Analysis of the Conceptions of Teachers Engaged in Developing the Statistical Learning Project Mobilised in a Focus Group

Cassio Cristiano Giordano [a]
Mauren Porciúncula [a]

ª Universidade Federal do Rio Grande, Instituto de Matemática, Estatística e Física (IMEF), Programa de Pós-Graduação Educação em Ciências (PPGEC), Rio Grande-RS, Brasil

ABSTRACT

Background: Teachers' conceptions about teaching and learning guide their beliefs, knowledge, and attitudes that impact their understanding of the proposed curriculum. Studying their origins, functions, and changes in didactic contexts makes it possible to rethink teaching practices more effectively**. Objectives**: With this research, we hope to answer the following questions: (a) what conceptions do teachers mobilise when managing and developing a statistical learning project from the perspective of exploratory data analysis? (b) what changes in conceptions might result from this experience? **Design**: For that, we structured qualitative research of the case study type, with recordings of a focus group analysed with the technological support of the NVIVO software. **Setting and participants**: The research sample consisted of six elementary school teachers from three public schools in Rio Grande do Sul, members of a collaborative group of continuing education offered by a local public university, and selected from many publicised calls in the second semester of 2021. **Data collection and analysis:** Data were collected in a focus group carried out with teachers after their experience in continuing education, tutoring, and development of learning projects. **Results**: It was possible to identify changes between the teachers' initial and final conceptions of statistics, mobilised during the development of the research projects. **Conclusions**: This allows us to suggest that the statistical learning project can favour changes in teachers' statistical conceptions, which, in the light of our theoretical framework, are signs of learning.

Keywords: Teachers' conceptions; Statistical learning project; Collaborative groups; Focus group; Exploratory data analysis.

Corresponding author: Cassio Cristiano Giordano. Email: ccgiordano@furg.br

Análise das concepções de professores envolvidos no desenvolvimento do Projeto de Aprendizagem Estatístico mobilizadas em um grupo focal

RESUMO

Contexto: As concepções dos professores a respeito do ensino e da aprendizagem norteiam suas crenças, conhecimentos e atitudes, afetando diretamente a sua compreensão sobre o currículo proposto. Estudando suas origens, sua função e suas transformações nos contextos didáticos, é possível repensar as práticas docentes de forma mais efetiva. **Objetivos**: Com essa pesquisa, esperamos responder às seguintes perguntas: (a) que concepções são mobilizadas por professores na gestão e desenvolvimento do Projeto de Aprendizagem Estatístico, na perspectiva da Análise Exploratória de Dados? E (b) que mudanças de concepções podem resultar dessa experiência? **Design**: Para tanto, foi estruturada uma pesquisa qualitativa, do tipo estudo de caso, com gravações de um grupo focal, analisadas com o suporte tecnológico do software NVIVO. **Ambiente e participantes**: A amostra da pesquisa foi constituída por seis professores dos Anos Iniciais e Finais do Ensino Fundamental, de três escolas públicas gaúchas, integrantes de um grupo colaborativo de formação continuada, oferecido por uma universidade pública local, selecionados a partir de ampla divulgação, no segundo semestre de 2021. **Coleta e análise de dados**: Os dados foram coletados em um grupo focal, realizado com professores, após a sua experiência de formação continuada, tutoria e desenvolvimento de projetos de aprendizagem. **Resultados**: Foi possível identificar mudanças entre as concepções estatísticas iniciais e finais dos docentes, mobilizadas ao longo do desenvolvimento dos projetos de pesquisa. **Conclusões**: Isso permite sugerir que o Projeto de Aprendizagem Estatístico pode favorecer mudanças de concepções estatísticas docentes, o que, à luz de nosso referencial teórico, são indícios de aprendizagem.

Keywords: Concepções Docentes; Projeto de Aprendizagem Estatístico; Grupos Colaborativos; Grupo Focal; Análise Exploratória de Dados.

INTRODUCTION

Brazilian basic education has been undergoing profound transformations, driven partly by the new curriculums resulting from the publication of the definitive version of the National Common Curriculum Base - BNCC (Brazil, 2018) and partly due to the emerging need for teachers' and students' appropriation of digital information and communication technologies (DICT) triggered by the Covid-19 pandemic context of emergency remote teaching (ERT).

In the mathematics curriculum component, more specifically in the thematic unit Probability and Statistics, a new version of the old Information Treatment block, present in the National Curricular Parameters - PCN (Brazil,

1997, 1998, 2002), there were many changes, some of them pointed out by Lima and Giordano (2021): the expansion of a space dedicated to probability and statistics in the mathematics curriculum, from the 1st grade of elementary school to the end of high school; introduction of the frequentist perspective of in the teaching of probability, with the suggestion of planning and execution of experiments and probabilistic simulations, preferably through computational resources; proposal of intramathematical and interdisciplinary articulations; emphasis on visual apprehension, with the implementation of new types of graphics, such as the box-plot and the stem and leaves graph, with or without the use of the DICT; strong incentive for students' central role and collaborative work through active methodologies, especially with regard to the project-based learning (PBL); appreciation of socio-emotional skills, which meet the elements of disposition, present in Gal's (2021) statistical literacy model, which we assume as our highest theoretical reference in this area.

In this article, we highlight one of those new demands (not all new, some revisited): the clear and direct orientation for the development of statistical research with real data collected by the students themselves, from the 1st grade of elementary school to the end of high school, not as a teaching strategy, but as an object of knowledge, along the lines of the investigative research cycle, as shown in Figure 1:

To contemplate this proposal, teachers could use new active methodologies, such as gamification, or revisit old teaching methodologies, such as mathematical modelling, problem-solving and PBL, the latter with more than a century of existence. The first scientific paper that explicitly mentions this theory was published by William Kilpatrick (1918) –The Project Method– exactly a century before the BNCC was published.

To better understand which teaching conceptions were mobilised during the development of learning projects and identify whether they could have changed, in 2021, we participated in a proposal for collaborative continuing education with six teachers of elementary education from different curriculum components from three public schools in Rio Grande do Sul. The aim was to promote multimedia statistical literacy using the statistical learning project (SLP).

Our material for analysis was the weekly meetings of this collaborative group —held in the second half of 2021— and the recordings of a focus group (data collection technique in qualitative research that uses group discussion sessions, centralising on a specific topic the participants should

debate) —carried out in December of that year, after the students of those school units presented the results of the statistical research.

Figure 1

Investigative Research Cycle. (Adapted from Guimarães & Gitirana, 2013)
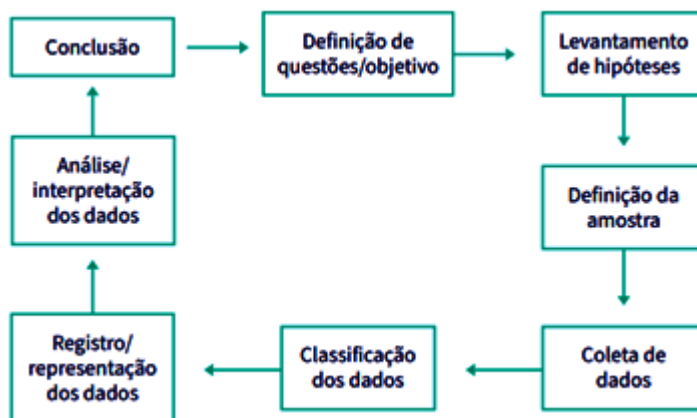
We sought to identify the teaching conceptions mobilised in the implementation and development of the SLP and eventual changes in conception to answer our research questions: (a) what conceptions do teachers mobilise in the management and development of the statistical learning project from the perspective of exploratory data analysis? (b) what changes in conceptions might result from this experience?

In the next section, we will present our main theoretical frameworks.

THEORETICAL BASIS

This section will present the theoretical frameworks that supported our research. It is divided into three subsections. In the first one, we present exploratory data analysis – EDA, which many researchers such as Batanero and Díaz (2004, 2011) define as a philosophy that guides exploratory investigations in statistics and probability and its connection with learning projects. The following subsection discusses the fundamental elements for promoting statistical literacy according to Gal's (2021) model. In the third and

last subsection, we will discuss the perspective of collaborative work in teachers' continuing education, teaching conceptions, and their possible transformations.

