THE INCLUSION OF TECHNOLOGICAL RESOURCES IN STATISTICS EDUCATION TEACHER TRAINING REPORTED AT SCIENTIFIC EVENTS ORGANIZED BY THE BRAZILIAN SOCIETY OF MATHEMATICAL EDUCATION (SBEM)

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ABSTRACT

To evaluate the evolution of statistical education research aimed at the inclusion of technological resources in the initial and continuing education of teachers in Brazil, a systematic literature review (SLR) was conducted on 25 works published in the Scientific Proceedings of the National Meeting of Mathematics Education and on 7 papers from the International Seminar on Research in Mathematics Education. This research was exploratory using both a qualitative and quantitative approach in which a descending hierarchical classification (DHC) was carried out. We consider that the inclusion of technological resources in the classroom still faces challenges stemming from the elaboration and execution of public policies that should guarantee a minimum of infrastructure for teaching institutions and teacher training.

Keywords: *Technological resources; Teacher training; Systematic literature review; Multivariate textual analysis.*

1. INTRODUCTION

The inclusion of technologies in the educational system is of fundamental importance, since the world is constantly changing and the onset of the digital age is now the reality of learners in education (Lévy, 1993; Libâneo, 2000; 2019).

We agree with Silva and Oliveira (2022) that technological advances have taken place in society, and have become increasingly necessary in people's daily lives. Schools in particular have been increasing their usage of technology in order to enhance students' experiences. In addition, using technologies in the school environment have additionally spurred the development of new teaching strategies, aimed at improving teacher education. However, it is still necessary for education researchers to reflect and work with teachers and students on digital inclusion in a positive and systematic way, to ensure that that technological knowledge learned is satisfactory and useful.

Thus, the present work was inspired by the growing scientific interest in the area of statistical education as evidenced by the increased presence in the proceedings of scientific conferences in recent years. This field is relatively new and, according to Cazorla et al. (2010), emerged in the 1970s in response to the difficulties faced by professors of higher education courses when teaching concepts and procedures to statistics users.

Statistical education is therefore characterized as an area of research whose objective is to study and understand how people teach and learn statistics, probability, and elements of combinatorial analysis, involving both the cognitive and affective aspects of the relationship between teaching and learning, the nature of concepts, and the development of teaching methods and materials for the purpose of their development.

With the rapid advancement of new technologies, especially the internet, a range of resources for teaching and learning have become available for students, ranging from kindergarten to higher education. Cobb (1993) and Lopes (2003) suggest there is an urgent need for investigating the way of teaching these concepts in conjunction with these technological advancements. It is these ways of teaching that are the focus of this research.

In addition, the public now has access to often free video classes, texts, software, and other resources from the diverse disciplines. Such resources have been increasing available at an exponential rate and keeping up with each new development is practically impossible. In the educational context, it can be argued that we live in an era where there is an abundance of educational tools, particularly for statistical education.

Therefore, the objective of this work was to conduct a systematic literature review (SLR) on the use of technological resources in the initial and continued training of teachers related to statistical education, in the proceedings of the two main events organized by the Brazilian Society of Mathematical Education (SBEM), that is, the National Meeting of Mathematics Education (ENEM) and the International Seminar on Research in Mathematics Education (SIPEM).

2. TECHNOLOGICAL RESOURCES AS CONTRIBUTIONS TO STATISTICAL EDUCATION IN TEACHER TRAINING

Libâneo (2019) discussed the relationships between virtuality and education from the perspective of pedagogy, as well as the need for critical training of students and teachers as consumers of media and their associated devices. Libâneo addresses the new tasks and repercussions that information and communication technologies impose on education, schools, teachers' work, and training processes.

According to the National Common Curricular Base (BNCC), the Brazilian curriculum standards, students must understand, use, and create digital information and communication technologies in a critical, meaningful, reflective, and ethical way in various social environments (including school environments) to communicate, access, and disseminate information, produce knowledge, solve problems, and exercise leadership and authorship in personal and collective life (Ministry of Education, 2018).

Pepin et al.'s (2023) edited a handbook including chapters authored by several mathematics education researchers from around the world. The authors of the book broadly discuss a variety of relevant topics such as: state of the art in theoretical frameworks; mathematical content; learning environments; pedagogical practices; professional learning of teachers; and policy issues related to the development and use of digital resources in mathematics education. In terms of digital resources, the mathematics education researchers highlighted that with the advent and increasing availability of open access technologies and materials, educators and students often have difficulty sifting through the enormous abundance of materials available, as they are unsure about their quality and use. They subsequently provide comprehensive analyses and insights into the transformative aspects of digital capabilities.

Given the breadth of the formative processes mathematics teachers encounter, it is necessary to understand the development of teachers themselves. This paper employs the definition of teacher training used by Pamplona and Carvalho (2009). Pamplona and Carvalho argue that mathematics education is a fertile field for reflection and constant change. It faces several challenges such as ensuring that teachers appropriately develop pedagogical skills in addition to content knowledge, as well as supporting their future professional development and ongoing education. Similarly, Maltempi and Richit (2013) believe teacher training in mathematics is a broad, dynamic, and continuous process that should involve the interweaving of different types of specialized knowledge, such as mathematics, pedagogy, and technology.

In order to understand the process of initial and continued teacher training, we need to ensure that teachers have a solid knowledge base for pedagogical practice. We discuss how teacher training

associated with statistical education has been perceived by official documents and literature on this subject.

Biehler et al. (2013), provide an overview of digital technologies relevant to teaching statistics, summarizing what is known about how they can support the development of students' statistical reasoning at school level. They metaphorically compare the role of digital technologies in statistical reasoning to the journey from data and conclusions; these digital tools similarly undergo rapid development and dissemination. Finally, Biehler et al. ends by suggesting future directions for research and practice developing students' statistical reasoning in technology-enhanced learning environments.

For Lee and Hollebrands (2008; 2011), developing the pedagogical knowledge necessary to engage students in learning statistics through technology requires teachers to have in-depth statistical knowledge, access to the technological tools, and knowledge of pedagogical issues associated with teaching and learning with these tools. They present framework for specialized knowledge called Technological Pedagogical Statistical Knowledge (TPSK), providing examples of how aspects of this knowledge can help teachers in addition to its implications for teacher training.

Thus, understanding how teacher training take place and which aspects of it influences teaching is essential for documenting the formative processes teachers experience. It is important to point out that teacher training is a fundamental area for educational change, especially in statistics (Estevam & Cyrino, 2014). Additionally, the inclusion of statistical education in Brazilian curricula is recent, meaning that many teachers have not undergone systematic training on the subject, either in their school or professional life (Guimarães et al., 2009; Oliveira Júnior & Dos Anjos, 2017).

In the Brazilian standards for statistics education (Ministry of Education, 2018), uncertainty and data processing must be studied in a thematic unit called “Probability and Statistics.” It proposes an approach to concepts, facts, and procedures present in many situations in everyday life, as well as in scientific and technological settings.

In other countries, researchers have focused on digital environments and bringing real situations to school. For example, Prensky (2001) examined individuals comfortable with technology, finding that they receive diverse information quickly, being able to perform several tasks at the same time. He argues that teachers need to be aware of these characteristics and use them as a resource to support student learning. He also emphasizes that they need to learn to communicate with students through new forms of teaching. Burril (2012), however, warns that content using tools from the past cannot prepare today's students for tomorrow's world.

Chance et al. (2007) similarly examined technology in school settings, suggesting that the use of technology requires careful planning, innovation and enthusiasm. The choice of a technological resource in a classroom should be based on ease of use and interactivity. He argues that appropriate choices can improve the relationship between students and teachers.

In addition, Sá and Endlish (2014) suggest that a critical and reflective dialogue is necessary on the theoretical and methodological foundations of the use of technological resources in schools, since educating with new technologies represents a great challenge.

Batanero and Borovcnik (2016) continue this discussion, indicating that with the creation of computer programs, especially those designed for teaching statistics and probability, data analysis has become accessible to a wide range of researchers and professionals from different areas. However, they emphasize that teachers should be careful not to overemphasize the use of technology over statistical and probabilistic concepts, as technology is meant to complement, not a substitute, statistical and probabilistic reasoning.

However, despite the evolution of technology associated with education, the technological infrastructure of several Brazilian schools is still deficient when compared to schools worldwide. We therefore hypothesize that the way of teaching statistics via probability and combinatorics as outlined by Brazilian standards has not followed the same trend.

3. METHODOLOGICAL PROCEDURES

This is a systematic literature review (SLR), which is a form of secondary study using a well-defined methodology to identify, analyze and interpret all evidence related to a research question (Kitchenham & Charters, 2007).

