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THE TEACHING OF MATHEMATICS AND EXPERIMENTAL SCIENCES: REFLECTIONS ON THE PANDEMIC AND POST-PANDEMIC PERIOD

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TEACHING AND LEARNING GRAPHS IN ELEMENTARY SCHOOL: A LITERATURE REVIEW

LA ENSEÑANZA Y EL APRENDIZAJE DE GRÁFICOS EN LA ESCUELA PRIMARIA: UNA REVISIÓN DE LA LITERATURA

O ENSINO E A APRENDIZAGEM DE GRÁFICOS NO ENSINO FUNDAMENTAL: UMA REVISÃO DE LITERATURA

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Abstract
This study aimed to identify academic research developed in Brazil regarding the teaching and learning of statistical graphs involving elementary school students. Considering the inclusion of Statistics as a block of Information Treatment in Elementary School according to the National Curricular Parameters up to the thematic unit of Probability and Statistics in the National Common Curricular Base, a descriptive analysis was carried out, qualitative approach, which resulted in a Systematic Literature Review of articles, theses, and dissertations. We used the databases Google Academic, SciELO and Brazilian Digital Library of Theses and Dissertations, from the search descriptors: statistics, graphics, and teaching. In these, 49 articles were located according to defined inclusion and exclusion criteria, remaining 13 for analysis. From the theses and dissertations, the search returned 314 works, of which 22 were selected according to the inclusion criteria. As a result, the following approaches were raised: the use of technological resources for teaching graphics; the use of manipulable resources; analysis of issues published in textbooks or other printed materials; forms of application proposed by teachers, activities with the students.

Keywords: Systematic Literature Review; Teaching; Graphics; Mathematics Education; Statistics Education.

Resumen
Este estudio tuvo por objetivo identificar investigaciones académicas desarrolladas en Brasil respecto a la enseñanza y el aprendizaje de gráficos estadísticos involucrando estudiantes de la Enseñanza Fundamental. Considerando la inclusión de la Estadística como bloque de Tratamiento de la Información en la Enseñanza Fundamental de acuerdo con los Parámetros Curriculares Nacionales hasta la unidad temática de Probabilidad y Estadística constante en la

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Base Nacional Común Curricular, se realizó un análisis descriptivo, de abordaje cuantitativo y cualitativo, que resultó en una revisión sistemática de literatura de artículos, tesis y disertaciones. Se utilizaron las bases de datos Google Académico, SciELO y Biblioteca Digital Brasileña de Tesis y Disertaciones, a partir de los descriptores de búsqueda: estadística, gráficos y enseñanza. En estos, se ubicaron 49 artículos de acuerdo con criterios definidos de inclusión y exclusión, quedando 13 para análisis. De las tesis y disertaciones, la búsqueda devolvió 314 trabajos, de los cuales 22 fueron seleccionados de acuerdo con los criterios de inclusión. Como resultados, se plantearon los siguientes enfoques: el uso de recursos tecnológicos para la enseñanza de gráficos; el uso de recursos manipulables; el análisis de cuestiones publicadas en libros didácticos u otros materiales impresos; formas de aplicación propuestas por los profesores, además de la discusión de las actividades realizadas con los estudiantes.

Palabras clave: Revisión Sistemática de la Literatura; Enseñanza; Gráficos; Educación Matemática; Educación Estadística.

Resumo
Este estudo teve por objetivo identificar pesquisas acadêmicas desenvolvidas no Brasil a respeito do ensino e da aprendizagem de gráficos estatísticos envolvendo estudantes do Ensino Fundamental. Considerando a inclusão da Estatística como bloco de Tratamento da Informação no Ensino Fundamental de acordo com os Parâmetros Curriculares Nacionais até a unidade temática de Probabilidade e Estatística constante na Base Nacional Comum Curricular, realizou-se uma análise descritiva, de abordagem quantitativa e qualitativa, que resultou em uma Revisão Sistemática de Literatura de artigos, teses e dissertações. Utilizou-se as bases de dados *Google Acadêmico*, *SciELO* e Biblioteca Digital Brasileira de Teses e Dissertações, a partir dos descritores de busca: estatística, gráficos e ensino. Nesses, foram localizados 49 artigos de acordo com critérios definidos de inclusão e exclusão, permanecendo 13 para análise. Das teses e dissertações, a busca retornou 314 trabalhos, dos quais 22 foram selecionados de acordo com os critérios de inclusão. Como resultados, foram levantadas as seguintes abordagens: o uso de recursos tecnológicos para o ensino de gráficos; o uso de recursos manipuláveis; análise de questões publicadas em livros didáticos ou outros materiais impressos; formas de aplicação propostas pelos professores, além da discussão das atividades realizadas com os estudantes.

Palavras-chave: Revisão Sistemática de Literatura; Ensino; Gráficos; Educação Matemática; Educação Estatística.

Introduction

Today's society is going through a whirlwind of information and technologies that change the ways we think and interact. Keeping up with such changes is not always just a matter of will, as it depends on the context in which the citizen is inserted, which is evidenced by television and the internet, for example. What could previously be considered a pastime for family moments is now a space capable of promoting changes in social habits, facilitating the dissemination and acquisition of products,

providing fun for all age groups, forming opinions and informing. When considering the use of graphs and tables during a newscast, the producers are seeking to capture the attention of the audience, conveying statistical details and information about the subject. However, the question arises: how do viewers understand such information? Even if terms such as error margin, average, percentage and others are used, is the presented data correctly interpreted?

Graphs, due to their visual aspect, tend to draw the attention of the public and can drive their interest in understanding the data. Graph data are used to emphasize all types of subjects, thus, "when constituted as a cultural instrument, graphs are also a school content, since this institution is responsible for teaching the knowledge developed by society throughout history" (MONTEIRO; SELVA, 2001, p.2). It's noteworthy that graphs are part of the complex Statistics system and, just like other topics, are included in Basic Education's curricular guidelines, since 1997, as a Block of Information Processing in mathematical subjects according to the National Curricular Parameters (PCN, from Brazilian Portuguese "Parâmetros Curriculares Nacionais"), through which Statistics became a topic in Mathematics for primary education.

