CREATIVE INSUBORDINATION IN STATISTICS TEACHING: POSSIBILITIES TO GO BEYOND STATISTICAL LITERACY

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ABSTRACT

Statistics education has the potential to assist students to develop their identities and engage in problems and social contexts that assist in empowering them to act politically in the future. The actions and narrative reported in this paper seek to identify the way in which teachers could develop and implement statistical inquiries that utilize aspects of creative insubordination to enhance student learning experiences. This paper reports on two students who were supported to produce information and act politically on a problem founded in their social and cultural context. Reported practices in this research involved inquiry tasks that promoted collaborative exploration of ideas, data analysis, and reporting. Results evidence that teaching statistics through projects that focus on the development of political actions, Creative Insubordination, have the potential to improve students' statistical skills. As a consequence, the students were able to go beyond being data producers and data consumers to being statisticians and political activists, a shift necessary for students to understand how data can be used to transform their lives and those of others.

Key words: *Creative Insubordination; Political and Social Development; Statistical Inquiry; Secondary Mathematical Education*

1. INTRODUCTION

Creative Insubordination was originally conceptualized as an activist movement to address social justice issues in education in the 1980s (Crowson & Morris, 1985). This involved principals and teachers not following mandated educational programs and guidelines but developing learning environments that were humane and meaningful for their students. The intention of the movement was not to cause derision or disruption, rather it was to provide an education that served the best interests of marginalized students (Haynes & Licata, 1995). The aim was to improve educational outcomes and services for students and school communities. A broader aim still, was to make changes in society by focusing educational experiences on social justice and social responsibility.

According to Wild, Utts and Horton (2018), statistics education has the potential to prepare students to deal with social complexity, thereby helping them to become critical citizens with

the capacity to make and understand data-based arguments and decisions. It is through learning experiences grounded in statistics that students have the opportunity to develop the statistical literacy skills needed to "interpret, critically evaluate, and communicate about statistical information and messages (Gal, 2002, p. 1). These sorts of skills are needed for students to go beyond demonstrating statistical literacy to being able to become data producers rather than data consumers, a shift necessary for students to be able to make decisions and take action related to issues important to them and their communities.

The research reported in this paper adopts a transformative paradigm to explore pedagogical practice aimed at empowering students to enact notions of creative insubordination within a statistical inquiry context. The motivation was to get knowledge on the following question: how to prepare students to understand statistical concepts and produce information instead of just consuming it? We illustrate advantages by the teaching approach taken to promote positive political action of students through the use of data and evidence to draw conclusions and make informal inferences. In doing so, the students' statistical, analytical, and critical thinking skills were fostered. It is contended that the skills developed within the creative insubordination context provided the basis from which the students developed the skills needed to promote change. The study was set in Brazil within an extra-curricular scholarship program for secondary students and it was led by the first author of this paper. The students had their first contact with the researcher at the beginning of the meetings, which means he was not their teacher and had no previous contact with them. Results show that students got knowledge on how to use statistical tools, defined a research theme, planned actions from organized information by them to conscientize their school community and the principal about a local problem.

2. BACKGROUND

2.1 CREATIVE INSUBORDINATION AND EDUCATION

The assumption that there is no neutrality in education and research in education is ambiguous (Aguirre et al., 2017). This ambiguity is established because most curricula are characterized by the content presented in a linear and progressive form of difficulty. In general, researchers in mathematics education continue to determine what content should be taught based on the epistemology of the Eurocentric school system, while in the classroom it is the teacher who remains the one who determines what should be learned. Often the path of dialogue that is established in these environments is unidirectional and brings a false sense of what constitutes a society of democracy (D'Ambrosio & D'Ambrosio, 2013). Democracy is the political regime where power is exercised by the people, but questions need to be raised about which part of the population has the capacity to exercise its political rights. Are the current school models enough for all the population to be able to participate in transforming, elaborating, and implementing public policies? Increasingly evident is the absence of policies in education for social inequality, which is a growing problem.

For Gutiérrez (2013a; b), mathematics transmits status in society, which should lead educators to be more aware of what to ask students to do during classes. Many teachers (and researchers) reproduce authoritarian models of teaching, ignore the political function of their role and the power of mathematics to influence society. These professionals are little aware of their tasks and become accomplices in reproducing mathematics in microaggression environments. Those who exercise or think they exercise neutrality in the educational sphere usually rely on the discourse of justice, impartiality, and standardization of the school process (Ortigão & de Oliveira, 2017). For this, they plan from disassociated content, which is divided by stages and by disciplines. The rationality imposed by the system generalizes the needs of learners and prevents the development of critical thinking and creativity by dictating to them what is important to be learned. At the end of the school process, which is likely to be

fragmented, students are assessed through a system of quantitative measures; a system used to verify what students are capable of reproducing.

Neutrality is ambiguous because teaching in this way exercises coldness, indifference, and insensitivity to the process of social development, and hides the potential of learners. Care must be taken when: teaching is approached with a static and progressive curriculum, whereby students' needs are placed secondary to the learning requirements; when it is forgotten that science is a human construction; when mathematics or statistics are presented as sciences of truths, of unique, precise and deterministic answers; and when teachers seek to generalize problems from contexts external to learners. This neutrality also occurs when the study of mathematics and statistics is devoid of context. In neutral environments, individuals are trained to obey blindly the rules by which have long been socially established. However, school should be the place where people learn about themselves, about who they are and who they want to be, about who they can and who they cannot be. Critically, D'Ambrosio (2017) reflects that it is in school that people learn their place in society, and how to live under rules and standards established by others. Consequently, people learn how to keep silent in the face of injustice when observing the mistreatment suffered by others. Also, it is in school where it is learned that some voices have no value and that a person can be measured by his or her submissive behavior and also by the results from evaluations; people learn rules are made to be discussed without question and without negotiation. Paradoxically, in school, people are shaped by different political contexts, and by different histories and experiences (Aguirre et al., 2017; Rosa & Orey, 2016).