To complement the systematic mapping with the SLR technique, we documented the evolution of research in statistics education by focusing on technological resources or tools in initial and continuing teacher training in order to determine the possible weaknesses of such training. We analyzed scientific proceedings from: 1) I to XIV National Meeting of Mathematics Education (ENEM), from 1987 to 2022; 2) I to VIII International Research Seminar in Mathematics Education (SIPEM), from 2000 to 2021.

We chose these proceedings because they are promoted by the Brazilian Society of Mathematics Education (SBEM), which brings together mathematics education researchers and, specifically, the Working Group, WG12 – Statistical Education.

According to their website (Brazilian Society of Mathematics Education [SBEM], 2024a), the SBEM was founded on January 27, 1988. It characterizes itself as a non-profit scientific and cultural society without any political or religious ties and is not affiliated with any particular political party. Its purpose is to bring together professionals in the field of mathematics education as well as researchers, teachers, and students who are part of the Brazilian educational system, ranging from early childhood education to higher education.

Considering the SBEM website, in the VII ENEM, held in 2001, Working Group 12 (WG12) was created in 2001 at VII ENEM; it was initially called the "Teaching Probability and Statistics" working group (SBEM, 2024b). Currently, the Statistics Education workgroup (WG12) is one of fifteen working groups at SBEM, aiming to study and understand how statistics, probability, and combinatorics are taught and learned and the cognitive and affective aspects of teaching and learning, in addition to the epistemology of concepts and the development of teaching methods and materials aiming to improve statistics literacy.

Thus, we implemented a SLR on the teaching of statistics, probability, and combinatorial analysis focused on the use of technological resources, with materials geared toward early childhood education up to higher education. We wanted to identify and describe the works published in the proceedings of ENEM since its first realization in 1987 until 2022 and SIPEM from its first realization in 2000 until 2021.

We conducted the search for studies online, collecting publications from years 1987 to 2022 (I to XIV ENEM) in the proceedings at SBEM (2024c) and from years 2000 to 2021 (I to VIII SIPEM) in the proceedings at SBEM (2024d), both available on SBEM's website.

It is noteworthy that the first version of ENEM was carried out in 1987 (still without the supervision of SBEM, which was founded in 1988), from II to IV ENEM until 1992 biannually. After 1992, it occurred triannually. XIV ENEM was last held in 2022 online, given the ongoing Covid-19 pandemic. XIV ENEM describes itself as the most important Brazilian mathematics education event (SBEM, 2024c) because it brings together all segments of mathematics education, including basic education teachers, teachers and students of mathematics and pedagogy, postgraduates and mathematics education researchers.

SIPEM was carried out from 2000 to 2021 at different higher education institutions in Brazil. As with XIV ENEM, the VIII SIPEM held in 2021 took place online (SBEM, 2024d). VIII SIPEM is one of the most important activities of SBEM as it allows Brazilian scholarly work in mathematics education to be debated and disseminated. Furthermore, SBEM seeks to promote exchanges between groups that in other countries are dedicated to research in this area, publicize Brazilian research, and promote the meeting of researchers who dedicate themselves to it, in addition to generating a space to learn about the studies that are being carried out in different institutions.

Therefore, we started from the guidelines proposed by Kitchenham and Charters (2007) to carry out an SLR, comprising three phases: planning, process, and reporting of results. In the planning phase, a protocol for the literature review was developed, which established the interaction that researchers should have, the procedure for conducting the review, the research questions to investigate, as well as search strategies, inclusion and data deletion criteria, collection, and analysis. In the second phase, we focused on executing the review protocol. This final report was prepared in the final phase.

Keywords or phrases were used to identify studies in this review. These include (1) Teaching Statistics, (2) Teaching Probability, (3) Teaching Combinatorics, (4) Teaching Stochastics, (5) Technological Resources, and (6) Technological Tools. The search also employed two other relevant criteria: temporal—all works published in all editions of ENEM and SIPEM—and linguistic – in Portuguese.

The abstracts and/or the full articles published in the proceedings were read as part of the study. Each work was analyzed and classified according to the following criteria: (1) year of publication or event held, (2) work modality, (3) region where the authors carried out their activities, (4) type of institution, (5) content area or course, (6) type of teacher training, (7) educational cycle, (8) technologies used, and (9) content covered.

Thus, of the 349 studies identified in statistical education in ENEM, 56 of them used technological resources, and of these, 25 focused on initial and continuing teacher training. Of the 108 studies identified in statistical education in SIPEM, 12 used technological resources, and of these, 7 focused on initial and continuing teacher training. Therefore, this search returned 32 results, and the titles, abstracts, and texts of these results were read to further analyze proposals aimed at using technological resources for the initial and continuing training of teachers in statistical education (Table 1 and Table 1.1).

Table 1. Works published in ENEM and SIPEM related to statistical education addressing the use of technological resources for initial and continuing teacher training

Text	Author(s)	Title (translated to English)	Event
T1	Viali (2007)	Learning by doing: How to take advantage of the computer to improve the learning of Statistics.	IX ENEM
T2	Scherer (2007))	Statistics applied to education in virtual environments: Evaluating processes.	IX ENEM
T3	Kawasaki and Magalhães (2007)	Continuing education of teachers in mathematics: Planning and collective development of a workshop using the electronic data sheet to learn statistics.	IX ENEM
T4	Asseker, Monteiro and Lima (2010)	Inserting the use of computers in rural schools: An experience of interpreting graphs by teachers.	X ENEM
T5	Andrade, Cazorla and Cruz (2010)	Planet water: A sequence for teaching mathematics, statistics and citizenship.	X ENEM
T6	Tinti, Nakayama and Januário (2010)	Processing and analysis of information with the aid of software.	X ENEM
T7	Almeida and Guebert (2013)	Different resources for teaching statistics.	XI ENEM
T8	Salles and Bairral (2013)	“Forget these drawings, let's use numbers”: an initial study focused on solving a combinatorics problem by pedagogy students in a virtual environment.	XI ENEM
T9	Santos (2013)	Statistical education in the face of technologies.	XI ENEM
T10	Machado and Becher (2016)	Learning statistics with R software.	XII ENEM
T11	Silva and Barbosa (2016)	Statistics teaching for the initial/final years of basic education using active methodology and the computational program R.	XII ENEM
T12	Severo (2019)	BNCC of Secondary Education and Statistics: Analysis and construction of box plots and branch and leaf diagrams through Geogebra applets	XIII ENEM
T13	Justo and Magalhães (2019)	Statistics Activity - Lowest Bid Auction	XIII ENEM
T14	Silva, Castro and Araújo (2019)	Use of technological tools in statistics teaching	XIII ENEM
T15	Velasque and Silva (2019)	Teaching statistics for the final years of elementary school using active methodology and the computational program R	XIII ENEM

Table 1.1. Works published in ENEM and SIPEM related to statistical education addressing the use of technological resources for initial and continuing teacher training

Text	Author(s)	Title (translated to English)	Event
T16	Moreira et al. (2022)	Training of mathematics teachers: A didactic proposal for approaching statistics in high school developed during the pandemic	XIV ENEM
T17	Samá, Silva and Dos Santos (2022)	Reading and interpretation of statistical graphs in the degree course in mathematics	XIV ENEM
T18	Malska (2022)	Mathematics workshop: A review of statistics	XIV ENEM
T19	Castro et al. (2022)	Use and contributions of the Moodle platform for the discipline of statistics applied to education: An experience report	XIV ENEM
T20	Oliveira (2022)	Statistical literacy in the 6th year of elementary school: Technological tools and maker culture	XIV ENEM
T21	Giordano et al. (2022)	The potential of the Statistical Learning Project (PAE) for exploring Contemporary Transversal Themes (TCT)	XIV ENEM
T22	Araújo and Kepler (2022)	Graphical data analysis mediated by Gapminder	XIV ENEM
T23	Medina et al. (2022)	Statistics and probability in elementary education: The experience of an integrated approach	XIV ENEM
T24	Kayser and Baltazar Junior (2022)	Geometric probability: Possibilities for learning mathematics	XIV ENEM
T25	Navarro and Borelli (2022)	Probability for the early years - Teacher training	XIV ENEM
T26	Lins (2003)	Logical classification procedures through a database: A case study	II SIPEM
T27	Bittencourt and Viali (2006)	Contributions to the teaching of Normal distributions or Gauss curves in undergraduate courses	III SIPEM
T28	Figueiredo (2018)	Statistics teaching: Discussion about didactic sequences applied by undergraduate pedagogy students in a virtual environment	VII SIPEM
T29	Samá and Amorim (2021)	Ecological and mediational dimension of didactic suitability in the initial training of teachers who teach statistics	VIII SIPEM
T30	Conti and Passos (2021)	Narratives of an extension activity: Teaching and learning processes of statistics in early childhood education and the early years of elementary education	VIII SIPEM
T31	Souza, Araújo and Pinto (2021)	The fake news phenomenon and the role of numbers in communication	VIII SIPEM
T32	Figueiredo and Coutinho (2021)	Continuing training of basic schoolteachers on statistics in a virtual environment	VIII SIPEM

3.1. DATA ANALYSIS

The studies were sorted and catalogued in order to answer the following research question: How does research in ENEM and SIPEM regarding the use of technological resources in teacher training in the teaching of statistics, probability, and combinatorics impact teaching in Brazil?

