STATISTICAL LITERACY AND CURRICULUM GUIDELINES IN BRAZIL FOR THE EARLY YEARS OF ELEMENTARY SCHOOL: A REFLECTION

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This work has been developed by the Fundão Project: Statistics and Probability, a collaborative project of the Federal University of Rio de Janeiro (UFRJ), composed of professors, undergraduate students, and school level mathematics teachers. The research is part of a study whose focus is the teaching and learning of statistics and probability at elementary school. Our goal is the professional development of mathematics teachers. Focusing on the initial stage of statistical literacy and based on an integrated approach, we considered the (recent) Brazilian normative orientations of Common National Curriculum Basis (BNCC) in statistics and probability to propose didactic sequences along the lines of the resolution of statistical investigation problems by the Guidelines for Assessment and Instruction in Statistics Education (GAISE).

BACKGROUND

With a quick search on the existing literature regarding the teaching of statistics in school level, it can be observed that there seems to be a consensus around the world on the importance of this content, and this can be seen by the inclusion of statistics by several countries in school level education from the beginning of the 21st century (Zieffler et al., 2018).

At the same time, in Brazil, in December 2018, the Common National Curriculum Base (BNCC) was approved, a normative document that defines the organic and progressive set of essential learning in Brazilian school level education. BNCC (Ministério da Educação, 2018) brings a change of perspective in the treatment given to the teaching of statistics in school level and is based on the fact that all citizens need to develop skills to collect, organize, represent, interpret, and analyze data in a variety of contexts to make well-informed judgments and to make appropriate decisions. An important question is, therefore, how to promote statistical literacy in the early years of elementary school in light of what determines BNCC?

Since the beginning of 2019, the Fundão Project: Statistics and Probability, an educational project of the Federal University of Rio de Janeiro (UFRJ), develops collaborative work with a focus on this question and proposes activities for the classroom that aim to develop statistical literacy. The project includes professors from UFRJ, undergraduate students in mathematics, and mathematics teachers from school level education in the public and private education networks.

METHODOLOGICAL APPROACH

The methodology used is based on a qualitative approach, supported by the documentary analysis of two baseline references in educational systems: the BNCC (Ministério da Educação, 2018) and the Guidelines for Assessment an Instruction in Statistics Education (GAISE) report (Bargagliotti et al., 2020). Thus, from a combined reading (Novaes et al., in press) of these two documents, we seek to identify possible potentialities and limitations for the development of statistical literacy in the pedagogical guidelines of the BNCC in light of the model of the statistical problem-solving process proposed by GAISE. Collaboratively, research results are translated into didactic sequences that are continually experimented and revised.

THEORETICAL FRAMEWORK

As a theoretical framework for the promotion of statistical literacy at the school level, we consider GAISE, published by the American Statistical Association (ASA) first in 2005 (Franklin et al., 2005) and revised in 2020, GAISE II (Bargagliotti et al., 2020). According to GAISE, the development of statistical literacy takes place in a two-dimensional structure in which one of the dimensions refers to the four stages of the Process of Solving a Statistical Investigation Problem (PRPIE), as illustrated in Figure 1. The four stages of the process are:

(i) *Question formulation*, which corresponds to clarifying the problem and formulating one or more questions that can be answered with data;
(ii) *Data collection*, which requires designing and implementing a plan to collect the appropriate data;
(iii) *Data analysis*, which is characterized by the selection and application of appropriate graphic and numerical methods to analyze the collected data; and
(iv) *Interpretation of the results*, which entails establishing a relationship between the analysis and the original question or questions.

The other dimension refers to the levels of statistical literacy development, identified by A (beginners), B (intermediate), and C (advanced). GAISE (2020) presents, for each of the levels, a list of skills to be achieved in each of the four stages of the PRPIE. In this work, we consider only the A level of development and the first six years of elementary school.
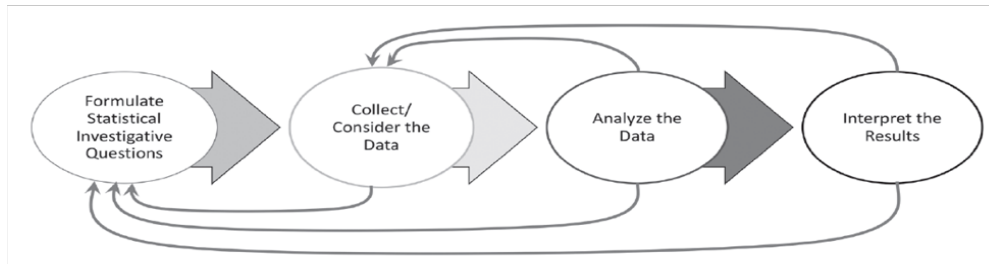

Figure 1 - Representative model of the statistical problem-solving process (Bargagliotti et al., 2020, p.13)

The GAISE report highlights fundamental aspects that must permeate the three levels of statistical literacy development:
● The importance of asking questions throughout the statistical problem-solving process and how this process remains at the forefront of statistical reasoning for all studies involving data.
● The inclusion of multivariate thinking at all levels of schooling.
● The role of probabilistic thinking in quantifying randomness at all levels.