In school, regarding the learning of Statistics, Fernandes and Morais (2011, p. 96) state that there are many difficulties for the student, especially referring "[...] to the concepts and interpretation of measures of central tendency, to the representation, analysis and interpretation of graphs and to the selection of the measures which best represent a distribution" [i]. There are some alleged reasons to explain why the teaching of graphs is not addressed or just briefly addressed at the end of the school year, such as: lack of time; the real notion of its importance in the education of students and teachers; and the lack of theoretical-methodological knowledge of the teacher regarding statistical and probabilistic concepts (WATSON, 2006; LOPES, 2010; CONTI, 2016). Conti (2016, p. 1119), when citing Lopes (2010), highlights that "[...] the constant presence of Statistics in today's world has become a reality in the lives of the citizens, leading to the need to teach Statistics to an increasing number of people [...]" [i].

Considering the above, this article is an excerpt from a thesis in development which aims for the analysis of the way in which tables and graphs are approached in the classroom based on expanded abstracts and experience reports published in the Annals of an event involving all levels of education. Given the importance of the topic, the goal of this article is to identify academic research developed in Brazil regarding the teaching and learning of statistical graphs involving Elementary School students, based on the guiding question: *What does research reveal about the teaching and learning of graphs with Elementary School students?* To answer this question, a Systematic Literature Review was carried out from the databases *Google Scholar*, *SciELO* (*Scientific Electronic Library Online*) and the Brazilian Digital Library of Theses and Dissertations (BDTD, from Brazilian Portuguese "Biblioteca Digital Brasileira de Teses e Dissertações").

In addition to the introduction, the final considerations and the references, this article has three main sections. The first one presents the theoretical foundation, briefly discussing some understandings of graphs studied by Curcio (1987, 1989) and by Friel, Curcio and Bright (2001). The second section describes the research methodology and the third presents the results and subsequent analysis of the selected materials.

Reading and Interpreting Graphs by Frances R. Curcio

Brazilian researchers such as Cazorla (2002), Guimarães (2002) and Lima (2019) addressed the topic of graphs using notes from Frances Rena Curcio, an author also used as the theoretical foundation for this SLR, as a source for their theoretical basis. The choice for Curcio is due to the emphasis given to the skills of reading and interpreting graphs by students of the same age group considered here, and the division into levels of understanding of these students.

In one of her studies, Curcio (1987) applied 12 graphs, equally distributed into bar, sector and line charts, and pictograms, each with 6 multiple-choice questions, to more than 300 students. The questions reflected three understanding tasks:

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> [...] two questions were literal (requiring literal reading of the data, title or axis label); two were comparison items (requiring comparisons and the use of mathematical concepts and skills to "read within the data"); and two were extension items (requiring an extension, prediction or inference to "read beyond the data". (CURCIO, 1987, p. 384) [i]

Lima (2019), in his study, details these comprehension tasks when citing Curcio (1989), highlighting that the first level, "reading the data", is one of low cognitive level, not requiring interpretation, as it is about reading the explicit facts from the graph. The "reading withing the data" level, in turn, requires "simple inferences". Thus, when relating the data and facts, the students exercise mathematical comparison, concepts and skills. The "reading beyond the data" level, however, requires an interpretation of the graph using previously acquired knowledge. In this case, the students expand the information contained in the graph (LIMA, 2019).

The categorization studied by Curcio (1989) might not be considered by teachers when creating and interpreting statistical graphs with Elementary School students if they are not involved in books and academic studies about this topic, which was experienced by one of the authors of this study and by close colleagues. When such knowledge is present, however, this sequence follows the step-by-step of the preparation of a class that involves the construction of graphs, for example, such as the execution of activities with the students in the classroom. Therefore, Friel, Curcio and Bright (2001) emphasize that it is necessary to properly instruct teachers so their knowledge about graphs will be enhanced, as well as on how to mediate such knowledge, to produce more materials and such that their professional teaching experiences can also help students to develop similar skills.

According to Curcio (1987, p. 382), the processing of "[...] information in our highly technological society" makes readers dependent on understanding graphs" [i], which goes beyond the mathematics covered in the classroom. It needs to connect to the world around the student so that its understanding and knowledge acquisition will be relevant, because "[...] Context is important for the comprehension of the graph, as it is for most learning" (FRIEL; CURCIO; BRIGHT, 2001, p. 152) [i]. In this sense, "[...] Elementary School children must be actively involved in the actual collection of data to

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build their simple graphs" (CURCIO, 1987, p. 391) [i]. Therefore, it can be said that applying mathematics to the students' daily lives gives a new meaning to concepts, applications and to the understanding of subjects expressed in graphs.

The above information shows that the theme is endless and, possibly, new studies may be incorporated into the development of the thesis. Still, the context presented in this article already presents the relevance of the initial and continuous training of the teachers so that they can teach graphs and help the students, spotting their difficulties.

Methodology

This section describes the studies that deal with the teaching of graphs, considering all interventions that were carried out, the materials, the technologies employed and the authors' notes after each application. The choice for this investigation is because graphs can be found in printed, digital and broadcast media, as well as being part of the school context in printed materials and tests developed to assess the learning about the topic. Graphs can also be considered in the family environment, for example, representing budget shares, through the use and interpretation of a sector graph.

In this sense, considering the diverse applications of this theme, a Systematic Literature Review (SLR), which is characterized as a planned action to answer a specific question, was chosen. The SLR uses explicit and systematic methods to identify, select and critically evaluate studies and to collect and analyze data contained in the works identified in the search (ROTHER, 2007). Similarly, for Hohendorff (2014), it is a survey of published studies, considering a specific theme while aiming to find answers to the researched questions.

