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Statistical literacy according to GAISE and BNCC: Parities and contrasts[1]

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ABSTRACT

The 21st century showed the potential of statistics for society, determining that statistical literacy should start in the school phase. In Brazil, the Common National Curriculum Basis (BNCC) reflects a change of perspective in the teaching of statistics including Probability and Statistics as a thematic unit of Mathematics in Elementary School. This study aims to contribute to the discussion on statistics education, investigating the extent to which the BNCC's Statistics and Probability skills for the first six years of Elementary School have the potential to develop statistical literacy. To provoke and lead reflection, we developed a documentary analysis based on combined reading that relates the skills of the thematic unit Probability and Statistics of the BNCC from the first to the sixth school year with the characteristic skills of the initial stage of the development of statistical literacy according to the Guidelines for Assessment and Instruction in Statistical Education (GAISE). In particular, it stands out as reflections emerging from the analysis that the BNCC has the potential to develop statistical literacy in the early

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years of Elementary School through the proposition of investigations and that the probability skills at BNCC reveal a construction aimed at working with probability as a separate discipline from statistics, without establishing a clear connection between them.
KEYWORDS: Teaching of Statistics and Probability. Statistical Literacy. Combined Reading. BNCC. GAISE.

Letramento estatístico segundo o GAISE e a BNCC: paridades e contrastes

RESUMO

O século XXI evidenciou o potencial da estatística para a sociedade, determinando que o letramento estatístico deve ter seu início na fase escolar. No Brasil, a Base Nacional Comum Curricular (BNCC) reflete uma mudança de perspectiva no ensino de estatística incluindo Probabilidade e Estatística como uma unidade temática de Matemática no Ensino Fundamental. Este estudo visa a contribuir para a discussão sobre a educação estatística, investigando em que medida as habilidades de Estatística e Probabilidade da BNCC para os seis primeiros anos do Ensino Fundamental têm potencial para desenvolver o letramento estatístico. Para provocar e conduzir a reflexão, desenvolvemos uma análise documental fundada na leitura combinada que relaciona as habilidades da unidade temática Probabilidade e Estatística da BNCC do primeiro ao sexto ano escolar com as habilidades características da etapa inicial do desenvolvimento do letramento estatístico segundo o Guidelines for Assessment and Instruction in Statistics Education (GAISE). Em particular, destacam-se como reflexões emergentes da análise que a BNCC tem potencial para desenvolver o letramento estatístico nos anos iniciais do Ensino Fundamental a partir da proposição de investigações e que as habilidades de probabilidade na BNCC revelam uma construção voltada para trabalhar a probabilidade como uma disciplina separada da estatística, sem estabelecer uma conexão clara entre elas.
PALAVRAS-CHAVE: Ensino de Estatística e Probabilidade. Letramento Estatístico. Leitura Combinada. BNCC. GAISE.

Alfabetización estadística según GAISE y BNCC: paridades y contrastes

RESUMEN

El siglo XXI mostró el potencial de la estadística para la sociedad, determinando que la alfabetización estadística debe comenzar en la etapa escolar. En Brasil, la Base Curricular Nacional Común (BNCC) refleja un cambio de perspectiva en la enseñanza de la estadística incluyendo la Probabilidad y la Estadística como unidad temática de las Matemáticas en la Educación Primaria. Este estudio tiene como objetivo contribuir a la discusión sobre la educación estadística, investigando hasta qué punto las habilidades de Estadística y Probabilidad de la BNCC para los primeros seis años de la Educación Primaria tienen el potencial para desarrollar la alfabetización estadística. Para provocar y conducir la reflexión, desarrollamos un análisis documental basado en lectura combinada que relaciona las habilidades de la unidad temática Probabilidad y Estadística de la BNCC del primero al sexto año escolar con las habilidades características de la etapa inicial del desarrollo de la alfabetización estadística de acuerdo con las Directrices para la Evaluación e Instrucción en Educación Estadística (GAISE). En particular, se destaca como reflexiones que emergen del análisis que el BNCC tiene potencial para desarrollar la alfabetización estadística en los primeros años de la Escuela Primaria a través de la propuesta de investigaciones y que las habilidades probabilísticas en el BNCC revelan una construcción orientada a trabajar com la probabilidad como una disciplina separada de la estadística, sin establecer una conexión clara entre ellas.

PALABRAS CLAVE: Enseñanza de Estadística y Probabilidad. Alfabetización Estadística. Lectura Combinada. BNCC. GAISE.

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Introduction

Statistics has become one of the most central topics of study in the modern world of information and big data. The dramatic increase in demand for learning statistics in all disciplines is accompanied by tremendous growth in research

> in statistics education. [...] However, despite the growth in statistics education, research has continually revealed many challenges in helping learners develop statistical literacy, reasoning, and thinking. New curricula and technology tools show promise in facilitating the achievement of these desired outcomes. (Ben-Zvi, Makar & Garfield, 2018, p.xvii).

