THE USE OF TECHNOLOGICAL RESOURCES IN TEACHER EDUCATION AS A CONTRIBUTION TO THE TEACHING OF STATISTICS AND PROBABILITY IN BRAZIL

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To evaluate the evolution of research in statistics education focused on the use of technological resources or tools in the initial and continuing education of teachers, a systematic literature review was carried out through analysis of the scientific annals of the National Meeting of Mathematics Education–ENEM, Brazil. Of the 294 studies identified in statistics education, forty-two studies used technological resources, and of these, fifteen focus on the initial and continuing education of teachers. We consider that the implementation of technological resources in the classroom still faces many challenges, from the elaboration and execution of projects and public policies that guarantee a minimum infrastructure for institutions, to the training of teachers for the selection, evaluation, and coherent use of technologies.

INTRODUCTION

According to Cazorla, Kataoka, and Silva (2010), statistics education research emerged in the 1970s with a need to investigate ways to solve the difficulties faced by professors of higher education courses when teaching statistics concepts and procedures. Even though statistics education is a relatively new area, there is growing scientific production of research in the area recorded in the annals of scientific events in recent years.

We consider that statistics education is characterized as a research area with the objective to study and understand how people teach and learn statistics, probability, and elements of combinatorial analysis. The research involves cognitive and affective aspects of teaching and learning, epistemology concepts, and the development of teaching methods and materials for the purpose of their development. In addition, with the rapid advancement of technologies, especially the internet, a range of resources for teaching and learning from kindergarten to higher education has emerged. Cobb (1993) and Lopes (2003) mentioned an urgent need to change the way of teaching "statistics" from basic education to higher education, and today we have access to video classes, texts, and software, along with other resources from the most diverse disciplines. In many cases, these resources are freely available on the internet. Such resources have been increasing at a rapid pace, and keeping up with each new feature is an almost impossible task. In the educational context, it can be said that we live in an era where there is an abundance of educational tools, particularly for statistics education.

The objective of this work was to develop a Systematic Literature Review (RSL) on the use of technological resources in the initial and continuing education of teachers related to statistics education. We reviewed literature published since 1987 in the annals of the National Meeting of Mathematics Education–ENEM, the biggest and main Brazilian event for mathematics education.

METHOD

An RSL 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). RSLs are characterized by offering a broad review of studies on a specific topic, which in our case is the teaching of statistics, probability, and combinatorial analysis. Our systematic mapping of the literature focused on the use of technological resources or tools in teacher education to determine any trends in the evolution of the research and any possible weaknesses of scientific production through the analysis of the scientific annals of the National Meeting of Mathematics Education–ENEM from 1987 to 2019. We identified studies from early childhood education to higher education and sought to identify, describe, and verify the general characteristics and trends of articles from Brazilian scientific production using the online annals of ENEM from the website of the Brazilian Society of Mathematics Education (SBEM) (http://www.sbembrasil.org.br/sbembrasil/index.php/anais/enem). We justify the choice of this Brazilian event because it is the main event in mathematics education promoted by SBEM and brings together researchers in mathematics education.