D'Ambrosio's (2017) conception of creative insubordination demands research in mathematics education and the decisions made by mathematical educators are not just choices, instead, they are political acts. Creative insubordination is actions by which teachers go about prioritizing student learning, imagining and implementing new possibilities in their classrooms. Teachers act with responsibility when they work to restore dignity, identity, and respect (Freire & Freire, 1994). D'Ambrosio and Lopes (2015a; b) suggest that the actions of creative insubordination are identified when teachers decide to: break with the generalizing discourses; analyze students' results as an object to improve learning, neglecting skills quantification tools; argue to explain differences in students' achievement, using discourses outside the simplification patterns; question the ways in which mathematics is culturally presented at school; emphasize the uncertainty of the discipline of mathematics and its historical-cultural construction; position students as authors of mathematics; and challenge discriminatory discourses about students.

Gutiérrez (2016) proposes that there are six creative insubordination strategies that could be implemented in educational contexts:

1. *Press for explanation* – listening to others defend their position to develop counter-arguments.
2. *Counter with evidence* – share examples of practice and outcomes of investigations.
3. *Use the master's tools* – position and justify actions within the policies and constructs (e.g., curriculum documents) that have the potential to be used to restrict practice.
4. *Seek allies* – work collaboratively with others to achieve common goals.
5. *Turn a rational issue into a moral one* – make the issue more emotive for others to convince them to "do the right thing."
6. *Fly under the radar* – covertly implementing practice to develop a track record of success.

These strategies are examples that have worked for some teachers. The list is offered in the spirit of inspiring others to be adventurous and courageous in addressing the needs of marginalized (and other) students. The strategies are not meant to be distinct and disconnected. Indeed, Gutiérrez suggests "combining two or more strategies can magnify their effects" (p. 54).

2.2 CREATIVE INSUBORDINATION AND STATISTICS EDUCATION

In regard to mathematics teaching, Gutiérrez (2016) suggests that creative insubordination includes: "decentering the achievement gap; questioning the forms of mathematics presented in school; highlighting the humanity and uncertainty of mathematics; positioning students as authors of mathematics; and challenging deficit narratives about students of color" (pp. 53-54). Teachers and teacher-researchers who work in the perspective of creative insubordination studies, go beyond the pre-established limits of social, political, hierarchical or bureaucratic rules; act with a posture of prioritizing their students' learning; imagine, plan, discuss, and implement new student learning possibilities with a focus on the well-being of the community where they are involved. According to Ortigão and Oliveira (2017), these are indispensable for making a sociological reflection on education and, especially, on the school. It is necessary to look at the social and cultural origins of students to understand their individual and collective paths as part of the learning process, so as to include the differences that integrate these contexts (Rosa & Orey, 2016).

Creative insubordination research has been extended to focus on its usefulness in secondary mathematics classrooms (e.g., Gutiérrez, 2013a; b). Creative insubordination is seen as a way of addressing inequity by repositioning teacher practice (Gutiérrez, 2016), and challenging and re-envisioning classroom norms through research (Aguirre et al., 2017). To facilitate the broader aim of addressing social justice issues, it would be beneficial for creative insubordination to extend beyond the work of teachers to become an integral part of student thinking and decision making. This will empower them in the future to make decisions based on evidence and an understanding of the context (Campos, Cazorla, & Kataoka, 2011). In order for this to occur, students need the opportunity to develop the ability to act when faced with issues of importance to them.

This perspective is considered by Pfannkuch (2018) when she suggests that it is extremely important to educate students to identify statistical situations incorporated in everyday contexts. It is beneficial for students to be able to critically evaluate real-life situations and the environment around them in order to challenge the status quo and create data-based arguments to promote change. Research has been conducted with students carrying out statistical inquiries (e.g., Lavigne & Lajoie, 2007; Meletiou-Mavrotheris & Paparistodemou, 2015; Watson & English, 2015); however, few provided the opportunity for students to take the findings and use them to evoke change. Watson and English did, however, get students to present their findings of an investigation that explored "Are we environmentally friendly?" to their classmates. For the most part, research has only reported students' development of understanding of statistical concepts and processes as they work through a statistical inquiry (e.g., Fitzallen, Wright, & Watson, 2019; Watson, Fitzallen, English, & Wright, 2019). There is a need to add an extra dimension to the inquiry process so that students are involved in taking action based on decisions made from the data collected. This may be in the form of a letter to the editor, a poster presented at a community gathering, or direct personal action to solve the problem. These sorts of activities will shift the use of statistical inquiries conducted in the classroom from being passive explorations of social issues to being active engagement in political and community-related decision making; thereby, giving students the skills and opportunity to be enactors of creative insubordination.

2.3 STATISTICS EDUCATION IN BRAZIL

Statistical education in Brazilian schools has been implemented through the mathematics curriculum for elementary and secondary school students aged 6-17 years since 1998 (Brasil Ministério da Educação, 2002). However, the teaching of statistics and probability for mathematics teachers at these levels of schooling is challenging. For example, textbooks used in schools do not aid greatly the work of mathematics teachers because, for the most part, they approach the content through isolated and sporadic activities. The disconnected organization of

textbooks and the conceptual errors included do not facilitate fully the development of a conceptual understanding of statistics (Campos et al., 2011). Therefore, the opportunity to build on established learning and reinforce understanding is minimized (Soares, Gonzaga Alves, & Xavier, 2016).

The educational scenario is compounded by the complexity that permeates the teaching profession. There is a need for teachers to engage in professional learning that will allow them to broaden their theoretical, methodological and pedagogical knowledge regarding the teaching and learning of probability and statistics (Campos et al., 2011; Souza, Lopes, & Pfannkuch, 2015). An experience by teachers in this process will give them greater autonomy over their pedagogical work, allowing them to make decisions based on consistent professional knowledge (Lopes & D'Ambrosio, 2016).