The statistical education area is not separate from mathematics education and can be defined as interdisciplinary, with attention focused on statistics teaching and learning. Possibly, the milestone of its emergence occurred in 1982, when the first ICOTS (First International Conference on Teaching Statistics) was held. Since then, much progress has been made; however, there is still a significant variation in the guidelines for teaching statistics in school education curricula in different countries (Zieffler, Garfield & Fry, 2018). The unity in this diversity lies in the fact that statistics content is taught under the umbrella of mathematics throughout the school years.

Certainly, the curriculum is also influenced by the educational objectives of a country or region. A goal that has guided many countries is the need for more statistically literate citizens (GAL, 2004). Brazilian curriculum guidelines, for example, emphasize statistical reasoning as part of education (Campos, Cazorla & Kataoka, 2011). The Brazilian Statistics Association (ABE) highlights the importance of teaching statistics to increase knowledge among the general population and underscores its principles at the school level (Louzada et al., 2015). Recommendations for teaching statistics at the school level have argued that teachers should adopt projects and other pedagogical methods to create a classroom that offers protagonism to students, promoting more effectively the recognition of the importance of statistics in the investigative processes of problem-solving and decision-making (Louzada et al., 2015).

Therefore, teaching statistics should foster statistical literacy, include data-based work in a more consistent and meaningful way, effectively contextualize statistical concepts, and provide active learning.

According to Gal (2021), the definition of statistical literacy evolves over time, currently being "the motivation and ability to access, understand, interpret, critically evaluate, and if relevant express opinions, regarding statistical messages, data-related arguments, or issues involving uncertainty and risk" (Gal, 2021, p.41).

ABE (Louzada et al., 2015) has been concerned with statistics teaching and emphasizes that it has also been a permanent concern of international statistical associations, giving as an example, the American Statistical Association (ASA), which maintains a teaching division on statistics to promote discussion on the topic. In particular, ASA endorses the Guidelines for Assessment and Instruction in Statistics Education – GAISE (Franklin et al., 2005; Bargagliotti et al., 2020), a report published for the first time in 2005 and revised in 2020 by the National Council of Teachers of Mathematics (NCTM).

Focusing on teaching at the school level, the GAISE (Franklin et al., 2005; Bargagliotti et al., 2020) recommends statistical literacy development in line with what was discussed above. It proposes that statistics teaching be based on an investigative problem-solving process, which must necessarily involve four stages that converge with those that typify the cycle of statistical investigation (Wild & Pfannkuch, 1999): the formulation of a research question, planning, and data collection, data analysis, and interpretation of results. In the GAISE, statistical literacy is observed from process and goal perspectives, developing throughout schooling, aiming to form citizens capable of thinking and reasoning statistically.

In Brazil, the National Common Curriculum Base (Base Nacional Comum Curricular - BNCC) (Brasil, 2018), a normative document "that defines the organic and progressive set of essential learning that all students must develop throughout the stages and modalities of basic education, so that

their rights to learning and development are assured" (p.7), does not explicitly discuss statistical literacy. However, its development is founded and guided by the thematic unit Probability and Statistics, which focuses on uncertainty and data processing.

The Fundão Matemática Project, a teaching, research, and extension program at UFRJ, focuses on teaching mathematics in basic education and teaching training and professional development. Since 2019, one of the collaborative groups in the project has been dedicated to investigating statistics and probability teaching in school education, driven by the implementation of the BNCC. There have been reflections on statistical literacy and curriculum guidelines in Brazil and the development of proposals for approach in the classroom (Baccar et al., 2022; Medina et al., 2022; Novaes et al., 2022). This study registers the research carried out by the group and reflects the maturity of the investigation presented in Baccar et al. (2022). We intend to discuss the approach to statistics and probability teaching by the BNCC about the development of statistical literacy. To incite and lead reflection, we developed a documentary analysis based on combined reading (Corrêa & Rangel, 2021a; 2021b; In Press) of the BNCC and the GAISE reports to raise questions and a critical reflection on the BNCC proposal. Our emphasis is on the initial approach to statistics and probability. Therefore, we focus on the guidelines for the first six years of elementary school. From the combined reading of the BNCC and the GAISE, we hope that the investigation highlights the extent to which the BNCC's statistics and probability skills for the first six years of elementary school have the potential to develop statistical literacy.

BNCC and GAISE: getting to know the documents under analysis

The BNCC (Brasil, 2018) determines general curricular guidelines for school education throughout the Brazilian national territory. Regarding statistics and probability teaching, the BNCC reflects a change in

perspective. The regulatory document includes probability and statistics as a thematic unit of mathematics in elementary education.