In the elementary school curriculum that makes up BNCC, the thematic unit of *probability and statistics* is organized by distinguishing objects of knowledge. These, in turn, are associated with skills, as illustrated by in Table 1 regarding the grade of the fourth year of elementary school.

Table 1. BNCC probability and statistics–Mathematics curriculum grade–Fourth year of elementary school (our translation)

Knowledge objects	Skills
Analysis of chance of random events	(EF04MA26) Identify, among everyday random events, those that are most likely to occur, recognizing characteristics of more likely outcomes without using fractions.
Reading, interpreting, and representing data in double-entry tables, single and grouped column graphs, bar and column graphs and pictorial graphs.	(EF04MA27) Analyze data presented in simple or double-entry tables and in column or pictorial graphs, based on information from different areas of knowledge and produce text with the synthesis of their analysis.
Differentiation between categorical variables and numerical variables. Collecting, classifying, and representing data from research carried out.	(EF04MA28) Conduct research involving categorical and numerical variables and organize data collected through tables and graphs of simple or grouped columns, with or without the use of digital technologies.

We also verified that, while in the list of GAISE skills related to the PRPIE stages at level A, there is no specific probability skill. In BNCC there is, for each of the elementary school years, at least one specific probability skill.

From the reading of BNCC's probability and statistics skills, we observed that, in general, the approach structure of this thematic unit is organized from the identification of three core themes, related to the set of skills of each school year: *probability*; *data treatment* (tables and graphs, measurement, readings and interpretations); and *conducting research* (which involves collecting data to answer a proposed statistical research question).

THE INTEGRATED APPROACH

Based on GAISE, we propose that the skills related to the thematic unit of *probability and statistics* in BNCC should not be considered in isolation, but worked together, composing what we call an integrated approach. Thus, the activities planned by the group sequentially include:
(i)   Conducting research
(ii) Organizing and processing data
(iii) Probability

The integrated approach has a direct influence on the work carried out by the Fundão Project, including investigating, developing, and proposing activities for the classroom. We observe that the integrated approach proposed to interpret the set of objects of knowledge and skills of BNCC is in line with and contemplates the GAISE. Generally, but not exclusively, conducting research involves the steps of formulating statistical investigative questions and collecting data; the organization and treatment of data involve the steps of analyzing data and interpreting the results (Table 2).

Table 2. Relationship between the integrated approach and process steps of statistical problem solving according to GAISE (our translation)

Nuclear Themes	BNCC Skills
Integrated Approach	Fourth year of elementary school
Conducting research	Formulate Statistical Investigative Questions Collect Data
Data treatment	Analyze Data Interpret Results

Probability is present at all stages. In particular, it is expected that probability will be approached from a statistical point of view and that probabilistic thinking will mature across different levels of development.

For the early years and transition to the final years of elementary school (reference ages 6 to 11 years), it is understood that the proposition of the context and the problem of statistical research still involves, to a large extent, the guidance of the teacher. Thus, stage 1 of formulating statistical investigation questions is marked by triggering activities. In addition, recognizing that statistics is a methodological discipline that does not exist by itself, but is made in relation to other fields of study, themes and contexts worked are based on interdisciplinarity. With the question formulated, we proceed with stage 2 that involves data collection in order to obtain information to answer the investigative question, making it possible to consider secondary sources of data. Stage 3 includes the organization of the collected data with the construction of frequency tables of the responses obtained and graphical representations. After the analyses, we proceed to stage 4 and interpretating the results obtained with the preparation of a report. The stages do not necessarily occur in sequence, and it may be necessary to return to the previous stages depending on the demand for new data and the formulation of new questions throughout the PRPIE. In this approach, BNCC skills for a given year of elementary school are worked in the reverse order in which they are presented. See Table 1 as an example. The elaborated didactic sequences are disseminated in mathematics education meetings through workshops, experience reports, and oral communications (Landim et al., 2019; Rangel et al., 2021).

CONTRIBUTIONS

This work is part of a study aimed at teaching and learning statistics and probability in basic education. Thus, the didactic sequences elaborated are in a continuous process of experimentation and evaluation, offering learning opportunities on the subject for teachers. In addition to the conceptual aspects of statistics and probability, the use of technological resources such as online questionnaires, QR Codes, and electronic spreadsheets was explored. We understand that this is a way to contribute to the development of the teacher's own knowledge and is fundamental for the teaching of statistics and probability, thus composing a technological pedagogical knowledge for the teaching of statistics and probability.

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