Equivalence-based instruction and the teaching of statistics: a systematic literature review

Instrução baseada em equivalência e o ensino de estatística: uma revisão sistemática de literatura

La enseñanza basada en equivalencias y la enseñanza de la estadística: una revisión bibliográfica sistemática

DOI: 10.54033/cadpedv21n2-096

Originals received: 01/02/2024
Acceptance for publication: 02/09/2024

Ailton Paulo de Oliveira Júnior
Post-Doctor in Education from the Universidade de São Paulo (USP)
Institution: Universidade Federal do ABC (UFABC)
Address: Av. dos Estados, 5001, Bangu, Santo André – SP, CEP: 09280-560
E-mail: ailton.junior@ufabc.edu.br

Diego Marques de Carvalho
PhD Student in Teaching History of Science and Mathematics
Institution: Universidade Federal do ABC (UFABC)
Address: Av. dos Estados, 5001, Bangu, Santo André – SP, CEP: 09280-560
E-mail: diego.marques@ufabc.edu.br

Priscila Benitez
PhD in Psychology at the Universitat de Barcelona and at the Centro de Investigación y Enseñanza del Lenguaje
Institution: Universidade Federal do ABC (UFABC)
Address: Av. dos Estados, 5001, Bangu, Santo André – SP, CEP: 09280-560
E-mail: priscila.benitez@ufabc.edu.br

Natália Galvão Simão de Souza
Master in Teaching History of Science and Mathematics
Institution: Universidade Federal do ABC (UFABC)
Address: Av. dos Estados, 5001, Bangu, Santo André – SP, CEP: 09280-560
E-mail: ngs.souza@outlook.com

Nilceia Datori Barbosa
PhD in Teaching History of Science and Mathematics
Institution: Universidade Federal do ABC (UFABC)
Address: Av. dos Estados, 5001, Bangu, Santo André – SP, CEP: 09280-560
E-mail: nilceiadatori@gmail.com
ABSTRACT
In this work, the objective was to systematically analyze the literature found in the world context that addressed the use of Equivalence-Based Instruction (EBI) in teaching statistical concepts at any level of education. Seventeen works were selected and the IRaMuTeQ software was used to carry out multivariate textual analysis by organizing texts that were prepared considering the focus of the research, the method used, the context in which the work was developed, the type of study and the main results and conclusions. The analysis showed the potential of using the EBI for teaching advanced concepts in Statistics (statistical inference) to higher education students. In addition, the research showed a large space to be filled by research that explores the use of teaching technologies derived from IBE associated with experimental applications aimed at teaching statistics in the context of basic education.

Keywords: equivalence-based instruction, teaching statistics, systematic literature review, multivariate textual analysis.

RESUMO
Neste trabalho, o objetivo foi analisar sistematicamente a literatura encontrada no contexto mundial que abordou a utilização da Instrução Baseada em Equivalência (IBE) no ensino de conceitos estatísticos em qualquer nível de ensino. Dezessete trabalhos foram selecionados e o software IRaMuTeQ foi utilizado para a realização de análise textual multivariada por meio da organização em textos que foram elaborados considerando o foco da pesquisa, o método empregado, o contexto em que o trabalho foi desenvolvido, o tipo de estudo e os principais resultados e conclusões. A análise evidenciou o potencial de utilização da IBE para o ensino de conceitos avançados em Estatística (inferência estatística) para alunos do ensino superior. Além disso, a pesquisa evidenciou um grande espaço a ser preenchido por pesquisas que explorem a utilização de tecnologias de ensino derivadas da IBE associada a aplicações experimentais direcionadas ao ensino de estatística no contexto da educação básica.

Palavras-chave: instrução baseada em equivalência, ensino de estatística, revisão sistemática de literatura, análise textual multivariada.
RESUMEN
En este trabajo, el objetivo fue analizar sistemáticamente la literatura encontrada en el contexto mundial que abordó el uso de la Instrucción Basada en Equivalencia (EIB) en la enseñanza de conceptos estadísticos en cualquier nivel de educación. Se seleccionaron 17 artículos y se utilizó el software IRaMuTeQ para la realización de análisis textual multivariado mediante la organización en textos que fueron elaborados considerando el enfoque de la investigación, el método empleado, el contexto en el que se desarrolló el trabajo, el tipo de estudio y los principales resultados y conclusiones. El análisis mostró el potencial del uso del IBE para la enseñanza de conceptos avanzados en Estadística (inferencia estadística) a estudiantes de educación superior. Además, la investigación ha mostrado un amplio espacio a cubrir por la investigación que explora el uso de tecnologías didácticas derivadas del IBE asociadas a aplicaciones experimentales dirigidas a la enseñanza de la estadística en el contexto de la educación básica.

Palabras clave: instrucción basada en equivalencia, enseñanza de la estadística, revisión sistemática de la literatura, análisis textual multivariado.

1 INTRODUCTION

For Fienup and Critchfield (2010), Equivalence-Based Instruction (EBI) can be an alternative for teaching statistical concepts, since Stimulus Equivalence (SE) is demonstrated by the consistent class response that arises after direct training of a series of related conditional discriminations between stimuli. Thus, learning is economized because the number of skills mastered exceeds the number explicitly taught.

According to Oliveira Júnior, Benitez and Souza (2021), research in Behavior Analysis, based on the stimulus equivalence model, has been documented with positive results for the teaching and learning of academic repertoires, considered basic, such as reading, writing and mathematics.

For Fiorentini, Arismendi and Yorio (2012), equivalence classes have been widely used to study the acquisition of categories and concepts. After learning arbitrary relationships between stimuli, new relationships are established experimentally, in an emergent manner, without direct teaching (Sidman, 1971; Sidman and Tailby, 1982; Sidman, 2000). The ability to transfer responses to stimuli within a class can be a fundamental condition for the development of symbolic behavior and thus, studying mathematical behavior.
Furthermore, considering the research area in Statistical Education, it is considered relevant to investigate the advances achieved by research that uses Behavior Analysis to teach statistical content at different levels of education and contexts. This work arises from the questioning of the current global scientific production on the teaching of statistical concepts through EBI.

Thus, the objective of this work was to systematically analyze the literature (articles published in journals and scientific events and postgraduate theses) found in the global context that addressed the use of EBI in teaching statistical concepts from elementary to higher education. The software IRaMuTeQ (R Interface for Multidimensional Text and Questionnaire Analysis) was used to perform computerized multivariate textual analysis, organizing the texts considering the following aspects: the focus of the research; the method used; the context in which the work was developed; the type of study; and the main results and conclusions.

2 THEORETICAL FRAMEWORK

Today's world, the large volume of information on social and economic issues is synthesized in tables and graphs disseminated by the media. In this context, it is essential that citizens read and critically analyze this information in order to actively participate in their personal, professional, and social environment. In addition, it is important to highlight the importance of developing individuals capable of making decisions, given that these decisions have a direct impact on the development of society.

