READING AND WRITING THE WORLD WITH CHILDREN: STATISTICAL THINKING AND MULTIVARIATE DATA

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ABSTRACT

This article reports on research in which a teacher and researcher from a Brazilian public school conducted civic statistics teaching practices with multivariate data, based on Engel's (2017) and on Freire's (1989) reading of the world. The research with seven- and eight-year-old children illustrates the complexity of statistical thinking that starts from examining real data from the virtual comparison tool Dollar Street on how people live in the world. The aim was to understand how children invest in a multivariate dataset of images, texts, coded symbols, and locations to draw conclusions about reality. During the progression of the research, the broader issue of promoting the learning and use of statistical language was encountered. The outcomes highlight the potential for using multivariate data from meaningful contexts and personal experiences to expand young children's awareness of themselves and of the world through statistics.

Keywords: *Statistical education research; Civic statistics; Multivariate data; Childhood*

1. CONTEXTUALIZING STATISTICAL LITERACY IN BRAZIL: AN INTRODUCTION

Today's society runs on data. Citizens, social organizations and governments make predictions, base their choices and justify their actions on statistical data. A plethora of serious information, as well as fake news and misrepresented facts are available to everyone on the computer network. This has lead to the increased need to educate critical readers, consumers and producers of statistics, who connect data with the reality they see and read the world with data, aware of its consequences.

Since 1997, Brazil has included Statistical Education in its curricula; teachers and specialists have sought to adapt their teaching materials and learning plans for this purpose. Commonly seen in school, however, is that statistics is reduced to the reading of graphs and tables that are presented ready and out of context. For Watson (2006), these graphs and tables have a quick passage through classrooms, as they appear, disappear and are considered as "data content."

Watson (2006) said that statistical literacy goes beyond school curricula, because it is embedded in a complex construction that unites alphabetization skills, critical thinking, contextual understanding, and motivation to embrace the data and make decisions. For statistics to be introduced in teaching practices, in this perspective, it is necessary that teachers recognize statistics as a possible instrument of reading and transforming action in the world. In this movement, statistics are part of the knowledge of a literate society that is aware of its own world. Therefore, it is urgent that statistical literacy takes place from childhood, along with learning the first letters of the alphabet, because "students do not become critical thinkers overnight. First, they need to learn to accept the joy and power of thinking itself" (hooks[1], 2020, p. 33). Thinking first involves discovering the "who", the "what", the "when", the "where" and the "how" of things, what happens through readings.

[1] bel hooks (1952–2021), American writer, chose to use her artistic name in lower-case letters over a political position, which was aimed to break with linguistic and academic conventions.

According to Freire (1989), reading the world precedes reading the word and reading the word modifies reading of the world. In his conception, *alphabetization* relates to a set of things that are part of a society that uses letters and numbers. For a long time, in Brazil, the word alphabetization related to consciousness, because for Freire, "alphabetization and awareness are never separated" (2020, p. 11). In keeping with Freire's definition, alphabetization is related to the understanding of the deep and contextualized meaning of the read and written word, which cannot be taught through mechanical repetition of syllables and meaningless sentences.

In Brazil, and universally, educators realize that the word alphabetization could bring other meanings that are not always linked to reading the world. Alphabetization could be synonymous with decoding of symbols, characters, and numbers (Brandt, 2009). After all, a person who knows how to sign their name is considered literate, and this is very different from Freirean alphabetization. After 1980, because of globalization and the influence of other languages and authors, in Brazil, a new word for this Freirean sense of alphabetization emerged, which was *literacy* (Soares, 2004). Discussions about the introduction of the new word, literacy, gained strength and became popular among teachers from 1990. In 2004, Soares distinguished alphabetization from literacy, advocating that schools should alphabetize from the perspective of literacy. Thus, *alphabetized* was the individual who knew how to read and write, who was no longer unalphabetized. *Literate* is the state or condition assumed by someone who knows how to read and write, implying "social, cultural, political, economic, cognitive, linguistic consequences, whether for the social group or individual who learns to use it" (Soares, 2004, p. 17). Alphabetizing from the perspective of literacy means teaching the techniques necessary for the decoding of reading and writing with the perspective of making this act an insertion in the written culture. "Alphabetizing by lettering" is more than decoding letters, sounds, numbers and quantities; it means taking written culture into the act of literacy, or literacy within written cultural practices. In support of this view, Street (2013) noted literacy "not as an issue of measurement or of skills but as social practices that vary from one context to another" (p. 21). For this paper, the authors refer to the autonomous model of literacy (Street, 1997), in which literacy is a neutral technique that can be applied in all social aspects and cultural contexts with generally uniform effects.

Today in Brazil, *letramento* (Brazilian word) is understood to be much more than a direct translation of literacy. It was a movement that took place because of Freire's ideas about reading the world, which prompted a review of old meanings based on a new word (Soares, 2004). The deep, historical and cultural meaning of the Brazilian word letramento, was demarcated and included in the dictionary. This did not end the discussions that continue nowadays, and it is in this context that we look at "statistical literacy" without intending to qualify literacy or literacies but understanding the necessary dimension of statistical education for the literate person.