To this end, the software IRaMuTeQ (R Interface for Multidimensional Text and Questionnaire Analysis) was used to improve the research work. IRaMuTeO makes use of the optimization of the organization process and the more specific delimitation of selected texts, which enables the survey of the constituent elements of socially shared representations. It highlights traces of mental worlds through

lexical worlds schematized by the software. Such mental worlds are subsequently inferred using a content analysis of said lexical worlds (Mutombo, 2013).

IRaMuTeQ works with Initial Context Units (ICU) that can be structured in different ways depending on the nature of the data collected. Each selected text or study must make up an ICU. The set of ICUs composed the analysis corpus that the program then divides into text segments, which are called Elementary Context Units (ECU). In the ICU, specific questions (SQ) were proposed, which collect, organize, and present relevant information about the development of research focused on the topic in question, namely: (SQ1) What was emphasized?, (SQ2) What is the methodology or methodological approach used?, (SQ3) What is the context in which it is developed?, (SQ4) What are the types of studies and areas involved?, and (SQ5) What are the main results and conclusions?

Subsequently, descending hierarchical classification (DHC) was carried out to create lexical classes characterized by vocabulary and text segments that share the same vocabulary (Camargo & Justo, 2013). In this sense, the different classes that emerge from the text corpus represent the space of meaning of the narrated words and can suggest how technological resources are used in teacher training in the teaching of statistics, probability and combinatorics in Brazil.

The set of each of the selected works was organized into a single text (corpus). The corpus was organized by command lines called “asterisk lines”, in which the text identification numbers are informed, followed by some essential variables for carrying out the textual analysis. By coding each of the participants' responses, we identified them, considering the following characteristics:

1. Text: text_01 (text 1) and so on, up to text_32 (text 32).
2. Year of the event: YearEvent_01 (IX ENEM - 2007); YearEvent_02 (X ENEM - 2010); YearEvent_03 (XI ENEM - 2013); YearEvent_04 (XII ENEM - 2016); YearEvent_05 (XIII ENEM - 2019); YearEvent_06 (XIV ENEM - 2022); YearEvent_07 (II SIPEM - 2003); YearEvent_08 (III SIPEM - 2006); YearEvent_09 (VII SIPEM - 2018); YearEvent_07 (VIII SIPEM - 2021).
3. Type of type of work carried out at the event: PublicEvent_01 (Scientific Communication); PublicEvent_02 (Report of Experiences); PublicEvent_03 (Short courses).
4. Region where the authors reside: Region_01 (South); Region_02 (Southeast); Region_03 (Northeast); Region_04 (Midwest).
5. Type of institution where researchers develop their research: TypeInst_01 (Public); TypeInst_02 (Private); TypeInst_03 (Public and Private).
6. Area or course for which the research is intended: Area_01 (Mathematics); Area_02 (Pedagogy); Area_03 (General).
7. Teacher Training: Training_01 (Initial); Training_02 (Continued); Training_03 (Initial and Continued).
8. Cycle for which the work is intended: Cycle_01 (Elementary School); Cycle_02 (High School); Cycle_03 (Basic Education - Elementary and High School); Cycle_04 (Higher Education); Cycle_05 (Childhood Education and Elementary Education); Cycle_06 (Elementary, Middle and Higher Education).
9. Technological tool indicated in the survey: Tool_01 (Electronic Spreadsheet); Tool_02 (Virtual Learning Environment); Tool_03 (Tinker Plot); Tool_04 (Software); Tool_05 (VMT-Chat); Tool_06 (Software R); Tool_07 (Geogebra); Tool_08 (Digital Game); Tool_09 (Spreadsheet, Google Forms and Kahoot); Tool_10 (Hypertexts); Tool_11 (Google Meet); Tool_12 (Moodle Platform); Tool_13 (Cultura Maker); Tool_14 (WhatsApp); Tool_15 (Gpminder); Tool_16 (QR Code); Tool_17 (PowerPoint); Tool_18 (Electronic database); Tool_19 (Youtube).
10. Content focus of the work: Content_01 (Statistics); Content_02 (Probability); Content_03 (Combination); Content_04 (Statistics and Probability); Content_05 (Inference).
11. SBEM Event: Event_01 (ENEM); Event_02 (SIPEM).

Furthermore, the texts that make up the textual corpus were configured as defined in the IRaMuTeQ tutorial (Camargo & Justo, 2013). These settings mainly regarded accentuation, the use of special characters, and formatting. We present the procedure for organizing the command lines for inserting scientific productions in following fragment of the first text (translated into English):

> ****** *text_01 *YearEvent_01 *PublicEvent_02 *Region_01 *TypeInst_03 *Area_03 *Training_03 *Cycle_04 *Tool_01 *Content_05 *Event_01**
> Obviously, the computer is not the Holy Grail of teaching. It is not possible to solve all the problems with its use, even because it is not always simple.

Reinert's method (1998) was used, which proposes a DHC which aims to obtain classes of text segments (TS) that present vocabulary similar to each other and vocabulary different from the TS of the other classes.

The choice to use an analysis technique depends on the characteristics of the problem and the research objectives (Leblanc, 2015). In this sense, this theoretical-methodological framework (previously highlighted), plus the support of lexicometric analysis software, can provide greater reliability to the inferences made in this study (Santos et al., 2017).

When beginning the study, the first analysis option that IRaMuTeQ makes available is related to the statistical data describing the textual corpus: the number of texts and text segments (32 and 588 respectively; fragments of text, usually three lines long, are generated by the software itself depending on the size of the corpus), occurrences (total number of words contained in the corpus), average word frequency (36.41 per text), the total frequency of each form (adjectives, nouns, verbs, and adverbs) and their grammatical classification.

The DHC maintained 588 text segments constitute each class, with a use rate of 79.08% (a minimum retention of 75% of text segments is suggested, which guarantees the qualification of the corpus). The software automatically grouped the classes based on the vocabulary and variables that contributed to the formation of each class and were selected according to the chi-square values (χ^2).

It should be noted that in order to be useful for classifying any textual material, DHC type analyses require a minimum retention of 75% of text segments, which demonstrates that this analysis can be considered statistically representative. When an analysis is lower than this value, it is not considered an adequate, as it offers only a partial classification (Camargo & Justo, 2013). In this sense, the textual corpus used for the analysis of the present study is considered representative and useful, as the use rate was 79.08%.

The interpretation of the DHC results was based on the hypothesis that the use of similar lexical forms is linked to common representations or concepts (Reinert, 1998), coinciding with our aim of identifying themes underlying these texts.

The analysis was based on lexical proximity and the assumption that words used in a similar context are associated with the same lexical world and are part of specific mental worlds or representation systems. In this analysis, the text segments were classified according to their respective vocabulary and the set of terms is partitioned according to the frequency of the word roots. The system obtained classes formed by words that were significantly associated with that class (significance is determined by a chi-square test).

To create a dictionary of words, the chi-square test reveals the associative strength between words and their respective class. This associative strength is analyzed when the test result surpasses 3.84, a setting that provides a margin of error less than .05, representing a statistically significant relationship between the word and the classes. A lower chi-square value (less than or equal to 3.84) represents a lower relationship between the variables.

According to Oliveira (2015), the test uses correlation logic, starting from segmentations of the textual corpus, together with the list of reduced forms and the dictionary (in Portuguese) made available to present a hierarchical class scheme. The text is processed so that vocabulary classes can be identified, making it possible to infer which themes the textual corpus contains.