ABE argues that teaching statistics and probability requires a methodological approach that allows progressive advancement throughout basic education, enabling the exploration of the same concepts at different in-depth levels (Louzada et al., 2015). The ABE perspective aligns with GAISE recommendations (Franklin et al., 2005; Bargagliotti et al., 2020), which establishes a two-dimensional model for the development of statistical literacy, whose dimensions are: the Process of Solving a Statistical Research Problem (Processo de Resolução de um Problema de Investigação Estatística - PRPIE) and the gradual levels of development of statistical literacy: Level A, beginner, Level B, intermediate, and Level C, advanced.

Such levels of development of statistical literacy, which characterize the model proposed by the GAISE, are not intended to be directly related to the stages that organize school education, even though they can guide and be consistent with such organization.

> Although these three levels may parallel grade levels, they are based on development in statistical literacy, not age. There is no attempt to tie these levels to specific grade levels. Thus, a middle school student who has had no prior experience with statistics will need to begin with Level A concepts and activities before moving to Level B. This prerequisite holds for a secondary student as well. If a student has not had Level A and B experiences prior to high school, then it is not appropriate for that student to begin with Level C expectations. (Bargagliotti et al., 2020, p.15).

Therefore, the GAISE is not a curriculum guidance document. However, the model proposed by the report offers guidelines that constitute a reference for developing statistical literacy based on parameters intrinsic to

the model itself. Thus, aiming at school education, this model allows the stage of development of a student, a class, and a curricular proposal to be assessed and the progressive advancement of learning to be planned according to the proposed levels. We developed a combined reading of the BNCC and the GAISE from this understanding. To do this, we relied on the structural organization of these documents.

Structural organization of the BNCC

The BNCC is a curriculum document that covers the three stages of Brazilian basic schooling: early childhood education, elementary education, and secondary education. In elementary school, the document is organized into five areas of knowledge (languages, mathematics, natural sciences, human sciences, and religious education), integrating different curriculum components. For example, the languages area comprises the curriculum components Portuguese Language, Art, Physical Education, and English Language. Mathematics is an area of knowledge that identifies with the only curriculum component. Probability and statistics is a thematic unit in Mathematics. For each school year and per curricular unit, the BNCC specifies learning objectives, which define the organic and progressive set of essential learning that all students must develop throughout basic education. Thus, in the curriculum that structures the BNCC, objects of knowledge are identified –contents, concepts, and processes – and their respective skills – essential learning that students must achieve**.**

Structural organization of the GAISE

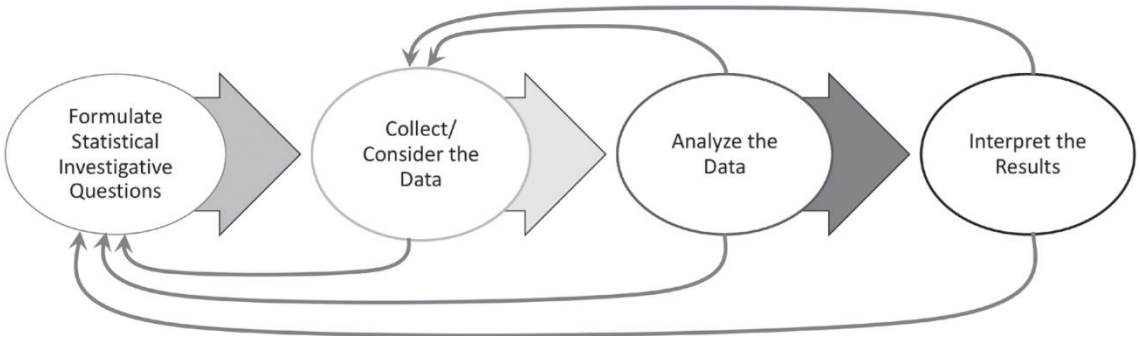
The GAISE focuses on statistical literacy, arguing that it should be developed from the first years of school. The report overviews the urgent demand for statistical literacy on its first pages, emphasizing that students must be prepared to live and work in a world guided by data

(Bargagliotti et al., 2020). The report also offers an introductory discussion on conceptual and fundamental aspects of statistics, such as the nature of variability, the role of questioning in statistics, probabilistic reasoning, the importance of context, the diversity of types of variables, multivariate reasoning, the use of technologies, and the future with the growing supply of data.

> Statistical problem solving and decision making depend on understanding, explaining, and quantifying variability in the data within the given context. “Statistics requires a different kind of thinking, because data are not just numbers, they are numbers with a context” (Cobb & Moore, 1997, p. 801). “In mathematics, context obscures structure. In data analysis, context provides meaning” (Ibid, p. 803). (Bargagliotti et al., 2020, p.7).