2. CIVIC STATISTICS

With the goal of wanting to support children's development of active citizenry, it is important to think about the nature of the statistical experiences to provide to children at school: mechanical repetitions with organized and plastered data or data in dynamic contexts in multiple meanings? Children are part of society and relate to information and data. In this way, they have the right to learn, from an early age, the statistics of the real world with multivariate and connected data, because it is in this world that they live and is where they need to find and understand their place. This demands from them a movement of statistical thought that is much more complex than what some statistics education in schools provoke.

The enactment of statistical thought and ideas in relation to the world beyond schooling is referred to as *civic statistics*.

> Civic statistics, which focuses on understanding statistical information about society … involves understanding evidence about key social phenomena that permeate civic life in many areas such as migration, unemployment, social (in)equality, demographic changes, racism, crime, poverty, access to services, health, climate change, education, and human rights. (Engel & Ridgway, 2022, p. 21)

Active citizenship occurs when people are "empowered to study evidence-based facts and that has the capacity to manage, analyze and think critically about data is the best remedy for a world that is guided by fake news or oblivious towards facts" (Engel, 2017, p. 45).

From a very young age, children learn to understand the world around them. Therefore, even before learning to read and write words and sentences, children are already reading, for better or worse, the world around them. But the knowledge they gain through practice is not enough. There is the need for them to go beyond practice. Children, and indeed all citizens, need to know better the things that are already known and to learn other things still unknown (Freire, 1989).

Through data organization and comparison, children can come to understand how their world works and how societies are organized. In civic statistics, there is the potential for reading the world and the word from the Freirean perspective of literacy/alphabetization. For Engel (2017), an enlightened citizenship education based on analysis and critical thinking about evidence is the best remedy for a world driven by fake or non-factual news. That is why today, more than ever, knowing how to choose information and understand the source and the truth of the data collected are basic literacy issues. Also, being able to act based on the data becomes imperative to ensure active citizenship becomes a way of existing in the world so that positive change can be realized. For example, Souza et al. (2020) illustrated how students investigated the food wasted in their school canteen and used the data collected to put a case forward for making changes to the menu, and Makar et al. (2023) illustrated how students used data from a cyber-space investigation to provide advice to their peers about how to respond when they receive messages that include abusive language.

From this perspective, we developed longitudinal research on the movement of statistical thinking in childhood, seeking to understand children's paths in developing statistical literacy and aiming to develop tools that allow students to expand their understanding and awareness of the world from multivariate data, improving thinking and vocabulary (Buehring, 2021). In 2019, we monitored a group of students aged seven and eight years old in the process of learning to read and write in their mother tongue. The researcher herself worked as a class teacher and the research data consisted of audio and video recordings, the researcher's field diary, and students' written productions.

Initially, the children demonstrated the need to talk about the place where they lived: their house, their street, their neighborhood. In addition, they showed interest in working with computers. Although many Brazilian schools have computers, they are not always used or are underused in the pedagogical context. This is due to several reasons such as obsolete computers, lack of technical support, teachers with little familiarity with technology and slow internet. Aware of this, we looked for teaching possibilities with a web database accessible to children that would allow them to know more about the way people live in the world. In this way, the *Dollar Street* (Gapminder, 2020) database met what we were looking for.

3. MULTIVARIATE DATA AND THE STATISTICS TAUGHT IN SCHOOL

Free access to information and the possibility for anyone to publish all kinds of content can be advantageous. At the same time, it can make life complicated, because it is necessary to select relevant data, to know the source and to contextualize its intentions in its historical and political context. Unfortunately, large amounts of data do not guarantee the quality or integrity of the information reported from the data, nor does it guarantee understanding better issues society encounters. False or misleading use of data and information may cause the de-structuring of beliefs, or even put lives at risk. An example of this was the COVID-19 pandemic, which killed more than 631 thousand people in Brazil in 2020 and 2021. One of the reasons for so many lives lost was the delay in implementing preventive measures caused by the acceptance of fake news reports (Szwarcwald et al., 2022).

Understanding the impact of issues facing society, such as housing and living conditions, requires the capacity to use statistics to explore complex sets of multivariate data, which include factors, influences, causes and consequences that cannot be understood in isolation. It is, therefore, necessary to be open to the world, to read it in its multifaceted characteristics (Engel & Ridgway, 2022). This complex information does not resemble data presented in the graphs and tables taught at school or in the textbooks organized in a few columns and rows for horizontal and vertical reading, or in perfect circles charts with well-defined edges and slices. It is becoming increasingly obvious that linear statistics analyses using graphical representations positioned on x and y axes or using data organized in

a table with a small number of rows and columns often taught at school, is not keeping up with the way in which statistics are presented todday. Statistics presented online show data in image, location, movement, and time that shock, convince and ask for action. Thus, the reality of multivariate data present in today's world, calls on educators to teach students to read the type of information that appears on the web, which can have a variety of formats: images, text, sounds, dates, coded symbols and locations (Engel, 2017). So, what statistics are we teaching our students? It is important that the statistics we teach at school serve so that people can live a better life, while remaining conscious of themselves, of their choices and their reality?