According to Batanero (2013), the statistical sense has three components: the understanding of basic statistical ideas, the ability to analyze and the ability to reason from the data. Thus, it is necessary that Statistical Education be introduced from the first years of basic school, aiming to form concepts that help students in the exercise of their citizenship (Lopes, 2008).

Statistical Education is important not only for professionals in the area, but also for citizens in general, who need to interpret and make decisions based on information, thus being an engine of development for the country (Batanero, 2001). In this sense, Vilas Bôas and Conti (2018) state that Statistical Education
aims to understand how teachers teach and students learn, encompassing cognitive and affective aspects of teaching and learning.

In Brazil, the National Common Curricular Base – BNCC (Brasil, 2018) indicates that the teaching of statistics should be present since kindergarten, proposing the approach of concepts, facts, and procedures in everyday problem situations. The first steps in teaching statistics involve collecting and organizing data from a survey of interest to the students, as well as reading, interpreting, and building tables and graphs for data communication.

In this way, teaching statistical skills since kindergarten allows students to build a critical attitude towards the data and information present in the world in which they live (Brasil, 2018).

We agree with Guimarães et al. (2009) on the need for research that offers didactic guidelines to support teachers in teaching specific concepts from the earliest stages of teaching. In addition, it is essential to develop innovative and diversified didactic-educational resources, such as didactic supports, didactic resources, and educational media. According to Morales (2012), teaching resources are defined as the set of physical or virtual materials used to facilitate the teaching and learning process, arousing students' interest, and adapting to their physical and mental characteristics, in addition to helping to teaching activity.

Thus, within the scope of research on mathematical behavior and teaching mathematics, from the perspective of Behavior Analysis, Henklain et al. (2017) found that there has been considerable growth in research on resources/strategies that favor the teaching and learning of Mathematics in recent decades.

Several works demonstrate the effectiveness of using Behavioral Analysis strategies, based on SE, for specific contents, such as solving arithmetic problems and counting in basic education (Gualberto, 2013; Henklain and Carmo, 2013; Seabra, 2014; Garcia, 2016; Angelotti, 2016; Amaral, 2018). However, there is still great space for the development of research involving other mathematical content.
Assis et al. (2003) state that the methodology of SE studies consists of directly training a set of conditional relations that have differential consequences for correct and incorrect choices. Then, tests are applied to verify the emergence of new conditional relations. Carmo and Galvão (2000) explain that SE is a theoretical model based on three properties extracted from set theory: reflexivity, symmetry, and transitivity. This model allows predicting that a stimulus belongs to a class of equivalent stimuli based on conditional relations arbitrarily established between it and members of the class. Given its proven impact on teaching mathematical repertoires, this study investigates the validity of this model for teaching statistical elements at different levels of schooling, on a global scale.

3 MATERIALS AND METHODS

This study carried out a Systematic Literature Review (SLR), which is a secondary methodology that seeks to identify, analyze, and interpret evidence related to a research question. The SLR aims to review all primary studies relevant to a research question, in order to integrate and synthesize the evidence related to that question, using a reliable, rigorous, and auditable methodology.

This study followed the guidelines proposed by Kitchenham and Charters (2007), which consist of three phases: planning, process and reporting of results. In the planning phase, the review protocol, research questions, search strategies, inclusion, and exclusion criteria, as well as procedures for data collection and analysis were defined. In the second phase, the review protocol was performed. In the third phase, the results were reported in this scientific article.

The aim of this study was to carry out an SLR to identify the available evidence on the use of Behavior Analysis in Statistical Education at any level of education and in any part of the world. The study sought to offer a comprehensive review of preliminary studies on the subject.

To obtain the sample, the search was carried out in different online databases, following the established order of priority: (1) Periodicals of the Coordination for the Improvement of Higher Education Personnel – CAPES, (2) Brazilian Digital Library of Theses and Dissertations (BDTD), (3) Catalog of CAPES theses and dissertations and (4) Google Scholar. The keywords in
Portuguese "Ensino de Estatística" (E) and "Equivalência de Estímulos" were used together. In addition, the search was also performed in English, using the keywords "Teaching Statistics" and "Stimulus Equivalence".

The texts selected to compose the corpus should belong to the categories (a) articles published in scientific journals and scientific events and (b) theses and dissertations. The search resulted in texts only from these categories.

After returning from the studies with the search through the keyword system, the title and abstract of each work were read. The inclusion criterion adopted was linguistic, that is, texts that mention in the title or abstract that the topic was related to research on the use of EBI for teaching Statistics. The exclusion criteria were the following: (1) works not related to the teaching of Statistics; (2) works not related to teaching strategies using the EBI; (3) repeat jobs.

Thus, Figure 1 shows the flow of data collection, with the first column presenting the number of papers identified in the databases considered for this research, based on the indicated keywords, and the second column showing those that were selected after applying the inclusion and exclusion criteria.

Therefore, in the CAPES Journal Portal, of the 120 works found, only 1 (one) scientific journal article was selected. In the Brazilian Digital Library of Theses and Dissertations (BDTD), among the five works indicated through the search, a master's dissertation was selected.
In the CAPES Catalog of Theses and Dissertations, 83,468 works were initially identified. Due to the large number, complementary search filters were selected to refine the results, and only 1 work met the inclusion criteria. However, it is the same master's thesis found in BDTD.

Through a Google Scholar search with keywords in Portuguese and English, 15 works were selected following the inclusion criteria, comprising 8 articles and 7 works presented and published in proceedings of national and international scientific events.

Thus, the search resulted in 17 works that were carefully examined through the reading of their titles, abstracts, and full texts, in order to identify the proposals that used the IBE for the teaching of Statistics. The texts in English and Spanish were translated into Portuguese (Table 1).