For Gutiérrez (2016), teachers are identity developers as they constantly make decisions during the mathematics teaching process, such as plan the teaching process from research activities or from socio-cultural contexts and students' learning needs. Also required from teachers are civic and political skills to be able to negotiate within their contexts to support, defend and critically empower students. Empowering students to become active members of their communities can be achieved through appropriate learning experiences. However, absent from the literature are examples that illustrate how teachers can build students' capacities to be agents of change, who identify and act on issues of importance to their communities and make decisions from an informed perspective. This paper, therefore, aims to offer one such example in anticipation it will stimulate debate and discourse about the teaching and research approaches taken, which not only reflect but also enact the notion of creative subordination. The research question is "What evidence related to the concept of creative insubordination emerges from a process of teaching and learning statistics through a student-lead statistical inquiry?"

3. METHODOLOGY

Creative insubordination suggests educators have the liberty to choose pedagogical practices and learning opportunities that suit their students' learning needs and cultural backgrounds. In the same vein, creative insubordination gives education researchers similar liberties when making decisions about research methodologies. Indeed, Orey and Rosa (2017) advocate for researchers exploring issues related to creative insubordination to adopt methodologies that break away from typical practices. To facilitate this to occur a transformative research paradigm is needed (Mackenzie & Knipe, 2006). This scenario fosters confronting rules and cultures that are rooted in school contexts, communities, families and the students (Mendonça & Lopes, 2015). The goal is to make education to be about not only what needs to be learned but also how to be, in this case, to be statisticians capable of interrogating issues through a socially critical lens.

3.1 TEACHER/RESEARCHER

In educational environments where the focus is on the fulfillment of a prescribed curriculum, adoption of pedagogical research perspectives requires initiatives and attitudes that go against the established order. Involved in the implementation of teaching and research strategies that recognize the issue at stake and how it is related to student learning and social justice (Gutiérrez, 2016).

This study is developed as a practitioner inquiry with the aim of generating knowledge about student learning through "systematic examination and analysis of students' learning juxtaposed to and interwoven with, systematic examination of the practitioner's own intentions, reactions, visions, and interpretations" (Cochran-Smith & Lytle, 2009, p. 4). When planning, acting, analyzing, observing and evaluating situations arising from educational acts, it becomes possible for the teacher to reinvent himself by reflecting on his own actions and making them

the cradles of theories that establish a dialogue between thinking and acting (Coutinho et al., 2009). During the educational act, teaching approaches are forged and become more effective when learning is being observed. In this process, there are important moments of reflection. This occurs after the educational act when teachers look to revise their approaches, analyze acts and answers of the subjects with whom he/she was engaged. Teachers become researchers by virtue of contributing to the improvement of or changes to educational practices when interpreting answers given by students and taking action to address their educational needs (Cochran-Smith & Lytle, 2009).

3.2 RESEARCH DATA AND ANALYSIS

Practitioner inquiries require researchers to be deeply entrenched in the context of the inquiry to capture detailed accounts of events. Therefore, the data collected in this study were in the form of video-taping the teaching episodes. In keeping with the creative insubordination context (Gutiérrez, 2016), the data analysis and the presentation of the findings from this study deviate from typical mathematics education research strategies. The results of this study are presented as a narrative. Narratives allow the voice of participants to come through to give a descriptive account of events that acknowledge the social and cultural aspects of an inquiry (Polkinghorne, 1995).

The data and the first stage of the data analysis are one of the same. That is because the interpretation of meaning of the data collected in the context of the study occurred in a continuous way. The teacher/researcher (Author 1) interpreted and reflected on the circumstances of the students' learning as it occurred during the teaching and learning episodes. This initial round of data analysis was focused on supporting student acquisition of data analysis skills and facilitating working through a statistical inquiry (Franklin et al., 2007). Also collected were student artifacts and calculations, which were in the form of graphical representations and reports. These multiple data collection instruments were then used with the analysis of the video data to build the story to be told from the research.

The second stage of analysis of the videos involved familiarisation and immersion with the data through repeated viewing of the videos and memo-ing by writing impressions of what occurred. Following this, the authors identified pivotal teaching moments that shifted students' thinking based on the teacher's perceptions of the students' learning. A narrative was then crafted to reflect the issues that arose from the research process and the evolving nature of the students' capacity to use statistical concepts and representations to enact creative insubordination strategies. The narrative sheds light on the cultural, social and personal resources that shaped the students' capacity to become social activists, who base actions and decisions on evidence.

3.3 CONTEXT OF THE RESEARCH

This study was set within the context of a scholarship program aimed at strengthening students' scientific and technological knowledge and to developing their attitudes, skills, and values about scientific and technological education. The program, *Institutional Program of Scientific Initiation Scholarships for High School* (PIBIC-JR-CNPQ) was supported by the Brazilian Ministry of Science, Technology, Innovation and Communications (cnpq.br/pibic-ensino-medio/). The program supports researchers from teaching and research institutions to develop a science education program that integrates students from high school, public schools, military schools, technical schools, or private schools into their research activities. The process was led by a researcher from a university (Author 1) who submitted a project to develop students' abilities in context-based statistical reasoning.

In this instance, the researcher's primary focus was on statistics education. The main goals of the program were to develop the students' knowledge of statistical inquiry techniques and to experience the way in which statisticians collect and analyze data when investigating social

issues and circumstances. The aim was to support the students to conduct an inquiry, which was based on using statistics appropriate for their level of schooling to identify and understand myths, beliefs, and truths related to a social problem. Two students received 1-year scholarships to participate in classes that would culminate in a research project whose theme would be chosen by them. The students participated in the program two times a month for 2 hours during their free time. The classes were conducted by the first author of this paper and a voluntary undergraduate student who was a beginning researcher.