Exploratory data analysis and learning projects

In statistics teaching and learning, we assume the theoretical framework of EDA, a perspective that emerged in the 1960s, which had as one of the precursors the North American statistician John Wilder Tukey (1977). He suggested that statisticians explored data and formulated hypotheses that would allow new data collection and experiments, independent of a pre-established statistical model, extrapolating the mathematical modelling and traditional statistical tests to extract as much information as possible from the data, creating plausible models that could support future research.

The researcher could then start their analysis by examining the available data first, modelling the most appropriate techniques to solve their problem afterwards. The EDA provides a vast repertoire of methodologies for a detailed study of the data before adjusting them. This proposal stood out in the context of a transition from a technical and procedural perspective of statistics and probability that overemphasised the mathematical aspect to an analytical perspective that sought to build realistic models from the study of collected data.

The EDA tries to be more accessible, motivating, and creative, imbued with the investigative spirit that characterises any and all scientific production, which is next to the teaching methodology of the PBL. Batanero, Estepa, and Godino (1991) highlight its potential to create learning situations on topics of interest to students based on graphic representations that favour the perception of variability, the evaluation of order measures that minimise unusual cases, the use of different scales, and the lack of need for a complex mathematical theory, with unnecessary tools for the stage of learning in the field. Those authors suggest that the traditional descriptive statistics curriculum should be transformed from the EDA, encouraging and supporting investigative attitudes, unlike the tendency of most didactic transpositions to reduce knowledge to technique.

Such ideas align with Cobb and Moore (1997) when stating that statistics requires different thinking because data are not just numbers but numbers in context. They point out that statistics is an intrinsically

methodological discipline that does not exist for itself but offers other fields of knowledge a coherent set of ideas and tools for dealing with data, where variability is ubiquitous. Wild, Utts, and Horton (2018) state that statistics is a meta-discipline, capable of transforming data into real-world insights. Those ideas, with which we fully agree, are in line with the observations of Cazorla and Giordano (2021), which highlight the potential role of statistics as an articulator and mediator of old and new curricular components in the post-BNCC context.

For Batanero and Díaz (2004), statistical projects motivate students, differing from the simple resolution of long lists of repetitive and decontextualised exercises. According to them, projects focus on realistic situations and contribute to the improvement of various skills and competencies that are essential to statistical literacy, such as communicative linguistic competence, mathematical competence, competence for recognition and interaction with the physical world, competence for processing information, digital competence, social competence to exercise citizenship, competence to "learn to learn", competence to question critically, and competence to achieve autonomy and personal initiative. The development of a statistical learning project (SLP) enables the exploration of statistical knowledge in meaningful contexts for students and techniques and strategies of great relevance for the education of critical citizens in times of disinformation and fake news.

Batanero and Díaz (2011) differentiate between strictly theoretical and practical knowledge in statistics. Applying knowledge of a statistical nature is usually much more difficult than it seems, as it does not only require technical-procedural knowledge, such as building a graph or calculating a measure of central tendency, but strategic knowledge, such as knowing how to choose the most appropriate type of graph, according to the nature of the variables and what is intended to be highlighted in it. To better understand those ideas and practices, it is necessary to develop statistical literacy (Gould, 2017; Gal, 2021).

Aiming to promote statistical literacy, Porciúncula (2022) suggests the implementation of the SLP, whose development comprises the steps: definition of the theme (given the interest and concerns of the research subjects), collection and organisation of data (through a survey); statistical analysis and discussion of results among group members; presentation/dissemination of results, with the sharing of information. In this process, the student experiences the role of a researcher, which is crucial for

the appropriation of the processes of construction of scientific knowledge, the improvement of criticality, and the full exercise of citizenship, for coexistence in a democratic and enlightened society, in an environment of social justice. The teacher's support as a mediator of interactions in the didactic environment and manager of the development of statistical literacy through the SLP is fundamental, which brings us to our following subsection.
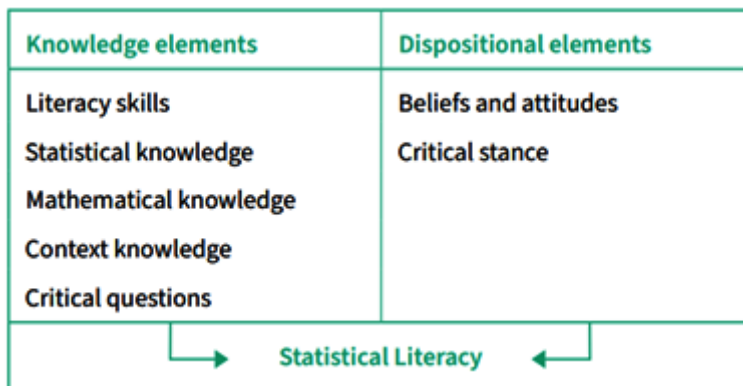
Statistical Literacy

According to Watson (1997), statistical literacy consists of textual understanding and its possible implications for contextualised statistical information. It involves a basic understanding of its terminology, language, and fundamental concepts and the development of critical and reflective investigative attitudes. Conti and Carvalho (2011) identify two dimensions in this literacy: the individual, based on the ability to establish relationships between ideas, and between textual and extratextual information, and the social, which involves interactions between participants in the situation, the demands of social contexts, and the representations and values intrinsically linked to the acts of reading and writing.

Gal (2021) sees statistical literacy as constructed from a critical and investigative stance, basic knowledge of statistics and mathematics, reading and analysis skills, beliefs, attitudes, and knowledge about human beings and the world around them. It is an essential skill for exercising citizenship in an information-overloaded world. Such literacy involves elements of knowledge and disposition, presented in Figure 2:

Gould (2017) considers that the continuous process of statistical literacy requires that we understand who collects data about us, by which means and how; know how to analyse and interpret data from random and non-random samples; understand privacy and data ownership issues; know how to create basic descriptive data representations to answer questions about common real-life situations; understand the importance of data provenance; understand how, by whom, and with what interests the data is stored; understand how computer representations can vary; understand basic aspects of predictive modelling.

Figure 2

Model of Statistical Literacy. (Gal, 2021, p. 42)

For the promotion of statistical literacy in its individual and collective dimension, a coherent alternative, both from the perspective of the EDA and the active methodologies, so present in the BNCC (Brasil, 2018), is the development of the SLP. Giordano (2016) asserts that PBL offers a wide range of unique possibilities for developing statistical literacy. Such an approach notably changes the relationships between teacher, student and knowledge, typical of the didactic contract, encouraging students' autonomy in the development of their authorial research. Porciúncula and Samá (2015) see the SLP not only as a methodology but as a way of reflecting on the role of statistics in society. The change in teaching posture in the face of statistical problems is in line with the proposal of working with projects. Porciúncula and Samá (2014) point out that this proposal requires a change in the teacher's role from transmitting information to guiding the students' learning processes.

Such a change in teaching posture requires continuous investment in initial and continuing teacher education, which leads us to our next section.

### Teachers' conceptions and the collaborative group

The word conception takes on multiple meanings in different contexts and is often associated with ideas, values, beliefs, and attitudes. Azcárate (1996) asserts that teachers' ideas, beliefs, and knowledge profoundly affect their understanding of the proposed curriculum and the actions necessary to

contemplate it. Artigue (1989) observes that this word is often associated with a local construct related to specific knowledge and the different problems to which they apply. The concepts emphasise the plurality of possible perspectives on a given object of knowledge, representations, and associated treatment modes, adaptation and adequacy in using tools and strategies in teaching and learning practices.