Table 1: Identification of texts selected in the database search

<table>
<thead>
<tr>
<th>Text</th>
<th>Year of publication</th>
<th>Type of publication</th>
<th>School level</th>
<th>Country of publication</th>
<th>Title of the text</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fields et al.</td>
<td>scientific journal article</td>
<td>University education</td>
<td>USA</td>
<td>Equivalence class formation: A method for teaching statistical interactions</td>
</tr>
<tr>
<td>2</td>
<td>Fienup et al.</td>
<td>scientific journal article</td>
<td>University education</td>
<td>USA</td>
<td>Building contextually controlled equivalence classes to teach about inferential statistics: a preliminary demonstration</td>
</tr>
<tr>
<td>3</td>
<td>Fienup and Critchfield</td>
<td>scientific journal article</td>
<td>University education</td>
<td>USA</td>
<td>Efficiently establishing concepts of inferential statistics and hypothesis decision making through contextually controlled equivalence classes</td>
</tr>
<tr>
<td>4</td>
<td>Critchfield and Fienup</td>
<td>scientific journal article</td>
<td>University education</td>
<td>USA</td>
<td>Usando a tecnologia da Equivalência de Estímulos para ensinar inferência estatística para um grupo.</td>
</tr>
<tr>
<td>5</td>
<td>Fienup and Critchfield</td>
<td>scientific journal article</td>
<td>University education</td>
<td>USA</td>
<td>Transportability of equivalence-based programmed instruction: Efficacy and efficiency in a college classroom</td>
</tr>
<tr>
<td>6</td>
<td>Critchfield and Fienup</td>
<td>scientific journal article</td>
<td>University education</td>
<td>USA</td>
<td>A “happy hour” effect in translational stimulus relations research</td>
</tr>
<tr>
<td>7</td>
<td>Albright et al.</td>
<td>scientific journal article</td>
<td>University education</td>
<td>USA</td>
<td>Teaching statistical variability with equivalence-based instruction</td>
</tr>
<tr>
<td>No.</td>
<td>Author(s) or Source</td>
<td>Type</td>
<td>Title</td>
<td>Place</td>
<td>Summary</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------</td>
<td>------</td>
<td>-------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td>8</td>
<td>Oliveira Júnior et al. (2018)</td>
<td>work event</td>
<td>A resolução de problemas no ensino de estatística no ensino fundamental: contribuições da teoria antropológica do didático e a equivalência de estímulos</td>
<td>Brazil</td>
<td>The aim of this study was to examine how Equivalence-Based Instruction (EBI) has been applied in the teaching of Statistics globally. Data were analyzed through a search for studies that used the EBI in teaching statistical concepts at various levels of education. The study focused on examining how EBI contributes to problem-solving in Statistics education, emphasizing the role of didactic theory and the equivalence of stimuli. This research aimed to contribute to the development of more effective teaching strategies for Statistics in the fundamental education stage. The findings from the literature review highlighted the importance of considering the equivalence of stimuli as a basis for teaching Statistics, which can enhance students' problem-solving skills and statistical reasoning. The study recommended further research to explore the practical applications of EBI in Statistics education and to understand its impact on student learning outcomes. The conclusions emphasized the need for teachers to be well-equipped with the knowledge and skills required to effectively implement EBI in their classrooms, fostering a more inclusive and engaging learning environment.</td>
</tr>
<tr>
<td>9</td>
<td>Oliveira Júnior (2019)</td>
<td>scientific journal article</td>
<td>A resolução de problemas y la equivalencia de estímulos contribuyendo para el pensamiento estocástico en la enseñanza fundamental</td>
<td>Brazil</td>
<td>The aim of this study was to examine how Equivalence-Based Instruction (EBI) has been applied in the teaching of Statistics globally. Data were analyzed through a search for studies that used the EBI in teaching statistical concepts at various levels of education. The study focused on examining how EBI contributes to problem-solving in Statistics education, emphasizing the role of didactic theory and the equivalence of stimuli. This research aimed to contribute to the development of more effective teaching strategies for Statistics in the fundamental education stage. The findings from the literature review highlighted the importance of considering the equivalence of stimuli as a basis for teaching Statistics, which can enhance students' problem-solving skills and statistical reasoning. The study recommended further research to explore the practical applications of EBI in Statistics education and to understand its impact on student learning outcomes. The conclusions emphasized the need for teachers to be well-equipped with the knowledge and skills required to effectively implement EBI in their classrooms, fostering a more inclusive and engaging learning environment.</td>
</tr>
<tr>
<td>10</td>
<td>Souza (2019)</td>
<td>work event</td>
<td>A Equivalência de Estímulos contribuindo para o ensino de Estatística nos anos iniciais do Ensino Fundamental</td>
<td>Brazil</td>
<td>The aim of this study was to examine how Equivalence-Based Instruction (EBI) has been applied in the teaching of Statistics globally. Data were analyzed through a search for studies that used the EBI in teaching statistical concepts at various levels of education. The study focused on examining how EBI contributes to problem-solving in Statistics education, emphasizing the role of didactic theory and the equivalence of stimuli. This research aimed to contribute to the development of more effective teaching strategies for Statistics in the fundamental education stage. The findings from the literature review highlighted the importance of considering the equivalence of stimuli as a basis for teaching Statistics, which can enhance students' problem-solving skills and statistical reasoning. The study recommended further research to explore the practical applications of EBI in Statistics education and to understand its impact on student learning outcomes. The conclusions emphasized the need for teachers to be well-equipped with the knowledge and skills required to effectively implement EBI in their classrooms, fostering a more inclusive and engaging learning environment.</td>
</tr>
<tr>
<td>11</td>
<td>Oliveira Júnior et al. (2019)</td>
<td>scientific journal article</td>
<td>A resolução de problemas no ensino de estatística no ensino fundamental: contribuições da teoria antropológica do didático e a equivalência de estímulos</td>
<td>Brazil</td>
<td>The aim of this study was to examine how Equivalence-Based Instruction (EBI) has been applied in the teaching of Statistics globally. Data were analyzed through a search for studies that used the EBI in teaching statistical concepts at various levels of education. The study focused on examining how EBI contributes to problem-solving in Statistics education, emphasizing the role of didactic theory and the equivalence of stimuli. This research aimed to contribute to the development of more effective teaching strategies for Statistics in the fundamental education stage. The findings from the literature review highlighted the importance of considering the equivalence of stimuli as a basis for teaching Statistics, which can enhance students' problem-solving skills and statistical reasoning. The study recommended further research to explore the practical applications of EBI in Statistics education and to understand its impact on student learning outcomes. The conclusions emphasized the need for teachers to be well-equipped with the knowledge and skills required to effectively implement EBI in their classrooms, fostering a more inclusive and engaging learning environment.</td>
</tr>
<tr>
<td>12</td>
<td>Souza (2020)</td>
<td>work event</td>
<td>Ensino de conceitos estatísticos no primeiro ano do Ensino Fundamental: Instrução baseada em equivalência</td>
<td>Brazil</td>