The GAISE proposes the Statistical Research Problem Resolution Process (Processo de Resolução Problemas de Investigação Estatística - PRPIE), illustrated in Figure 1, which is structured based on identifying four interrelated steps: (i) formulation of a statistical research question - which corresponds to clarifying the problem and formulating one or more questions that can be answered with data, (ii) data collection and consideration - which requires developing and implementing a plan to collect appropriate data; (iii) data analysis - characterized by the selection and application of appropriate graphical and numerical methods to analyze the collected data and (iv) interpretation of results - establishing a relationship with the original question or questions.

FIGURE 1: Process of Solving a Statistical Research Problem (PRPIE).



Source: BARGAGLIOTTI et al., 2020, p.13.

The characterization of each of the steps that compose the PRPIE is discussed in the report. It begins by highlighting that the formulation of statistical research questions that anticipate variability leads to productive investigations, that is, with meaning from a statistical point of view. The question "How fast does a plant grow?" essentially differs from asking "How tall is a given plant?" Data collection, which marks the next stage, requires recognizing and considering the variability that characterizes the data. The analysis stage allows us to explore, describe, compare, and reason based on variability through graphical representations and numerical summaries. The interpretation of results will enable us to go beyond the data, offering (or not) the possibility of generalizing the results. Guided by the PRPIE stages, the document provides parameters for developing individuals' basic skills in statistical literacy according to three progressive levels of deepening, described as Levels A, B, and C. (Figure 2).

FIGURE 2: Skills characteristic of the "Formulation of a statistical research question" stage of the PRPIE for the three levels of statistical literacy, according to the GAISE model.

Process Component	Level A	Level B	Level C
I. Formulate Statistical Investigative Questions	Understand when a statistical investigation is appropriate Pose statistical investigative questions of interest to students where the context is such that students can collect or have access to all required data Pose summary (or descriptive) statistical investigative questions about one variable regarding small, well-defined groups (e.g., subset of a classroom, classroom, school, town) and extend these to include comparison and association statistical investigative questions between variables Experience different types of questions in statistics: those used to frame an investigation, those used to collect data, and those used to guide analysis and interpretation	Recognize that statistical investigative questions can be used to articulate research topics and that multiple statistical investigative questions can be asked about any research topic Understand that statistical investigative questions take into account context as well as variability present in data Pose summary, comparative, and association statistical investigative questions about a broader population using samples taken from the population Pose statistical investigative questions that require looking at a variable over time Understand that there are different types of questions in statistics: those used to frame an investigation, those used to collect data, and those used to guide analysis and interpretation Pose statistical investigative questions for data collected from online sources and websites, smartphones, fitness devices, sensors, and other modern devices	Formulate multivariable statistical investigative questions and determine how data can be collected and analyzed to provide an answer Pose summary, comparative, and association statistical investigative questions for surveys, observational studies, and experiments using primary or secondary data Pose inferential statistical investigative questions regarding causality and prediction

Source: BargagliottI et al., 2020, p.16.

Thus, for example, let us consider the PRPIE statistical research question formulation stage. At Level A, we should "pose statistical investigative questions of interest to students where the context is such that students can collect or have access to all required data" (Bargagliotti et al., 2020, p.22). For example, considering choosing a band to play at the class' end-of-year party, answer the question: "What type of music do the students in our grade like?" (ibid, p.24).

At Level B, students must "pose summary, comparative, and association statistical investigative questions about a broader population using samples taken from the population" (ibid, p.44). Thus, one can consider the choice of a band to play at the school's end-of-year party, which involves larger groups, allowing comparison between subgroups: "What kind of music do students at our school like?" Finally, inferential statistical research

questions about causality and prediction can be proposed at Level C. For example, the following question can be asked about musical preferences: "Do those who like rock music tend to also like rap music more than those who do not like rock music?" (ibid, p.83).

Progression according to sequential levels, although in line with the American school organization, is intended for any individual developing statistical literacy, regardless of age or school stage.

We observed that both the BNCC and the GAISE describe their learning objectives based on the description of skills students should achieve throughout their school life and the development of statistical literacy. For example, according to the BNCC, a Brazilian student in the fourth grade of elementary school is expected to be able to "conduct research involving categorical and numerical variables and organize data collected through tables and graphs with simple or grouped columns, with and without using digital technologies" (Brasil, 2018, p.293). An individual in Level A of the development of statistical literacy according to the GAISE is expected, regarding the PRPIE data collection stage, to be able to "understand how to collect and record information from the group of interest using surveys and measurements collected from observations and simple experiments" (Bargagliotti et al., 2020, p.17).