Recognising the multiplicity of coexisting conceptions, often intertwined, often contradictory, contributes to demystifying possible transparency of didactic communication present in empiricist models of teaching and learning, making the reading of interactions in the teacher-student-knowledge didactic triangle unique (Brousseau, 1986, 2007). Many conceptions ($\mathcal{c}_1$, $\mathcal{c}_2$, $\mathcal{c}_3$,..., $\mathcal{c}_n$) are mobilised in the cognitive processes that lead to the construction of specific knowledge (K). The knowledges (K_1, K_2, K_3,... , K_n), in turn, are articulated in the elaboration of concepts (C_1, C_2, C_3,... , C_n). The resolution of a mathematical problem, in turn, involves a great deal of conceptions, knowledge, and concepts, according to Balacheff (1995, 2001, 2002).

Figure 3

Relationships between conceptions, knowledge, and concepts. (Adapted from Balacheff, 1995)
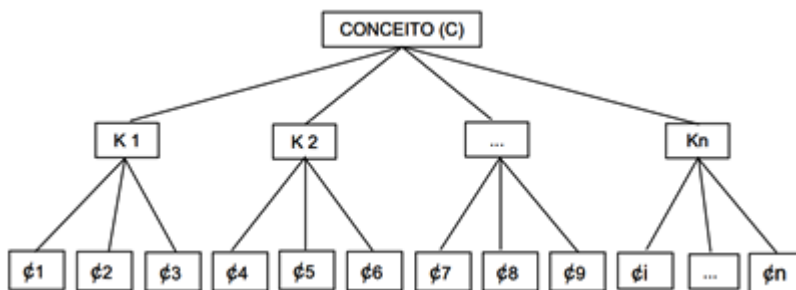
Artigue (1989) asserts —although assuming a local nature, each conception in the subject's interactions with the problem— that understanding the conceptions is important for the researcher insofar as it is representative of an educational context, common to other students and teachers. According to the theory of conceptions (Balacheff, 1995, 2001, 2002; Balacheff & Gaudin, 2002; Balacheff & Margolinas, 2005), changing concepts is an indicator of learning.

Artigue (1991, 1993, 1994) states that a better understanding of students' and teachers' conceptions is essential to promote mathematics teaching and learning. Balacheff and Gaudin (2002) emphasise that knowledge should not be reduced to behaviours but cannot be taught in their absence. In teaching and learning processes, each action mobilises a large amount of knowledge, and to develop new knowledge or deepen previous knowledge, one must mobilise concepts associated with the problems faced.

Giordano (2020) highlighted that the interaction between conceptions of different subjects could be necessary for the construction of new conceptions when they work in a cooperative and collaborative way. In the educational context, those two words have often been used as synonymous, as Fiorentini (2013) observes, affecting our understanding of their organisation and functioning and our way of using them and/or investigating them.

Heargreaves (1998) emphasises that adopting a collaborative work proposal changes the educational paradigm due to its articulating and integrating character. Individual work has been undervalued in a society where socio-emotional skills have gained more and more space within curricular proposals. However, Heargreaves (1998) suggests that the choice for a collaborative proposal should result from a conscious and democratic choice, not an imposition.

For Garfield (1993, 2013), learning in cooperative activities is more effective in small groups, with common goals such as solving problems and completing tasks. Such learning falls into a broader category of collaborative learning, seen as working in groups of two or more individuals mutually involved on an equal footing in the search for understanding, solutions, or meanings or the creation of a product.

Hall and Wallace (1993) believe that cooperative work would be a phase of collective work, on a scale that goes from conflict to collaboration, the latter seen as a superior stage. In cooperative work, although people carry out joint actions consensually, not everyone enjoys autonomy and decision-making power.

For Fiorentini (2013), volunteering, identity, spontaneity, co-responsibility, shared leadership, peer support, and mutual respect are the fundamental principles of collaborative work. Those principles guided our work on continuing teacher education in 2021, which we present in this article.

The following section will bring our methodological procedures.

METHODOLOGICAL PROCEDURES

This research is qualitative, from the perspective of Creswell and Creswell (2021), of the case study type, according to Yin (2015). Data were also collected in the context of emergency remote teaching (ERT) in the first half of December 2021 through audiovisual recording carried out in a focus group consisting of six teachers from the curriculum components (Portuguese Language, Sciences, Geography, Mathematics, History, and Pedagogy), with lessons imparted to one 2nd-grade group of the initial years and two groups of the 7th and 8th grade of elementary school from three Brazilian public schools, and the researchers involved in collaborative continuing education. This meeting lasted two hours.

The teachers were invited to join a statistical multimedia literacy programme that has been developed for ten years by researchers from a local federal university in Rio Grande do Sul. In 2021, this programme was financially and strategically backed by two partner institutions that support education and culture to promote social transformation through playful and contextualised pedagogical practices. Its main objective is to promote the statistical literacy of basic education students, mediated by DICT, making them more capable of autonomously and critically reading the statistical information that is conveyed by the most diverse media, especially in times of disinformation (fake news).

The material recorded in audio and video was analysed using the qualitative research package NVIVO version 12.7, software of qualitative analysis that, among its many resources, contributes to textual analysis, lexical analysis, and cluster analysis. In this focus group, held at the end of the semester project, after the presentation of the final results of the research of the students of the public schools involved, the teachers answered ten questions about the development and management of the SLP, namely: 1. How did you feel throughout the project? Tell us briefly how the development was (challenges, successes, adaptations) 2. Did you observe interdisciplinary aspects in the development of the SLP? Was there a relationship with Mathematics, Portuguese Language, History, Geography, Arts, Religion, Physical Education or other curriculum components? 3. In your opinion, how did the students feel? Was it playful for them? 4. Based on the experiences lived in the collaborative group, what teaching knowledge do you consider to have been mobilised and/or produced in this process? 5. What knowledge do you consider that still needs to be developed, given the continuity in carrying

out the SLP at school, at other times? 6. What statistical skills did you notice the students developed? After all this time of reading, workshops, dynamics, and exchange of experiences, can you tell us if it was possible to develop the construction of statistical knowledge (requirements)? 7. Did the authorial themes (that the students themselves chose) make it possible to bring adolescent and youth cultures closer to school culture? With these themes, was there a deepening of learning and the construction of autonomy/leadership of students? 8. What has changed in your way of looking at statistics after your collaborative experience? 9. Do you believe that project-based learning can contribute to optimising time and resources, including articulating curricular components? 10. If you were to start your research now, given this interdisciplinary experience, what partnerships would you look for in terms of curriculum components and co-workers? Would you look for external partnerships?

One last observation: the postgraduate programme in which this postdoctoral research is inserted has its Ethics Committee in the approval phase. However, we have available all the Terms of Free and Informed Consent (ICF) duly signed by the teachers, principals, and students who participated in this statistical literacy programme, which included, among other things, collaborative teacher education, although, in this article, we only mentioned the teachers. We also have documentation of the approval of the two partner institutions (research funding bodies) as responsible for funding and strategic support of our investigative work. We assume full responsibility for the research and explicitly exempt Acta Scientiae from any consequences arising therefrom, including full assistance and eventual compensation for any resulting damage to any research participants, per Resolution n. 510, of April 7, 2016, from the National Health Council of Brazil.

In the following section, we will present some results of our research.

RESULTS AND ANALYSIS

During the continuing education course aimed to promote the statistical literacy of the basic education students, we recorded the weekly meetings with teachers and researchers and tutoring groups with teachers, researchers, and students on the Google Meet platform. In addition, we constantly monitored WhatsApp groups and the presentation of the research results in the schools and for the school communities shortly after the face-to-

face classes resumed. However, this article will limit our analysis to the focus group.

This focus group is highlighted because it was carried out after all the teaching and learning experiences that the partnership between public elementary schools and the local public university developed, with the support and funding of two partner institutions.

The focus group meeting lasted two hours, during which we asked ten questions. The participating teachers were six, one multipurpose teacher who taught in the 2nd grade of elementary school and five specialist teachers who taught different curriculum components in the 7th and 8th grades of elementary school.

The first block had two general questions: 1. How did you feel during the project? Tell us briefly about the development of the project (challenges, successes, adaptations) 2. Did you observe interdisciplinary aspects in the development of the SLP? For example, was there a relationship between Mathematics, Portuguese Language, History, Geography, Arts, Religion, Physical Education or other curriculum components?