In summary, in the context of DHC, cluster analysis is used to identify groups of text segments that have similar vocabularies. From an operational perspective, this procedure occurs in four stages (Nascimento & Menandro, 2006), namely:

1) The textual corpus is automatically read and is divided the 32 texts into 588 text segments based on the length of the statements, punctuation, stems, and occurrences, and calculates the dictionaries that will be used in subsequent steps. There is a distinction between active forms (e.g., verbs, nouns and adjectives) and supplementary forms (e.g., pronouns, articles and adverbs). This differentiation is fundamental, as most calculations are performed with active forms, which indicate the semantic characteristics of the statements.
2) Contingency matrices are constructed with the 588 text segments and their respective vocabularies to carry out the DHC itself. Initially, the set of text segments is divided into two

classes based on the contrast between their vocabularies. The procedure is continuously repeated in the resulting clusters until no new stable classes are produced.

3) Chi-square tests are carried out to verify the degree of association between lexical forms and classes, presenting a dendrogram with the most specific forms of each partition. Thus, the lexical profiles of each class are produced, bringing together detailed information on the distribution of active and supplementary forms, as well as the detailed results of the chi-square tests. A Correspondence Factor Analysis (CFA) is also carried out, which crosses the reduced forms and categorical variables with the resulting classes.
4) Complementary calculations are carried out and the most characteristic text segments of each grouping are identified, which allows the contexts of the lexical forms to be recovered.

4. RESULTS: DESCRIPTION OF CLASSES (CLUSTERS) ACCORDING TO DHC

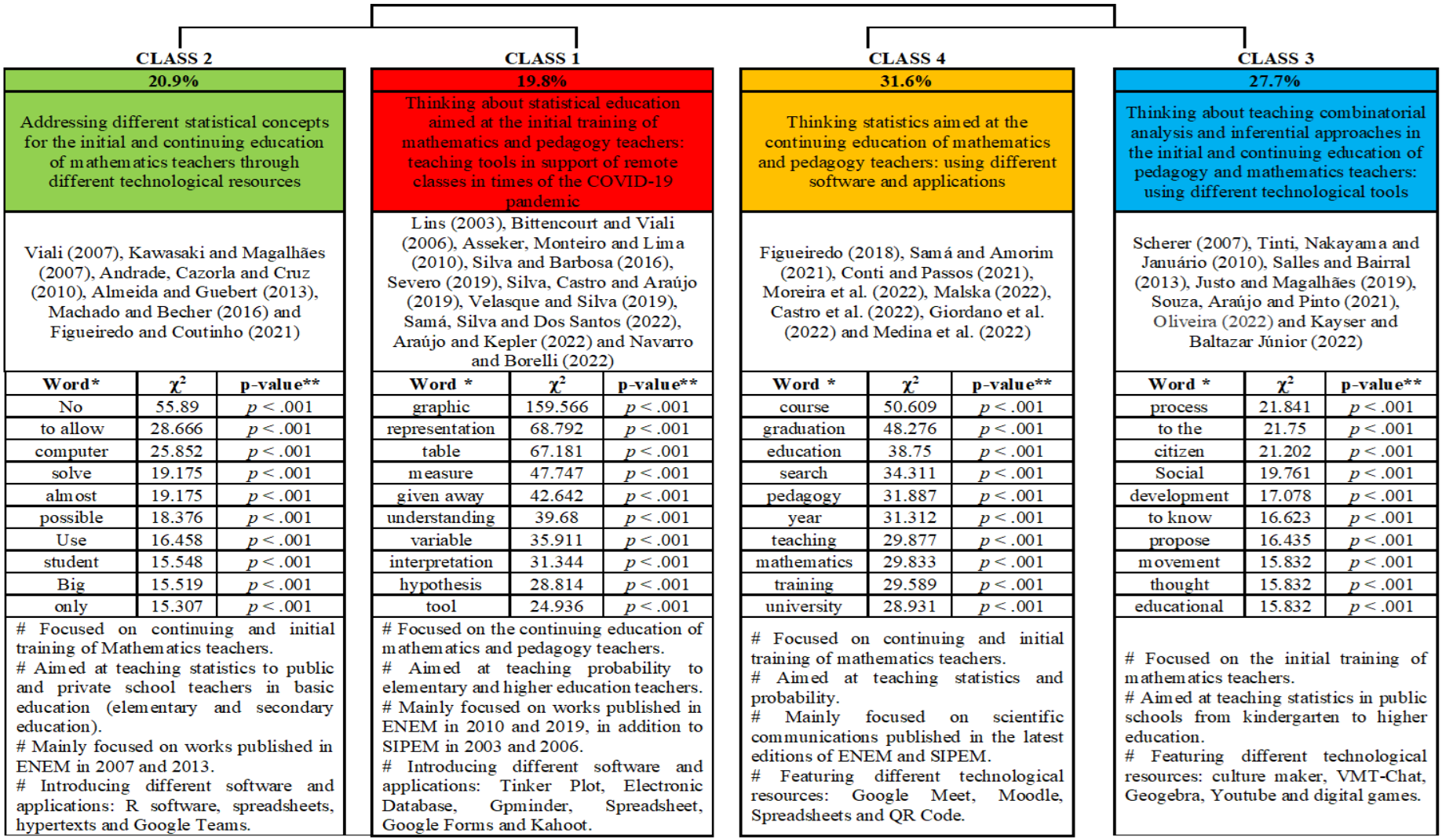
Four classes represented in the dendrogram in Figure 1 contain the active forms of organized words that presented the highest frequency in the textual corpus. They are presented in descending order and were significant enough to represent the subcorpus through the chi-square association test generated in the IRaMuTeQ reports. In other words, the dendrogram displays the clusters for classification that represent the greatest adherence of 32 texts within a class and between classes resulting from the Reinert Method.

In the dendrogram presented in Figure 1, the four classes are named, the 32 texts used in the analysis are cited, and the primary words that represent important aspects of each of these classes are identified. Additionally, the percentage of word occurrence on the text segments of each class/cluster towards its occurrence in the corpus is provided as well as chi-square association (association between word and class), type (grammatical cluster identifying the word in the forms dictionary), form (identifies the word), and p-value (identifies the significance level of the association between word and class). Finally, characteristics that constitute each of the classes are highlighted.

In the classification using the Reinert Method displayed in Figure 1, the “Body” corpus was divided (1st partition or iteration) into two subcorpuses, Classes 2 and 1, which represent, respectively, 20.9% and 19.8% of the textual corpus. In the second partition, the subcorpus was subdivided, identifying Classes 4 and 3, which represent, respectively, 31.6% and 27.7% of the total. The four classes contain the active forms or organized words that presented the highest frequency, in descending order, and which were significant to represent each of the subcorpus through the chi-square association test, that is, their greater adherence within the class and between classes.

Examining the classes from left to right in the dendrogram depicted in Figure 1, Class 2 address[es] different statistical and probabilistic concepts for the continued training of mathematics teachers through different technological resources in a computer.

Figure 1. Classification result by Reinert Method: Dendrogram



* Word association with class.

** Identifies that there is a level of significance when associating the word with the class.

Table 2 and Table 2.1 present six texts that make up this first grouping. It identifies each of them, their authors, the event at which it was presented, and in what form. It also provides a description of the technological resources used, the methodological and/or didactic approaches employed, the primary results, and the conclusions.

Table 2. The texts that comprise Class 2 addressing different statistical concepts for the initial and continued training of mathematics teachers regarding different technological resources

Text	Author(s)	Description of the presentation at the event	Research description
T1	Viali (2007)	Experience report on the IX ENEM	The teaching of descriptive statistics was approached by considering a computational resource (the spreadsheet), in which one learns by doing. This approach has been used to teach students from different university courses, including teacher training courses. The range of features is wide in most statistical packages, however, what makes it suitable for teaching is not what it does, but how it does it. Students already have difficulties with the content and forcing them to learn to use software that they will probably never use again is not very encouraging. Thus, spreadsheets' simplicity makes it suitable to filling this role, as it likely will be part of students' professional lives in the future.
T3	Kawasaki and Magalhães (2007)	Experience report on the IX ENEM	The starting point was a report on mathematics teachers who participated in a continuing education workshop in 2006. The workshop was for two groups of high school students from the Education for Young People and Adults (EJA). EJA is a teaching modality in the primary and secondary education stages of the Brazilian public-school system. The investigation modality has been adopted by some private systems that receive young people and adults who have not completed basic education at the typical age for any reason. In this case, students were aged between 15 and 17 years. These students often delay school to work and contribute to the family income. The experiences included moments of experimentation with teaching materials in parallel with classroom activities. Whenever possible, these sought to contextualize and attribute meanings, promoting autonomy in the construction of knowledge. They concluded that, more than the activities themselves, the interrogative postures of the teachers and the space given to students' discussions stimulated investigation. The immediate result obtained by students through the software (spreadsheet) allowed greater interactivity, allowing the experimentation of changes and generating new problems.
T5	Andrade, Cazorla and Cruz (2010)	Short course at X ENEM	The Planet Water teaching sequence made available by the Virtual Environment for Supporting Statistical Literacy (AVALE) was presented to students, starting from the need for the conscious and rational use of water, probing the profile of the household in relation to water, measuring the level of awareness of the use of water and analyzing the water consumption profile of students' families. In addition to focusing on the specificities of time-dependent variables (time series), tables, graphs, measures of central tendency, and dispersion were presented. This sequence was part of several teacher training courses and in a public elementary school with 6^{th} year students. The results were promising despite the difficulties with the quantitative aspects of the sequence, students were very comfortable with using the computer and were able to give meaning to the content addressed in the sequence. This result suggested how this teaching sequence may aid in the teaching of statistics.