Costa and Zoltowski (2014) list eight steps that guide the writing of an SLR, including: delimiting the research question; choosing the data source and keywords; and paying attention to the proposed goal. Chart 1 presents the sequence of strategies

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used in search of the materials. When it comes to investigating the teaching and learning of Statistics using graphs in Elementary Education, since its inclusion as a Block of Information Processing for mathematical content, it is important to consider the time frame that covers the publication of the National Curricular Parameters, until more recently, with the National Common Core Curriculum (BNCC, from Brazilian Portuguese "Base Nacional Comum Curricular"). Borba et al. (2011) stress that the approach to these Statistics-related contents in basic education (with students aged 6 to 17) is incipient when compared to other fields, such as algebra and geometry. In this context, the time frame from 1997 to 2021 is necessary to define which studies have been developed since the inclusion of Statistics as a curricular content in the documents that guide basic education. It should be noted that this research was carried out at the beginning of the doctoral studies and, therefore, limited to the year 2021.

For this research, articles were searched from the databases *Google Scholar* and *SciELO*, as well as theses and dissertations from the Brazilian Digital Library of Theses and Dissertations. These data sources were chosen due to information accessibility and the concentration of works developed and published in Portuguese. Having well-defined criteria allows to observe, in an initial research effort that will continue during the development of the thesis, that the employed research tools already allow the mapping of actions developed in Elementary Education regarding graphs.

The choice of the keywords was punctual, considering studies regarding **teaching** and, as defined by the National Common Core Curriculum, belonging to the theme unit Probability and **Statistics** and to the knowledge object **graphs**. For the queries, the combined use of the three keywords: Statistics, graphs and teaching, in the title or in the abstract, was adopted as a basic criterion.

Chart 1 - Detailed research stages.

Stage	Description
Theme	Study the academic production that deals with the teaching of graphs in Elementary Education
Research Question	*What do research works reveal about teaching and learning graphs to Elementary School students?*

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Stage	Description
Search strategies	
Keywords	Statistics, graphs and teaching
Level of education	Elementary Education (initial and final years)
Search tools	*Google Scholar*, *SciELO*, BDTD
Type of publication	Articles, Theses and Dissertations
Time frame	1997 to 2021
Language	Works developed/applied in Brazilian schools and published in Portuguese
Period of study	Between the months of February and May 2021 (*Internet*)
Organization and categorization of study information	Performed through reading the materials and convergences found
Data analysis	Quantitative and qualitative analysis
Use of systematic review	Literature review: initial survey of studies related to the topic of the ongoing doctoral research work.

Source: Produced by the authors (2023).

The studies were accessed through the mentioned search tools, using the keywords. Chart 2 shows the criteria for the selection, inclusion or removal of the studies, with attention to the numbering of the stages of each criterion. Thus, item (1) corresponds to the first stage of selection and inclusion of works that contain the three keywords in the title or in the abstract.

Then, the title and the abstract were read, in a stage defined in Chart 2 as (2). Studies taking place in the Elementary Education context (initial and final years), which may use computer resources or phone applications, besides investigations in the students' notebooks or textbooks which present graphs, were included. Repeated studies, studies applied to high school or higher education, studies focusing on teacher training and those taking place outside of the school environment, such as prototypes and studies linked to the areas of health or production, were excluded.

The third selection took place based on the introduction, methodological procedures and final considerations of each article, thesis or dissertation - Stage (3). Works that, in the abstract, did not clearly define the level of education or did not give enough details on the research approach during Stage (2) could be better understood in this more detailed reading. Chart 2 shows that the exclusion of works followed nearly the same criteria from stages (2) and (3).

Chart 2 - Selection, inclusion and exclusion criteria for the published studies.

Criterion	Stages	
Selection	(1). (2). (3).	search for the three keywords combined in the title or abstract: Statistics, graphs and teaching; reading of the title and abstract; reading of the introduction, methodological procedures and final considerations.
Inclusion	(1). (2) and (3).	have the keywords as defined in the search criteria in the title or abstract and; be conducted with students in the school context, with or without the use of technological resources, or resulting from the analysis of teaching materials.
Exclusion	(2), (3). (2). (2), (3).	applied to other education levels, such as high school and higher educations, linked to the area of health; other contexts outside of the school environment, such as the development of prototypes and production sector; studies focusing on new teachers and their training as a teacher, not as a student.

Source: Produced by the authors (2023).

Next, following the criteria described in Chart 2, the results of this investigation are presented. After reading the articles, theses and dissertations, pieces of information such as school year, location and developed activities were organized into charts to systematize what is being studied, followed by their details. The descriptive study is complemented with support from the software IRAMUTEQ (*>Interface de R pour les Analyses Multidimensionnelles de Textes et de Questionnaires)*, version 0.7/alpha-2, with a quantitative approach, using the Descending Hierarchical Classification (DHC) and analysis of significant words (at a significance level of 5 %), and a qualitative approach, using the word cloud generated from the abstracts of the analyzed works. For Vilela, Ribeiro and Batista (2020), the figures resulting from the word clouds allow for greater reflection on the results, since they highlight the most searched terms on websites and, as in this study, work as a tool for analyzing qualitative data returned by the software.

Results

From the criteria defined in Charts 1 and 2, Table 1 shows the quantitative of the analyzed works, considering the selection and inclusion steps detailed in Chart 2. The keywords returned 42 works from *Google Scholar*, which were reduced to 20 after the reading of the titles and abstracts. After the third stage (reading the introduction,

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methodology and conclusion), only 11 studies were considered relevant to the investigation. A similar process was followed for the articles from *SciELO* and BDTD's theses and dissertations.

Table 1 - Quantitative of the selected and included studies

Quantitative of Works	Selection (1)	Selection/Inclusion (2)	Selection/Inclusion (3)
Google Scholar	42	20	11
SciELO	07	03	02
BDTD – Theses	65	02	01
BDTD – Dissertations	249	27	21

Source: Produced by the authors (2023).

Articles, theses and dissertations were searched, as detailed in Chart 1. Considering the difference in page numbering between articles, theses and dissertations, the mapping of these studies was prepared separately, as presented below.

- General Aspects of the Selected Studies

The presentation of general aspects begins with the mapping of articles searched in *Google Scholar* and in *SciELO*. Chart 3 highlights the authors, publication date, classes considered for the study, state (when available) and how the activity application with graphs was performed.