Answering the first question, teacher P5 replied:

> *This exchange with my colleagues... because are we from such different areas, right? Then we got together, one of the languages, one from the exact [sciences] and one of the human [sciences], right? And this exchange, each one contributing in their own way according to their experiences, with their formation, that was very cool. So, I think it was all very divided in the end, very cohesive, each contributing in their own way to make the work happen.*

In turn, teacher P3 said:

> *I'll be very honest, I went there on P2's advice, let's do a project, I went because of the students mainly because I think they get... well, you met some there, you know, many of them don't have much chance to do something different, the school always doing the same thing, that dispute over content, you have to give content, you have to overcome the content, and sometimes we end up spending the whole year on it, right, and the students are not very interested. Myself... the content I work with, sometimes makes me want not to pass it on to*

them. And then it was an idea to do a different project, so well, let's do it, let's try to see what it is, then P2 [said] 'ah, it's on statistics', I hesitated a little because it's something I don't like it anyway, maths, numbers, but ok, let's do it, and then as it went on it was... we learned with the process, which was also the objective, it wasn't just for the students, then we too understand [...]. I think that was it, I really enjoyed participating, I think it was very good for me, including thinking about my role as a teacher at school and all, it opened up several other possibilities of how to work with the students in class, I think for me, it will be very good, thinking individually, right. And for the school, the challenge is to keep going with the project, it's for us to keep trying to do things that are just that, the students like and need it.

It seemed that, at first, P3 was a little afraid of accepting the challenge of implementing an unknown methodological strategy, especially when knowing that it was a proposal that involved knowledge, skills, and statistical competencies. Finally, however, we noted that the teacher was happy to have overcome the difficulties.

Based on collaborative work between specialists in different subjects, Fazenda (2011) emphasised that the educator must reflect on the teaching practices of scientific subjects to overcome the soliloquy and establish a dialogic practice, in which teaching turns into the art of making people discover, of making people understand, and of making invention possible.

In the first question, teacher P4 recognised "*a mix of feelings*" and, as for students, a "*sudden fear that they would give up*", but, in the end, concluded: "*Thank God we got it*". In addition, the support offered to researchers was preponderant. P1 attributed part of this success to the creation of a WhatsApp group and the tutorials: "*The university staff, with the monitors, with the masters' and doctoral students, was a very strong base, which helped a lot*".

Such facts exemplify how an interdisciplinary collaborative environment, according to Fazenda (2011), can become a space rich in reciprocity, mutuality, and co-ownership relationships, enabling dialogue between stakeholders. For example, we noticed that, initially, the project aroused in teachers feelings of insecurity, of fear of the new. Then, they accepted the new teaching methodology, and recognised the support; they understood that they were not alone, that everyone played a leading part and

could contribute with their background. Finally, they showed they had overcome fear and trusted external assistance, in a welcoming collaborative group.

Regarding the second question about the possible interdisciplinary aspects involved in the development of the project, teacher P1 answered:

> *We work with Portuguese, mathematics, religion, and Spanish, including through WhatsApp groups, the texts were placed... every time the students gave ideas of what they would like to research, most research has already been published since the beginning, right, except for animals in general, which at first would be about dogs, after which it became about animals in general. So, based on the students' interest —I work with mathematics and religion classes—, I have already gone after what could collaborate within the religious education module, and P4 has also taken advantage of those texts to take to students in her subjects. In fact, this was a very cool thing, because we brought curiosities, websites, texts, that is what I said, and this was fundamental for many choices they made based on those studies. So, we did have religion, mathematics, Spanish, and Portuguese involved in this learning process within our work. And the book, you brought it, didn't you? Because I brought it to the students during my classes, because we had a Meet class, but we had our classes, where I presented the measures of central tendency, they already knew how to interpret graphs, they already knew about percentages, but that thing I say, right, what impaired [us is] that not everyone was always present, some were, others were not. So, some 7th-grade students, even though I asked the 7th-grade teacher to work with it, I gave her the material and everything, some saw it, others didn't, because all this part of this work was done mainly during remote classes.*

In line with those ideas, P4 stated that:

> *[...] the issue of geography, we are not specialists in the area, but I think it was very present there, especially when we were talking about other countries, right, when Japan appeared, when Israel appeared, so, in class I talked with them, as we took [the texts], I took the texts and P1 also [did] to the whole*

class, right, both of us there posting the activity on the platform and applying it in class, questions arose, right, regarding the location, where it is, very far, close, where it is, the continent, some issues as we got by there, working. But as we had two groups that were interested in other countries, in the culture of other countries, I would also raise the issue of the arts, which was also very present, implicitly when they talked about the issue of culture, the issue of symbology there, right, mainly in Japan, that they brought, right. So, of course, because of this context, we were not able to have direct contact with colleagues in these areas, but I think that within our classes we managed to do this interdisciplinarity, work and open the range, suggest and discuss, show that it is not because we are not... we would not only work in Portuguese and mathematics, we can work with a series of knowledge, right, and learning together with them, which I think this was a great positive point too, the knowledge of the other disciplines, we researched and learned together with them".

In that direction, teacher P5 added:

Oh, sure, since their writing at their time... because we asked them to write about what they learned, right, what the project brought them in terms of learning, their feelings about the project, the part of geography in the group that worked on space and the universe, the science part, in the group that worked on the issue of garbage, the environmental issue. So, yes, there was interdisciplinarity all the time. Art was also present. So, sure there was interdisciplinarity, yes.

Agreeing with her colleagues, teacher P2 admitted:

[…] and I kept thinking, when the girls chose the theme of the environment, they were very connected to what the science teacher was working on, right, they were interested in that, but they wanted to make their own way, through the theme, they wanted to build their own path, but they dialogued with the science teacher's contributions, right, so I think it was the students who brought this dialogue into the project. And I think it also appears there in the drawings, right, the interest in cartoons, the issue of language, graphic editing, there are several elements there that cross this thematic choice.

Finally, P3 added:

> *I think it's the idea of the project, you who conceived it for longer, that this interdisciplinarity was on purpose, there's no way not to appear, right, because this is a free topic and a free topic, you'll have to understand the topic, see how is that you do the research and end up entering several areas. Of course, I think the ideal would be if we had more time to focus on the historical aspect of the topic, the mathematical aspect, I don't know. But that's not the goal, right, it encompasses everything from the research and then I think that's it, that's what's cool, sometimes we do it and we don't even realise how interdisciplinary it is, but it is, you research, you go after it and you have to at least know a little about the other areas, right?*

Such testimonies can be considered indicators of the recognition of articulations between the curricular components, greater closeness between teachers and greater freedom of teaching and student performance. As for the students, teacher P3 noted that "*the main thing about the project is that they have a collective space for dialogue, discussion, research*", fundamental elements for the effective development of active methodologies, so much valued at BNCC (Brasil, 2018).

Dealing more specifically with interdisciplinarity, teacher P3 said: "*there's no way not to be evident, right?*". And added, "*sometimes we were like 'ah, they won't have autonomy', but they did. So, during the process, they managed to grow* ". Isn't it what we expect when working with active methodologies?" The work carried out from the implementation of the SLP provided the opportunity for interdisciplinarity in the persons' actions throughout the process, individually or collectively, which, according to Tomaz and David (2012), is how they conceive this way of conducting the learning environment. The authors state that interdisciplinarity is the students' and teachers' participation in school practices while they are being developed, not determined from pre-established meanings in a work proposal.

Teacher P2 recognised "*we were in a time and the students, in a different one*", and she added, "*the biggest adaptation was this*". We consider this need to adjust the teachers' and students' pace to be natural. It was a new experience for everyone, and we must consider that the difficulties worsened with the pandemic context and the readaptation with the return to face-to-face classes at the end of the year.