Learning program The planning of the activities developed focused on specific points of teaching approaches of Statistics; however, a flexible approach was developed, which was based on dialogue and questions that reoriented students' actions. The analysis was based on reasoning employed and materials produced by the students while performing their tasks and answering questions. Data were collected through video recording of the meetings, written reflection and images of the material produced in the notebooks by the students and in the software. The spreadsheet software Excel, and the data analysis software Fathom were used in the classes so that the students could construct tables and graphs when passing between different representations.

Stages of the learning program The learning program was developed to accommodate the learning needs of the students. The students' prior learning was established before the learning program was initiated. The learning experiences implemented covered the statistical knowledge and skills the students needed to be able to undertake a statistical inquiry. The sessions were informal and involved much dialogue among the teacher and the students.

1. Interview students to verify previous experience students had with statistics, use of technological resources, and data collection.
2. Survey to determine the students' level of understanding of representations and statistical concepts.
3. Learning activities developed (based on results from Stages 1 & 2) and implemented. The learning activities focused on the interpretation, construction, and deconstruction of representations, as well as in the concepts of variation, expectation, and sampling.
4. Development of a student-led statistical inquiry.
5. Implementation of the statistical inquiry.
6. Data analysis.
7. Reporting on inquiry outcomes.

This paper reports on Stages 4–7; outcomes from Stages 1–3 are reported in Souza (2017).

3.4 RESEARCH PARTICIPANTS

Student participants Two students, a girl and a boy, aged 16 and 19, respectively, participated in the research. Both were selected by the school where they studied because they were considered to be students with good school performance. The students were given a scholarship to attend, which was paid by the national agency, CNPQ. The scholarships were a financial boost for their families. Both became involved in the project when they were enrolled in the second year of secondary school at a public school located in the municipality of Ituiutaba, in the state of Minas Gerais. To preserve the students' identities, pseudonyms are used to report their contributions to the data. Their pseudonyms are Andréia and Ronaldo. The students' participation was voluntary.

Researcher/Teacher The researcher/teacher participants (herein, referred to as the teachers) in the study worked at a teaching and research institution eligible to participate in the PIBIC-JR-CNPQ program. He designed and delivered the learning activities and worked with the students to initiate and implement a statistical inquiry. Motivation for developing the learning program was based on an interest in assisting students to understand statistical concepts and be producers

of information, rather than merely consumers of information. Both students and researcher had not met before.

4. RESULTS

This section reports on the outcomes of Stages 4-6 of the teaching and learning intervention implemented as part of the PIBIC-JR-CNPQ scholarship program. Stages 1-3 examined student prior learning and delivered the learning activities (Souza, 2017) to provide students with the opportunity to develop the skills needed to conduct a student-led statistical inquiry. The following narrative was written in Portuguese and then translated using Google Translate. The narrative is presented here without modification. The authors have not changed the narrative to comply with English language grammar and sentence structures so that the sense of the research being conducted in Brazil is maintained. In this instance, the authors consider it more important to maintain the cultural connection to the context of the study than to make the narrative correct according to English language conventions.

4.1 DEVELOPING AN INQUIRY STATISTICAL PROJECT

Students were asked to choose a theme to develop a research project. The problem chosen from the school context was the restaurant. When reporting the organization of the meal moment, during the break period, we noticed frustration on the part of Ronaldo and Andréia. One complaint was that the school served soup many times a week. Regarding to the soup they said they were dissatisfied with several questions: they understood that soup did not match the heat of the region and with the time it was served, at 9:30 am (culturally in this region of Brazil, people's lunch hours are around 11am to 1pm). The lack of variety in food made them uncomfortable, they also understood that the break time was not enough to feed with hot soup. Another problem reported was the waste and mismanagement of food by staff.

We asked if they could produce any information on this subject. They both agreed it would be a good topic and we kept talking. About wasting food Ronaldo reported that often colleagues did not even throw food in the trash, they left their plate full on the table. We asked them to write down what they would like to know about the subject: waste, acceptance of the menu, and timing of the meal. While we reflected, Andréia considered that she thought it would be interesting to know more about how much money was received by the school to buy food.

We questioned Ronaldo and Andréia whether it would be possible to measure the waste. Ronaldo said there would be no problems, they should stay during the lunchtime watching and, in the end, to check the waste, they would place the remains in a plastic bag and then on a scale. We questioned who they thought was wasting more food, boys or girls. Ronaldo believed it was the boys. Andréia agreed and also said that it seemed boys were attending restaurants more than girls. Ronaldo disagreed, believing that the frequency was the same. To find out, which group was wasting more food, they came to the conclusion that it would be necessary to divide the remains into different buckets. The students realized that they needed help from school staff, teachers, and probably from the principal of the school. We suggested that, for the next meeting, students should watch the film Island of Flowers (www.youtube.com/watch?v=ZQcdXh9v0pA).

This old though short movie criticizes a very serious issue that afflicted Brazil in previous decades, hunger. The irony of the criticism is that although the country was one of the world's largest food producers and exporters, due to social inequality many families did not have access to food and therefore resorted to wasted food. In the next meeting, we had a discussion about the movie. The issue of poverty, misery and hunger in Brazil in the 1980s and 1990s was commented on. The students related this fact to the present day and realized that reality has changed. Currently, in Brazil, a very small part of the population does not have access to school, and at least in this environment children are expected to have something to eat. We questioned the students if the movie had motivated them in any way. Ronaldo revealed that students needed to be aware of these issues, and one way to promote that would be to communicate the results of

the research within the school itself. Ronaldo's proposition was according to our research goal, which involves finding ways to help students to produce information and act politically on the problems identified by them in their context.

In discussing the problem with the students, delicate issues surfaced, for example the school lunch budget, responsibility for the food choice process, bureaucratic decisions about time and break time and organization of the environment (restaurant). The students reported that they were only informed about the rules and the menu, and did not participate in the decisions. We noticed that for each of the problems raised by the students they elected a school staff to be held accountable.