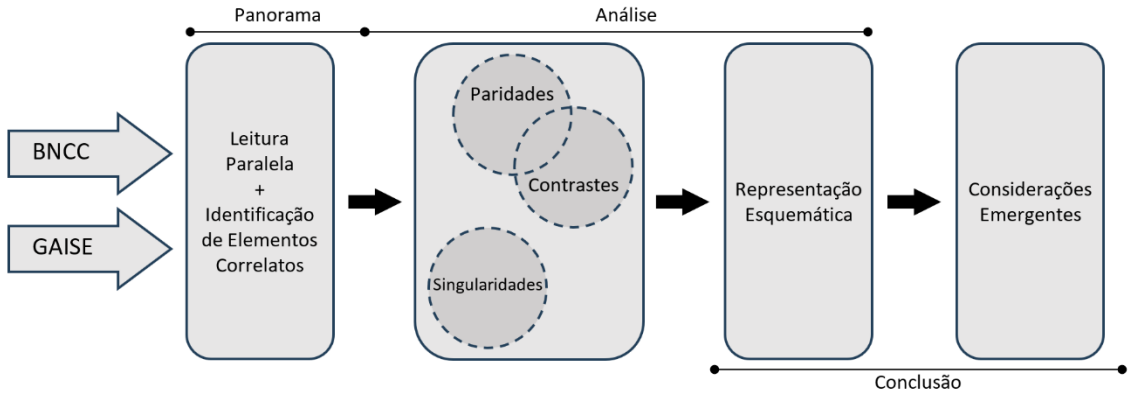
The skills that structure and mark the BNCC curriculum and those that characterize the three levels of depth that structure the statistical literacy development model according to GAISE will be fundamental in developing this study based on combined reading (Corrêa & Rangel, 2021a; 2021b; In Press), which we will describe below.

Methodological approach: combined reading

This work is based on a qualitative analysis of documents. It aims to raise reflections on the BNCC proposal for teaching statistics in the first six grades of elementary school. The research is grounded on a combined reading

(Corrêa & Rangel, 2021a; 2021b; In Press) of the BNCC and the GAISE documents. This methodology offers a way to guide and organize the document analysis process from the emerging reflection of the relationships identified in the documents. Developing combined reading foresees sequential research emphases: overview, analysis, and conclusion (Figure 3),

FIGURE 3: Combined reading methodological process



Source: Prepared by the authors, 2023

Based on the research question, we begin reading the documents side by side, aiming to understand the curriculum references and identify related elements supporting the analysis. The analysis will identify parities (relating to solid correlation), contrasts (identifying a lack of correlation), and singularities (or particularities) between the documents. The combined reading process is marked by a schematic representation, which aims to illustrate and synthesize the analysis, having the value of a product and an analytical instrument supporting the emerging reflections.

Parallel reading, the starting point of combined reading, refers to the simultaneous reading of documents, which allows familiarization with the proposals and the survey of potentially related elements. These elements will be the main object of support for the qualitative analysis. Identifying related elements is part of the development of the methodology and must be related to the research question. Examples of possible related elements between documents that guide the teaching of a subject are the distinction of school

stages, the organization of conceptual topics on specific subjects, the listing of learning objectives, or a list of skills to be developed. In this study, we consider the skills that compose the BNCC curriculum, observing the thematic unit probability and statistics and the skills that characterize Level A of the statistical literacy development model according to the GAISE as related elements. As seen in the previous section, the identification of these elements in the documents above takes place in their organizational structures, which support and organize the characterization of the development of statistical education by school year, in the BNCC, and by levels in the GAISE document.

In the BNCC, elementary school skills are identified by alphanumeric codes that inform the school stage (elementary education - EF), the school grade (1 through 9), the curriculum component, and the order in each grade's skill set: skill EF04MA27 is the 27th mathematics skill (MA), fourth grade (04) of elementary school (EF). The skills that describe each level of depth in the model proposed by the GAISE for the development of statistical literacy are not identified using codes. They are sequentially listed considering, for each stage of the PRPIE, the three levels of depth that characterize the model, as illustrated in Figure 2, which highlights the skills of stage 1 of the PRPIE.

In this study, considering the initial stage of learning statistics, all 22 skills from the probability and statistics thematic unit of the BNCC from the first to the sixth grade were related to all 20 skills that characterize Level A of the model proposed by the GAISE. To identify the skills in the GAISE document, for this research, we established specific criteria: each Level A skill of the GAISE model was determined by the letters G and A (G, the initial letter of GAISE, and A, the level) followed by two digits corresponding sequentially to the PRPIE stage (1, 2, 3, or 4) and the order of presentation of the skill for that stage (1 through 7). Thus, for example, the GAISE skill identified in this study by GA13 is the third skill presented for Stage 1 of the PRPIE at Level A of statistical literacy development.

Analysis

Once the skills were identified, we started the analysis, supported by the schematic representation illustrated in Figure 4: a spreadsheet whose rows are associated with the BNCC skills and the columns with the skills characteristic of the GAISE model. When developing the analysis, each BNCC skill was related to all the skills in the GAISE model, and the assessment was categorized according to three possibilities, which gradually reflected the intensity of the relationship. The analysis categories are described below.