Table 2.1. The texts that comprise Class 2 addressing different statistical concepts for the initial and continued training of mathematics teachers regarding different technological resources

Text	Author(s)	Description of the presentation at the event	Research description
T7	Almeida and Guebert (2013)	Scientific communication at X ENEM	The authors suggest Excel® can provide faster resolution to statistical problems. They estimate that teachers can help students achieve permanent objectives such as learning, retaining and transferring the concepts studied using this tool. A short course was designed with the aim of presenting some of the functions available in Excel® for statistical analysis, with topics such as the graphical representation of data, absolute frequency and relative frequency, frequency tables, count of class elements, bar charts, histograms, circular diagrams, arithmetic averages, median, variance, standard deviation, and amplitude.
T10	Machado and Becher (2016)	Short course at XII ENEM	Their objective was to present the R software within the RStudio development environment and demonstrate its potential for didactic-pedagogical use. A short course they presented contained an introductory component and included a series of activities that would allow teachers without prior knowledge of the software to learn to use the software and simulate and solve statistical or probabilistic problems commonly treated in the teaching of statistics in high school. In addition, they suggest that a potential benefit of R, in addition to being free, is that it offers numerous didactic possibilities for teaching statistics, from resources for solving calculations and simple problems to the possibility of carrying out simulations and modeling.
T32	Figueiredo and Coutinho (2021)	Scientific communication at the VIII SIPEM	A continuing education course for teachers dealing with statistical concepts in elementary virtual environments was taken as a starting point for this study. In this text, an excerpt of the topics covered in this course were presented to highlight aspects of the technological knowledge (in this case, using Excel®) utilized to solve a problem related to data interpretation. The authors recommend that more continuing education courses for basic education teachers be offered that address statistical knowledge and its association with technology. They also suggest that additional research should be conducted that identifies potential difficulties with these approaches as well as possible future directions.

Then, still in the first partition or iteration and the second subcorpus of the dendrogram presented in Figure 1, Class 1 addresses different stochastic representations through graphs, tables, descriptive measures, and probabilistic concepts in support of initial training and continuous training of mathematics teachers by employing different technological tools. Table 3 and 3.1 presents ten texts that make up the second grouping of the first partition of the dendrogram as in Table 2 and 2.1.

Table 3. The texts that comprise Class 1, addressing different stochastic representations through graphs, tables, descriptive measures, and probabilistic concepts in support of initial and continuing education of mathematics teachers by employing different technological tools

Text	Author(s)	Description of the presentation at the event	Research description
T4	Asseker, Monteiro and Lima (2010)	Scientific communication at X ENEM	The use of TinkerPlots software by two rural school teachers was investigated. A teaching activity was carried out using a database available on TinkerPlots, in which the teachers manipulated tools to assist in the interpretation of data (age, sex, weight, height and eye color). The use of TinkerPlots by the teachers provided rich moments of reflection and interaction with the new technology. They interacted with the proposed tools, for example, to generate statistical graphs and executed commands demonstrated by the researchers. Teachers also demonstrated a high level of acceptance and availability to work in computational environments, despite their little experience with the use of computers.
T11	Silva and Barbosa (2016)	Scientific communication in the XII ENEM	The study investigated the new possibilities offered by the National Common Curricular Base (BNCC) standards for Brazilian secondary education (students aged 15 to 17), approved in December 2018. These outlined the types of statistical work that should occur in the classroom. The activities involved the creation of boxplots and stem-and-leaf diagrams using applets available on the Geogebra software website. An analysis was carried out on the skills and competencies related to statistics, as well as associated technologies. They investigated how the selection and adaptation of such activities could lead to a better fit with these skills and competencies.
T12	Severo (2019)	Mini course at the XIII ENEM	The authors emphasized that the statistical concepts used in their research considered the objects of knowledge according to the National Common Curricular Base (BNCC). Activities to work on statistical concepts using teaching and active learning methodologies were presented and discussed, as well as computer programs available on the internet. In particular, the use of the R software was examined together with the Rcmdr interface, as they are free, open source, and have a large number of discussion forums, blogs, and pages designed to facilitate their use.
T14	Silva, Castro and Araújo (2019)	Mini course at the XIII ENEM	Technological tools were presented in which teachers could use to spark students' interest and participation in the teaching and learning process of statistics. The course was intended to help students with a variety of topics such as data collection, they representation of research data expressed in terms of tables and graphs, and the calculation of central and dispersion measures. Google Forms was used for data collection, spreadsheets were used for processing and analyzing data, and Kahoot was used as an assessment tool.
T15	Velasque and Silva (2019)	Mini course at the XIII ENEM	Activities were presented that allow working on the data collected by a questionnaire and the analysis of said data using graphs and calculating descriptive measures by using active learning methods and computer programs available on the internet. In particular, the R software, in conjunction with the Rcmdr interface, were considered as they are free, open source, and have a large number of discussion forums, blogs, and pages designed to facilitate their use.

Table 3.1. The texts that comprise Class 1, addressing different stochastic representations through graphs, tables, descriptive measures and probabilistic concepts in support of initial and continuing education of mathematics teachers by employing different technological tools

Text	Author(s)	Description of the presentation at the event	Research description
T17	Samá, Silva and Dos Santos (2022)	Scientific communication in the XIV ENEM	This paper contained a teaching activity that was carried out in the exploratory data analysis discipline of a mathematics undergraduate course at a public university in southern Brazil in 2020 and 2021. This course was offered remotely due to the COVID-19 pandemic. It was based on the three levels of understanding of representations, namely: level I - reading the data, level II - reading between the data and level III - reading beyond the data. The analysis showed that undergraduate students had more difficulties with levels I and III. The authors emphasized the need for and importance of working with future teachers to read and interpret information represented by statistical graphs in their initial teacher training..
T22	Araújo and Kepler (2022)	Scientific communication in the XIV ENEM	The use of technological resources in the context of statistical education was problematized through a manuscript that included an excerpt that dealt with graphical data analysis mediated by Gapminder. The procedures consisted of groups of up to three participants proposing activities and presenting their analyses from the classroom. The authors argue that activities supported by Gapminder can promote the development of transnumeracy, as they provide access to resources that improve the understanding of statistical topics covered in initial training..
T25	Navarro and Borelli (2022)	Scientific communication in the XIV ENEM	Introductory teacher training activities were presented that included teachers as the main focus of the training using virtual learning environments. They focused on the formation of probabilistic concepts outlined by the BNCC for the initial years of Brazilian elementary education (students aged 6 to 10 years). Randomness and uncertainty was outlined as one of the types of knowledge required to live in today's society. Teachers were given experiences that allowed them to reflect on their practices occurring in a virtual environment.
T26	Lins (2003)	Scientific communication at the II SIPEM	In this study, the logical classification procedures developed by teacher training students were investigated in the context of a series of classification activities using an electronic database (spreadsheet). Using Venn diagrams in parallel with their classification activities, students began to understand how tables represent data, identifying the extent and components of classes. In turn, the use of tables significantly improved their understanding of Venn diagrams and the logical mechanisms of the classes they represent. However, they had persistent difficulty in coordinating the extent, understanding and identification of classes in the table without having to manipulate the diagrams. Despite this difficulty, a significant improvement was identified when comparing the pre-test with the post-test.
T27	Bittencourt and Viali (2006)	Scientific communication at the III SIPEM	The teaching of the normal distribution and the central limit theorem was studied using three practical examples, supported by random functions of an Excel spreadsheet. University professors of probability and statistics were inspired to use electronic spreadsheet resources with activities that illustrate probabilistic and statistical concepts, especially those involving simulations. The Excel spreadsheet allowed for the generation of pseudorandom numbers that follow a uniform distribution ranging from 0 to 1. From this distribution, any other distributions could be simulated, illustrating the distribution in a concrete manner that would otherwise be quickly forgotten. Using the spreadsheet resource, students took charge of their learning and played an active part in the construction of their knowledge.