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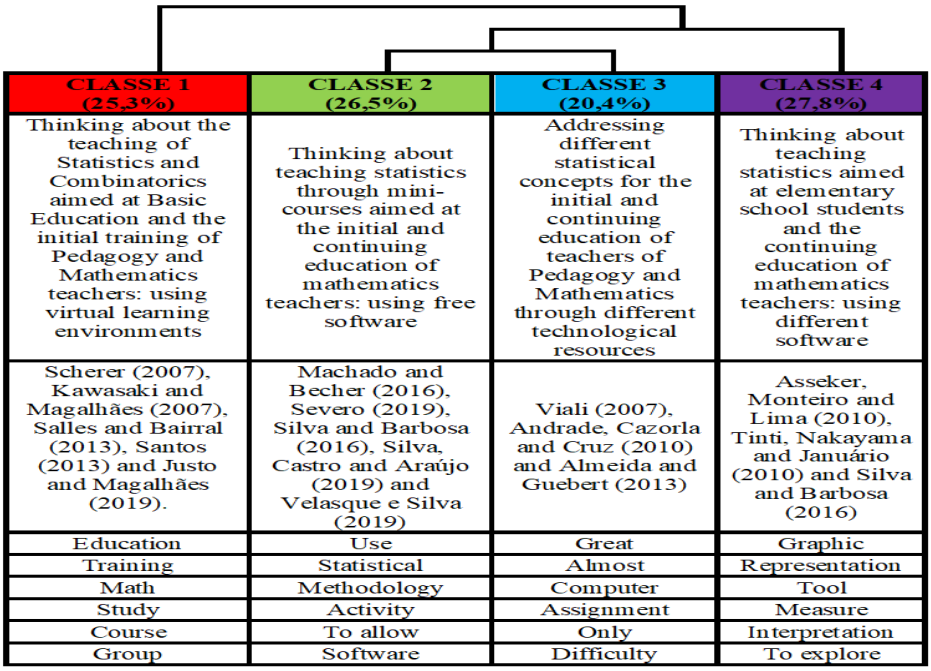
We carried out the search using associated terms or keywords for the teaching of statistics, probability, and combinatorial analysis for articles with the following characteristics: (a) temporal—published in EBEM between 1987 and 2019 and (b) linguistic—written in Portuguese. The search returned 15 results, and all titles, abstracts, and text were read to identify work aimed at the use of technological resources for the initial and continuing education of teachers in statistics education.

The software IRaMuTeQ (R Interface for Multidimensional Text and Questionnaire Analysis) was used with an objective of improving the research work by using the optimization of the organization process and the more specific delimitation of selected texts. This allows for the survey of constituent elements of socially shared representations, which highlights traces of mental worlds through lexical worlds schematized by text and later inferred to the content analysis technique (Mutombo, 2013).

We performed a Descending Hierarchical Classification (CHD) in order to give rise to 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 corpus of the text represent the space of meaning of the narrated words and may suggest elements on how technological resources were used in the training of teachers in the teaching of statistics, probability, and combinatorics in Brazil. We emphasize that CHD-type analyses, in order to be useful for classifying any textual material, require a minimum retention of 75% of text segments (Camargo & Justo, 2013). In this sense, the textual corpus used for analysis in the present study is considered representative and useful, as the usage was 83.62%. The interpretation of CHD results is based on the hypothesis that the use of similar lexical forms is linked to common representations or concepts (Reinert, 1998). For this reason, the Reinert method is often used to identify underlying themes in a set of texts.

RESULTS

In the CHD tab of the IRaMuTeQ results, it was possible to access the phylogram (Figure 1) that presents the evolutionary partitions that were made in the corpus until reaching the final four classes. The resulting dendrogram that displays data clusters is read from left to right. Thus, in the result of the classification by Reinert's Method, the corpus "Body" was divided (1st partition or iteration) into a subcorpus, Class 1 that represents 25.3% of the textual corpus. In the second partition, the subcorpus was subdivided. Class 4 indicates 27.8% of the total textual corpus, and Classes 2 and 3 indicate, respectively, 26.5% and 20.4% of the total.



CLASSE 1 (25,3%)	CLASSE 2 (26,5%)	CLASSE 3 (20,4%)	CLASSE 4 (27,8%)
Thinking about the teaching of Statistics and Combinatorics aimed at Basic Education and the initial training of Pedagogy and Mathematics teachers: using virtual learning environments	Thinking about teaching statistics through mini-courses aimed at the initial and continuing education of mathematics teachers: using free software	Addressing different statistical concepts for the initial and continuing education of teachers of Pedagogy and Mathematics through different technological resources	Thinking about teaching statistics aimed at elementary school students and the continuing education of mathematics teachers: using different software
Scherer (2007), Kawasaki and Magalhães (2007), Salles and Bairral (2013), Santos (2013) and Justo and Magalhães (2019).	Machado and Becher (2016), Severo (2019), Silva and Barbosa (2016), Silva, Castro and Araújo (2019) and Velasque e Silva (2019)	Viali (2007), Andrade, Cazorla and Cruz (2010) and Almeida and Guebert (2013)	Asseker, Monteiro and Lima (2010), Tinti, Nakayama and Januário (2010) and Silva and Barbosa (2016)
Education	Use	Great	Graphic
Training	Statistical	Almost	Representation
Math	Methodology	Computer	Tool
Study	Activity	Assignment	Measure
Course	To allow	Only	Interpretation
Group	Software	Difficulty	To explore