(i) Category *parity*, highlighted in green: there is a strong relationship between what BNCC intends and what GAISE indicates, reflecting parity. Thus, by having the BNCC skill as a learning objective, achieving the characteristic skill of the GAISE model is possible. For example, the BNCC skills that refer to conducting research are strongly related to the GAISE skill GA13, "proposing descriptive research questions about a variable, observing small, well-defined groups and extending these to include research questions of comparison and association between variables" (Bargagliotti et al., 2020, p.16).

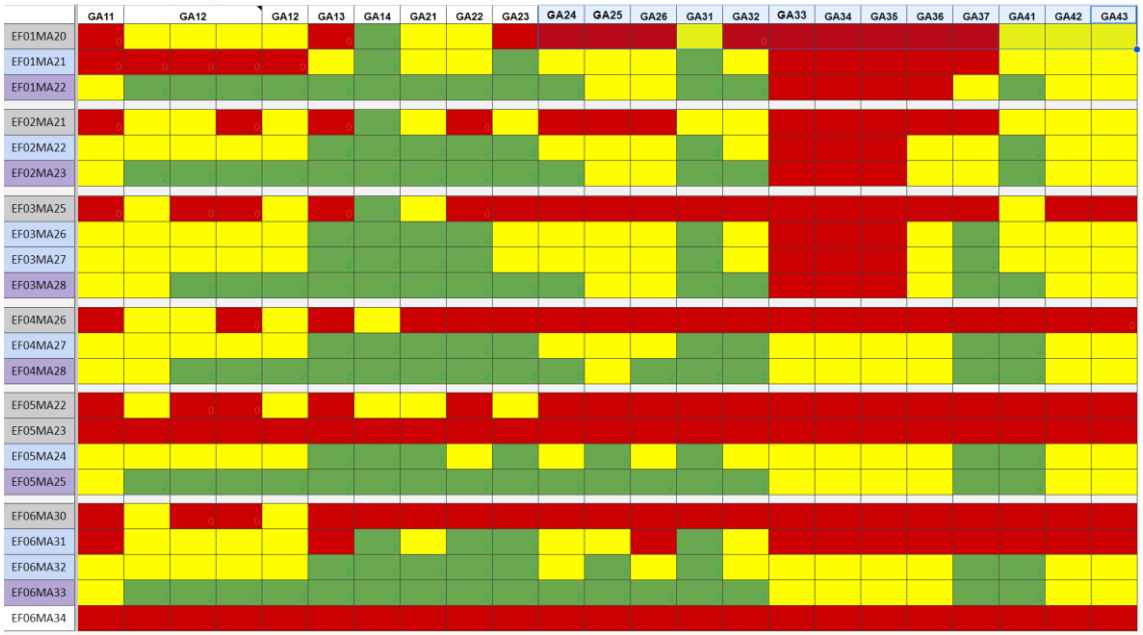
(ii) Category *conditional parity*, highlighted in yellow: the relationship between what is intended by the BNCC and what is indicated in the GAISE is not strong, nor does it appear to be immediate; it is possibly conditioned by external factors, such as a didactic-pedagogical action that requires the teacher's intentional intervention. Therefore, when having the BNCC skill as a learning objective, it is not natural to also achieve the characteristic skill of the GAISE model. For example, when aiming to "compare research information presented through double-entry tables and simple column or bar graphs to understand aspects of the immediate reality better" (EF02MA22) (BRASIL, 2018, p. 285), intentional teaching action may lead the student to "understand that a

variable measures the same characteristic on several individuals or objects and results in data values that may fluctuate" (GA23) (Bargagliotti et al., 2020, p.17).

(iii) Category *contrast*, highlighted in red: indicates that a relationship has not been identified between what was intended by BNCC and what was proposed in the GAISE, revealing a contrast. In that case, the skills seem to have no relationship; when aiming for one of them, the other most likely will not be achieved. For example, skill EF06MA30: "Calculate the probability of a random event, expressing it as a rational number (fractional, decimal, and percentage form) and compare this number with the probability obtained through successive experiments." (Brasil, 2018, p. 305) is not related to any of the GAISE skills for level A, regardless of the approach chosen by the teacher.

Singularities, that is, specificities of one or another document, emerged in the analysis process. For example, although the statistical literacy development model proposed by the GAISE recognizes the importance of applying digital technological resources, there is no direct mention of the development of computational thinking. However, the BNCC skill EF06MA34 is explicit in its relationship with computational thinking, even though it is not clear how the proposal is formulated in the context of statistics and probability: "Interpret and develop simple flowcharts, identifying the relationships between the objects represented; for example, the position of cities considering the roads that connect them, the hierarchy of employees in a company, etc." (BRASIL, 2018, p.305).

FIGURE 4: Illustrative section of the schematic representation of the analysis



Source: Prepared by the authors, 2022.