Chart 3 - Studies (articles) highlighting activities involving graphs in Elementary Education

Study - Authors	Year(s)/Grade(s) School - State	Developed activity				
		Analysis of Teaching Mat. / Publications	Use of computer resources	Manipulable Materials	Construction of graphs	Analysis or interpretation
Scielo						
Cazorla, Henriques, Santana (2020)	Initial years Not defined			x	x	x
Lemos (2006)	1st to 4th grade PNLD* collections	x				x
Google Scholar						
Azerêdo and Arruda (2020)	3rd grade Municipal School in João Pessoa - PB				x	x

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Balbinot et al. (2020)	7th and 8th grade State School in Palmeira das Missões - RS		x	x	x	
Buehring and Grando (2021)	1st grade Not defined - SC			x	x	x
Cazorla, Utsumi, Santana (2020)	1st to 9th grades Public schools in Bahia - BA				x	x
Guimarães, Cavalcanti, Evangelista (2020)	1st to 5th grades Not defined	x			x	x
Lopes, Poffal, Meneghetti (2020)	3rd grade Municipal school - RS		x	x	x	x
Maia et al. (2020)	6th grade State School in Humaitá - AM			x	x	x
Martins, Borelli, Curi (2020)	1st, 2nd and 3rd grade State schools in São Paulo - SP	x				x
Mello, Dalcin, Nunes (2020)	7th grade Private school in Canoas - RS		x	x	x	x
Petró (2020)	8th grade Municipal School in Sombrio - SC		x		x	
Toledo and Lopes (2021)	9th grade Municipal School in Campinas - SP				x	x

* From Brazilian Portuguese "Programa Nacional do Livro Didático", or National Textbook Program.
Source: Prepared by the authors (2023).

In the analyzed materials, some authors present some considerations, including: use of technological resources as an incentive in approaching statistical graphs; use of manipulable materials; analyses focused on the construction of graphs and interpretation of results. Others focused on scientific studies or textbooks - used by educational institutions - that contain graphs. The search showed recent research works and all Elementary Education classes were covered by at least one article, with an emphasis on the initial years. Among the most used graphs, considering that the authors may have used more than one graphical representation, twelve indicated the bar chart, five included the sector chart and three showed the line chart.

Regarding the analysis of published materials, the authors investigated types of graphs contained in textbooks, students' notebooks and/or discussions that took place in study groups. Lemos (2006) analyzed the activities published in three collections recommended by the National Textbook Program (PNLD, from Brazilian Portuguese "Programa Nacional do Livro Didático"). In the 12 analyzed volumes, according to the author, the approach to information processing is far from ideal, because only one collection (three volumes) considered interpretation and construction of graphs.

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Guimarães, Cavalcanti and Evangelista (2020) compiled their own publications and those by other researchers regarding the understanding of the scales found in graphs. This work is the result of discussions and research developed in the Study Group on Teaching Statistics in Elementary Education at the university where they work. They conclude that neither the activities proposed in textbooks nor life experiences are enough to promote students' learning about scale. Therefore, systematized teaching is necessary. Martins, Borelli and Curi (2020) analyzed the activities proposed in the curricular material called Student Notebook, used by the São Paulo State Education Network in the first three years of Elementary Education. They verified that the activities, although not mainly focused on the construction of graphs and tables, are in accordance with the São Paulo state curriculum and aligned with the National Common Core Curriculum. They showed that all the situations contained in the analyzed material are linked to the family context, enabling greater interest and participation from students.

Studies that used technological resources focus on smartphone applications or the use of digital spreadsheets to create graphs with students and by students. Balbinot et al. (2020) carried out - with 7th and 8th grade students - the entire investigative process of collecting and organizing data to create graphs, using posters, colored pencils and rulers. Subsequently, students were asked to use *Google* spreadsheet on their phones to create graphs, promoting communication and socialization. For the authors, the use of playful teaching methods in the school space enables meaningful learning, even though there is no in-depth detail on students' understanding of this application. They also emphasize that the use of technology can raise students' interest in topics of Mathematics. Petró (2020), in turn, describes the stages of a practical activity that took place in the computer laboratory of a partner institution. After conceptualizing Statistics and measuring the students' heights, graphs were constructed with these measurements in digital spreadsheets. He concludes by considering that, despite being surrounded by technological devices, students were not familiar with the use of the digital spreadsheets.

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The last three columns from Chart 3 are intrinsically related. The six studies on manipulable materials indicate the construction of graphs on cardboard, the use of a round tray and pieces of EVA rubber to construct a sector chart, the handling of books or atlases (the result of interdisciplinary work with other areas of knowledge) to collect data or the printing of figures to assemble a pictogram.

In general, studies that focused on the construction and analysis of graphs based on investigation or application with students emphasize the importance of teaching Statistics from the beginning of the school life, as there is a progression of skills depending on education levels. It is necessary to consider the learning of procedures and concepts so that, later, students are able to develop appropriate instruments for research, data collection, organization, analysis, and interpretation. As an example, Azerêdo and Arruda (2020), among other reference points presented, based their application and analysis on the entire process defined by Curcio (1987), focusing on reading the data, within the data, and beyond the data. According to the authors, students have greater difficulty solving problems with implicit values in the graphs or when the exercises require resolution in the additive field. Considering the importance of interpreting graphs, Cazorla, Utsumi, and Santana (2020) emphasize that this should happen from the early grades, but they found a stagnation in this understanding in the later years of Elementary School. In this sense, Buehring and Grando (2021) describe activities involving sector charts with 1st-grade Elementary School students. Even though it is not mandatory in this age group, it can be applied and students understand these graphs. In order for students to become producers and consumers of information and critical thinkers regarding the understanding and construction of graphs, Toledo and Lopes (2021) define that this learning will only be meaningful if it is associated with the reality of the school community and begins from the early years of schooling, eliciting prior knowledge to then generate new knowledge.

To end the detailed analysis of the articles obtained in Chart 3, the results of the theses and dissertations are presented, respecting the defined mapping (Chart 4).