Teacher P6, who works with the 2ⁿᵈ grade of elementary school, with children aged seven or eight years old, said: "*I am a little older than you, I came from a very traditional teaching, it was all online, it was this, then that, then that other [thing], little interdisciplinarity*", recognising the difficulty of rethinking her practices based on a teaching methodology scarcely known to her. Finally, however, she observed that the SLP "*mobilised knowledge, content that was not from that grade's curriculum, but we need to think like this: 'how are we going to deal with it, we must approach and try a strategy that doesn't deviate from that content, that theme that is being addressed*", and, although she admitted that being "*complicated for us*", she was surprised to realise that "*for them, it's simpler*". thus, she stated that "there are several things, also skills that they learned, that is from this hidden curriculum that we... it is not something that is there in the curriculum, but we address all the same. So, this work was very enriching. I fell in love [with it]".

The second block of questions addressed topics from research partners' research lines, namely playfulness, teaching knowledge, statistical skills and competencies (literacy, reasoning and statistical thinking), interdisciplinarity and school culture. They were: three. In your opinion, how did the students feel? Was it playful for them? 4. Based on the experiences lived in the collaborative group, what teaching knowledge do you consider to have been mobilised and/or produced in this process? 5. What knowledge do you consider that still needs to be developed, given the continuity in carrying out the SLP at school, at other times? 6. What statistical skills did you notice the students developed? After all this time of reading, workshops, dynamics, and exchange of experiences, can you tell us if it was possible to develop the construction of statistical knowledge (requirements)? 7. Did the authorial themes (that the students themselves chose) make it possible to bring adolescent and youth cultures closer to school culture? With these themes, was there a deepening of learning and the construction of autonomy/leadership of students?

Unfortunately, we will not have enough space to deal with those themes separately, but they will be present later in the word cloud, word tree, and project map created using NVIVO.

However, some comments are worthy of note, such as the one by teacher P5, about teaching knowledge:

> *I think, for me, it was daring, daring to do things differently [...] I never dared to make a presentation, I never dared to work together with my colleagues from other areas. [...] the*

project made this possible, we deconstructed it, that we worked without an order of contents and covered several things. So, for me, those were the great learnings, working together with my colleagues from several different areas from mine, daring to present... I never allowed myself that at school as a teacher, I had never allowed myself this kind of thing, I always thought ... the tendency of what we do is not enough for us to show, and today with the project I see that, no, that we have to show it and it eventually rubbed off on many colleagues, because other colleagues got in the way, I saw them saying 'ah, can it be done with the little ones?' and I said 'yes', another approach is possible with the early years, yes. So, I think that it somehow stimulated other colleagues who thought of developing something like this. That was a learning experience for me.

As well as this comment by P4: "*I think it's a great knowledge for the teacher to know the great ability we have to solve, to see what is really worth working on at that moment, so that group doesn't get stuck to what the legislation imposes on us, right?*"

For Fazenda (2011), interdisciplinary work requires engaging specialists from different disciplines, but teachers do not always have the formation or guidance for this type of work. This author proposes that interdisciplinarity depends on a change in attitude towards the problem of knowledge, on the replacement of a fragmented conception with a unitary conception of the human being. We see evidence of this change in attitude when P5 says: "*I think for me it was daring, daring to do [something] different*". Teacher P6 highlighted that in a "very traditional teaching, everything was online, it was this, and later, that, little interdisciplinarity". With a stifled curriculum, it is only possible to adopt a traditional teaching proposal, which for decades has proven to be ineffective, whereas if we want to work with gamification, mathematical modelling, problem-based learning, station rotation, hybrid teaching, and learning projects, we must be more flexible, giving freedom of action to both the teacher and the student. The approach through projects requires this flexibility and freedom, as Giordano (2016, 2020) shows us, even more so now, when this proposal has been incorporated into the BNCC (BRASIL, 2018). In this regard, P2 made the following comment that called our attention: "*The greatest learning was to allow us not to be in control*".

The third and final block brought three questions more: 8. What has changed in your way of looking at statistics, after your collaborative experience? 9. Do you believe that project-based learning can contribute to optimising time and resources, including articulating curricular components? 10. If you were to start your research now, given this interdisciplinary experience, what partnerships would you look for, in terms of curriculum components and co-workers? Would you look for external partnerships?

Teacher P4 replied: "*Well, so if I were to start this experience, I think that the base, the support of the mathematics colleague is fundamental, right?*" and then adds "to do the statistical project without a math colleague, it's not impossible, nothing is, but the math colleague, he gives us a lot of support, he gives us this support to start from there so that we can [start] looking for it. And then it will depend a lot on the topics, right?" Cobb and Moore (1997), Batanero and Díaz (2004, 2011), Giordano (2016, 2020), Gal (2021), and Porziuncula (2022) emphasise the unique nature of statistics, which works from a perspective that values randomness and variability, differentiating it from mathematics, which has a more deterministic bias. Those sciences differ in their historical constitution, the object of study, and methodology, among many other points. However, most teachers still consider statistics as a field of mathematics, establishing a relationship of dependence with this professional, when seeking partnerships in projects involving stochastic knowledge (related to combinatorics, probability, and statistics). Regarding possible partnerships, P1 replied:

> *As for partnerships, you know, in projects, I think the main thing is, before doing it, sit down with peers, talk and see who runs the boat, who will stick together. I was very lucky, and I was saying it this morning at school, what a pity that P4 was absent, but I was very lucky that P4 was together, and we set up a pair in which we held hands, and each one did one part to lighten the load because each of us teaches in two schools, a different work. So, regardless of the subject... is a math teacher important? Yes, but I think that above all, the greatest importance is the desire to do it, it is from those who are involved in the project, and to try to bring as many people as possible to our side, to research together, because the more people you have, the lighter the trajectory and course of the entire project will be. And I agree on the role of partnerships, I think there should be, as P4 said, there in the part of the animals, to bring the university people.*

In the same direction, teacher P5 replied:

> *And if I were to start today... ah, I would look for passionate colleagues. I think we have it [passion], no matter how long you've been in the profession. So I think this is a... that's what I think, this amazement of ours, sometimes, leaving school exhausted, but we are still being able to be marvelled by things, even with everything, sometimes going wrong, but the people find something that works and value those things that work.*

We reiterate our position, which is supported by Batanero and Díaz (2011) and Cobb and Moore (1997): statistics is not mathematics; it is an autonomous science with its own objects of study, its own research methods. Statistics is the science of numbers in context. But one can understand this position because, in basic education and, many times, in university, the topic is imparted by mathematicians. On the other hand, we observe an opinion that values socio-emotional skills more than academic education: the curriculum component does not matter so much, but the teacher's attitude towards the new, the challenge, as highlighted by teacher P5, "*well-disposed and passionate*" teachers. We note that this attitude is related to the attitude that Fazenda (2011) characterises for interdisciplinarity to happen. Such an attitude is made of openness, curiosity, and intuition of the relationships between teaching knowledge. Each specialist can contribute to the research according to the themes and thus enrich the discussions fostered by the themes and research problems and provide an interdisciplinary environment. From this perspective of interdisciplinary work, Fazenda (2011) highlights that no subject is more important than the other but a collaboration between several subjects, which is characterised by reciprocity in exchanges, with the objective of mutual enrichment.

Agreeing with colleagues, teacher P3 replied:

> *The ideal would be for this practice to be what P2 said, right, to be naturalised in schools, to be a practice that does not need to have something more, this thing of interdisciplinarity, of conversation among colleagues, planning together, executing together, students having more autonomy. [...] schools need this and it optimises time and resources, it is possible to articulate a lot with the curricular components, including making them more interesting for the students, it would be nice if one day we could do this for the students in*

the classroom. And if I were to start the research now, I think so, I would invite more colleagues and such, but this question would have to be thought about a little more, in addition to inviting colleagues, what to do, I would not be able to answer in a concrete way now. I realised that you could do a lot of things like that, you could look for people from outside, you could call colleagues, you could call more students too.

Those testimonies show the perception, on the part of those teachers, that the realisation of projects optimises time and resources, allows approximations between the different curriculum components, with retakes and anticipations of objects of knowledge in a non-linear and complementary way, from a new curriculum perspective, more connected to the student's reality and close to the requirements of the BNCC (Brasil, 2018), in line with the provisions of a SLP (Porciúncula, 2022).