It is plausible that students shy away from reflecting on the problems that permeate their routine at school. This is a reflection of the undemocratic management that has occurred since the beginning of their schooling process. Usually the community that benefits from the services offered by the school does not participate in the decisions that involve the educational process (definition of curriculum, rules of coexistence, routine and projects that will be developed) (Souza, 2017). That is why young people reject the participative role in schools and impute the inefficiency of the service provided to those who subordinate them.

Lawy and Biesta (2006) criticize the model of social and educational policy that seeks citizenship by nurturing and guiding young people toward pre-described outcomes. It is suggested that citizenship is related to young people's living conditions and the processes by which they learn, which includes attitudes in which all are engaged in continuous and conscious dialogue. Contrary to seeing citizenship as the result of the school learning trajectory, it is recommended that young people learn to be citizens as a consequence of their participation in the actual practices that make up their lives.

One of the points of tension of this research involved the fact that for Ronaldo and Andréia to obtain information so that they could understand the problematic, it was necessary to deprive them of the preconceived vision of guilt someone. In order to have access to information and collect data at school, it was necessary to involve the subjects (students, staff and teachers) with responsibility. We understand that the neutrality of Ronaldo and Andréia would be paramount for this to occur in the research phase. As the students described their problems, we sought through dialogue to reflect on possible somebody else narratives that could be used to describe the same situation.

The dialogue made Ronaldo and Andréia feel the need to talk about the project with the principal. The students, on their own initiative, held a meeting. The purpose of the conversation was to refine their hypotheses to construct data collection tools. The need was raised by the students themselves because they realized that their first statements could had been based on information raised from common sense.

4.2 PLANNING AND EXECUTION

This stage began with the definition of the research aim. During the conversation, Andréia revealed that she had already anticipated and written some topics about what they could do. We asked her to summarize them in one sentence, and she replied that the goal would be to avoid wasting food. Andréia's goal made us reflect. It is common for student focus during project execution to go directly to action. Without data information, actions are executed in a simplistic way and aim only to solve the problem and not understand its cause. This demands attention from statistics teachers because effective action on the problem should be the last step of the inquiry process. The focus of the research should be to collect as much information as possible and then act with clarity on the situation of discomfort.

We question Andréia if what she presented would not be a possible ultimate goal for investigation and if they were not anticipating, by saying that there was food being wasted. Ronaldo brought concrete evidence, saying that there was certainly wasted food. He reported that he had eaten in the restaurant that day and had sat near of the wastebasket to observe, he had judged that the food was good, but noted that there were people in the queue who were

throwing food away. We then asked him if he could say how much. He was in doubt and said that the amount could vary. We asked Andréia to read again her objective and instead of using the verb "avoid" they would use another word. One to give the idea that they would investigate the situation. Ronaldo asked if we could use the verb to "analyze" and continued: "Analyze if there is wasting food in school to draw strategies (raise actions) of awareness."

A few days after establishing the purpose of the investigation the students brought information they had collected with the principal. The students questioned whether the school's menu was fixed. The principal replied that at that time the menu could vary, because the school would receive funds only in April, it was March 2017. There was an economic crisis and the transfer of public funds from the state was compromised. Food that was being served came from the previous year, such as rice, pasta and other non-perishable foods. The principal explained that because of the difficulty of financial management, only after that month the school could determine a weekly menu. She even told the students that the menu was prepared by a nutritionist, but the school had some flexibility to choose between the suggested foods. Only soup should necessarily be served at least once a week. At the end of the conversation, the principal asked the students, before starting the project, to bring to her the questions they wanted to ask and a plan of action. The principal told them she would be happy to attend their presentations, provide the necessary materials, and assist with whatever was needed for the execution. According to Andréia, she suggested that they check the acceptance of each food. In addition to the conversation with the principal, the students talked to the kitchen clerks and their classmates.

From these conversations, the students drew up a plan of action to collect data: put two separate baskets of wasting food, one for girls and one for boys; to know how many boys and girls feed each day; check if there was a scale in the school; create a table with the number of students per gender and the amount of food wasted by gender; know the weight of the bucket; create a table or other questionnaire to collect statistical data. To collect data, Andréia and Ronaldo worked for one and a half month between April and June 2017. They produced a table in which they recorded the date, the amount of food wasted by boys and girls, how many students attended the restaurant (boys and girls), the type of food served and waiting time in line. In addition, both stood next to the queue watching the behavior of colleagues.

4.3 DATA TREATMENT AND ANALYSIS

After the data were collected the students presented them in a table (Table 1). While they showed and talked about the results, we asked questions to confront them with their initial hypotheses. In order to respond, the students presented representations that they thought were more appropriate. One of the questions we did for Ronaldo and Andréia was whether or not the soup was actually the most served food and whether the waste was large if it were compared to the other foods. To respond they presented Table 2, followed by a pie chart (Figure 1).

Another question we recalled was that the students wished to compare whether boys or girls wasted more food. Ronaldo said, "How could we compare if the number of people of each sex is different?" We let them think about it to seek answers. To answer they used Excel and the same strategy as before (refers to Stages 1–3). They viewed graph by graph without being successful. At the end they seem to have felt obliged to present a graph to answer the question, then they presented the time series of Figure 2. When reflecting on the graph both reported that they could not interpret who was wasting more, then Ronaldo had an idea: "I think we could see on average how much an individual wastes and then compare." The researcher asked, "And how are you going to do this?" Ronaldo replied: "We can calculate the mean of waste food for each of the genders per day and then compare the total mean." After some time working with Andréia they presented Table 3.