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Chart 4 - Theses and Dissertations highlighting activities that involve graphs in Elementary Education

Study - Authors	Year(s)/Grade(s) School - State	Developed activity				
		Analysis of Teaching Mat. / Publications	Use of computer resources	Manipulable Materials	Construction of graphs	Analysis or interpretation
BDTD Theses						
Albuquerque (2018)	1st to 5th grades Public and Private schools in Recife - PE		x		x	x
BDTD Dissertations						
Amorim (2017)	1st to 3rd grade PNLD Collections	x	x			x
Caetano (2004)	4th grade Public school in São Paulo - SP		x	x	x	x
Castro (2012)	5th grade Municipal School in Fortaleza - CE		x		x	x
Chagas (2010)	6th grade Public school in Cotia - SP				x	x
Estevam (2010)	9th grade State School in a small city in SP		x		x	x
Fernandes (2014)	4th grade Municipal school in Curitiba - PR		x		x	x
Fontana (2016)	9th grade SARESP* and SAEB** tests	x				x
Garcia (2008)	8th grade State School in Santo André - SP		x		x	x
Golfeti (2017)	1st, 2nd and 3rd grade PNLD Collections	x				x
Medici (2007)	5th grade Private school in São Paulo - SP				x	x
Megid (2002)	6th grade State School and Private in Campinas - SP				x	x
Mello (2017)	7th grade Private school in Canoas - RS		x		x	x
Moraes (2017)	9th grade Municipal School in Salto de Pirapora - SP				x	
Nascimento (2007)	5th grade State School in São José dos Campos - SP			x	x	x
Neves (2009)	5th to 8th grade Most adopted PNLD collection - PA	x				x
Pontarolo (2019)	9th grade State School in Campo de Prudentópolis - PR		x		x	x
Ribeiro (2016)	7th grade Municipal School in Curitiba - PR				x	x
Schwanck (2019)	9th grade Municipal School in Porto Alegre - RS		x		x	x
Silva (2018)	6th grade Private school in Guarulhos - SP		x		x	
Vargas (2013)	9th grade State school in Santa Maria - RS				x	x
Vasconcelos (2007)	8th grade Public school in Mauá - SP				x	x

* São Paulo state School Performance Assessment System. ** Basic Education Assessment System.
Source: Prepared by the authors (2023).

Similarly to the investigation in Chart 3, the search returned research works involving the inclusion of Statistics since the creation of the National Curricular Parameters (Chart 4). In the collected data, all school years/grades were covered in at least one research work, however, more studies were carried out in private schools than what Chart 3 shows. The bar chart stands out among the used graphs.

In the work by Mello (2017), after all research stages were detailed, *Microsoft Excel* was used as an auxiliary tool for the construction of sector, bar and line charts, checking for their relevance in terms of their use in accordance with the intended investigation. The author highlights the importance of using technological resources in order to promote interaction between students and between them and the research teacher, contributing to a more interactive class, sharing and understanding the content covered.

The teaching materials were approached in two ways. Amorim (2017) analyzed PNLD guides and textbooks from 2004 to 2016. The statistical activities proposed in the collections were analyzed in accordance with the proposal in the document from the Ministry of Education for the National Program for Literacy at the Proper Age (PNAIC, from Brazilian Portuguese "Programa Nacional de Alfabetização na Idade Certa"). The data collected from the activities were entered into a database and analyzed with the software program *Statistical Package for Social Sciences* (SPSS). Fontana (2016) and Golfeti (2017) analyzed and discussed questions containing graphs found in PNLD textbooks and/or in the tests from the Basic Education Assessment System (SAEB, from Brazilian Portuguese "Sistema de Avaliação da Educação Básica") and the State of São Paulo's School Performance Assessment System (SARESP, from Brazilian Portuguese "Sistema de Avaliação do Rendimento Escolar do estado de São Paulo"), considering the level of education. From the same perspective, but integrating mathematical contents with the environment, Neves (2009) analyzed if they were included in the most adopted PNLD/2005 book collection in the state of Pará. Despite not listing the number of questions among the 15 analyzed, for the author, those that address the topic do not achieve what is "desirable for the region". The need for questions that address tables and graphs simultaneously, allowing students to carry out conversions is, therefore, emphasized "[...] as a learning instrument and its own language, making it possible to choose which would be the best path for its implementation [...]" (NEVES, 2009, p. 122) [i].

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As for computer resources, 11 studies mentioned their use. Estevam (2010), Fernandes (2014), Garcia (2008) and Schwanck (2019) chose *Excel* or *LibreOffice Calc* spreadsheets as a support for their interventions with the students. Caetano (2004), based on the investigation by Curcio (1987) and applying activities in two groups, one of them with an intervention, created the graphs on the manipulable material called "graphics board". Thus, a piece of software in which data can be represented in three ways, the Venn diagram, a histogram and a double entry graph, was adopted as a model. At the end, the results found in these two groups are comparatively analyzed, highlighting the importance of the association between the teaching intervention and the use of manipulable materials. More specifically, Castro (2012) also focused on the proposal of an experimental and a control group (with and without an intervention), using an online *blog* as the learning object. The *blog* offered exercises with data which could be manipulated by the students to verify their adequacy in the representation of graphs and tables. The author, to study the construction of bar charts, used the *Mann-Whitney* U test to compare the results of a pre-test, confirming, in this stage, that there was no significant difference between the two groups. After the intervention, in the post-test, the experimental group showed a superior performance. The *Wilcoxon* test was also employed to compare the initial and final performance of both groups, once again emphasizing the significant performance improvement of the experimental one.

The works of Moraes (2017) and Silva (2018) did not have an exclusive application in the construction of graphs, being, therefore, a consequence of the activities developed with a focus on probabilistic literacy. Moraes (2017) carried out activities with data entry. After finishing, students had to fill out tables with the obtained results. The activity began with the manual input of the absolute frequency for ten experimental rolls of two dice, and later with *Excel*, simulating the same activity for 1000 rolls. The construction of the graphs was a consequence of the answer found in the simulation and for better understanding by the students, but only superficially. Silva (2018), in one moment of his research work, addressed probability through students' everyday situations, using dice rolls, coins and a set of balls. From these

activities, tables, charts and tree diagrams were constructed and, after the coins activity, they were requested to create a bar chart with the occurrence of events, without, however, discussing the results.