<td>The aim of this study was to examine how Equivalence-Based Instruction (EBI) has been applied in the teaching of Statistics globally. Data were analyzed through a search for studies that used the EBI in teaching statistical concepts at various levels of education. The study focused on examining how EBI contributes to problem-solving in Statistics education, emphasizing the role of didactic theory and the equivalence of stimuli. This research aimed to contribute to the development of more effective teaching strategies for Statistics in the fundamental education stage. The findings from the literature review highlighted the importance of considering the equivalence of stimuli as a basis for teaching Statistics, which can enhance students' problem-solving skills and statistical reasoning. The study recommended further research to explore the practical applications of EBI in Statistics education and to understand its impact on student learning outcomes. The conclusions emphasized the need for teachers to be well-equipped with the knowledge and skills required to effectively implement EBI in their classrooms, fostering a more inclusive and engaging learning environment.</td>
</tr>
<tr>
<td>13</td>
<td>Souza and Oliveira Júnior (2020)</td>
<td>scientific journal article</td>
<td>O ensino de estatística no primeiro ano do ensino fundamental a partir da equivalência de estímulos?</td>
<td>Brazil</td>
<td>The aim of this study was to examine how Equivalence-Based Instruction (EBI) has been applied in the teaching of Statistics globally. Data were analyzed through a search for studies that used the EBI in teaching statistical concepts at various levels of education. The study focused on examining how EBI contributes to problem-solving in Statistics education, emphasizing the role of didactic theory and the equivalence of stimuli. This research aimed to contribute to the development of more effective teaching strategies for Statistics in the fundamental education stage. The findings from the literature review highlighted the importance of considering the equivalence of stimuli as a basis for teaching Statistics, which can enhance students' problem-solving skills and statistical reasoning. The study recommended further research to explore the practical applications of EBI in Statistics education and to understand its impact on student learning outcomes. The conclusions emphasized the need for teachers to be well-equipped with the knowledge and skills required to effectively implement EBI in their classrooms, fostering a more inclusive and engaging learning environment.</td>
</tr>
<tr>
<td>14</td>
<td>Souza and Oliveira Júnior (2021)</td>
<td>scientific journal article</td>
<td>Equivalência de estímulos e ensino de estatística no ensino fundamental: o documento GAISE e a formação de classes de equivalência</td>
<td>Brazil</td>
<td>The aim of this study was to examine how Equivalence-Based Instruction (EBI) has been applied in the teaching of Statistics globally. Data were analyzed through a search for studies that used the EBI in teaching statistical concepts at various levels of education. The study focused on examining how EBI contributes to problem-solving in Statistics education, emphasizing the role of didactic theory and the equivalence of stimuli. This research aimed to contribute to the development of more effective teaching strategies for Statistics in the fundamental education stage. The findings from the literature review highlighted the importance of considering the equivalence of stimuli as a basis for teaching Statistics, which can enhance students' problem-solving skills and statistical reasoning. The study recommended further research to explore the practical applications of EBI in Statistics education and to understand its impact on student learning outcomes. The conclusions emphasized the need for teachers to be well-equipped with the knowledge and skills required to effectively implement EBI in their classrooms, fostering a more inclusive and engaging learning environment.</td>
</tr>
<tr>
<td>15</td>
<td>Oliveira Júnior and Souza (2021)</td>
<td>Master's thesis</td>
<td>Abordagem baseada em equivalência e a metodologia de resolução de problemas estatísticos segundo o documento GAISE</td>
<td>Brazil</td>
<td>The aim of this study was to examine how Equivalence-Based Instruction (EBI) has been applied in the teaching of Statistics globally. Data were analyzed through a search for studies that used the EBI in teaching statistical concepts at various levels of education. The study focused on examining how EBI contributes to problem-solving in Statistics education, emphasizing the role of didactic theory and the equivalence of stimuli. This research aimed to contribute to the development of more effective teaching strategies for Statistics in the fundamental education stage. The findings from the literature review highlighted the importance of considering the equivalence of stimuli as a basis for teaching Statistics, which can enhance students' problem-solving skills and statistical reasoning. The study recommended further research to explore the practical applications of EBI in Statistics education and to understand its impact on student learning outcomes. The conclusions emphasized the need for teachers to be well-equipped with the knowledge and skills required to effectively implement EBI in their classrooms, fostering a more inclusive and engaging learning environment.</td>
</tr>
<tr>
<td>16</td>
<td>Verdun et al. (2022)</td>
<td>scientific journal article</td>
<td>Arranging peer-tutoring instruction to promote inference-making</td>
<td>USA/Brazil</td>
<td>The aim of this study was to examine how Equivalence-Based Instruction (EBI) has been applied in the teaching of Statistics globally. Data were analyzed through a search for studies that used the EBI in teaching statistical concepts at various levels of education. The study focused on examining how EBI contributes to problem-solving in Statistics education, emphasizing the role of didactic theory and the equivalence of stimuli. This research aimed to contribute to the development of more effective teaching strategies for Statistics in the fundamental education stage. The findings from the literature review highlighted the importance of considering the equivalence of stimuli as a basis for teaching Statistics, which can enhance students' problem-solving skills and statistical reasoning. The study recommended further research to explore the practical applications of EBI in Statistics education and to understand its impact on student learning outcomes. The conclusions emphasized the need for teachers to be well-equipped with the knowledge and skills required to effectively implement EBI in their classrooms, fostering a more inclusive and engaging learning environment.</td>
</tr>
<tr>
<td>17</td>
<td>Oliveira Júnior and Carvalho (2023)</td>
<td>work event</td>
<td>Abordagem baseada em equivalência e a metodologia de resolução de problemas estatísticos para o ensino fundamental</td>
<td>Brazil</td>
<td>The aim of this study was to examine how Equivalence-Based Instruction (EBI) has been applied in the teaching of Statistics globally. Data were analyzed through a search for studies that used the EBI in teaching statistical concepts at various levels of education. The study focused on examining how EBI contributes to problem-solving in Statistics education, emphasizing the role of didactic theory and the equivalence of stimuli. This research aimed to contribute to the development of more effective teaching strategies for Statistics in the fundamental education stage. The findings from the literature review highlighted the importance of considering the equivalence of stimuli as a basis for teaching Statistics, which can enhance students' problem-solving skills and statistical reasoning. The study recommended further research to explore the practical applications of EBI in Statistics education and to understand its impact on student learning outcomes. The conclusions emphasized the need for teachers to be well-equipped with the knowledge and skills required to effectively implement EBI in their classrooms, fostering a more inclusive and engaging learning environment.</td>
</tr>
</tbody>
</table>
any level of education and geographic region, using a Descending Hierarchical Classification (DHC) for lexical analysis. For this purpose, the IRaMuTeQ software was used, which improved the research through the organization of selected texts and allowed the identification of constituent elements of socially shared representations (Mutombo, 2013).