What we realized at this stage is that the students have become more critical about their responses. When presenting their representations, instead of making direct statements, they also raised questions about the data, they observed context and the objectivity of the representation

they made. By working on the data collected by them, we noticed more proactivity of the students. We realized that they sought strategies to respond to the stimulus concerned with the coherence and basis of their statements. For example, they did a box-plot to compare the wasted food by gender (Figure 3), however they were not sure how to interpret it, even after we had a class about box-plot. They felt more confident arguing grounded on the mean they calculated.

Table 1. Students' spreadsheet for data collection

Day	Male wasting (kg)	Female wasting (kg)	Male	Female	Type of food	Total of people	Time to finish the line (min)
1	1.5	2.2	55	79	Soup	134	10
2	2.5	3.9	85	134	Salad and cooked cassava with cooked meat	219	17
3	3.2	4	70	115	Rice. beans and cooked corn	185	15
4	1	1.9	37	83	Soup	120	7
5	0.5	1.2	71	119	Pasta with Bolognese sauce	190	13
6	1.6	4.8	81	100	Rice. sausage. grated carrot and salad	181	15
7	0	0	85	129	Bread with ground meat	214	11
8	2.7	4.6	82	129	Rice. beans and cooked corn	211	19
9	1.7	3.9	95	174	Ground beef with potatoes. carrots. rice and beans	269	14
10	0.7	1.2	87	120	Pasta with Bolognese sauce	207	13
11	2	2.6	99	107	Rice. beans and dried meat with salad	206	11
12	3.6	6.5	83	159	Salad and cooked cassava with cooked meat	242	18
13	2.5	1.3	72	154	Ground beef with potatoes. carrots. rice and beans	226	16
14	2.6	2.1	33	77	Soup	110	10
15	1.7	4.8	74	117	Rice. beans and cooked corn	191	12
16	3	3.9	106	139	Ground beef with potatoes. carrots. rice and beans	245	16
17	0.8	3.3	30	80	Soup	110	7
18	2.5	3.6	93	146	Chicken and rice	239	15
19	3.3	4.6	92	151	Rice. beans and cooked corn	243	17
20	2	3.2	89	148	Rice. beans and dried meat with salad	237	14
21	1.9	3	46	86	Soup	132	11
22	2	2	82	110	Ground beef with potatoes. carrots. rice and beans	192	16
23	1.5	2.3	62	91	Soup	153	10
24	1.7	2.5	88	101	Rice. beans and cooked corn	189	17
25	0.3	1.3	72	127	Chicken and rice	199	12
Mean	**1.9**	**3.0**	**75**	**119**		**194**	**13**

Table 2. Data summarized by students

Type of food	No. of days served	No. of people	Mean people/day	Total waste (kg)	Mean (waste by day)	Time in line to be served	Mean (time by day)
Rice with sausage. grated carrot and salad	1	181	181	6.4	6.4	15	15
Rice. beans and dried meat with salad	2	443	222	9.8	4.9	25	12.5
Ground beef with potatoes. carrots. rice and beans	4	932	233	20.3	5.1	62	15.5
Chicken and rice	2	438	219	7.7	3.9	27	13.5
Pasta with Bolognese sauce	2	397	199	3.6	1.8	26	13
Bread with ground meat	1	214	214	0	0	11	11
Rice. beans and cooked corn	5	1019	204	33.1	6.6	80	16
Soup	6	759	127	24.1	4.0	55	9.2
Salad and cooked cassava with cooked meat	2	461	231	16.5	8.3	35	17.5
Total	**25**	**4844**		**121.5**	**4.5**		