Graph construction, analysis and interpretation can be checked in the studies by Vasconcelos (2007) and Chagas (2010), who presented a questionnaire with questions and tables and/or graphs for the students to solve. These studies were carried out in two moments and the analysis of the responses occurred *a priori* and *a posteriori*. The authors considered the stages of reading the data, within the data and beyond the data from Curcio (1987), supporting the analysis of the research works cited. Megid (2002), through a project developed with students, focused on choosing the topic, preparing and applying a questionnaire, collecting responses, creating tables and graphs and publishing the results. According to the author, the research process is endless, and it is necessary to strengthen relationships with the students, listen to them and, as a teacher, "[...] abandon the routines and certainties that prevent advancements and improvements, always instigate towards the advancements, seeking to improve practice, taking advantage of every moment experienced in the life as an educator" (Megid, 2002, p. 185) [i]. A similar work was applied by Medici (2007, p. 80), highlighting that what is important "[...] is the meaning of each of the research stages, and not the calculations to construct the representations" [i]. He adds that the use of a calculator is necessary, as it allows the student to perform calculations more quickly and understand the meanings; that group work is a form of socialization; that knowledge in construction is explained and that students have their questions answered.

Furthermore, Albuquerque's (2018) research focused on teachers' mathematical knowledge for teaching the scales found in graphs. Three studies were carried out, including the application of activities to 168 students from the 1st to the 5th year of Elementary School, which is why the study was included in this analysis, as it met the criteria presented in Chart 2. The author describes that the seven activities planned and applied were correlated to the students' daily lives, considering "[...] skills and difficulties raised by the literature in the area [...]" (ALBUQUERQUE, 2018, p. 89) [i]. The data resulting from the activities were entered into a statistical program (*SPSS*).

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With the results from SPSS, Albuquerque (2018) found that the students show understanding when explicit values are in the bar chart (and pictograms) with unitary and non-unitary scales. When changed to the line chart, students from early grades demonstrated difficulties in locating these explicit values and other considerations for each of the activities carried out.

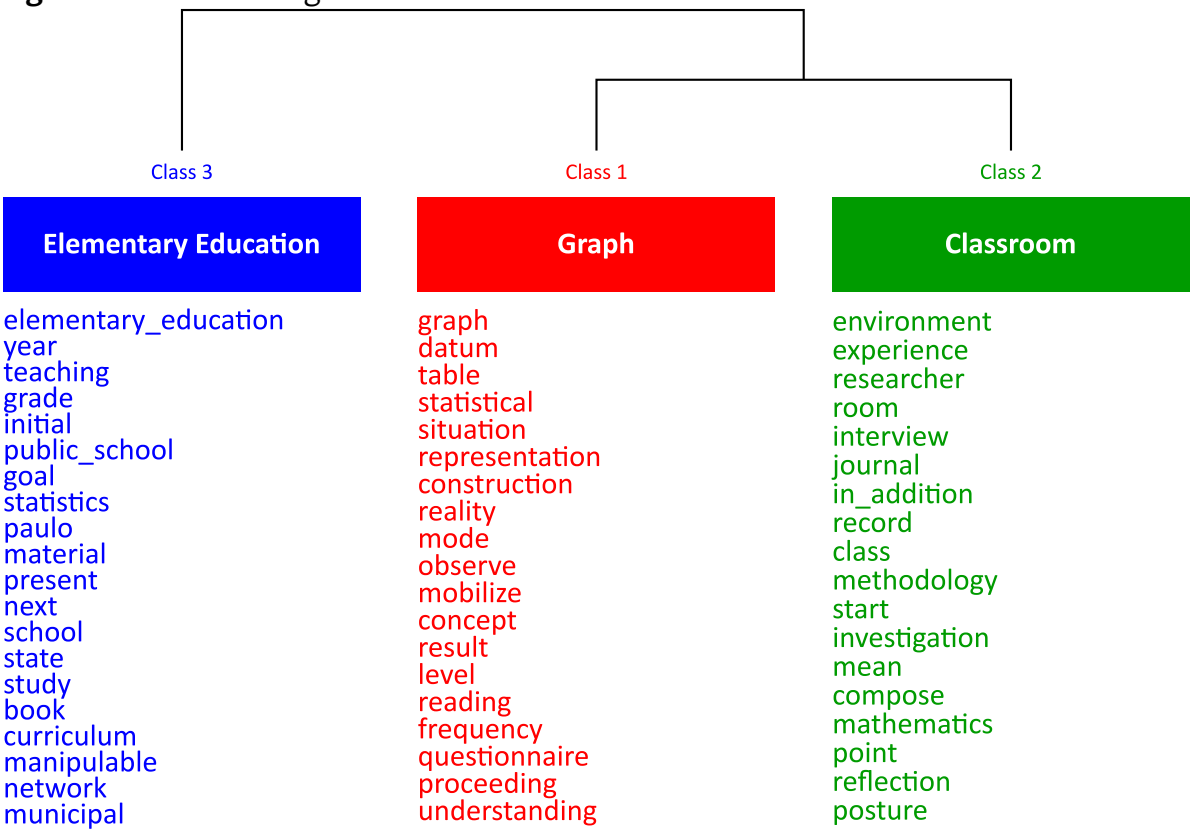
- Data analysis

From all material considered in this article, a total of 35, a *corpus* with all abstracts was created in a notepad. Given the context of the research, some words or expressions were 'unified' in this file so as not to compromise the result. As an example, we have the case of Elementary Education, which can also be written in lowercase, elementary education, which was unified as elementary_education[3], considering that it covers two stages, initial and final years, and the *corpus* includes both. The same treatment was given to pre-test, post-test, information processing, public school, and private school. Furthermore, expressions such as the National Textbook Program, National Curricular Parameters and the National Common Core Curriculum were replaced by their acronyms in Portuguese, PNLD, PCN and BNCC, respectively.