IRaMuTeQ works with initial context units (ICUs), which, in the case of this study, correspond to each selected work. The set of ICUs formed the corpus of analysis, divided into elementary context units (ECUs) for textual analysis.

For the ICUs, specific questions (SE) were proposed, who collected, organized and presented relevant information about the development of research aimed at the use of EBI in teaching Statistics, namely: SE1: What was emphasized? SE2: What is the methodology or methodological approach used? SE3: What is the context in which it is developed? SE4: What are the types of studies and areas involved? SE5: What are the main results and conclusions?

Next, we performed a DHC in order to generate lexical classes characterized by vocabulary and text segments that share the same vocabulary (Camargo and Justo, 2013). In this sense, the different classes that emerge from the text corpus represent the space of meaning of the narrated words and may suggest elements belonging to the study in question.

The set of each of the selected works was organized into a single text (corpus), each of which is defined by IRaMuTeQ as a “text segment”. The corpus was organized by command lines called “asterisk lines”, in which the text identification numbers are informed, followed by some indispensable variables for carrying out the textual analysis. In this research, the variables were coded as follows:

1. Text: text_01 and so on up to text_17.
2. Type of publication: pubType_01, articles published in scientific journals; pubType_02, works published in scientific events; pubType_03, master's thesis.
4. Educational level focus of work: pubTeaching_01, Higher Education; pubTeaching_02, Elementary School.

5. Country where the work was developed/published: countryPub_01, USA; countryPub_02, Brazil.

In addition, the texts that make up the textual corpus were configured as defined in the IRaMuTeQ tutorial (Camargo and Justo, 2013), mainly regarding accentuation, use of special characters and formatting. The procedure for organizing the command lines, for the insertion of scientific productions, can be observed in part of the fragment of the first text, translated into English:

```
**** *text_01 *pubType_01 *yearPub_01 *pubTeaching_01 *countryPub_01

The ability to manipulate, interpret, and describe data are fundamental skills needed to evaluate published empirical work, design experimental research, and function effectively in the natural and social sciences. Furthermore, these skills can improve a person's ability to understand the complex information found in everyday environments in our increasingly sophisticated world.
```

Thus, we use the method described by Reinert (1998), who proposes a CHD, aiming to obtain classes of text segments (TS) that, at the same time, present similar vocabulary among themselves and different vocabulary from the TS of the other classes.

We emphasize that the choice to use one or another analysis technique depends on the characteristics of the problem and the research objectives (Leblanc, 2015). In this sense, the researcher’s theoretical-methodological framework, plus the support of lexicometric analysis software, provide greater reliability to the inferences made in qualitative research (Justo and Camargo, 2014).

In view of this, the study presented here used the IRaMuTeQ software to enable data analysis based on lexical proximity and the idea that words used in similar contexts are associated with the same lexical world, being part of specific mental worlds or representation systems.
In this analysis, the text segments are classified according to their respective vocabulary and the set of terms is partitioned according to the frequency of the roots of the words. The system seeks to obtain classes formed by words, significantly associated with that class (significance starts with the chi-square test – $\chi^2$ – association of the word with the class).

The chi-square test is an essential analysis of the IRaMuTeQ software, as stated by Oliveira (2015). It uses correlation logic to identify vocabulary classes from segments of the textual corpus, along with the list of reduced forms and the dictionary in Portuguese. The result is a hierarchical class scheme that allows inferring the ideas conveyed by the textual corpus. This computational statistical approach applied lexically results in an accurate analysis of the processed text.

4 RESULTS AND DISCUSSIONS

When starting the analysis of the textual corpus, one of the options made available by IRaMuTeQ was the analysis of statistical data. This option revealed that the corpus is composed of 17 texts, corresponding to the paragraphs that present the specific questions (SE) related to the use of EBI in the teaching of Statistics. For this analysis, we considered the words considered active, such as adjectives, nouns, verbs, and adverbs, in addition to supplementary words, such as articles and pronouns, excluding articles and prepositions.

It should be noted that analyzes of the DHC type, in order to be useful for the classification of any textual material, require a minimum retention of 75% of the text segments, when an analysis is lower than this value, it is not considered an adequate analysis, as it offers only a partial classification (Camargo and Justo, 2013). In this sense, the textual corpus used for the analysis of the present study is considered representative and useful, as the use was 75.1%.

To create a dictionary of words, IRaMuTeQ used the chi-square test, which revealed the associative strength between words and their respective class (cluster). This associative strength was analyzed when the test indicated a value greater than 3.84, representing $p<0.0001$. The smallest chi-square value represents a smaller relationship between the variables (Lahlou, 2012). The interpretation of the results of the DHC was based on the hypothesis that
the use of similar lexical forms is linked to common representations or concepts (Reinert, 1987).

Thus, in the DHC tab of the IRaMuTeQ results, it was possible to access the phylogram (Figure 2), favoring the visualization of the main words that make up each class built by the software, which presented the partitions carried out in the corpus until the final five classes were reached. As a result, the corpus was divided (1st partition or iteration) into a subcorpus, composed of Classes 2 and 3, which represent, respectively, 14.5% and 19.7% of the textual corpus. In the second partition, the subcorpus was subdivided, being able to observe Classes 5, 1 and 4 that indicate, respectively, 19.2%, 25.9% and 20.7% of the total.

The DHC generated five classes that proved to be stable, being composed of units of text segments with similar vocabulary, containing the active forms that presented the highest frequency, in descending order, and that are significant to represent each of the subcorpus through the test of chi-square association, that is, greater adherence of them in the class and between classes, observable in the phylogram.

Taking the phylogram shown in Figure 2 (reading from left to right) we can name the five classes and describe them as follows:

1. Class 4 presents the relationship between teaching statistical inference skills and the application of Equivalence-Based Instruction (EBI) at different school levels.
2. Class 1, in turn, addresses the verification of the consistent efficiency of instructional procedures in teaching statistical concepts in higher education students.
3. Class 5 describes the application of classroom instruction programs and regular assessment activities for teaching statistics in higher education courses.
4. Class 3 is related to theoretical proposals for the use of EBI in teaching statistics in the early years of Elementary School, following the Brazilian curriculum.
5. Class 2 highlights the description of experimental data collection procedures to verify the efficiency of an instruction program, based on a
Brazilian curricular proposal and with emphasis on the formation of equivalence classes in the teaching of statistical interactions through repetition.

The highlighted words that formed the subcorpus shown in figure 2, specifically by classes 1, 4 and 5 (indicated by the colors red, blue and orange in the phylogram), indicate that five of the seven texts (2, 3, 4, 5, 6 and 16) shown in Table 1, have direct contributions from the researchers, Daniel M. Fienup, associate professor at Columbia University and Thomas Critchfield, professor at Illinois State University, both institutions in the United States. These have brought significant and lasting contributions to behavior analysis, addressing results of experimental EBI procedures for teaching Statistics, among others, mostly in applications with higher education students. Regarding the other two texts (1 and 7) identified in this subcorpus, text 1, prior to the works by Fienup and Critchfield, does not cite them and text 1 bases its theoretical framework through these two researchers.

Thus, starting a more in-depth presentation of Class 1, for Verdun et al. (2022), text 16, in the behavioral analytic literature, research in the area of EBI generally analyzes the conditions under which inferences are made or derived. EBI is based on a rich history of basic research on the SE topic (Fienup; Brodsky, 2020).

Specifically in this research, Verdun et al. (2022) selected participants from a third-grade classroom at a public elementary school outside a large metropolitan area. There was a teacher, two teaching assistants and 18 students in the classroom.
Figure 2: Classification Result by Reinert's Method: Phylogram

**Word association with class**

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

Source: Prepared by the authors based on IRaMuTeQ outputs
In addition, SE according to Verdun et al. (2022) is the study of how physically different stimuli, such as the fraction 1/4 and the decimal 0.25, begin to function interchangeably, despite there being no direct teaching. Thus, EBI is a pedagogy whereby instructors carefully superimpose stimulus-stimulus relationships that will result in the emergence of additional relationships through inferences.