Next, the third subcorpus is presented, referring to the second partition in the dendrogram in figure 1. Class 4 refers to the thinking about statistics aimed at the initial and continued training of mathematics and pedagogy teachers. This class used different software and applications to conduct remote classes during the COVID-19 pandemic. Table 4 and 4.1. presents nine texts that comprise the third grouping.

Table 4. The texts that constitute Class 4, addressing statistics aimed at initial and continued training of mathematics and pedagogy teachers. This class reported different software and applications to support remote instruction during the COVID-19 pandemic

Text	Author(s)	Description of the presentation at the event	Research description
T9	Santos (2013)	Scientific communication at the XI ENEM	An interview was carried out with elementary school mathematics teachers to verify how statistics content work utilizes technological resources, among other topics. Their results indicate the need to develop pedagogical practices that integrate statistics, education, technology, and society. This suggests that appropriate training and teaching resources should be made available to support teachers in the classroom in order to promote quality statistics education.
T16	Moreira et al. (2022)	Report of experiences in the XIV ENEM	These authors examined the initial and continued training of teachers that included action research, favoring the process of collective elaboration on a didactic teaching sequence about basic concepts in statistics. Despite the meetings being held online (via Google Meet), these student teacher groups engaged in reflective and collaborative meetings and exchanged knowledge and experiences. This allowed for the proposed sequences to be carried out in the context of the classroom that stimulated the development of competences and skills outlined by the BNCC and to understand the relationship between theoretical and practical concepts, as outlined by the curricular guidelines of the new Brazilian high school.
T18	Malska (2022)	Report of experiences in the XIV ENEM	The development of a statistics workshop was detailed in this study which was part of the Technologies Applied to Mathematics Education II program, a mandatory area of study in the mathematics degree course at the Federal University of Rio Grande (FURG). The author's proposal recommended that students, in pairs, organize workshops for teaching mathematics using some type of technology to enhance student learning. One such workshop involved a survey administered to students. Data was then recorded in an Excel spreadsheet in order to determine position and dispersion measures.
T19	Castro et al. (2022)	Scientific communication in the XIV ENEM	The use of the Moodle platform in the elective subject of applied statistics is described in this study and its contributions to the training of future mathematics teachers in the early years of elementary school (6 to 10 years). The use of the Moodle platform promoted the integration and synthesis of previously acquired theoretical and practical knowledge, as well as highlighted the need for more in-depth studies based on the problems that arose during remote classes. The authors argue that the use of the Moodle platform was fundamental to their formative experiences as instructors.
T21	Giordano et al. (2022)	Scientific communication in the XIV ENEM	This paper provided the results of a study involving the development of a multimedia statistical literacy program, carried out in two public elementary schools in southern Brazil in 2021. Collaborative training was carried out through Google Meet and WhatsApp. The training included technical and didactic-pedagogical assistance, in addition to materials for developing the project and public dissemination of the research carried out. It was an opportunity for teachers to reinvent themselves, deconstruct and reconstruct knowledge, establish partnerships, collaborate and share knowledge and feelings, be humble, let go and dare.

Table 4.1. The texts that constitute Class 4, addressing statistics aimed at initial and continued training of mathematics and pedagogy teachers. This class reported different software and applications to support remote instruction during the COVID-19 pandemic

Text	Author(s)	Description of the presentation at the event	Research description
T23	Medina et al. (2022)	Experience report on the XIV ENEM	The aim of this report was to contribute to the discussion on the teaching of statistics and probability in elementary school through an investigation carried out by the Fundão Project: Statistics and Probability. The discussion of the joint experiences of elaboration and application of didactic sequences for an integrated approach of statistics and probability was reported in this document. In the initial stage of the study in which the questions that guide the investigation were formulated, a triggering activity introduced the context and the investigation, i.e. a conversation with students about the practice of aerobic physical activities.. Data was collected via a Google Form questionnaire administered to the classes, which was accessed by an internet address or QR Code. In this way, data could be obtained via students' cell phones, via a notebooks made available by the teacher, or even through hardcopies of the questionnaire.
T28	Figueiredo (2018)	Scientific communication at the VII SIPEM	Student teachers reflected on their shared practices as part of their pedagogy degree, integrating the statistical knowledge brought on by teacher training in the initial years in a VLE with their reflections on their teaching practices. The author intended for this work to help the student teachers still enrolled in education programs who have not yet taught or through the continuing education of students who already work as teachers.
T29	Samá and Amorim (2021)	Scientific communication at the VIII SIPEM	A training process for future basic education statistics teachers was analyzed in this study. With the Covid-19 pandemic, social distancing was adopted in order to prevent the spread of Sars-CoV-2, requiring the reorganization of academic activities. For this reason, an exploratory data analysis course took place remotely and the data from this course were collected in the Virtual Learning Environment (AVA), Moodle. Students in this course were able to appreciate that statistics does not consist only of applying formulas and performing calculations, but as a science that can help explain and interpret the results of investigative processes.
T30	Conti and Passos (2021)	Scientific communication at the VIII SIPEM	A remote program entitled Teaching and Learning Processes: Statistics in Early Childhood Education and Early Years took place between 2020 and 2021, remotely. During its online meetings on Google Meet, debates and studies took place, leading to discussions about the importance of undergraduate students, teachers, and researchers participating in groups like the one organized to discuss statistics at the beginning of the school year. The authors investigated the role of the narrative as a mediator in the formation and professional development of participating teachers, allowing them to reflect on future practices. The program helped to minimize teacher anguish, especially at the beginning of teaching, and also encouraged the development of a self-training identity, valuing the knowledge produced by teachers and enabling sharing of said knowledge with other teachers.

Finally, we present the fourth subcorpus, referring to the second partition in the dendrogram in figure 1. Class 3 involves thinking about the teaching of statistics, probability and combinatorics using

technological tools in the initial and continued training of pedagogy and mathematics teachers ranging from early childhood education to higher education. Table 5 presents seven texts that constitute the third grouping.

Table 5. The texts that comprise Class 3, which addresses the teaching of statistics, probability and combinatorics using different technological tools in the initial and continued training of pedagogy and mathematics teachers from kindergarten to higher education

Text	Author(s)	Description of the presentation at the event	Research description
T2	Scherer (2007)	Report of experiences in the IX ENEM	Communication and learning processes were evaluated in a virtual learning space in a statistics education pedagogy course. The subject's bimodal education (spaces for face-to-face and distance communication) proposal was discussed based on the analysis of records left by the students in the virtual environment. The study ends by identifying the aspects that can favor student learning in virtual environments and how they relate to those used in face-to-face classrooms.
T6	Tinti, Nakayama and Januário (2010)	Short course at X ENEM	The authors highlighted the need to create training spaces that use and share new technologies. They emphasize the potential for coordination between technology and teaching. They see these training environments as potentially motivating as they can provide spaces to reflect on the teaching of statistics at different levels, as well as aiming to increase the importance of data analysis, the applicability and the understanding of the software-aided descriptive statistics resources like electronic spreadsheets.
T8	Salles and Bairral (2013)	Scientific communication at the XI ENEM	It focused on the online interactions in virtual learning environments that can allow teachers to build discursive strategies to begin and maintain collaborative debate. The learning environment used was VMT-Chat, a space where students solved introductory combinatorics activities. The virtual sessions were held in three classes of a *lato sensu* postgraduate course in pedagogy. The analysis focused on finding aspects of the speech that showed the development of mathematical reasoning and the resolution strategies adopted by participants. The results identified two heuristics used by learners in the online resolution of a combinatorics activity: the tree diagram and the list of possibilities.
T13	Justo and Magalhães (2019)	Scientific communication at the XIII ENEM	This paper discussed statistical activities involving an auction game. The Lowest Bid Auction game helped in the interpretation of the concepts of mean and median and a version for the classroom is available at the AtivEstat of the Institute of Mathematics and Statistics of the University of São Paulo (IME-USP). A digital version was developed with suggestions that help teachers in the implementation and application of the game. The authors observed that the game contributed to students' statistical literacy, which they define as the ability to understand basic concepts such as mean and median.