With the aid of the software *program* IRAMUTEQ, the general *corpus* was constituted by the 35 independent texts into 250 text segments (TS). 9 096 occurrences (words, modes and expressions) emerged, of which 1 907 were distinct and 1 070 appeared only once. The analyzed content was categorized into three classes based on the Descending Hierarchical Classification (DHC) of the words found in 188 TS. In the DHC, the *corpus*, with a success rate of 75.20 %, is divided into: Class 1, with 71 TS corresponding to 37.77 %; Class 2, with 28 TS representing 14.89 %; and Class 3, with 89 TS and 47.34 % of the total.

[3] In IRAMUTEQ, some words were unified with an underscore symbol so they wouldn't lose their meanings when considered individually.

Figure 1 – DHC Dendrogram: Division of content into classes.



Source: Prepared by the authors (2023).

Class 1, in red, entitled "Graph", involves concepts that refer to the activities and to the understanding of Statistics. Combining the Portuguese expressions "gráficos", "gráficas" and "gráfica", which correspond to "graphs" and "graphics" in English, the term "Graph" is found 44 times in 10 articles and 16 dissertations. One of the excerpts highlights that the students were able to give a new meaning to "[...] the process of graph construction, as it favored the mobilization of different concepts [...]" (Estevam, 2010, p. 9) [i] when using a graph construction software as part of the process. Another work evidences some gaps, such as "[...] difficulties in reading the components of the graphs, especially when they carried implicit information [...]" (Azeredo; Arruda, 2020, p. 215) [i]. The term "mode" revealed, in seven studies, how the proposed interventions combine to achieve the goals.

Class 2, in green, called "Classroom", highlights the environment in which the activities were carried out and some methodologies adopted in the studies. The expression "environment" appeared seven times in five different studies, describing the school environment as investigative and curiosity driven, or a study that analyzed,

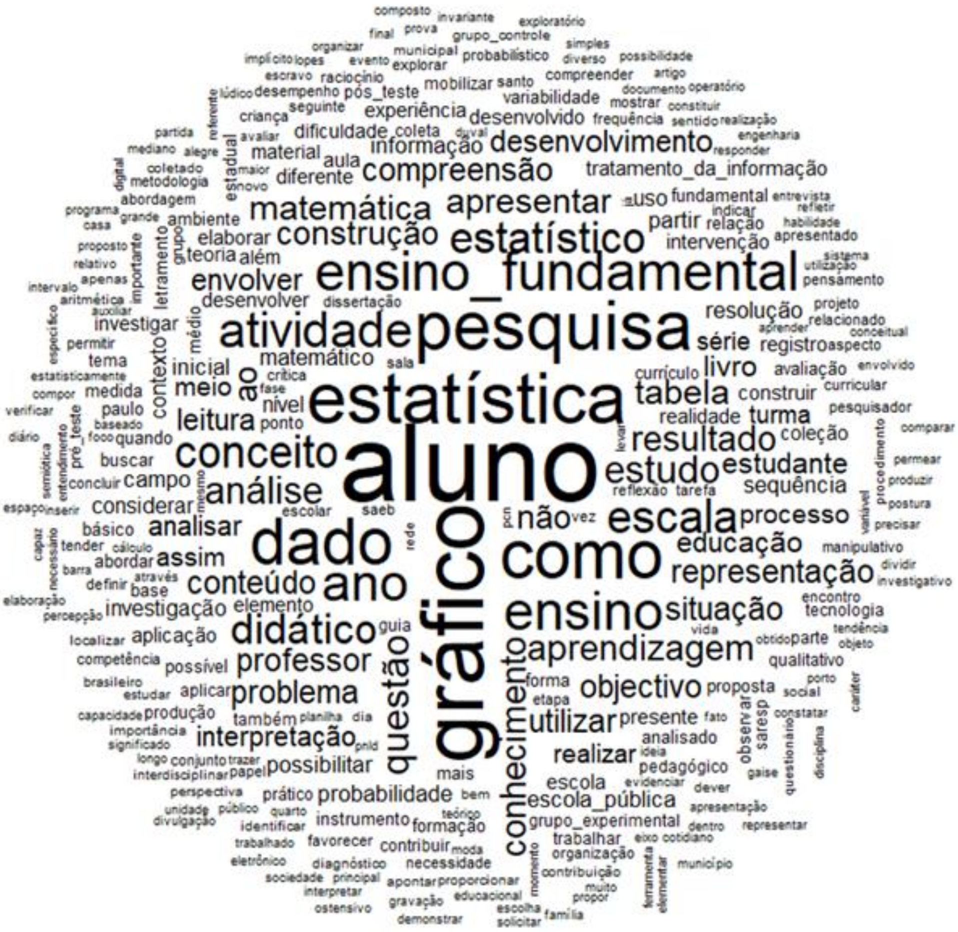
in textbooks, the environmental content associated with graphs. The terms "journal" and "in_addition", mentioned four and seven times, respectively, appeared in contexts such as Megid (2002, p. 8), when considering that "the investigation data were collected through a field journal, of audio and video recordings, interviews with students and research assistant teachers, in addition to the students' written productions, being analyzed in two categories [...]" [i]. It is clear that the first is associated with the logbook or field journal for recording and reporting the activities carried out, while "in addition" designates additional activities carried out in published studies.

Class 3, highlighted in blue, "Elementary Education", provides the level of education, grades or school years and public or private schools. The expression appears 43 times in 24 different works in the *corpus*, in contexts such as the goal "[...] is to reflect on the understanding of the students (children and adults) from the early years of Elementary School about the scales found in bar and line charts" (Guimarães; Cavalcanti; Evangelista, 2020, p. 43) [i], or "[...] analyze the impact that a study sequence, based on the teaching and learning of Statistics and Probability, can cause to the early years of Elementary School" (Fernandes, 2014, p. 7) [i]. The word "Paulo", mentioned nine times in eight studies, reveals that investigations occur more frequently in state public schools in São Paulo.