Teacher P5 noted that "it *contributed, made possible this approach with the teachers in a different way, where we were not taking everything to them. They (the students) were also teaching us* ", to which teacher P6 added: "*really, when they choose the subject, right? it makes us get closer to them* ", and added: " *we articulate those components, optimising our time, because several teachers can work on the same subject and, each one trying to bring closer to their skills, developing their abilities".*

These statements reveal that the teachers recognise the importance of interdisciplinary work, the contribution of statistical learning projects (SLP) in strengthening the relationship between teachers and students and the understanding regarding teachers' continuous learning. The reported changes align with the changes in the relationships between those who teach and those who learn, proposed by Fazenda (2011), a necessary transformation for interdisciplinarity. Not only is student involvement a determining factor in teaching and learning processes, but teachers must engage too.

At this point, we are left with P1's words: "*I think that, above all, the greatest importance is the desire to do it, it is from those who are involved in the project and try to bring as many people as possible to our side, to do research together*". For interdisciplinarity to exist, it is necessary to reflect on the possibilities of action that lead to partnerships and integration.

The following graphs were originally generated using the NVIVO software, in Portuguese, and cannot be modified. Thus, we will keep the original form, but we will translate the highlighted words.

Using the qualitative research software NVIVO, we built a word cloud with the 40 most used terms with five letters or more. The only significant word for our research that was left out because it contains four letters was BNCC, but with the NVIVO tools, it was possible to verify that it was only mentioned by the teachers twice (Figure 4).

Figure 4

Word cloud emerging in the speeches of the six teachers involved in the research, in the focus group.

The word cloud (Figure 4) elaborated from the focus group represents the importance of learning statistics by doing statistics, from the EDA perspective (Batanero; Díaz, 2011), of doing in the sense of 'doing statistics', as Conti argues (2009) when stating that it is possible to promote literacy and 'do statistics' in a public school, in the periphery, despite all its own difficulties, and that this possibility is not limited to statistical knowledge. Emphasising *fazer* (doing), we find highlighted, in Figure 4, *trabalho* (work), *trabalhar* (to work), and *projeto* (project). The word *tempo* (time) was associated with three different contexts: the time available to carry out the project, without prejudice to the curriculum program, especially at the beginning of the work, the remaining time, with the return to face-to-face classes, to enable the culmination of the project with the disclosure of the research results, and the time optimisation by incorporating objects of

knowledge from different curriculum components and transversal themes (Brasil, 2019).

Among the most significant words brought by the six teachers (P1 to P6), selected with the help of NVIVO: BNCC, school, groups, playful, graphics, project, statistics, work, interdisciplinarity, doing, and time. The use of the words: school, time, doing, work, project, and graphics was unanimous in the six teachers' answers. The others are represented in Figure 5.

Of the six teachers, only two of them mentioned the BNCC, and they did so only once, which we believe to be significant, since it was mentioned several times in the initial meetings in the context of the teachers' expression of concern about not meeting the demands with the time they could "waste" in the development of projects. Thus, the idea that the SLP allows for optimising time, efforts, and resources in school dynamics prevailed.

Figure 5

Project map based on teachers' discourse.
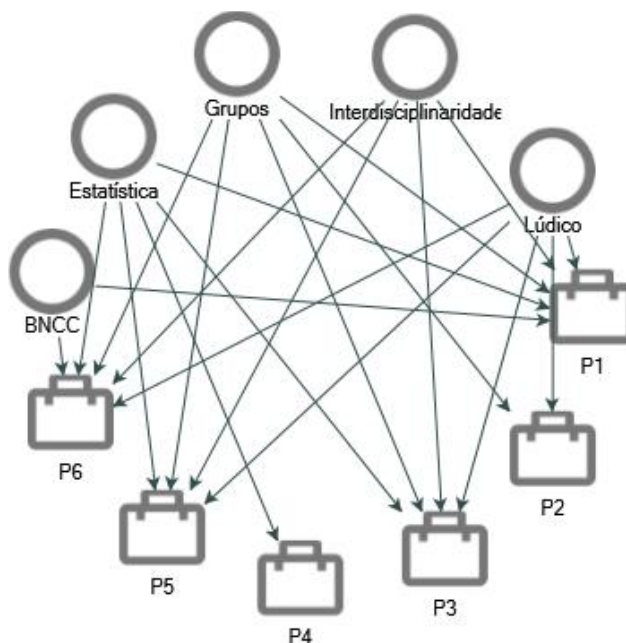
Teacher P2 was the only one who did not mention the word *estatística* (statistics). With teacher P4, P2 did not think it was significant to mention the word *interdisciplinaridade* (interdisciplinarity). However, by not mentioning interdisciplinarity, they ignored group work, the interaction between peers, and the ludic aspect of the SLP. *Lúdico* (playful) was remembered by half of the participants. One teacher observed that in "*very traditional teaching, everything was online, it was this, then, later, that, little interdisciplinarity*". It was a safe path, although not very motivating for the students and the teacher.

The SLP proved to be challenging, requiring the teacher to accept living with uncertainty, as the directions of the research were in the students' hands. According to this teacher, "*the biggest learning was to allow ourselves not to be in control*". A third teacher was delighted with the result, especially with the students' engagement: "*How important they feel when they gave us a thousand and one explanations of their research!*". Figure 6 represents many of the ideas associated by teachers about projects in the teaching of statistics.

Figure 6

Tree of words associated with the term projetos *(projects), in the focus group.*

This and the word trees that will be presented below associate the term under analysis to the ten words before and after it, mentioned in the focus group teachers' speeches, except when they find the beginning or the end of a clause.

The conceptions about the teaching methodology based on learning projects initially implied challenges, something beyond the teacher's capacity, especially those who did not say they did master the objects of mathematical knowledge, especially regarding graphics. There was also a great fear of not being able to comply with the regular curriculum, impacted by the context of the ERT during the Covid pandemic. Working on projects could mean wasting precious time. Finally, these concepts changed profoundly, with the perception of time optimisation, material resources, shared between different teachers and students, and human resources, through internal and external partnerships.

The BNCC was mentioned twice, both associated with the new demands of the thematic unit Probability and Statistics (Figure 7).
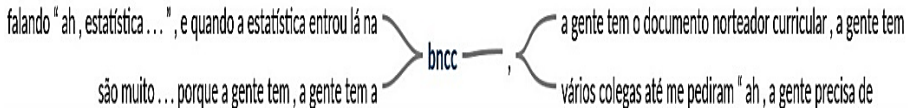
Figure 7

Word tree associated with the term estatística *(statistics), in the focus group.*

Isolating the BNCC term, we have (Figure 8).

Figure 8

Word tree associated with the term BNCC, in the focus group.

One of the most significant difficulties foreseen before the projects began to be developed was the students' construction of statistical graphs. When in the collaborative group, faced with the impositions of social isolation resulting from the Covid-19 pandemic, the teachers chose to collect the data through Google Forms (which totalled the data and automatically offered statistical graphs), they relaxed a little but were still a little apprehensive about the analysis. Figure 9 is revealing.

Figure 9

Word tree associated with the term gráfico *(graph/graphic), in the focus group.*

At the end of the investigative work, however, the teachers were surprised with the students' progress in reading, besides the construction (as they did it without digital resources) on cardboard of the research results to present and disseminate them to the school and surrounding community. Phrases such as "*they will never look at a graph the same way*", "*the graph provides quick reading, right?*" The teachers' discourse denotes both changes in teaching and student conceptions.

The emphasis on *fazer estatística* (doing statistics), on *estatisticar* (statisticscizing) (Conti, 2009), is present in the use of the term *trabalhar* (to work) and *trabalho* (work) (Figures 10 and 11).

Figure 10

Word tree associated with the term trabalhar *(to work), in the focus group.*

Figure 11

*Word tree associated with the term* trabalho *(work) in the focus group.*

The concepts mobilised around the practices when teaching statistics during a research planning and execution process contemplate the principles of exploratory data analysis.