In recent times, the use of multivariate data has been advocated for teaching statistics at the secondary level of schooling (e.g., Kazak et al., 2023). Progress, however, has been made in the advancement of using messy multivariate data sets with elementary students (e.g., Makar et al., 2023). Cleaning, transforming, and structuring data are necessary skills, but these are not always taught in the traditional classroom (Engel, 2017) or acknowledged in the curriculum (Makar et al., 2023). Still, a critical attitude towards the source of the data and its form of collection and presentation is necessary. It is desirable children ask questions like: Why were these data presented in this way? What does this type of presentation want to show us? How were the data collected? What was the source of the information? Why are the data being presented at this historic moment, via this vehicle of information? A major challenge to overcome is finding multivariate datasets that are accessible to young children. This conundrum was addressed in this research by accessing *Dollar Street* (https://www.gapminder.org/dollar-street/matrix).

4. *DOLLAR STREET:* A MULTIVARIATE DATA SOURCE

Dollar Street is a curated data set of images of household items and demographic data such as region, country and home monthly income (USD) from around the world. It is one of the tools available on the *gapminder.org* website, freely accessible at https://www.gapminder.org/dollar-street/matrix. It was created by the Swedish Anna Rosling Rönnlund to show how people live in the world at different income levels, using photographic and video images. The images are organized in an unusual design (Figure 1): a horizontal street, on which 264 houses from 50 countries are arranged, with a sample of people from all over the world living there. In each house on the street "lives" a family and the neighborhood is determined by family income regardless of geographic location: at one end of the street live people with lower consumption power, at the other end live people with higher consumption power. It is up to the user to choose which houses to visit.

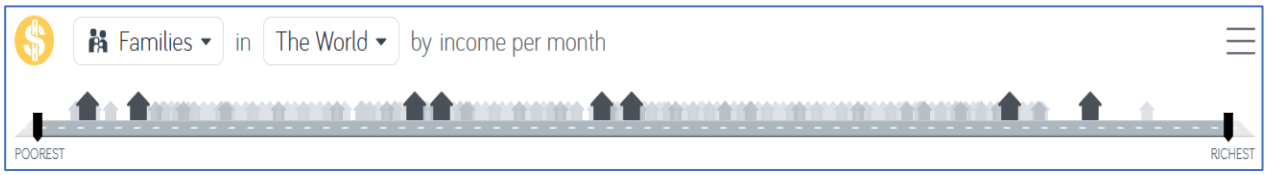


Figure 1. Dollar Street (https://www.gapminder.org/dollar-street)

When choosing a house to visit, it is possible to see up to 135 photos of different categories of objects in the house, such as bed, sofa, bathroom, toothbrush, cutlery, meat, toys, pets, among others. It is also possible to choose a category of household items (Figure 2), which are classified by country, continent and income. The database provides automatic translation into several languages (including Portuguese) and works with icons to identify categories, which allow children, even if they are not alphabetized, to explore it. There is also a map where you can choose the place to visit (Figure 3).

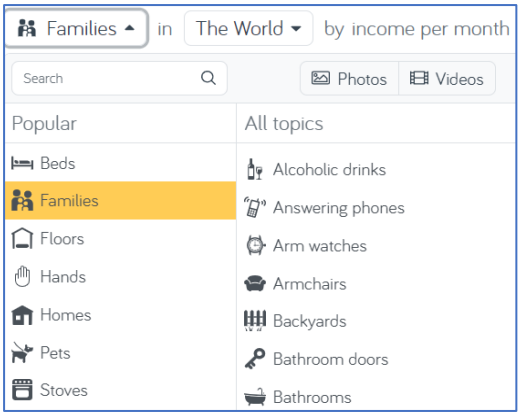


Figure 2. Some of the Dollar Street categories (https://www.gapminder.org/dollar-street)

Figure 3. Map location (https://www.gapminder.org/dollar-street)

Dollar Street's data are organized to focus on consumer power, bringing to the fore that income is a determining factor in people's ways of life, more than their location in the world (country, continent). This is made possible by the volume of data available. Despite the direction, the readers make their own observations and comparisons, and establish their focus of attention, which results in personalized readings of varying nature.

Dollar Street gives the impression of being in front of a window to the world because it gives an external view to see regular people in other countries doing simple things in their daily lives. The surprise caused by the encounter with the other is inevitable, because maybe people who are very distant geographically are not strange in some ways and are totally exotic in others. Factual data such as cooking, drinking, sitting on the sofa, pressing a button to turn on the light or to turn on a faucet, show characteristics of people's lives and what their needs are. The reading of *Dollar Street* depends a lot on the reality of the person who reads it and that is why, while looking outside, an inward window is opened, which allows readers to understand themselves. Looking at the way little things that are dealt with daily, can help to know and appreciate how people live and find their place in the world (on the street). Having or not having resources (money) makes human beings different from each other and widens the social chasms created by capitalism that separate people. Insights from *Dollar Street* images, along with income and location information, are statistical data that tell stories that become intertwined with the lives and the contexts on display and those of the reader.