In our study, we also understand that the skills of the probability and statistics thematic unit refer to three core statistics themes: *conducting research*, which involves planning and collecting data to answer a statistical research question and the data processing typical of subsequent stages; *organization and processing of data*, which consists in dealing with tables and graphs, descriptive measures, readings, and interpretations and *probability*. For example, the probability and statistics thematic unit in the third school grade is associated with four skills, as illustrated in Figure 4. The EF03MA25 skill concerns the *probability*, while the skills EF03MA26 and EF03MA27 refer to *organization and data processing*, and the last, EF03MA28, concerns *research conduction*. For a visual effect to support the analysis, each core theme was associated with a color: *probability*, gray; *organization and data processing*, blue; and *conducting research*, lilac. This classification was made explicit in the schematic representation that supported the analysis (Figure 4).

The analysis process was developed in two stages: the first was carried out individually by three authors of this work. After completing

this stage, we sought, through a collective discussion, to establish a consolidated assessment. The purpose of the debate that marked the collaborative stage was to ratify or review individual evaluations and confirm a consensual assessment. This assessment was not determined by a majority but came from a reflective process. Thus, for example, a relationship evaluated by two of the authors as *parity* (green) and by the third author as *conditional parity* (yellow) may have the category *conditional parity* (yellow) as a consolidated assessment. This is the case of analyzing the relationship between the skills EF01MA21 (Identify, in random family events, all possible outcomes, estimating those with greater or lesser chances of occurrence) (Brasil, 2018, p.281) and GA22 (Understand how to collect and record information from the group of interest using surveys and measurements collected from observations and simple experiments (Bargagliotti et al., 2020, p.17)) (Figure 4).

We understand that the analysis recorded in the schematic representation does not propose to establish a degree of hierarchy between the individual analysis and the consolidated analysis. It should also not be observed from a direct, absolute reading. We understand that the richness and potential of the instrument lie precisely in the fact that it allows varied readings and frameworks that consider assessments, analyses, and reflections from different perspectives. In the next section, we discuss some reflections emerging from the analysis process from different perspectives.

Emerging reflections

In line with the statistical education literature (Ben-Zvi, Makar, & Garfield, 2018), the BNCC has the potential to develop statistical literacy in the early years of elementary school by proposing investigations or problems of a statistical nature. Suppose we fully consider the spreadsheet that characterizes the schematic representation of the BNCC and the GAISE combined reading. We observe a predominance of relationships of

the type *parity* (green color) and *conditional parity* (yellow color) between the skills corresponding to the probability and statistics thematic unit from the first to the sixth grade of elementary school and the Level A skills of the statistical literacy development model proposed by the GAISE. We believe this fact shows that the BNCC proposal is based on recognizing the relevance of carrying out research for statistics teaching. More specifically, the BNCC opens space for the development of statistical literacy anchored in solving problems of a statistical nature, as foreseen by the PRPIE. It is worth noting, however, that the assessment does not allow us to conclude that research will be proposed to students. This evaluation is based on a significant number of evaluations of the *conditional parity* (yellow color) type, which records the understanding of dependence on intentional teacher intervention. For example, as highlighted in Figure 4, according to the analysis, only the BNCC skills associated with the nuclear theme "*carrying out research"* achieve parity with GAISE skill GA12, "Pose statistical investigative questions of interest to students where the contexto is such that students can collect or have access to all required data" (Bargagliotti et al., 2020, p.16). The other correlations are understood as conditional parities; i.e., they depend on intentional teaching action to be achieved. In other words, they are understood as conditional parities (yellow color). As a derived reflection, the relevance of teacher education for teaching statistics in basic education as per the BNCC is highlighted.

The order in which the BNCC skills from the probability and atatistics thematic unit from the 1st to the 6th grade of elementary school are presented may compromise the proposition and conduct of investigations or problems of a statistical nature. In fact, if we look at the first column of the schematic representation that supports the study, we see in the BNCC skills that throughout elementary education, there is always at least one skill that explicitly refers to carrying out research (highlighted in green). However, these skills are last on the list for each school year. The most current recommendations for teaching statistics

and probability, as well as the GAISE, propose that the approach to the topic starts from formulating a research question. From this question onwards, we proceed to the survey, collecting relevant data to answer the question and, subsequently, move to the stages of analysis and interpretation of the results.

Of course, knowing that a BNCC skill is the last in a sequence does not mean it is not dealt with. However, we observed that the normative document for the other thematic units clearly adopts a sequential order that gradually addresses the deepening and sequential interdependence between the contents to be addressed. For example, in the fourth grade, in Numbers thematic unit, "students are expected to know how to read, write, and order natural numbers up to the order of tens of thousands" (EF04MA01) (Brasil, 2018, p.291) before "solving and elaborating problems with natural numbers involving addition and subtraction, using different strategies, such as calculation, mental calculation, and algorithms, in addition to estimating the result" (EF04MA03) (Brasil, 2018, p.291). This pattern can lead us to believe that skills related to *conducting research* are the last to be addressed in the development of statistics teaching guided by the BNCC. Even more serious, noting that this skill usually requires more time to complete; it may not even be properly dealt with.