Batanero, Estepa, and Godino (1991), from the perspective of Tukey (1977) and Cobb and Moore (1997), observe that students learn better statistical concepts from visual resources such as graphs, diagrams, charts, and tables, in contexts that are familiar to them and that attract their interest, especially when they have the right to choose the topic to be investigated

(Batanero & Díaz, 2004, 2011). The teachers, in turn, feared not having enough knowledge for the didactic management of this work, but in the end, they were more confident in their work, saying, without fear, that they learned together with their students.

Figure 12

Word tree associated with the term escola *(school) in the focus group.*
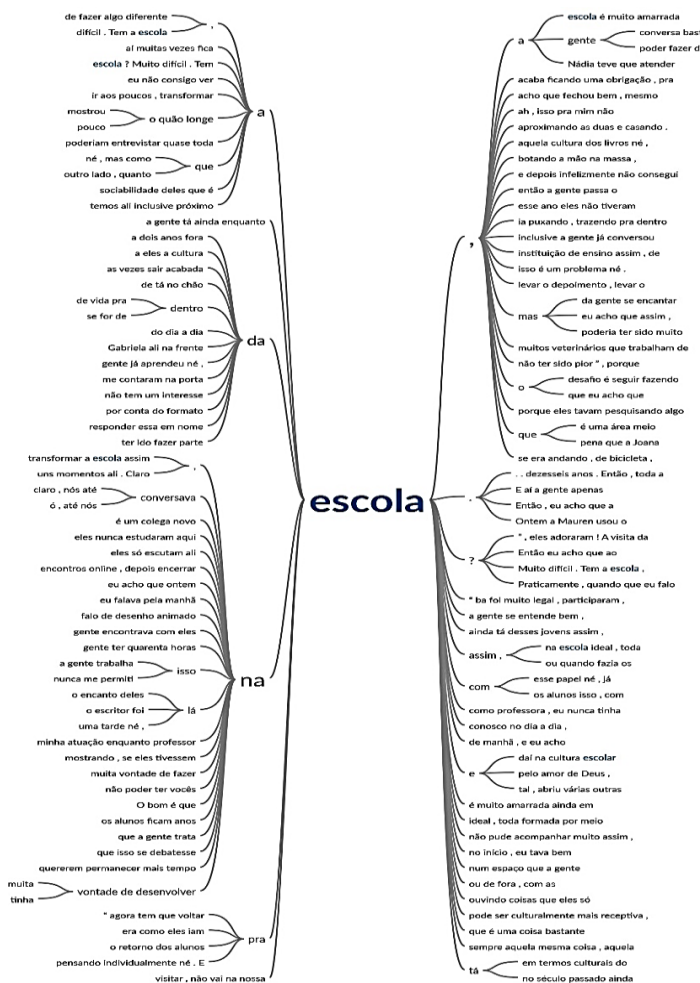
We believe that the change in teachers' conceptions about the management and development of the SLP may have been influenced by two factors: a) in the collaborative group meetings, they were able to create, develop, and present their projects, living the experience they would propose to their students; b) the researchers, who followed all the work, starting from the invitation to schools and teachers to participate in this statistical literacy programme to the culmination of student work, with the presentation to the school community, with their posters, and the final meeting with the teachers, with the focus group, despite their training in the academic career (master's students, masters, doctoral students, PhDs and post-docs) always made it clear that they were learning together with teachers and students, as argued by Freire (1996, 2014).

The school was almost always mentioned positively, as a space for meeting, for learning: a place for coexistence (Figure 12).

We attribute part of this relationship with the school as a result of the students' prolonged distance from school, while teachers were tired of remote classes with little interaction, as teacher-student contact at the ERT proved to be below expectations (Saviani & Galvão, 2021; Borba, 2021). Teachers reported that many students wanted to go to school on Saturdays to get work done when they reopened in November. They found this behaviour unusual and were surprised by the motivation of these students aroused by the SLP.

Finally, a point worth noting: we consider it an achievement for the teaching in the participating schools the meeting of the school community (parents, other students and teachers, authorities of the local education department, with an audiovisual record of the experience and publication, in the coming months, of a book reporting that experience, with chapters written by the researchers and all the teachers involved) at the culmination of the SLP. Seeing students play the part of researchers, presenting the results of their authorial investigations, was evidence of the potential of the learning projects to promote student leadership and autonomy.

Finally, the above guides us to our final considerations.

CONCLUSIONS

When we started this research, our main objectives were to answer the following questions: (a) what conceptions do teachers mobilise in the management and development of the statistical learning project from the

perspective of exploratory data analysis? (b) what changes in conceptions might result from this experience?

We could identify many conceptions about what statistics is, what its function within the prescribed curriculum is, what its potential in the face of new curriculum challenges is, what statistical research is, how it can be conducted in a school environment, what collaborative work is and how it is carried out, how to build, read, and interpret statistical graphs, frequency distribution tables and measures of central tendency and dispersion, how to plan and execute the SLP, what its possible contributions to education are, with emphasis on its exploration of interdisciplinarity, and what its use in the formation of the student, the citizen, for the reading of the world and social transformation is, among others.

In this process, we realised, through evidence present in the discourse of professors, in the focus group, that a large part of their conceptions changed. We observed that those teachers appropriated not only specific statistical knowledge, the technical-procedural knowledge, but also the domain of active methodologies practices, especially PBL, knowledge about classroom management, about collaborative work.

This allows us to suggest that the SLP can favour changes in teachers' statistical conceptions, which, in the light of our theoretical framework, are signs of learning. For teachers, developing the SLP in the middle of a pandemic was an opportunity to reinvent themselves, deconstruct and reconstruct knowledge, establish partnerships, collaborate, share knowledge and feelings, and, above all, be daring.

They began to see statistics differently, realising that they knew much more than they imagined by assisting their students to build statistical graphs, with the technological support of multiple computational resources and even in the paper and pencil environment, in reading and interpreting tables of frequency distribution, in writing and reviewing students' arguments, based on scientific data, especially in the moments that preceded the presentation of the results of their research. They also recognised the need to seek partnerships, to participate in continuing education from a collaborative perspective.

We hope this research contributes to deepening the reflection on changing teaching concepts, through a collaborative proposal, in the development of teaching and statistical learning through learning projects.

AUTHORSHIP CONTRIBUTION STATEMENTS

CCG conceived the idea and presented it to MP, the leader of the research group, who articulated the execution of actions with the other members of this group. CCG and MP developed the theory and adapted the methodology to this context. MP has been developing this project for a decade and CCG joined it a year ago. Both actively participated in the moment of data collection and organisation, discussion, and analysis of results. CCG reviewed and MP approved the final version of the work.

DATA AVAILABILITY STATEMENT

The data that support this article are under the custody of CCG and MPMS and may be made available upon request from other interested parties for a period of five years.

REFERENCES

Artigue, M. (1989). Épistémologie et didactique. Paris: *Cahier de DIDIREM*, *3*, 14-19.

Artigue, M. (1991). Épistémologie et didactique. *Recherches en didactique des mathématiques*, *10*(2), 241-285.

Artigue, M. (1993). Connaissance et métaconnaissance, une perspective didactique. In: Baron M., Robert A. (eds.) Métaconnaissances en IA, en EIAO et en Didactique des Mathématiques. *RR Laforia*, *93*(18), 29-42.

Artigue, M. (1994). Didactical engineering as a framework for the conception of teaching products. *Didactics of mathematics as a scientific discipline*, *13*, 27-39.

Azcárate, P. G. (1996) *Estudio de las concepciones disciplinares de futuros profesores de la primaria en torno a las nociones de la aleatoriedad y probabilidad.* Comares. Colección Matema.

Balacheff, N. (1995). Conception, connaissance et concept. In: Grenier, D. (Ed.). Séminaire de l'équipe DidaTech. *IMAG*, 219-244.

Balacheff, N. (2001). Les connaissances, pluralité de conceptionsle cas des mathematiques. In: *Actes de la Conference Ingenierie de la Connaissance*, Toulouse. (p. 83-90).