Rosling et al (2020) asserted people have the impetus or even the instinct of separation, to understand the world by the extremes, in a dichotomous way, between rich and poor, eastern and

western, developed and developing, or even "us and them". These kinds of separation give a distorted view of the world. Today, we cannot think that a person lives in this or that way because of their geographical location, but because of their consumption power. The tools available on *Gapminder* (https://www.gapminder.org), including *Dollar Street*, have the potential to make people realize that these simplifications, though necessary, can be misleading. Care must also be taken with the use of averages because they can lead to dramatic or extreme comparisons. According to Rosling et al (2020, p. 52), "most [people] usually find themselves in the middle and tell a very different story." Indeed, Siegle (2021) suggested *Dollar Street* has the potential to challenge global stereotypes. Gaviria Rojas et al. (2022) also confirmed the balanced view presented by *Dollar Street* through comparison with other data sets. They suggested "the *Dollar Street* dataset is a step forward toward being more inclusive of the rich socioeconomic and geographic diversity that is present in the world" (p. 10) by including images of household items from lower-income homes from often underrepresented populations.

5. RESEARCH OF THE PRACTICE: METHODOLOGY AND TEACHER LEARNING

The reality that surrounds data published in the media can maintain or exacerbate the complexities and inequalities present in the lives of children. This affects them, because it is in this environment that they experience relationships with the world, try to read it, understand how it works, and find their own place in it. But being able to experiment with multivariate data with children in the classroom, teachers and researchers need to be able to read data in a critical and personalized way, to be able to see new possibilities of reading the world. This demands they position themselves in the place of the other as an imbedded, internalized, and embodied gesture (Rinehart et al., 2014). Therefore, the research reported in this paper adopted an interpretivist paradigm and was ethnographic in nature (Mackenzie & Knipe, 2006). It involved the lived experiences of the children and their teacher (first author) as the potential of *Dollar Street* as a multivariate data set for young children was explored. The research setting was the regular classroom, which made the study a naturalistic inquiry with the teacher taking on the roles of teacher and researcher.

Cochran-Smith and Lytle (1999) argued that teachers who research are theorists connected with their own practice and they place themselves in a different position because they problematize their own knowledge. It is about the production of local knowledge, of those who are "inside" and are capable of reformulating models based on the analysis of practice. Cobb and Steffe (1983) maintained that "there is no substitute for experiencing the intimate interaction involved in teaching children" (p. 19) and assert that "the activity of exploring children's construction of mathematical knowledge must involve teaching" (p. 20). Although there are disadvantages in terms of introducing personal bias, which may influence the interpretation of experiences, the benefits are associated with the ability to collect and analyse rich descriptive data that illuminates student learning and teaching practice set within cultural contexts and assists with avoiding misunderstandings (Higgins, 2018). Roberta (first author) was the class teacher of 23 children (7–8 years old) at a regional elementary school in the South region of Brazil. She collected data by carrying an audio recorder in her pocket and keeping a field diary. Also, a fixed camera was placed to capture the total image of the classroom. Meanwhile, a fellow researcher filmed the lessons focusing on small groups or conversations between the children and the teacher. The work students produced was also collected.

The research focus was on understanding how children invest in a multivariate dataset of images, texts, coded symbols, and locations to draw their own conclusions about reality. To make it possible, the teacher connected with and engaged the children through dialogue, approaching data collection in a dialogic way (Freire, 1987) with a common objective of reading and better understanding the world through statistics. The student learning goals were:

- to understand what data are, where data comes from, and what data are for;
- to know how to ask a question;
- to make comparisons;
- to use statistical language;
- to be a multivariate data reader;
- to use data lenses;
- to deal with data in a contextualized way, in different dimensions;
- to use math skills to read the data;

- to use probabilistic ideas to read the data (even if intuitive, subjectivist and frequentist);
- to understand themselves as capable of expressing themselves in relation to statistics; and
- to be willing to analyze data critically and actively.

This pedagogical path provided the direction of the classroom investigation. The *Dollar Street* tool was used as a starting point for children to see and explore different realities of life in the world, establishing similarities and differences, possible and improbable material situations in the daily lives of people in the world. Although the learning pathway was organized, it was flexible enough to respond to potential surprises and necessary changes that arose from the classroom. Data, forms of records and their readings are culturally and socially produced and can change according to people's needs and creativity. Throughout the learning experience, the teacher-researcher was attentive to new perspectives that emerged and ensured the dialogue was the bridge between the children's thoughts and different ways of understanding the data. The intention was for the children to go as far as they were able in terms of statistical literacy development. The data analysis was carried out narratively, stitching together theories and practices (Figgou, & Pavlopoulos, 2015) with the video and audio recordings, photographs of the children's productions, and memories of the practice itself recorded in the field diary. The story that encapsulates the teacher's and children's lived experiences is presented in the following section and is told from the teacher's perspective.