In Experiment 1, two different relations were instructed. Tutor 1 taught the fraction (A)-pictogram (B) relationship, while tutor 2 taught the percentage (C)-pictogram (B) relationship. In Experiment 2, the effect of including mixed stimuli of the two relations in teaching by fellow tutors on the acquisition of trained relations, inferences (derived relations) and transfer of functions to comparative relations was evaluated. The results obtained in both experiments indicated that teachers and students learned all the relations taught and derived equivalence relations. In addition, there was a transfer of functions to comparative relations. A comparative analysis of experiments pointed out that, when designing peer tutoring instructions that promote inferences, instructors should consider the difficulty of training relationships (Verdun et al., 2022).

Fienup et al. (2009) discuss that the vocabulary of inferential statistics presents expressions that have a similar meaning, such as the low p-value, defined as $p \leq 0.05$, which indicates the statistical significance of a research result. Thus, understanding the equivalence of these ideas is essential for mastering aspects of statistical inference. In addition, the ability to discriminate characteristics of hypotheses and research results, together, is important to promote decisions to reject null hypotheses and their respective scientific hypotheses. In this context, the proposed study seeks to teach students conditional discriminations to form equivalence classes related to concepts of inferential statistics and hypothesis tests, aiming at the development of emergent relations skills that can increase instructional efficiency.

Starting from learning stimuli and the match-to-sample model – MTS (defines conditional relations between stimuli), the study by Fienup et al. (2009) presents the stimuli used and the assigned notation. Stimuli in a set were associated with each other during the study. Thus, we have the following: 1)
Lesson 1 of Experiment 1 used stimuli A (low p-value or high p-value), B (statistically significant or not statistically significant) and C (p ≤ 0.05 or p > 0.05); 2) Lesson 2 of Experiment 1 used stimuli D, E (consistent with the scientific hypothesis or not consistent with the scientific hypothesis), and F (reject null hypothesis or fail to reject the null hypothesis). In the case of stimulus D, it is described as follows.

1. Scientific Hypothesis: The Independent Variable (IV), the variable used to perform the explanation – cause of a behavior, will increase the Dependent Variable (DV), the variable being explained – cause of an effect.
   1. Results: DV increased or DV did not.
   2. Scientific Hypothesis: The Independent Variable (IV) will decrease the Dependent Variable (DV).
   3. Results: DV decreased or DV did not decrease.
   4. Scientific Hypothesis: The Independent Variable (IV) will change the Dependent Variable (DV).
   5. Results: DV has changed or DV has not changed.

In Experiment 2, students were asked to attend to stimuli A in order to make decisions about how stimuli D (representing different types of predictions about changes in a dependent variable) were related to stimuli E and F.

Thus, the results presented in Fienup et al. (2009), indicate that Experiment 1 involved the formation of two equivalence classes inspired by academic concepts. An observer of statistical inference will notice that the relationships from Experiment 1 (Lesson 2) inaccurately portray the hypothesis decision process. This lesson taught relationships that were unconditional; that is, students were taught to evaluate hypotheses based only on the correspondence between the prediction of the scientific hypothesis and the direction of effects. In contrast, the relationships involved in hypothesis decisions are conditional. They are based both on the correspondence between the prediction of the scientific hypothesis and the direction of effects and on inferential statistical information (Huck, 2000).
Subsequently, based on the limitations observed in Experiment 1, the focus of Experiment 2 was established, that is, the students learned that the D-E-F class is only valid when stimulus D is accompanied by a low p-value (stimulus A). When accompanied by a high p-value (stimulus A), an effect that matches the prediction of the scientific hypothesis (stimulus D) is inconsistent with the scientific hypothesis (stimulus E) and the occasion on which it fails to reject the null hypothesis (stimulus F). Together, these studies describe the preliminary formation of a relevant repertoire for statistical inference.

Class 1 was composed of texts 3, 5 and 7 (Fienup and Critchfield, 2010; Fienup and Critchfield, 2011; Albright, 2016), in which we will present the main aspects of this grouping of studies.

The study by Fienup and Critchfield (2010), text 3, used computerized classes based on SE principles to teach concepts of inferential statistics and decision making to university students. Participants received three lessons: the first on inferential statistics concepts, the second on how to base decisions on a scientific hypothesis, and the third on the conditional influence of inferential statistics on decisions about scientific and null hypotheses. Students entered the study with low skills in the target areas and left with a high level of accuracy, demonstrating mastery of relationships that were not formally taught. The study showed the efficiency of SE in the development of academic skills in university students.

In Fienup and Critchfield (2011), text 5, university students in a research methods course in Psychology, similar to the study by Fienup and Critchfield (2010), text 3, learned concepts related to inferential statistics and decision making, hypothetical decisions. One group received equivalence-based instruction in conditional discriminations that were supposed to promote the emergence of many untaught and academically useful skills (i.e., stimulus equivalence group). A negative control group received no instruction, and a positive control group (complete instruction) received instruction on all possible relationships (those taught and emergent not taught in the stimulus equivalence group).

On post-tests, the stimulus equivalence group performed as well as the positive control group (and both outperformed the negative control group), but those in the EBI condition achieved this result with significantly less training, thus
demonstrating its efficiency. Social validity measures indicated that participants found the instruction beneficial and as enjoyable as traditional teaching methods (Fienup and Critchfield, 2011).

Finally, in this grouping, text 7 (Albright et al., 2016), presented the results of an experiment carried out in a laboratory context with 10 university students, where concepts of statistical variability were taught. The pre- and post-test steps were performed on a computer and on paper, while the relationship training procedure was performed only on a computer.

The study by Albright et al. (2016) demonstrated that scores improved from pretest to posttest on both computerized and multiple-choice tests for all students after using EBI. Class-consistent selections were also generalized from training with new stimuli and to a new context (i.e. written test). Finally, it is concluded that this can be used to teach identification of statistical variability and that a selection-based teaching protocol administered on a computer can promote the emergence of responses to a written selection-based test protocol.

In Class 5, we initially present the study by Fields et al. (2009), text 1, which addressed the following four research questions, namely:

1. Can computer-based procedures known for forming equivalence classes with arbitrary stimuli also be used to establish classes of stimuli representing four types of statistical interaction where each class contains different representations of the designated type of interaction?

2. Would the trained and derived relations in the equivalence classes be maintained when tested in the context of new negative exemplars, a form of generalization across contexts?

3. Did the trained and derived relations in the equivalence classes generalize to new representations of statistical interactions in a new paper-and-pencil test format that contained more options than those used during class formation?

4. Would students prefer the procedure used to establish equivalence classes based on interaction (i.e., social validity)?