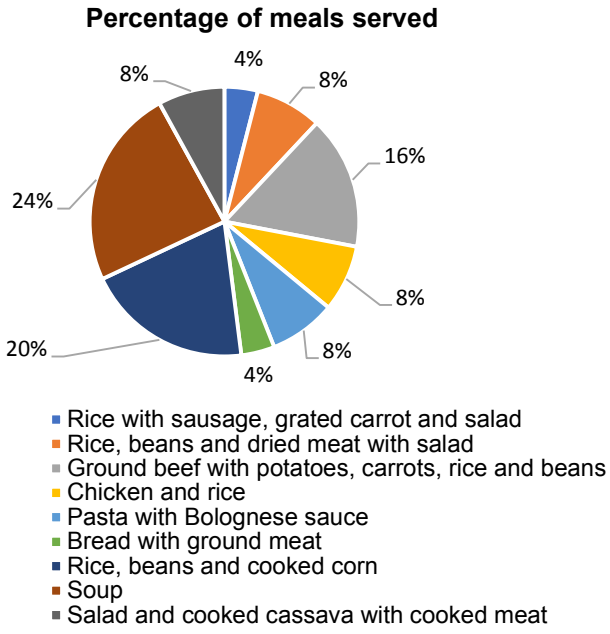

Figure 1. Comparing food waste

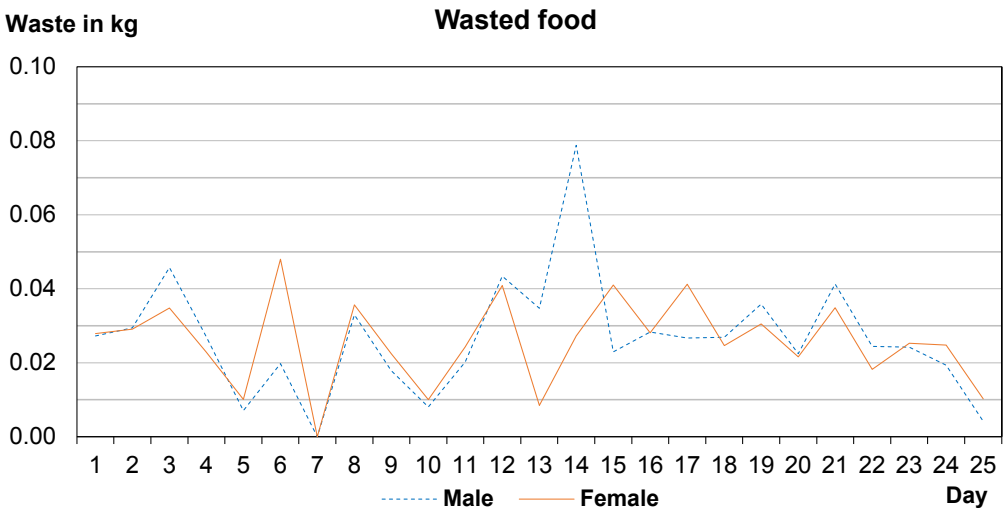

Figure 2. Time series graph made by students

Table 3. Summarized data and mean calculated by students

Individual waste (mean)		
Day	**Male (kg)**	**Female (kg)**
Day 1	0.027	0.028
Day 2	0.029	0.029
Day 3	0.046	0.035
Day 4	0.027	0.023
Day 5	0.007	0.010
Day 6	0.020	0.048
Day 7	0.000	0.000
Day 8	0.033	0.036
Day 9	0.018	0.022
Day 10	0.008	0.010
Day 11	0.020	0.024
Day 12	0.043	0.041
Day 13	0.035	0.008
Day 14	0.079	0.027
Day 15	0.023	0.041
Day 16	0.028	0.028
Day 17	0.027	0.041
Day 18	0.027	0.025
Day 19	0.036	0.030
Day 20	0.022	0.022
Day 21	0.041	0.035
Day 22	0.024	0.018
Day 23	0.024	0.025
Day 24	0.019	0.025
Day 25	0.004	0.010
Mean	**0.027**	**0.026**

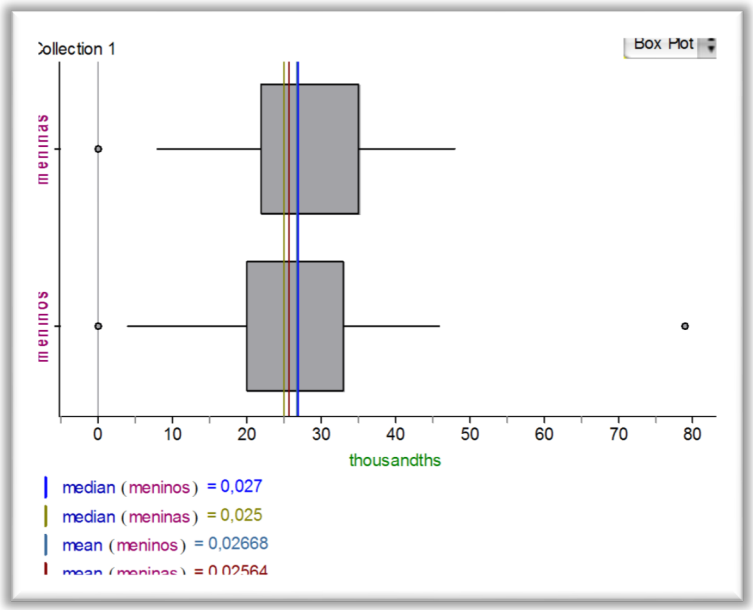

Figure 3. Comparing food waste by gender

4.4 INQUIRY RESULTS AND COMMUNICATION

The communication stage was divided into two. First, the students made a written report in which they had the opportunity to reflect on their data, then presented their results at a conference on the campus of the University of the city where they participated in the project. During the research, all stages of a Statistical project was done, raising a problem, planning an experiment or defining a sample, collecting and analyzing the data, and finally writing a report to be presented orally or through a poster. According to Garfield and Gal (1999), most students are consumers of statistical information, in our view, this is because they rarely have the chance to collect and analyze data in a supervised manner into the classroom. We believe that it is important for students to reflect on and analyze media-produced research (Watson, 1997; Gal, 2002), although we believe this is not enough. Being critical and developing the skill to question data involves a long dialectical process of training. It is necessary for students to learn to pose a question on the data. In this sense, the dialogue can help them to perceive the contexts by others points of view of which could diverge from theirs.

Thinking, reasoning, and arguing from and with data involves attention to general literacy. New curricula recommend that throughout the educational process, students improve their verbal and written skills based on formulating compelling arguments from statistics (Pfannkuch, 2018). However, communication skills require political training that is grounded in social development. Students need to be involved in the study and understanding of contexts, as well as situations that bring problems for them. This training process requires learning to raise questions that can be answered with data. It requires determining and discussing measures, planning the collection, analyzing and interrogating multivariate datasets, revealing stories about the data, and communicating and evaluating results. We thought the students achieved through this research. Following the report Andréia and Ronaldo:

> [...] Analyzing all that, we could see that the time spent in line and the waste of food varied greatly depending on the type of meal served. Several students even before starting the meal, threw some of their food away because they did not like some food that had been placed on their plate. When the time was insufficient, the waste seemed to be greater, because there were often students left eating after the break time, so many of them did not finish eating and ended up throwing the food away.

> We have as an example the days when they were served on the menu cooked cassava with cooked meat and salad. This was the meal that took the most time to be served and had the highest rate of wastage compared to other meals. We observed that many students, even before they had started to eat, threw the salad outside. Most said they did not like salad in the middle of the meal cooked or because it was without seasoning, many asked not to put the salad. The kitchen clerks chose not to take it in consideration because it took time for them.
>
> We were also able to note that the soup was the most served meal while we did the research. In these days there was a lower average of people attending the restaurant, as far as wastage was not the least or the greatest compared to other meals. The time to serve was shorter since consumption was less.
>
> In all types of food, the number of girls who fed themselves was always higher than the number of boys, so initially we thought that the girls at the end of the research would waste more than the boys. But with results the we have obtained, we note that the wastes compared by both parties have in themselves little difference.