Balacheff, N. (2002). Cadre, registre et conception. *Les cahiers du laboratoire Leibniz*, *58*, 1-19.

Balacheff, N. & Gaudin, N. (2002). Student's conceptions: an introduction to a formal characterization. *Les cahiers du laboratoire Leibniz*, *65*, 1-21.

Balacheff, N. & Margolinas, C. (2005). CK¢: modèle de connaissances pour le calcul des situations didactiques. In: Mercier, A. & Margolinas, C. (Eds.). *Balises pour la didactique des mathématiques* (p. 75-106). La Pensée Sauvage.

Batanero, C. & Díaz, C. (2004). El papel de los proyectos en la enseñanza y aprendizaje de la estadística. In J. Patricio Royo (Ed.), *Aspectos didácticos de las matemáticas* (p. 125-164). ICE.

Batanero, C. & Díaz, C. (2011). *Estadística con proyectos*. Universidad de Granada.

Batanero, C.; Estepa, A. & Godino, J. D. (1991). Análisis exploratorio de datos: sus posibilidades en la enseñanza secundaria. *Suma*, *9*, 25-31.

Borba, M. C. (2021). The future of mathematics education since COVID-19: humans-with-media or humans-with-non-living-things. *Educational Studies in Mathematics*, 1-16.

Brasil. (1997). Ministério da Educação. Secretaria de Educação Fundamental. *Parâmetros Curriculares Nacionais: Matemática*. Ministério da Educação.

Brasil. (1998). Ministério da Educação. Secretaria de Educação Fundamental. *Parâmetros Curriculares Nacionais: Matemática*. Ministério da Educação.

Brasil. (2002). Ministério da Educação. Secretaria de Educação Média e Tecnológica. *PCN Ensino Médio: Orientações Educacionais complementares aos Parâmetros Curriculares Nacionais – Ciências da Natureza, Matemática e suas Tecnologias*. Ministério da Educação.

Brasil. (2018). *Base Nacional Comum Curricular - Educação é a Base*. Ministério da Educação.

Brasil. (2019). *Temas Contemporâneos Transversais na BNCC: Contexto Histórico e Pressupostos Pedagógicos*. Ministério da Educação.

Brousseau, G. (1986). Fondements et méthodes de la didactique des mathématiques. *Recherches en didactique des mathématiques*, *7*(2), 33-115.

Brousseau, G. (2007) Os diferentes papéis do professor. In. Parra, C.; Saiz, I. *Didática da Matemática: reflexões psicopedagógicas* (p. 48-72). Artmed.

Cazorla, I. M. & Giordano, C. C. (2021). O papel do letramento estatístico na implementação dos Temas Contemporâneos Transversais da BNCC. In Monteiro, C. E. F.; Carvalho, L. M. T. L. *Temas Emergentes em Letramento Estatístico* (p. 88-111). Editora UFPE.

Cobb, G. W. & Moore, D. (1997). Mathematics, Statistics, and Teaching. *The American Mathematical Monthly*, *104*, 801-823.

Conti, K. C. (2009). *O papel da estatística na inclusão de alunos da educação de jovens e adultos em atividades letradas*. 227f. Dissertação (Mestrado em Educação). Campinas: Faculdade de Educação, Universidade Estadual de Campinas.

Conti, K. C., & de Carvalho, D. L. (2011). O letramento presente na construção de tabelas por alunos da educação de jovens e adultos. *Bolema - Boletim de Educação Matemática*, *24*(40), 637-658.

Creswell, J. W. & Creswell, J. D. (2021). *Projeto de pesquisa - Métodos qualitativo, quantitativo e misto*. 5. ed.. Penso.

Fazenda, I. C. A. (2011) *Integração e interdisciplinaridade no ensino brasileiro*: efetividade ou ideologia. 6. ed. Loyola

Fiorentini, D. (2013). *Pesquisar práticas colaborativas ou pesquisar colaborativamente?* In: Borba, M. C.; Araújo, J. L. (Orgs.). Pesquisa qualitativa em Educação Matemática. 5. ed. (p. 53-85). Autêntica.

Freire, P. (1996). *Pedagogia da autonomia*: saberes necessários à prática educativa 25. ed. Paz e Terra.

Freire, P. (2014). *Educação como prática da liberdade*. Editora Paz e Terra.

Gal, I. (2021). Promoting statistical literacy: Challenges and reflections with a Brazilian perspective. In Monteiro, C. E. F.; Carvalho, L. M. T. L.

Temas Emergentes em Letramento Estatístico (p. 37-59). Editora UFPE.

Garfield, J. (1993). Teaching statistics using small-group cooperative learning. *Journal of Statistics education*, *1*(1), 1-9.

Garfield, J. (2013). Cooperative learning revisited: From an instructional method to a way of life. *Journal of Statistics Education*, *21*(2), 1-9.

Giordano, C. C. (2016). *O desenvolvimento do letramento estatístico por meio de projetos:* um estudo com alunos do Ensino Médio. 155f. Dissertação (Mestrado em Educação Matemática). São Paulo: Pontifícia Universidade Católica de São Paulo.

Giordano, C. C. (2020). *Concepções sobre Estatística*: um estudo com alunos do Ensino Médio. 268f. Tese (Doutorado em Educação Matemática). São Paulo: Pontifícia Universidade Católica de São Paulo.

Gould, R. (2017). Data literacy is statistical literacy. *Statistics Education Research Journal*, *16*(1), 22-25.

Guimarães, G.; Gitirana, V. (2013). Estatística no Ensino Fundamental: a pesquisa como eixo estruturador. In: Borba, R. E. S. R.; Monteiro, C. E. F. (org.). *Processos de Ensino e Aprendizagem em Educação Matemática 1*. (p. 93-132). Ed. UFPE.

Hall, V., & Wallace, M. (1993). Collaboration as a Subversive Activity: a professional response to externally imposed competition between schools? *School Organization*, *13*(2), 101-117.

Hargreaves, A. (1998). *Os professores em tempos de mudanças: o trabalho e a cultura dos professores na Idade Moderna*. McGraw-Hill.

Kilpatrick, W. (1918). The project method. *Teachers College Record*, *19*(4), 319-335.

Lima, S. O. & Giordano, C. C. (2021). Letramento estatístico: um olhar sobre a BNCC. In Monteiro, C. E. F.; Carvalho, L. M. T. L. *Temas Emergentes em Letramento Estatístico* (p. 473-491). Editora UFPE.

Porciúncula, M. (2022). *Letramento Multimídia Estatístico - LeME: Projetos de Aprendizagem Estatísticos na Educação Básica e Superior*. Appris.

Porciúncula, M. & Samá, S. S. (2014). Teaching statistics through learning projects. *Statistics Education Research Journal*, *13*(2), 177-186.

Porciúncula, M. & Samá, S. S. (2015). Projetos de aprendizagem: uma proposta pedagógica para a sala de aula de estatístico. In: Samá, S.; Porciúncula, M. (Orgs.). *Educação Estatística: ações e estratégias pedagógicas no ensino básico e superior* (p. 133-141). CRV.

Saviani, D. & Galvão, A. C. (2021). Educação na pandemia: a falácia do "ensino" remoto. *Revista Universidade e Sociedade*, *67*, 36-49.

Tomaz, V. S.; David, M. M. M. S. (2012). *Interdisciplinaridade e aprendizagem da matemática em sala de aula*. Autêntica.

Tukey, J. W. (1977). *Exploratory Data Analysis*. Addison Wesley.

Watson, J. M. (1997). Assessing statistical thinking using the media. In: Gal, I.; Garfield, J. (orgs.) *The assessment challenge in Statistics Education*. (p. 107-121). IOS.

Wild, C.; Utts, J. & Horton, N. (2018). What is Statistics. In: Ben-Zvi, D.; Makar, K.; Garfield, J. (ed.). *International Handbook of Research in Statistics Education* (p. 5-36). Springer.

Yin, R. K. (2015). *Estudo de Caso: planejamento e métodos*. Bookman.