6. STATISTICAL LITERACY WITH MULTIVARIATE DATA: READING THE WORLD

Getting to know *Dollar Street* put me in front of multivariate data about people from across the world. It made me think more about what kind of statistics I wanted to introduce to the children in my class. Some questions hit me when thinking about the challenge of bringing the world into the classroom: How much should children know about the realities that may seem to be cruel? Would I be "adultizing" children by bringing them face to face with social chasms that seem harsh? Would I be making the children feel overwhelmed by the immensity of the data?

I took my doubts and concerns to the university's research group, because I believed that in the space of exchanging ideas with other teachers and researchers, I could get to know *Dollar Street* better. The first question that colleagues asked me was related to "how" the organizers calculated the income and how they chose the sample. They also questioned why the street was represented in a straight line, why people were separated based on how much money they had. These questions led a better understanding of how the site was planned, the developers' intentions, and the data presented.

The *Dollar Street* learning experience started with talking to the children about what a "visit" is, about their experiences of making or receiving visitors in their own homes. I then went on to explain that they would be visiting homes around the world by exploring the data presented by *Dollar Street*. Working in pairs in the computer room, the children learned quickly how to walk down the street, enter houses, and discover the artifacts and items inside the houses and/or the living environment. The children accessed the map, chose categories of things to observe, and made many exclamations: "Wow", "Look at this"! The astonishment and admiration were remarkable. I soon realized that it would be an opportune moment to expand the repertoire of categories and attributes explored, so I questioned the children about what they were seeing, the characteristics of the objects, and the reasons for the surprises. Thus, through language, it became obvious that the children were able to look at specificities and generalities, compare attributes, and perceive similarities and differences in the multivariate dataset.

At the heart of all statistics is variation and that variation can sometimes be surprising (Watson, 2009). Luis certainly became surprised when he saw the toilets (Figure 4). The different and the unusual toilets drew his attention and soon the whole class was analyzing the toilets in houses in places around the world or in Brazil. With excitement, everyone started looking for other surprises. Among other things they found a spider as a pet, a toothbrush classified as a toy, and a hole in the floor as a toilet. The children compared the data and images from *Dollar Street* with their own situations.

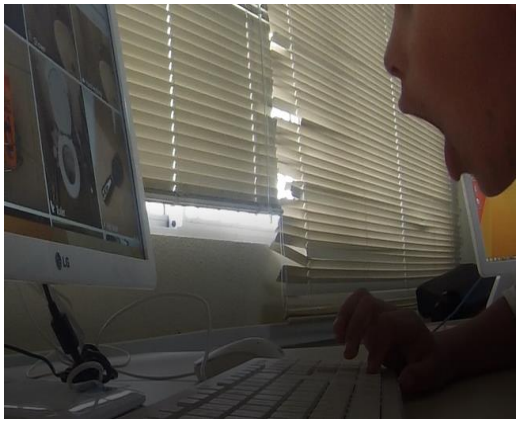


Figure 4. Luís surprised.

During the session I noticed that with the *Dollar Street* map open, the children wanted to see Florianópolis, Santa Catarina, Brazil, where they lived. As they couldn't find it, they accessed *Google Maps* to observe the neighborhood and the school. The children who wanted to see themselves represented on *Dollar Street* continued to persist at finding data about where they lived. At various times they went to *Google Maps* to check something out and then returned to *Dollar Street*. The back and forth between the websites helped the children realize that the world shown on *Dollar Street* was not exactly their world, but a "sample". The generalizations they made left out the things they saw every day, which may have made *Dollar Street* appear to be abstract. At the same time, the children showed how much they were able to deal with multivariate data because they sought information in different media at the same time. I realized that their curiosity to look at *Dollar Street* and search for more on *Google Maps* simultaneously, can be understood as a statistical disposition (Gal, 2002) in the face of multivariate data (Engel, 2017).

Representing the world on a straight street is a way of allowing a quick and synthetic view of the place that people occupy, according to their income. But the children showed no interest in the value of the family income and the street made no sense to them. They chose the families based on feelings of sympathy or curiosity regarding the initial photos, the location on the world map, or the list of categories. Perhaps, at that moment, the street demanded an insurmountable change of representation for those who see and explore the globe on *Google Maps*, or the street with houses on one side only made no sense for those who walk through hills and lowlands, through curves and corners. The representation of the straight street could have been too simplistic given the complexity of their world. Perhaps this is the way we adults learn to conceive the world (simplistic, straight) and by which children do not share because they explore its curves and dimensions. Reflecting on the conversations and exchanges of ideas with the children about their perceptions and personalized readings, I saw that the initial learning goals were relevant, and many occurred at the same time: comparisons, classifications, variability, sampling, and use of statistical vocabulary.