Figure 1. Result of classification by Reinert's method: dendrogram

Description of the Classes in CHD

The four classes contain the active forms of organized words that presented the highest frequency in the textual corpus, in descending order, and that were significant for representing subcorpuses using the Chi-square association test generated in the IRaMuTeQ reports. That is, the dendogram displays the clusters for classification that represent the highest adherence of text in a class and between classes resulting from the Reinert Method (Figure 1). Using the dendrogram presented in Figure 1, we name the four classes. We cite the texts used in the analysis and highlight the main words that indicated important aspects for shaping each of the groups. Initially, Class 1 is observed, followed by Class 4, which is associated by the dendrogram with Classes 2 and 3, which are strongly associated.

Class 1: Scherer (2007) evaluated the communication and learning process from a virtual learning space in a pedagogy course that focused on statistics content applied to education. Kawasaki and Magalhães (2007) sought to contextualize and attribute meanings to classes that promoted maximum autonomy in the construction of knowledge by conducting experiments of teaching material in parallel with classroom activities. Salles and Bairral (2013) analyzed online interactions focused on learning in virtual environments to consider signals that allow the teacher to build discursive strategies to contribute to the continuity of the collaborative debate. To promote quality statistics education, Santos (2013), indicated the need to develop pedagogical practices that integrate statistics, education, technology, and society and the need to reflect on educational practices in an attempt to seek training and didactic resources that subsidize the classroom teacher. And, in Justo and Magalhães (2019), use of the digital version of the game, *Auction of the lowest bid*, to teach statistics presented suggestions that can help the teacher in implementing and applying the game.

Class 4: Asseker, Monteiro, and Lima (2010) investigated two rural schoolteachers' use of TinkerPlots software to interpret data in response to questions suggested by the researchers. Tinti, Nakayama, and Januário (2010) highlighted the need to create training spaces to consider, learn, and share new technologies, highlighting the potential of technology-teaching articulation. And, Silva and Barbosa (2016) used teaching and active learning methodologies and the computer program R to implement a mini-course with activities that allowed for working on statistical concepts.

Class 2: In Machado and Becher (2016) the presentation of R software demonstrated some possibilities of didactic-pedagogical use. Severo (2019) used the R program and the large number of discussion forums, blogs, and dedicated pages designed to facilitate its use. Silva and Barbosa (2016) presented activities to work with box plots and stem and leaf diagrams using applets available on the GeoGebra website. Silva, Castro, and Araújo (2019) used technological tools that the teacher can use to stimulate student interest and participation in statistics teaching and learning. And, Velasque and Silva (2019) indicated activities that use active teaching/learning methodologies and computer programs available on the internet to allow data collection through a questionnaire and data analysis through the construction of graphs and calculation of descriptive measures.

Class 3: Viali (2007) used a computational resource in which one learns by doing to approach the teaching of descriptive statistics. Andrade, Cazorla, and Cruz (2010) socialized the teaching sequence "Water planet" provided by the "Virtual Environment to Support Statistical Literacy–AVALE." Teachers from Almeida and Guebert (2013) used Excel® to provide faster resolution of statistical problems for their students to obtain permanent objectives such as learning, retaining, and transfer of the concepts studied.