From the same perspective, we also observed, in relation to probability and statistics skills from the 1st to 6th grade of elementary school, that, in most cases, those referring to *organization and data processing* could be explicitly articulated with the skills that refer to *conducting research*. For example, skill EF04MA27 - "analyze data presented in simple or double-entry tables and column or pictorial graphs, based on information from different areas of knowledge, and produce text summarizing your analysis" (Brasil, 2018, p.293) can be achieved by carrying out research involving categorical and numerical variables, proposed in the following skill, and last in the list of the 4th grade of that thematic unit. The research recommended in skill EF04MA28 - "Conduct

research involving categorical and numerical variables and organize data collected through tables and simple or grouped column graphs, with and without the use of digital technologies" (Brasil, 2018, p.293), naturally can promote the collection and organization of data presented in single or double-entry tables and column or pictorial charts. Furthermore, it may involve information from different areas of knowledge and be summarized.

We observed that the BNCC skills from the probability and statistics thematic unit from the 1st to 6th grade of elementary school give little or no emphasis to summary measures, which, in the development of investigations or problems of a statistical nature, usually emerge in the data analysis stage. The highlight in the columns referring to the GAISE skills concerning the third stage of the PRPIE – Analyze the Data, that is, the skills identified by GA31 (Understand that the distribution of a categorical variable or quantitative variable describes the number of times a particular outcome occurs (Bargagliotti et al., 2020, p.18)) to GA37 (Observe whether there appears to be an association between two variables (Bargagliotti et al., 2020, p.18)), reveals a higher number of relationships of the types *conditional parity* (yellow color) and *contrast* (red color) with BNCC skills. In particular, skills GA33 to GA35 (Describe key features of distributions for quantitative variables, such as: center: mean as the equal share, and median as the middle-ordered value of the data (GA33), variability: range as the difference between the greatest and least value, and dispersion as how many units from the equal share (GA34) and shape: number of clusters, symmetric or not, and gaps (GA35) (Bargagliotti et al., 2020, p.18)), presented only contrasts, precisely the skills that deal with summary measures. In our reading, this picture reveals little emphasis on the guidance of the normative document so that such measures are explored in the first six grades of elementary school. Skills that explicitly include summary measures appear in the BNCC only from the seventh grade of elementary school onwards. Given the students' lack of maturity in mathematical operations, we understand that relationships of the

contrast (red color) category are expected in the first three grades. However, we believe that aiming at statistical literacy, more relationships in the category could have been revealed *parity* (green color) in the fifth and sixth grades. For example, at this stage, students can be expected to be able to describe key aspects of the distributions of quantitative variables, such as range, median, and mean.

The sequence of probability skills for the first six grades of elementary school at the BNCC reveals a construction aimed at working on probability as a separate discipline from statistics without establishing a clear connection between them. The GAISE highlights the importance of probabilistic thinking in the development of statistical literacy, but none of the skills listed in this document are specific to probability. Regarding the initial stage of learning, the report highlights that "students should also begin to understand that probability is a measure of the chance that something will happen. It is a measure of the degree of certainty or uncertainty." (Bargagliotti et al., 2020, p. 27). In this sense, for the development of statistical literacy at Level A, probability must be understood as a tool used by statistics to evaluate chances of events in contexts guided by research the students themselves carried out, using terms such as impossible, unlikely, equally likely, very probable, or certain. Disconnected with this understanding, the BNCC presents one or two specific probability skills for all elementary school grades without making a connection with statistical investigation.

Final considerations

The investigation based on the combined reading of the BNCC and the GAISE presented in this work has guided the actions and reflection of the Fundão Project group dedicated to investigating the teaching of statistics and probability in basic education. In particular, we understand that the investigation confirms the project's commitment to research on

mathematics and statistics teaching and its role in supporting all actions carried out by the group.

We believe the combined reading between the BNCC and the GAISE offered a critical reflection on the BNCC. The study pointed out aspects potentially favorable to the development of statistical literacy, such as the inclusion of skills involving research in contexts of interest to students in all elementary school grades. On the other hand, he highlighted that there is still much to be investigated and revised in the normative document. For example, the study pointed out that the BNCC probability skills offer a construct aimed at working on probability as a separate discipline from statistics without establishing a clear connection between them.

We highlight that the study has guided the development of didactic sequences that, in the light of a research work, seek to explore BNCC skills aiming at statistical literacy from an integrated approach. These actions are essential to the Fundão Project's commitment to dialogue between schools and universities.

Finally, we hope the study contributes to the necessary reflection on the BNCC's contribution to the development of statistical literacy in Brazilian education.

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