These questions were investigated through a pre-experimental two-group pre-test and post-test study, in which the experimental group performed a paper-
and-pencil pre-test on statistical interactions, followed by class formation training, computer-based equivalence test and then a paper-and-pencil posttest. The control group, in turn, only performed the pre-test and the post-test. The analysis of the results was carried out by comparing the scores obtained in the pre-tests and post-tests of both groups.

The four questions of the Social Validity Questionnaire provided the following average ratings:

1. “Please rate your current understanding of statistical interactions” produced a mean rating of 6 (standard error of mean – SE = 0.5) for experimental group participants and 3 (SE = 0.5) for experimental group participants of the control group.

2. “Are you satisfied with the methods used in this study?” produced a mean rating of 6 (SE = 1.0) for experimental group participants and 3 (SE = 0.33) for control group participants.

3. “Are the methods used in this study acceptable?” produced an average rating of 6 (SE = 0.66) for experimental group participants and 3 (SE = 0.66) for control group participants. Thus, participants in the experimental group reported that computer training was acceptable and effective.

4. “Is it a good goal to use effective teaching methods to teach students the concept of statistical interactions?” produced an average rating of 6 (SE = 0.5) for experimental group participants and 6 (SE = 0.66) for control group participants.

Finally, during a post-experience debriefing session, participants in the experimental group reported feeling more confident in their understanding of statistical interactions, and several students reported that they would like to see a similar teaching format used for other difficult concepts in statistics.

In text 4, Critchfield and Fienup (2010) indicate some of their other published studies (Critchfield and Fienup, 2013; Fienup and Critchfeld, 2010; Fienup et al., 2009), which addressed the teaching of inferential statistics for higher education students in Psychology. Specifically in this study, students indicated mastering some fundamental skills (conditional discriminations) that
were taught directly and, according to the generativity inherent to SE, they also began to master many other skills. In other words, students reliably learned more than they were taught. However, they consider that these results occurred in laboratory conditions in which students could work without the distraction of other people nearby and learning could be evaluated through detailed and time-consuming test batteries, incompatible with classroom routines.

The study presented in Text 4 was designed as a first step towards evaluating your statistics classes under classroom conditions, addressing two objectives to: (a) determine whether a group environment adversely affected learning outcomes using your classes, simultaneously, with a roughly equal-sized group of students in a statistics class at their university; (b) determine whether learning gains, such as those observed in controlled situations in sample-matching procedures, would be recorded on a multiple-choice paper-and-pencil exam such as those commonly used in classes.

The results of the study by Critchfield and Fienup (2010) reproduce the findings of studies in controlled situations, raising expectations that statistics classes can be used productively with students in an academic course.

In Critchfield and Fienup (2013), text 6, the subjects participating in the research were 54 students in a research methods course for second year and third-year students. Students worked in a classroom containing 30 IBM-compatible computer stations. The experimental events were controlled by a custom program created in Visual Basic®2005 (Dixon; Maclin, 2003) and executed in the operating system Microsoft Windows XP®.

The stimuli were presented on a computer screen, with text in black font inside white boxes, based on concepts of inferential statistics and hypothesis testing. During the matching attempts with the model understood in the lessons, a sample stimulus was displayed near the top of the screen, accompanied by two comparison stimuli (Fienup; Critchfield, 2013). The results of further studies suggest that our intervention has a greater potential to resist the effects of extra experimental variables. To date, no new opportunities have been identified to directly challenge the "Happy Hour" effect through other studies.
Finally, we highlight Classes 2 and 3 that bring a study by a Brazilian research group, presenting discussions and theoretical proposals on the use of the EBI for teaching statistical content present in the Brazilian curriculum for the initial years of elementary school, with emphasis on the work de Souza (2020) that generated the other four works published in national and international scientific events.

In Class 3, we have texts 8, 9 and 10, 11 and 13 by Oliveira Júnior, Souza and Barbosa (2018), Oliveira Júnior (2019), Souza (2019), Oliveira Júnior et al. (2019) and Souza and Oliveira Júnior (2020), respectively.

In Oliveira Júnior et al. (2018), text 8, it was indicated that the problems proposed in the study led to the conclusion that the establishment of equivalence relations between the different ways of presenting statistical problems may be relevant to improve the performance of students in the first year of Elementary School in problem solving, since the progressive apprehension of basic concepts of statistics reduces the effect of variables that increase the complexity of the succession of skills necessary for mastering the reading of statistical tables from the collection of real data.

Finally, equivalence relationships were established between different ways of presenting statistical problems, taking care to vary situations in the student's daily life, as a way for the teacher to lead the student to learn that the behavior (resolution strategy) presented in a given situation can be used in situations that are similar, that is, solving problems with the same form (structure) with the same strategy, and learning that the same strategies are applicable in situations in which the same problems are presented in different formats (Oliveira Júnior et al., 2018).

Oliveira Júnior (2019), text 9, highlights the search for new teaching methods that can promote student development. In order to contribute to the teaching and learning process of statistics, the author used the Problem-Solving Methodology, based on SE, to subsidize the teaching of statistics in the early years of Elementary School. Teaching curricular units were designed to develop and fix statistical content from the first to the fifth year, providing operational criteria to specify symbolic behaviors.
The SE is a theoretical model that allows predicting that a stimulus belongs to a class of equivalent stimuli, where these are interchangeable based on conditional relations arbitrarily established between it and one or some members of the class (Oliveira Júnior, 2019).

Text 10 by Souza (2019) is related to the work by Souza (2020), where a theoretical-conceptual discussion was presented that provided advances in the area of Statistical Education and Behavior Analysis, through the establishment of a relationship between the model of the SE and the methodology for solving problems in the teaching of Statistics proposed in the North American report entitled Report of Guidelines for the Evaluation and Instruction in Statistical Education (GAISE I): a Curriculum Structure for Basic Education, prioritizing the objects of knowledge and the skills present in the BNCC (Brasil, 2018) for the first year of Elementary School.

In Oliveira Júnior et al. (2019), text 11, presents the theoretical foundation used to create problems in the teaching and learning process of statistical contents of the 1st year of Elementary School, following the principles of the Anthropological Theory of the Didactic – ATD, in the praxeological organization didactics and mathematics (statistics) and SE, to elaborate small teaching units, describing a simple repertoire to be taught and progressively increasing the complexity.

Based on these assumptions, the elaboration of subtasks was presented, addressing the need to apprehend the nomenclature and visual representation for tables and the reading of simple column tables and the collection and organization of information suggested by the BNCC. It is believed that using problem solving as a teaching methodology is an interesting way of presenting basic statistical concepts, as it allows them to be presented in an attractive way and favors creativity in the elaboration of resolution strategies and search for solutions (Oliveira Júnior et al., 2019).