The Technology Used

When focusing on the publications present in the annals of ENEM from 1987 to 2019, the 15 research publications that involve teacher training in statistics for initial and continuing teachers attended to four types of technologies: (a) learning objects; (b) software; (c) virtual learning environments (VLE); and (d) language and programming. Learning objects are resources that have reusability as a characteristic, that is, the object must support its pedagogical objectives and be structured in such a way that it is self-contained (with regard to the content covered), allowing it to be reused, such as: videos, hypertexts, and interactive games (Silva & Schimiguel, 2014). Software, according to Okuyama, Miletto, and Nicolao (2014), are stored electronic instructions known as programs; this software is the component that gives life to the machine. VLEs are a means of communication that have been used to mediate the teaching and learning process, especially in the distance mode. Chats and discussion forums are communication tools that are part of the VLE and

through these tools, teachers and students can interact with each other to socialize productions and information (Meireles & Schimiguel, 2019). In terms of programming languages, we highlight R, which is an object-oriented language created in 1996 by Ross Ihaka and Robert Gentleman for statistics. When combined with an integrated environment, R allows for manipulating data, performing calculations, and generating graphs (Souza et al., 2014). The 15 publications are divided into these four subgroups, as displayed in Table 1. Some works present more than one type of technology.

Table 1. Group of technologies from works published in ENEM from 1987 to 2019

Technology Group	Description of technologies*	Work published in ENEM
Learning Objects	Lowest Bid Auction Game (AtivEstat Portal)	Justo and Magalhães (2019)
Software	Excel (spreadsheet)	Viali (2007); Tinti, Nakayama, & Januário (2010); Almeida and Guebert (2013)
	BrOffice.org Calc. (spreadsheet)	Kawasaki & Magalhães (2007); Santos (2013)
	SPSS (Statistical Package for Social Sciences)	Almeida & Guebert (2013); Justo & Magalhães (2019)
	GeoGebra	Silva & Barbosa (2016)
	Minitab	Almeida & Guebert (2013)
	TinkerPlots	Asseker, Monteiro, & Lima (2010)
	Statistic	Almeida & Guebert (2013)
Virtual Learning Environments	Virtual Environment to Support Statistical Literacy - AVALE	Andrade, Cazorla, & Cruz (2010)
	Virtual Online Environment: VMT-Chat VMT = Virtual Math Team	Salles & Bairral (2013)
	Virtual Environment (general)	Scherer (2007)
	Kahoot	Silva, Castro, & Araújo (2019)
Programming Languages	R language	Machado & Becher (2016); Silva & Barbosa (2016); Velasque & Silva (2019)

DISCUSSION

In this text, we present an analysis of scientific productions in the Brazilian context on the use of different technological resources for Brazilian statistics education. The inventoried works offer important elements to understand the production of knowledge and highlight contributions and gaps in this area of research, thus allowing the field to be further explored by researchers. The focus is on statistics content from early childhood education and the early years of elementary school (pedagogy degree), through the final years of elementary and high school (mathematics degree), to higher education (initial teacher training), with only one work focusing on combinatorial analysis. Thus, we realize that there is a need to develop more works aimed at teaching probability and combinatorics or aspects aimed at stochastics by considering approaches that associate statistical and/or probabilistic and/or combinatorial contents.

Undoubtedly, teacher training needs attention for teachers to be given the opportunity to gain this knowledge. Guidelines and directions need to be arranged so that teachers can understand the importance of statistics education for daily life, so that, throughout reflections and work, they can mediate knowledge on the subject. We consider that the presentation of works developed with technological support in ENEM is still incipient, having as support the software that can be used and/or classified as educational (Excel, BrOffice Calc, R, SPSS, etc.). Research on the use of technology in teacher education can be given more attention in future research.

We believe that digital technologies can be a powerful support tool for statistics education because their characteristics can favor awareness and understanding of certain statistical, probabilistic, and combinatorial concepts. In addition, they constitute resources that enable and speed up the research and data analysis processes.

We suggest that technological resources should be used in classes as an alternative to prioritize reasoning, the understanding of data analysis processes, and the concepts that permeate them, while pointing to a devaluation of algebraic calculations and the repetition of procedures. Perhaps this is the great differential of technological resources when compared with didactic alternatives and that justifies its pertinence to statistics education.

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