Liu (2005).

PCN FOR MATHEMATICS IN HIGH SCHOOL

After the Law for Policy and Foundation of Education, edited in 1996, was published, high schools had their goals amplified to prepare students for life, qualifying them for citizenship and enabling them to continue learning throughout life (Brasil, 2002). At this teaching level, one of the aims related to the mathematics curriculum is that it will contribute to enabling the student to "understand and to interpret situations, in order for them to be able to use specific language, argument, analyse and evaluate, draw their own conclusions, take decisions, generalise" (p. 111). Therefore, related to the previous level, there is an improvement in the development of statistical literacy in the definition of the goals as it is expected that the student will interpret information and make a decision in the face of a reality.

The data analysis and probability strand of the high school curriculum incorporates line graphs, histograms, variance and standard deviation. Variation measures are the heart of statistics and the reason why it exists (Watson & Kelly, 2002), and the variability concept is important in the growth of the statistical literacy (Gal, 2002). However, the PCN argue that if the mathematics teacher has less than four class-hours per week, the focus should be on the key ideas of each content area, and that, in the case of statistics, it should focus on the central tendency measures (averages). This orientation could induce the mathematics teacher to repeat at high school the statistics content worked in middle school, not allowing the student go grow in the levels of statistical literacy.

The pedagogical orientations related to the mean for a set of data warn about the role of discrepant values, as at the previous scholar level but do not mention the importance of the variation measures in this identification, leaving the mathematics teacher the task of searching for pedagogical alternatives to develop the concept of variation. It is in fact shape, center and spread that we look for in each distribution.

Related to understanding media information, the PCN (Brasil, 2002, p.112) suggest that a high school student should be able to read a line graph that presents the voting intentions of the population in relation to three candidates during an electoral campaign, making it clear that, in order to do so, the student needs to understand that the "growth in the voting intentions could be dropped or reverted by new facts or new political information." This means that it requires context knowledge and makes explicit 'specific knowledge, such as related variable, analysing growing rates, calculating percentages and comparing quantities.' However, this reading demands the reader to mobilize knowledge of statistical inference that goes beyond that suggested for this level of teaching, such as estimator, punctual and by interval estimative, reliability levels, significance levels, error margin, among others.

In order to make it possible for the mathematics teacher to help students to "question generalizations based on a single study or in a small sample" (Brasil, 2006, p.79), the teacher should know and master a set of key statistical ideas that are absent in curricular orientation: including distribution, sample and sampling, variability, comparing groups, statistical models, and the interrelationship among them.

Pedagogical orientation emphasises the use of diagnostic research: "interviews and making tables of the answers and for that, the students will be able to use tables and graphs, which they already know from media and research organizations in the divulgation of survey and data analysis" (Brasil, 2002, p.130). However, at no time does this survey refer to a scientific hypothesis nor does it make connections with the mathematics contents, such as, relations between the height of a plant and its life time or the measurement of the arms and the height of the students, experiments that can be done in the classroom and raise hypotheses on the nature of the relationships, the need to mathematically model the situation, and the discovery of mathematical functions.

FINAL CONSIDERATIONS

The analysis of the PCN for mathematics shows a strong concern about the production of critical citizens for the future. In this sense, the inclusion of statistical content and pedagogical orientation that suggest to the teacher its implementation has been a great improvement. Our analyses suggest that this orientation is clearer in the documents aimed at the middle school than in those for the high school level, narrowing the possibility of reaching the critical mathematical level of statistical literacy level.

Some concepts and procedures are necessary for both teachers and students to understand statistical thinking. For example, the statistics research cycle, such as parameter, estimator, estimative, sample, sample's representatives, randomness, among others, could be presented, even in an intuitive way. If these basic concepts were inserted in compulsory school in this way, they could meaningfully contribute to the development of statistical literacy.

Another barely explored aspect is the distinction between statistics research and scientific research. The PCN could encourage mathematics teachers to develop scientific research that is committed to science and ethics, which are supported by the rigour in methodology and by replication principles that help identify sources of bias. Unfortunately this is not always the case in some statistical surveys that support information in the media and permeate the citizen's life. For example, some election surveys are not always done in a scientific way or intended to improve the population welfare. In this sense, the pedagogical orientations also should raise awareness about misused statistics as well as indicate suitable mathematics tools to construct arguments related to possible fallacies.

The increasing interest in statistics education and the greater number of researchers and teachers interested in the development of statistical literacy show that Brazil is on its way to developing statistical literacy. However, there is much to be investigated, done and corrected in the official documents in order to ensure that the compulsory school has an effective role in helping Brazilian students to develop the minimum knowledge needed to allow them to exercise their citizenship as a statistically literate citizen. This first step to promote statistical literacy development needs to involve more than curriculum documents; it needs also to encompass other institutional factors, such as teacher education (pre-service and in-service) and mathematics textbooks.

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