Table 5. The texts that comprise Class 3, which addresses the teaching of statistics, probability and combinatorics using different technological tools in the initial and continued training of pedagogy and mathematics teachers from kindergarten to higher education

Text	Author(s)	Description of the presentation at the event	Research description
T20	Oliveira (2022)	Scientific communication in the XIV ENEM	This communication related the cognitive and affective components of statistical literacy to the appropriate use of technologies in maker environments. These environments helped develop autonomy in students, enhanced their skills, and improved their critical thought processes. They suggest that uniting statistics, maker culture, and Digital Information and Communication Technologies (TDIC) promotes democracy in school environments and ultimately in society, creating literate citizens who are capable of critically analyzing data.
T24	Kayser and Baltazar Júnior (2022)	Scientific communication in the XIV ENEM	Geogebra software was used to analyze and interpret probabilistic problems. Geometrically solving probabilistic problems helped students explore the empirical aspects of probability such as sample space. Discussions stemming from the usage of this software helped students reflect on problems as well as build arguments and knowledge that are consistent with mathematical generalizations, which together contribute to mathematical learning.
T31	Souza, Araújo and Pinto (2021)	Scientific communication at the VIII SIPEM	This paper describes a study of mathematics teachers' and undergraduate mathematics students' conceptions of numerical statistical information through YouTube videos and political media. The results reinforced the need for mathematics education to examine communicative structures in the media and social networks. This activity reinforced the ideas that statistical data may be politically to manipulate public opinion. The authors wish to focus in the future on communicative scenarios, seeking to understand ways of teaching mathematics and statistics with a focus on political power relations.

4.1. THE TECHNOLOGY USED

When focusing on publications present in the ENEM proceedings from 1987 to 2022 and in those of SIPEM from 2000 to 2021, the 32 research publications involving teacher training in statistics education for teachers in initial and continuing training covered five types of technologies (Table 6 and 6.1): (a) learning objects, (b) software, (c) Virtual Learning Environments (VLE), (d) programming languages, and (e) applications, digital platforms, and sharing sites. Below, we describe what each of these types of technology are and which can be thought of as supporting the teaching and learning of statistics, specifically probability or combinatorial analysis.

Table 6. Group of technologies of works published in ENEM (1987 to 2022) and SIPEM (2000 to 2021)

Technology group	Description of technologies	Papers published in ENEM	Papers published in SIPEM
Learning objects	Lowest Bid Auction Game (Portal AtivEstat)	Justo and Magalhães (2019)	

Table 6.1. Group of technologies of works published in ENEM (1987 to 2022) and SIPEM (2000 to 2021)

Technology group	Description of technologies	Papers published in ENEM	Papers published in SIPEM
Software	Excel (spreadsheet)	Viali (2007); Tinti, Nakayama and Januário (2010); Almeida and Guebert (2013); Malska (2022)	Lins (2003); Bittencourt and Viali (2006); Figueiredo and Coutinho (2021)
	BrOffice.org Calc. (spreadsheet)	Kawasaki and Magalhães (2007); Santos (2013)	
	SPSS (Statistical Package for Social Sciences)	Almeida and Guebert (2013); Justo and Magalhães (2019)	
	GeoGebra	Silva and Barbosa (2016); Kayser and Baltazar Júnior (2022)	
	Minitab	Almeida and Guebert (2013)	
	TinkerPlots	Asseker, Monteiro and Lima (2010)	
	Statistica	Almeida and Guebert (2013)	
Virtual Learning Environments - VLE	Virtual Environment to Support Statistical Literacy - AVALE	Andrade, Cazorla and Cruz (2010)	
	Online Virtual Environment: VMT-Chat VMT = Virtual Math Team	Salles and Bairral (2013)	
	Virtual Environment (general)	Scherer (2007); Oliveira (2022)	
Programming language	R language	Machado and Becher (2016); Silva and Barbosa (2016); Velasque and Silva (2019)	
Applications, digital platforms and sharing sites	WhatsApp	Giordano et al. (2022)	
	Moodle	Samá, Silva and Dos Santos (2022); Castro et al. (2022)	Figueiredo (2018); Samá and Amorim (2021)
	Google Meet	Moreira et al. (2022); Giordano et al. (2022)	Conti and Passos (2021)
	Google Forms	Medina et al. (2022)	
	Google Classroom	Navarro and Borelli (2022)	
	Kahoot	Silva, Castro and Araújo (2019)	
	Gapminder	Araújo and Kepler (2022)	
	Youtube		Samá and Amorim (2021); Souza, Araújo and Pinto (2021)
	Microsoft Teams		Souza, Araújo and Pinto (2021); Figueiredo and Coutinho (2021)

Learning objects are resources characterized by reusability; they must support their pedagogical objectives and be structured in such a way that they are self-sufficient (about the content covered), allowing it to be reused. Examples of said objects include videos, hypertexts, and interactive games (Silva & Schimiguel, 2014).

Based on the use of different technologies (Table 6), the game Lowest Bid Auction is classified as a learning object that helps in the interpretation of mean and median. A classroom version is available at AtivEstat, the Institute of Statistics and Mathematics (IME) at the University of São Paulo, Brazil (USP, 2024), which helps teachers improve their classes by encouraging the inclusion of statistical topics in their classrooms as well as the discussion and verification of concepts.

Therefore, below, we present some indications about the technological tools used in the studies presented. Thus, initially, as defined by Okuyama et al. (2014), software are stored electronic instructions, also known as programs. They argue that these instructions are the components that give life to machines.

One of the most cited and used technologies are electronic spreadsheets (Excel and Br Office Calc). They are software that help with statistical interpretation in several ways. They can organize and represent numerical data in the form of a graph, facilitate the understanding of data, and help users interpretation of data in the form of a graph. For Tajra (2001), they enable calculations to be carried out more quickly, given that the software can that facilitate the visualization of information.

Another software mentioned is SPSS (Statistical Package for the Social Science), which, according to Santos (2018), is a statistical package with different modules, developed by the International Business Machines Corporation. It is an easy-to-use and comprehensive tool, allowing you to perform statistical and graphical analyses with a wide range of data. It also interfaces with electronic spreadsheets, in addition to being able to save the output as a Word document.

GeoGebra, according to Estevam and Kalinke (2013), contains three different user interface components: the Graphical Zone, the Algebraic (or numerical) Zone and the Spreadsheet. GeoGebra allows you to show mathematical objects in three different representations: graphically, algebraically, and in the cells of the spreadsheet. Thus, all representations of the same object are dynamically linked and automatically adapt to changes made to any of them, regardless of how these objects were initially created.

Minitab is also presented, which is a statistical software that has an interface similar to that of an electronic spreadsheet (Microsoft Excel and Br Office Calc), in addition to saving the resulting statistics in Word and PDF format (MAAT, 2015).

Unlike the other software presented, TinkerPlots (Konold & Miller, 2001) is an educational data analysis application developed for students in the early years of elementary school. It is a complex statistics teaching tool that motivates students to carry out activities inside and outside the classroom (Konold, 2006).

Finally, Statistica is a paid software developed by StatSoft whose main function is to create statistics graphs stored on the computer's hard drive. The software offers several possibilities for viewing graphs according to the user's needs. It includes a data analysis matrix, data management, data visualization, exploratory techniques, etc.

Virtual Learning Environments (VLE) are means of communication that have been used to mediate teaching and learning, primarily distance learning. Chats and discussion forums are communication tools that can be used by teachers and students to interact with one another to share productions and information (Meireles and Schimiguel, 2020).

This study identified the Virtual Environment to Support Statistical Literacy for Basic Education (AVALE-EB), which was designed to the develop statistical literacy and scientific thinking. It uses teaching sequences involving interdisciplinary activities the school context, making it possible for instructors to help students explore not only the cognitive aspects of learning statistics but also develop critical awareness of the use of environmental resources as well as respect for diversity (Cazorla et al., 2012).

Virtual Math Teams (VMT-Chat) encourage groups of students to work together online visually, by dragging and constructing dynamic geometry figures and talking about what they are accomplishing. VMT-Chat incorporates a multi-user version of GeoGebra and allows students, teachers and researchers to select chat rooms with geometric tasks and with histories of work conducted in those rooms (VMT, 2024).

In terms of programming languages, R is notable. It is an object-oriented statistics language created in 1996 by Ross Ihaka and Robert Gentleman. When combined with an integrated environment, R allows users to manipulate data, perform calculations, and generate graphs (Souza et al., 2014).

The final class identified is that which includes applications, digital platforms and sharing sites as pedagogical resources. The instant messaging application WhatsApp was initially identified as gaining ground in education during the Covid-19 pandemic. With 120 million users in Brazil and installed on 98% of smartphones in the country, this platform became a teaching tool in which teachers sent activities to students and communicated with parents and guardians about pedagogical issues (Riga, 2021).

For Sabbatine (2007), Moodle is free and open-source software, which means that anyone or any institution can use, modify and adapt it. It is a teaching and learning management system which helps educators create online courses or support face-to-face courses. Moodle is high quality and includes many types of resources.