Souza and Oliveira Júnior (2020), text 13, consider that from the studies carried out in the elaboration of this work, that teaching through EBI can provide students with the opportunity to develop skills and learn conceptual relationships that were not directly taught, increasing the teaching efficiency. From this, this
work provides the beginning of the process of elaborating a teaching program that will be applicable in future experiments to verify the effectiveness of SE for teaching statistical content related to this stage of Basic Education.

Finally, in Class 2, we have texts 12, 14, 15 and 17 by Souza (2020), Souza e Oliveira Júnior (2020, 2021), Oliveira Júnior e Souza (2021) and Oliveira Júnior e Carvalho (2023), respectively.

Souza's work (2020), text 12, master's thesis that generated the works of this second subcorpus, considered that the teaching of statistics should be based on problem solving methodology, not just about information, calculations and technical models. This methodology is aimed at developing the student's reasoning, encouraging him to find the best possible solution and through this the student can solve problems of his daily life and prepare for future situations.

Texts 14, 15 and 17 (Souza and Oliveira Júnior, 2020, 2021; Oliveira Júnior and Souza, 2021; Oliveira Júnior and Carvalho, 2023), in addition to text 12 by Souza (2020), had the general objective of building a theoretical discussion-conceptual that would provide advances in the area of Statistical Education and Behavior Analysis, establishing a relationship between the SE model and the methodology for solving problems in teaching statistics proposed in GAISE I, prioritizing the objects of knowledge and skills present in the BNCC for the first year of elementary school.

By relating the GAISE I report, prepared in the United States, with the objects of knowledge and statistical skills present in the BNCC for the first year of Elementary School, it was possible to propose a study on the formation of classes of equivalent stimuli, consisting of a pre-test, teaching, post-testing and generalization. This proposal considered the four components of the GAISE I problem solving methodology as four different classes of stimuli, using the formation of equivalence classes to elaborate a teaching program. The use of SE as a teaching method can provide students with the development of skills and the learning of conceptual relationships, increasing the efficiency of teaching. A teaching program was presented for future experiments in order to verify the effectiveness of SE for teaching statistical content in Elementary School, as well
as to discuss the limitations observed in the formation of basic education teachers and in the curricular guiding documents.

5 FINAL CONSIDERATIONS

Starting from the question about the current global scientific production on the teaching of statistical concepts through EBI, searches were carried out in important global online databases that identified its use in different levels of education and countries, identifying 17 works that use it for teaching Statistics, from primary to higher education.

From the analysis of the set of works, it was possible to identify the following aspects:

1. In Brazil, investigations focus on a group of researchers linked to a federal university in the state of São Paulo. Furthermore, it is associated with the National Institute of Science and Technology on Behavior, Cognition and Teaching (ECCE) which researches the learning of symbolic and conceptual relationships, as well as their precursors, and the implications of learning these relationships on behavior.

2. In the rest of the world, the investigations are directly associated with researchers Daniel M. Fienup and Thomas Critchfield, professors at higher education institutions in the United States. The researchers are behavioral science specialists with an interest in education and educational performance, including the design and evaluation of instructional variables that lead to positive educational outcomes.

According to the results obtained, the inventoried works offer important elements to understand the importance and contribution of the use of EBI for teaching statistics in different levels of schooling and contexts.

Outside Brazil, the potential academic benefits of SE in relation to statistical concepts were recognized in early investigations as interaction effects in factorial research (Fields et al., 2009) and brain-behavior relationships (Fienup et al. 2009). Next, we sought to teach concepts of inferential statistics and hypothesis testing in decision-making in higher education (Fienup et al., 2009; Critchfield and Fienup, 2010, 2013; Fienup and Critchfield, 2010, 2011) and in
basic education (Verdun et al. 2022), in which students consistently mastered more relationships than they were directly trained. Unlike these works, Albright et al. (2016), still in higher education, addressed concepts of statistical variability.

Regarding international research, it was observed that studies show positive results for the use of EBI in higher education, however, there is a gap with regard to experimental research on teaching statistics through the formation of equivalence classes in basic education.

In Brazil, the objective was to relate the SE model to the methodology for solving problems in teaching statistics proposed in the GAISE I report by Franklin et al. (2007), prioritizing the objects of knowledge and statistical skills present in the BNCC (Brasil, 2018). The investigation provided definitions and initial guidelines for planning a teaching program that is applicable in future experiments to verify the effectiveness of SE for teaching statistical content related to this teaching stage.

The Brazilian research offers a significant contribution to studies on the validity of using the EBI approach for teaching statistical concepts, in addition to bringing reflections on the training of teachers who teach statistics in basic education, with the aim of providing useful guidelines for its practical performance and the proposition of structured strategies for teaching these contents.

Considering the results obtained in this research, it is believed that they can help in the development of new studies as they indicate how EBI is used to support the teaching of statistics in the world, as well as its advances (there are studies carried out since 2009 in the States United States and 2018 in Brazil) and weaknesses, such as the lack of studies in the area, in addition to few works focused on basic education.

It is crucial to develop studies that assess the effectiveness and adaptability of teaching statistics with EBI for basic education students, starting with the initial years of elementary education. This initiative can be driven by the results obtained at other levels of schooling and stimulate new lines of research in Brazil and in other parts of the world.

Thus, it is recommended that future work relate the EBI to the problem-solving methodology in teaching statistics proposed in the North American
documents Guidelines for Assessment and Instruction in Statistics Education (GAISE I) Report: A Pre-K-12 Curriculum Framework (Franklin et al., 2007) and GAISE II (Bargagliotti et al. (2020), prioritizing the objects of knowledge and skills present in the BNCC (Brazil, 2018) for students between 6 and 10 years old.

Another aspect that can be addressed refers to the fact that no work identified in this study is focused on teacher training or that the teacher can analyze the potential of these teaching procedures in their daily practice, considering that the equivalence of stimuli is an alternative and viable for teaching statistics in the school context.

Another point referred to the measures identified in studies that involved only the correct and incorrect performance of students in the proposed experimental tasks, recommending the use of additional measures that can complement understanding beyond correct and incorrect results in the statistical task.
REFERENCES


ANGELOTTI, Vanessa Cristina. *Ensino informatizado de frações a crianças surdas e ouvintes por meio do paradigma de equivalência de estímulos*. 2016. 61f. Dissertação (Mestrado em Educação Especial) – Centro de Educação e Ciências Humanas, Universidade Federal de São Carlos, São Carlos, 2016.


SEABRA, Diego Felipe Silveira. Relações de equivalência entre elementos de funções do primeiro grau para alunos do Ensino Fundamental. 2014. 50 f. Dissertação (Mestrado em Psicologia) – Centro de Educação e Ciências Humanas, Universidade Federal de São Carlos, São Carlos.


SOUZA, Natália Galvão Simão. A Equivalência de Estímulos contribuindo para o ensino de Estatística nos anos iniciais do Ensino Fundamental. In: Encontro...