At the next meeting, before going to the computer room, I proposed that the children outline their goals. In pairs, they chose categories and places they wanted to explore on *Dollar Street*. This moment demanded arguments about their preferences, and it was necessary to use a linguistic repertoire accessible to the partner, as each one needed to see and understand the perspective of the other. In the dialogue about the data, it was necessary to organize the information, classify, connect with its reality, and generalize its meaning. What they chose to see, or their data (Konold et al., 2014), was manifested in the use of language. The children then recorded their choices with drawings and writings on a sheet and when they arrived at the computer room, they already knew what to look for.

After their investigations on *Dollar Street*, I organized a conversation circle to talk to the children about what they wanted to see initially and what they ultimately saw. People's pets was the main topic of the conversations. Some of the children verbalized a perceived pattern: most families have dogs. Another exciting topic of the conversation was the unusual: someone had a very ugly spider as a pet. From these interests, I continued with the learning plan.

In the next class, I talked to the children about *Dollar Street* pets, and we collectively made a list of street animals, another of possible pets that didn't appear in the street data, and the impossible ones (dinosaur, for example). It was not easy to manage the lists (Figure 5) as they changed according to the children's arguments. It was an important moment because they used statistical language to convince their colleagues, "But the alligator is wild, it is impossible for him to be in the group because he is not your friend." Meanwhile, another child said, "It is possible because I saw a man who has a pet alligator."

Figure 5. List of Dollar Street animals.

I wrote the total number of *Dollar Street* households with various pets on the board. I gave stickers containing all the pets on the street and asked them, in groups of four, to classify them. While organizing the data, the children played at pulling a random sticker out of the pile, trying to guess, "It's a dog" and saw that they almost always got it right. I asked why this was happening and they concluded, "It's because most are dogs." From the game the children invented themselves, they experimented with the ideas of data and chance, that, according to Garfield (2002), can lead to inferences and interpreting results. When making the classification, the children expressed many doubts and contributed to discussions. Some wanted to classify birds and chickens into distinct groups, others wanted to divide the birds into those that live in and out of cages, and others wanted to put all the birds in one group. Their data lenses (Konold et al. 2014) for classifying and reclassifying animal images were based on observable or unobservable categories in the stickers. Through dialogue, it was possible for the children to see the lens of others' data and review their own ways of organizing the data.

After the classifications, I distributed plates of different sizes for them to place the classified animal stickers (Figure 6). The children had to choose the size of the plate in proportion to the number of stickers. The arrangement of the plates resembled the representations of the bubble chart tool from www.gapminder.org. Proportionality is a resource for readings and comparisons between statistical representations and the plates helped us to access it even without formally knowing fractions or percentages. Then the children made their own records (Figure 7) according to the size of the plates:

Figure 6. Proportion on paper plates

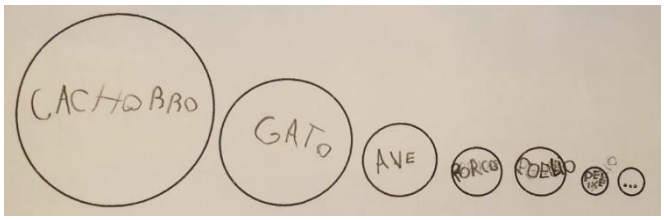
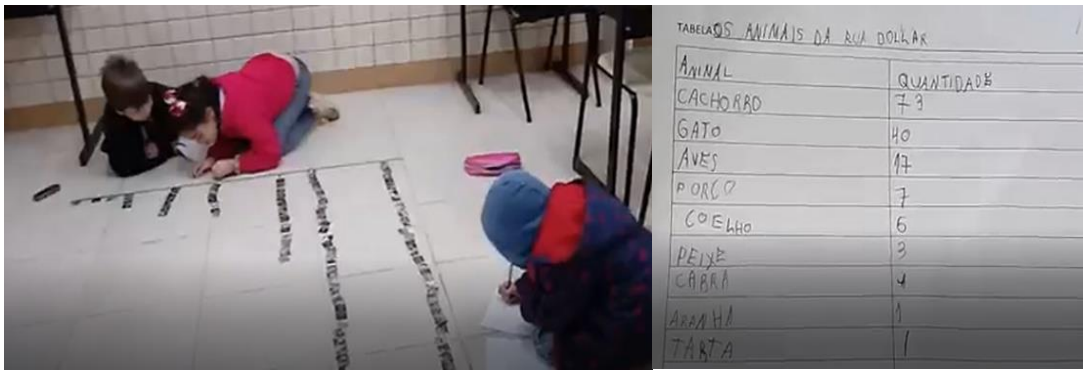


Figure 7. Record of the proportions "dog, cat, bird, pig, rabbit, fish...".

After that, I invited the children to make a chart with the number of each type of animal on *Dollar Street* using the same stickers. From this graph, they made the counts to record in the table.



Figures 8. Dollar Street animals' chart and table.