According to Iftakhar (2016), Google Classroom is a central teaching and learning platform; it is a a virtual classroom environment for educational institutions, teachers and students. Google Classroom centralizes several resources, allowing users to access all learning tools and manage multiple classes at once. Google offers many services which can work together with Google Classroom, including Google Meet, Google Sheets, Google Forms, Gmail, Google Calendar, Google Drive, and others. Teachers and students can access the platform from anywhere with internet access on any device, which makes it immensely beneficial. It combines flexibility, mobility, technology, innovation, and education.

YouTube is a website for sharing videos uploaded by users over the internet. The term comes from the English word “you” which refers to the listener or watcher and “tube” which is older English slang for “television” (Enciclopédia Significados, 2024). YouTube can be an effective teaching and learning tool because it allows students to access videos freely and at any time. Teachers can use videos as a teaching resource to supplement formal teaching or to support learning.

Gapminder Tools is a platform that presents open online data resources dynamically, enhancing the ability to interact with visual representations of the data. Gapminder Tools makes different types of data more accessible, aiding in the interpretation of said data without the need to use advanced statistical techniques (Leblanc, 2012).

Kahoot, according to Teixeira and Andrade (2022), is a learning platform based on a multiple-choice quiz that can be used to carry out interactive activities between the teacher and their students (audience). To use it, students must use personal computers or smartphones, all with internet access.

Microsoft (2024) Teams for Education brings everything and everyone together in a powerful communication application for schools and is free for students and teachers of all levels who have a valid email address.

4.2. THE TECHNOLOGY USED IN CONTINUING TRAINING OF STATISTICS AND PROBABILITY TEACHERS

In the search to identify the technological resources used in the initial and continuing training of statistics and probability teachers, different technologies were listed that were used in research highlighted in ENEM and SIPEM. We identify below how these technologies were used.

From the first work identified in the IX ENEM in 2007 to the XII ENEM in 2016, it is clear that training spaces in which new technologies are used and shared are disparately needed. Technology makes it possible to overcome long and repetitive activities and can therefore facilitate students' concentration on statistics and probability concepts. Technologies are also tools that provide teachers with the ability to present and illustrate different concepts that would not be possible using conventional methods, allowing for better exploration of data and encouraging more active learning.

While several examples of the interface of technology and statistics education were apparent in this study, it should be noted that there is still much to do. Subjects' learning processes need to be better understood, requiring greater experimentation and examination of new technologies.

In SIPEM, only three works were observed until 2018 (VII SIPEM) focusing on the topic. In the first two works, II SIPEM in 2003 and III SIPEM in 2006, probability and statistics teachers were encouraged to use electronic spreadsheets in activities that illustrated probabilistic and statistical

concepts, specifically simulations, analyzing the evolution of students' cognitive processes. However, these studies were limited in number and only provide partial insight into the use of spreadsheets.

Another concern was noticed at the VII SIPEM, in 2018, where teaching sequences involving basic statistical concepts offered to teaching training of pedagogy students was analyzed. Through a distance learning course, teachers in initial training, some of whom were already working as basic education teachers or already had contact with students during internships, applied these teaching sequences to their own elementary students. This distance course model generated new opportunities in continuing teacher training with the possibility that this practice will be provided to teachers in the public education network promoting statistics literacy in basic education students.

The last two ENEM (2019 and 2022) offered new possibilities based on the teaching of statistics and probability guidelines outlined by the BNCC (Ministry of Education, 2018). Statistical and probabilistic skills were analyzed using different technologies, allowing the interpretation, understanding, and argumentation of information involving the collection, exploration, and presentation of data to identify patterns and trends. It is also suggested that the technological advances experienced in recent years have allowed the generation of a large amount of data that can be manipulated and analyzed, in addition to the usage of technology being a requirement for all domains.

In the last ENEM, in 2022, researchers reported that the Covid 19 pandemic spurred changes to instructional models. Teacher training was carried out through remote meetings, via video conference services such as Google Meet, with teachers from basic education or initial training participating in courses similar to those offered by extension programs. Reflective and collaborative work was promoted through the development of didactic proposals for teaching and learning statistics and probability concepts in accordance with BNCC guidelines for elementary and secondary education.

It is noteworthy that, at that time, teachers considered that the courses helped them adapt to the challenge of conducting their own remote classrooms given the imposition of social isolation. These moments of recognition made it easier for student teachers to go through the difficult process of no longer having face-to-face courses, allowing them to not feel alone or helpless.

At VIII SIPEM in 2021, the pandemic permeated much of the research as platforms such as Google Meet or Microsoft Teams were used so that teachers could work in groups on various issues. The challenge of offering continuing education courses to basic education teachers while adhering the necessary social distancing was not an easy task, as being in a virtual environment made it more difficult to propose activities using technologies involving group discussion and manipulation.

Throughout all of the studies, teaching moves and activities adopted with the support of digital technology better helped teachers-in-training understand statistics concepts and statistics. This suggests that the development of statistical understanding not only includes the application of formulas and carrying out calculations, but as a scientific process that involves the explanation and interpretation of data.

5. FINAL CONSIDERATIONS

In this text, an analysis of statistics education studies in Brazil involving the use of technological resources was presented. The inventoried works offer important insights into understanding the production of statistics knowledge. We examined the highlights of the findings discussed in this body of work as well as the areas needing further exploration by researchers.

The number of articles involving the use of different technologies for teaching statistics, probability and combinatorics and aimed at teacher training has grown over the years. Eighteen articles (56.25%) have been published in the proceedings of XIII ENEM in 2019, VIII SIPEM in 2021, and XIV ENEM in 2022. This work was likely spurred by the publication of the BNCC (Ministry of Education, 2018), a document that outlines competencies, skills, and essential learning that all students must develop during each stage of Brazilian basic education. In the BNCC, probability and statistics has been identified as a unit and can be an area that technology can be used to teach statistics and probability from kindergarten to high school. This boom in research was further encouraged by the Covid-19 pandemic, when educational institutions, teachers, and students had to learn to navigate the virtual environment, accelerating the introduction of unprecedented technological practices in teaching and learning.

It is worth highlighting that not all Brazilian scholarly output in the area under study in this article goes through ENEM and SIPEM, as not all researchers who develop studies focused on statistics education participated in these events.

Thus, it can be seen in the four classes identified by the IRaMuTeQ software that there are different areas of the research focusing on, for example, initial and/or continued training, different types of presentations (experience reports, scientific communications or short courses), and different technological resources.

The focus of the 32 studies/texts selected in SLR is on statistical content from early childhood education and the initial years of elementary education (Degree in Pedagogy), through the final years of elementary and secondary education (Degree in Mathematics) to higher education (initial teacher training), with few works focusing on combinatorial analysis.

Combinatorial analysis is the part of mathematics that studies methods and techniques that solve counting problems suggesting its potential utility by teachers. It is generally used in studies on probability associated with the analysis of possibilities and possible combinations between a set of elements. Thus, there is a need to develop more work focused on teaching probability and combinatorics, or even aspects of stochasticity, considering approaches that associate statistical and/or probabilistic and/or combinatorial content.

Teacher training needs attention and should be improved. Doing so can involve offering extension courses or more mini courses at scientific events and providing opportunities to consolidate statistical, probabilistic, and combinatorial knowledge. Guidance and direction need to be provided so that these teachers can understand the importance of statistical education in the daily lives of students and so that they can mediate knowledge on the topic through their reflections and work experiences.

Works developed with technological support in ENEM and SIPEM is still incipient, supported by software or programming languages that can be used and/or classified as educational (Excel, BrOffice Calc, "R", SPSS, among others) indicating that it can be given more emphasis in future research. We argue like Lee and Hollebrands (2008, 2011), Batanero and Borovcnik (2016), Oliveira Júnior and Dos Anjos (2017) and Pepin et al. (2023) that digital technologies can be powerful tools to support statistics education, as their affordances can promote awareness and understanding of certain statistical, probabilistic, and combinatorial concepts. In addition, these digital technologies are capable of spurring and accelerating research and analysis processes.

Finally, Chance et al. (2007) and our results suggest that technological resources should be used more in the classroom as an alternative to understanding analytical processes and the concepts that permeate them, while also pointing out the non-manual repetition of algebraic calculation procedures. Perhaps this is the great difference in technological resources when compared to other alternative teaching methodologies mentioned previously in this paragraph, justifying their relevance to statistical education. No less important, the use of computer technologies is aligned with the teaching and learning process, providing the student with new experiences and practices.

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