Analyzing the written report of the students we noticed that the focus of their arguments was not on the data collected and measures produced by them. We noticed that Ronaldo and Andréia sought to understand the context by surrounding different positions. Their arguments were based on the observation that occurred during data collection in the school restaurant. Although in the written report it is not possible to see their statistical analysis, when the students did the communication of the project, they used a PowerPoint presentation in which the statistical representations of them appeared. To each of them Ronaldo and Andréia explained what they were representing and contrasted with their initial observations. We note a great deal of ease of both, and confidence in justifying their observations. They used tables, boxplot, chart of rows and columns, also measures (average and median).

In the end, although Ronaldo and Andreia were satisfied with the results and had been proud by being praised by lecturers from the university following their project's outcome, they were frustrated by the absence of representatives from their school. Their teachers and the principal of the school were invited to accompany their presentation at the University. Unfortunately, no representative came. We are not sure what the reasons were, but we believed that too much schoolwork and routine still follow a model that does not stimulate students' pro-activity. It is a pity, they lost an opportunity to make students being part of the solution of problems which pervades day-to-day. We realize that the students are better prepared to understand the politics of their context and develop actions based on social responsibility, however, to put into practice the actions requires a change of attitude of the subjects who manage the school environment. It is necessary to understand how to involve the school in a process of formation, in a way they get conscious of how hierarchical or bureaucratic rules disrupt the process of learning, and how action focused on improving services for students or school communities could make better the acquaintanceship.

5. DISCUSSION AND CONCLUSION

Statistical Education is concerned with researching the problems pertaining to teaching and learning statistics from early childhood education to higher education. The problems addressed in research focusing on statistics are distinguished from those presented in teaching and learning mathematics, as they are distinct sciences. Thus, Statistical Education, as an area of knowledge, is not subordinated to research guidelines in other areas and interdisciplinarily dialogues with them. In this study, we discuss a proposal for teaching and learning in statistics ruled on the principles of creative insubordination, which are based on awareness of when, how and why to act against established procedures or guidelines aiming to promote the welfare of others.(D'Ambrosio & Lopes, 2015a). This refers to defending a Statistical Education as a social practice that will contribute to the improvement of human life. The essence of creative insubordination is that no matter what the circumstances are at any particular point in time,

people have the capacity to reflect on those circumstances and identify and potentially enact on social issues that affect their communities (Crowson & Morris, 1985). Thus this paper suggests that having the skills to conduct a statistical inquiry can assist in being able to gather evidence that can be used to justify a position taken or decisions made. It also posits that statistical inquiries provide rich learning experiences within which students can develop the skills needed to go beyond being statistically literate students to being agents of change. The narrative presented in this paper elucidates the contexts where political acts emerged. This process aimed to break with pre-established rules, achieve progress and changes in society with a focus on social justice. Such assumptions are in agreement with many studies in statistical education, which defend that the development of probabilistic and statistical reasoning could be promoted from statistical investigations carried out by students, which focus in understanding the reality in which they live (e.g., Pfannkuch, 2018).

The creative insubordination strategies (Gutiérrez, 2016) operationalized in this study varied from the teachers to the students. The teacher-researcher enacted a “fly under the radar" strategy by choosing to use the scholarship program to deliver the statistics curriculum in a way that was different to how it is delivered in Brazilian schools (Campos et al., 2011). The teacher also supported the students to “turn a rational issue into a moral one” by helping them reposition the problems about not liking the canteen food and not having enough time to eat to become an issue of social significance, food wastage. The students engaged with the principal to “press for an explanation,” and presented their findings to others to “counter with evidence” the situation in the canteen. Incorporating these aspects of creative insubordination into the student-led statistical inquiry added value to the learning experiences. The students worked through the steps of a statistical investigation which included, posing a question, collecting data, analyzing data, and making decisions from the data (Watson, Fitzallen, Wells, & Madden, 2018). In this case, they went further and used their results to advocate for change. It is this step that empowered the students to move beyond being statistically literate students to being social activists.

The relationship established in this paper between the concept of creative insubordination and statistics education, aims to demystify the political passivity of mathematics teaching. Statistics education is a powerful tool that can help to learn about producing information and solving problems from their own context by finding out about the issues, investigating the problem, and then communicating the evidence collected to others. In the classroom, teachers need to go beyond identifying statistical inquiry opportunities. To support students to develop the skills needed to be able to challenge the status quo, address inequity, and promote change, teachers need to extend the regular statistical investigations to include opportunities for students to disseminate findings to a broader audience or other stakeholders. Students need opportunities to make not only decisions from the data (Watson et al., 2018) but also go further to make decisions with the data. It is not unusual for students to present results of inquiries to their fellow classmates (e.g., Watson & English, 2015), with some creative thinking there is ample opportunity to extend that audience when the issues investigated apply beyond the classroom and the findings can be used to make a difference to the lives of others or the way people think about the social issues explored.

A limitation of this research is the small sample size. Although appropriate to focus on two students, in accordance with qualitative studies such as this one (e.g., Fitzallen & Brown, 2017), the results are not offered as being generalizable to a larger population. Working with two students allowed the researchers to explore in-depth the way in which students reason about data when involved in inquiries that position them as producers of data. This was in contrast with their regular learning experiences in statistics education where they were primarily consumers of data, which involved analyzing data sets generated or exploring outcomes reported by others. The insights from this study have the potential to inform pedagogical practices, such as creative insubordination (Haynes & Licata, 1995), that embraces the need for developing statistically literate citizens who can be proactive in determining their future (Gutiérrez, 2016; Wild et al., 2018).

Another limitation of the research is related to the context of the study. The research involved working with students in an extra-curricular learning program. It is recommended that the exploration of implementing data-producer inquiries that focus on social issues familiar to the students within regular classroom environments be the topic of future research. This research has illustrated the benefits of giving students the opportunity to go beyond developing statistical literacy skills to utilizing those skills for the greater good of their community. Follow-up studies could examine further how students develop an understanding of how to make convincing statistics-based arguments within social contexts across the compulsory years of schooling, both within Brazil and internationally.

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