From what each Class showed, complementary to Figure 1, a word cloud was built (Figure 2). From the research question presented in Chart 1, Figure 2 shows the centrality of the word "student" ("aluno", in Portuguese), which appeared 109 times and was the most common in the analyzed *corpus*.

The keywords Statistics ("estatística"), graph ("gráfico") and teaching ("ensino"), occurring 69, 85 and 50 times, respectively, stand out next to the central word student ("aluno"). Next, the most frequent, in descending order, were: "research" ("pesquisa"), "datum" ("dado" - associated with data), "Elementary Education" ("ensino fundamental"), "teaching" ("ensino"), "year" ("ano"), "activity" ("atividade") and "scale" ("escala"). This sequence highlights the consonance of research works that deal with teaching graphs and activities developed with Elementary School students involving data collection and scales.

Figure 2 - Word cloud of abstracts considering the studies resulting from this SLR.



Source: Prepared by the authors (2023).

The word "table" ("tabela", also representing tables in plural) is found 29 times, as it is interrelated to graph-related topics, providing the data to be analyzed. Even though it is a way of representing this data for the purpose of building the graphs, the process of collecting, organizing, representing and discussing these results (which can involve an entire class) is important in the student teaching process. Furthermore, the analyzed *corpus* was composed of the abstracts of the research works, in which the authors highlight the objectives, methodology and results.

The word "teacher" ("professor"), found 26 times, associating the corresponding feminine, masculine and plural forms, reinforces that the studies focus on the investigation and the concern with activities developed in the classroom of the "schools" ("escolas") in which the authors of the articles work as teachers.

Terms which complement the activities developed in the classroom, such as "analysis" ("análise") (32), "question" ("questão") (33) and "problem" ("problema") (25), may be used by the authors in the proposed "investigation" ("investigação"), with defined "objective"(s) ("objetivo") that express "result"(s) ("resultado") on the appropriation of "statistical" ("estatístico") "concept"(s) ("conceito"), consequently, the "development" ("desenvolvimento") of students.

Finally, words such as "technologies" ("tecnologias"), "material" ("material") and "manipulable" ("manipulável"), used in Charts 3 and 4 and described in the discussions, accounted for fewer occurrences. Which does not reduce their importance in the research works, only confirming the directions given by the authors in their investigations. However, the "learning" ("aprendizagem") of "Mathematics" ("Matemática") and "Statistics" ("Estatística") in the analyzed studies is reinforced by the terms "investigation" ("investigação"), "interpretation" ("interpretação"), "understanding" ("compreensão") and "construction" ("construção").

The material proposed here must be refined and its field of investigation expanded, both during the research period and in the works published and organized in Capes' Digital Theses and Dissertations database and abroad, for example. However, this selection would require additional criteria than those established here. Still, as mentioned in Chart 1 regarding the use of this SLR, this is also the initial research for a doctoral thesis addressing the theme of statistical graphs.

As Chart 3 shows, from the 13 studies included for analysis from *Google Scholar* and *SciELO*, 12 were published during the last two years, 2020 and 2021 (considering the search period). Regarding theses and dissertations, Chart 4, investigations stand out since the inclusion of Statistics into the National Curricular Parameters, highlighting the importance of this study and that its application has not yet been concluded. Among all the materials selected, none raised considerations regarding the application and/or interpretation of statistical graphs during a pandemic. This indicates that the works were developed before the pandemic period, which is why students participated, when considered, in the application of the proposed activities. Other studies will be added to the scope of the thesis, which may corroborate the research works already listed and point to new discussions.

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Final considerations

This study had, as its guiding question: *What do research works reveal about the teaching and learning of graphs with Elementary Education students?* The objective of this SRL was to identify academic research developed in Brazil regarding the teaching and learning of statistical graphs involving Elementary School students.

As a result, we were able to identify that all classes in Elementary Education had activities with the application of the studied theme, predominantly in public schools. Furthermore, they report the use of computer resources and/or phone applications for the students to organize the data and view the resulting graphs, aiding in the understanding and discussion of results they found. In other studies, teachers chose to use manipulable materials, such as cardboard and EVA rubber. Research analyzing the topic of Statistics in textbooks was also present. However, some investigations stress that, when activities are applied to two groups, those who underwent intervention through the use of materials, both technological and manipulable, performed better than those that did not participate in the experimental activity.

Since the inclusion of Statistics as a Block of Information Processing, the National Curricular Parameters suggest schools, in the first five years of Elementary Education, develop, with the students, skills in collecting, organizing, reading and interpreting data presented in the form of lists, tables and graphs, as well as the construction of graphs and tables based on information contained in journalistic and scientific texts, among others. From the above, it is important to understand that many actions are being developed in the initial grades of Elementary Education, represented here by 44 % of the studies. Whether using simple, manipulable materials (such as cardboard and recycled materials) or computer resources (such as *Calc* and *Excel* spreadsheets or phone applications), all Elementary School grades/years were covered.

Among these works, 66 % took place in municipal or state public schools, as opposed to 11 % carried out in private schools. Furthermore, the study of graphs in

Elementary Education was performed in ten states of the Federation, with São Paulo standing out with the largest number of studies, followed by Rio Grande do Sul. Materials that assist the teacher in the training or assessment process, such as teaching materials and tests, were also considered at a percentage of 14 %. Most authors highlight that statistical research involving graphs should begin in the early years of Elementary School, be related to the students' context - considering their specificities - and that continued training should be provided to teachers who work in the classroom.

Finally, other investigations can be added. In addition to the keywords used as descriptors, other terms, such as technologies, can expand the study of graphs, indicating that the topic demands constant investigation, even expanding the search into international publications. Other questions can be added to the proposal, among them: Why is the number of studies in private schools so small? How are statistical graphs covered in the textbooks of the final years of Elementary Education? If extended to subsequent education levels, such as High School, will the search profile be similar to that presented in Elementary Education studies? These and other questions will drive reflections and discussions if contextualized with the students' daily lives, which could yield meaningful learning regarding the reading and interpretation of statistical graphs.

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