I started the fifth class with the question, "How many dogs do you have in all of Brazil? I wrote "52000000 dogs" on the board and the children were ecstatic with the number of zeros, trying to read the big number! Soon after, I asked for their guesses about the population of children in Brazil. Again, the number 45000000 caused astonishment, so I asked if there were more dogs or children. Seeing such comparisons, Carolina stated that it made no sense to compare dogs with children, because "Children are a phase of a person's life and a dog is not a phase of the dog's life, but its entire life." So, she implied that we should compare the population of people with the population of dogs. From Carolina's point of view, the data I presented had limitations. The ability to see limits in data is paramount to statistical literacy, as "understanding the powers and limitations of data is fundamental to active citizenship and to the prosperity of democratic societies" (Ben-Zvi, p. vii, 2018).

Carolina and her colleagues were also understanding the meaning of "population" and realizing that within the population of people, children are included. Next, we imagined what the animal population in Brazil would be like. Based on the size of the plates (Figure 6), they made a prediction that the population of Brazilian animals would be greater than that of people. This showed the children felt confident enough to take a risk in predicting data. Watson (2009) suggested that prediction arises from the variation in the data when summarized, that is, the prediction of the result is the summary of a variation's context. From this discussion, I invited the children to check the number of pets in their homes. From that data, we built an infographic (Figure 10) about the number of animals they reported to have. For each reported animal, a house was placed on the street and for each type of animal, a different color of house.

Figure 10. Class animals' infographic.

I then showed an infographic produced on a large paper strip (Figure 11). It showed that half of *Dollar Street*'s households did not have pets, and of those that did, half owned dogs. To show this, I folded the strip of paper in half and then in half again, taking advantage of the children's knowledge of the half and quarter proportions. The choice to produce horizontal infographics with a "street" image was made to improve children's understanding about the possibilities of representing the world using a straight line.

Figure 11. Dollar Street animals' infographic

From the reading and interpreting the infographics, the children inferred that on the school street half of the houses should have pets and that the majority should be dogs. In addition to interpreting the infographics, they considered their experiences of walking on the street and seeing, or not, animals in the houses. On-site research became necessary to test their predictions and see that behind generalizations made, data can tell specific stories about people's lives.

The next day, the class prepared a survey form (Figure 12) with the questions to ask the residents in the street from the school and wrote a text with what we intended to tell the residents. Then we role-played conducting research to test the form. "Good afternoon, I am [name] and I am in the second year of the [school name]. We are doing a survey. 1) Are there children in the house? [age] 2) Do you have a pet? How many? 3) Which pet? What's their name? 4) How many people live in the house?" (Field Diary of 07/29/2019).

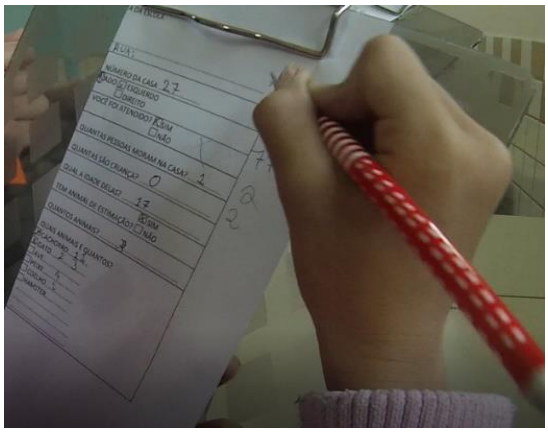
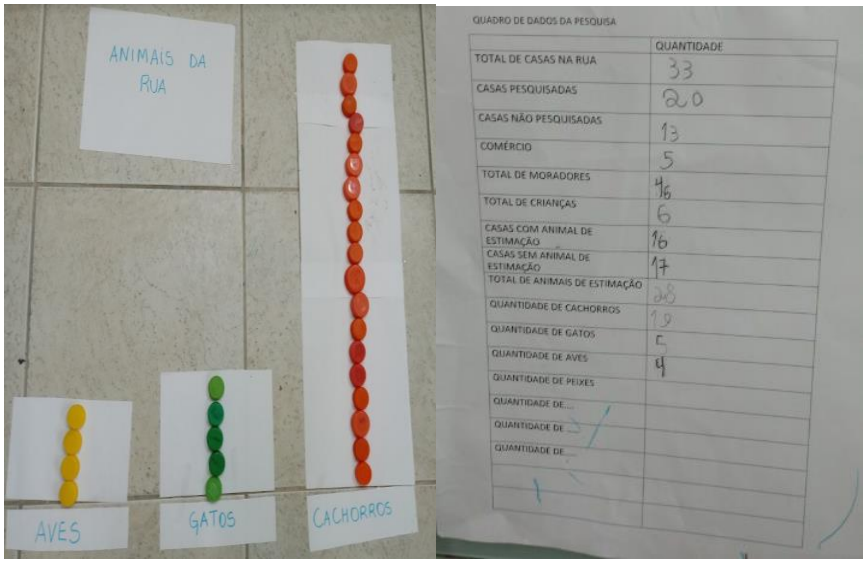


Figure 12. Interviewing fellow classmates.

The next step was to go to the school street, carry out the census, ring the bells of all the houses and ask the residents questions. This street had large houses, which were very different from those in the neighborhood next door, where most of the children lived. The children were happy to be welcomed and to talk to the residents, but they were disappointed with the small number of people in each house and the very small number of children.

Upon returning to school, we collated the data. The children were careful to count all the data in the forms and record them in a single frequency table. To organize this moment, I took plates of different sizes and colored plastic lids. The children matched a lid to each piece of data collected, placed them on the plates while the others counted and wrote down the numbers. After classifying the data, the students recorded all frequencies in the table and made graphs (Figures 13).



Figures 13. Graph and table of results for the school street's animal data

With the data organized, the children and I continued to walk through the street every day and to read it more consciously. The walls that we accessed informed us that this reality was different from that of the children, therefore, I knew that the next step would be to get to know their neighborhood. On the eighth day, we went up the "Morro" (that's how they call their neighborhood) with a group of teachers with the children acting as guides. They took us along shortcuts and tracks that did not appear on *Google Maps*: the big jackfruit tree, the dam, and the view from the neighborhood were important things to read about their lives. This was only possible by being part of the experience with the children.

The children did the research with their forms in their neighborhood (Figure 15). A house was never just "one house," there were several houses together, several allotments where several families lived. The interviewees counted on their fingers to calculate how many people there were in their homes. We walked through streets that led upwards in grand staircases, and everything looked very different from the school street and *Dollar Street*.

Figure 15. Data collection about the houses of the neighborhood.

When the class returned to the classroom to organize the data, they found that Morro had more of everything: more houses, more people, more children, and more pets than in the school street. In addition to the data, we had many stories to tell. Our joint paths through statistics had given us much more than results, they had given us the joy of the search. For Freire (1997, p. 160), "joy does not come just when meeting the found but is part of the search process. And teaching and learning cannot take place apart from the search, apart from beauty and joy."

7. FINAL CONSIDERATIONS

The experience of collecting data included the children in each other's realities and made the children and I more aware of differences in the lives of others. We read numbers, data, images, and stories from our immediate world and from a world far away (*Dollar Street*). We looked at people, asked questions and listened to their responses to understand ourselves as people, capable of drawing our own conclusions from factual reality, of knowing the history of the data, and telling the stories from the data. From our stories about the statistics, we got to know better our place in the world.

With *Dollar Street*, we confirmed that the readings depended on people and their contexts. Walking down these paths together with the children would be a very different experience from the one we walk in our own homes and in the research group. With childhood eyes we would learn other things about reading the world with multivariate data.

The readings and writings of the world were only possible with a directed look, which was a result of the statistical investigation based on the question, research, comparison, classification, analysis, organization of the data and on the elaboration of meanings in the interpretation of the data. The experience made obvious data are not just numbers, they are stories of people. Our experiences have shown that statistics can be a way of reading the world, because it connects words, numbers, images, the body, emotions, people, and their contexts. As the data were multivariate, different forms of communication were required. Statistical literacy was developed together with the reading and writing of words and numbers in context.

At all times, it was necessary to have a focused look at the immensity of data that was presented. Seeing similarities and differences were no longer accomplished just by the appearance of objects (color, shape, size), there were other things to be seen, such as country, continent, income, number of people in the family, stories and dreams. Making decisions, whether this or that individual fell into this or that category depended on the data lens that each of the children used.

The children generalized and then made deductions about what the same data would look like in other realities. Everything happened in the dialogical movement, in the awareness of the word from the world and in the understanding the world through the word. Through verbal exchange, we expanded our awareness of the world, developed conceptual instruments for thinking, and increased our statistical vocabulary. This repertoire began to be incorporated in situations of argumentation.

When planning a school street census, we learned that a question reveals our data lens and denotes our expectation regarding the answer. Before asking, we think about possible and impossible answers and draw a route showing where they can go. The children and I learned that the choices and intentions of those who plan research are part of the production of data, are implicit in the entire process of collection, organization, analysis and communication of the data, and are fundamental to the interpretation of the data.

The critical look at the variability allowed us to see that the number of people and animals in the houses was data involved in many contexts. We realized that income could be a determining variable to modify the data. The uncertainties of statistics became evident, which led us to speculate, detect the limitations of the data, and understand that some generalizations do not hold up in some contexts.

Seeing multivariate data is also understanding how misreading happens and realizing how fake news is produced from factual data that involves a culture of post-truth production (Engel, 2017). For Engel (2017), an enlightened citizenship education based on analysis and critical thinking about evidence is the best remedy for a world driven by fake or non-factual news. That is why today, more than ever, knowing how to choose information and understand the source and the truth of the data collected are basic literacy issues.

This research has shown that to work with statistics in the classroom it is necessary to go through all the steps, from data creation to data interpretation. These steps involve pedagogical freedom to come and go in the data, as children tell stories from the data and for those stories to make sense. Statistical literacy is not a point of arrival, but a path to be travelled together.

> *The educator's thinking only gains authenticity in the authenticity of the students' thinking, both mediated by reality, therefore, in intercommunication.* (Freire, 1987, p. 64)

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