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Manifestations of Teachers' Statistical Knowledge in Continuing Education

Manifestações do conhecimento estatístico de professores em formação continuada

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Abstract

This article presents the analysis of the statistical knowledge manifested by teachers in the actions of the extension project Pedagogical Workshop of Mathematics (OPM), organised based on the assumptions of the teaching guiding activity, which, in turn, is based on the foundations of historical-cultural theory and activity theory. To this end, we analysed some episodes in which teachers manifestations in the face of a situation that triggers the learning of statistical concepts. As a result, it was possible to recognise that the situation - which was elaborated considering essential relations of statistical knowledge from its historical and logical movement - triggered teachers' need to establish links between the concepts of statistics. The needs evidenced by the situation and in the process of organising training, in general, triggered teachers' actions of research and synthesis, which reveals the importance of projects such as the OPM for the training of basic education teachers.

Keywords: Statistical knowledge; Teaching guiding activity; Teaching experiment; Mathematics pedagogical workshop.

Resumo

Este artigo apresenta a análise sobre o conhecimento estatístico manifestado por professores nas ações do projeto de extensão Oficina Pedagógica de Matemática (OPM), organizado a partir dos pressupostos da Atividade Orientadora de Ensino que, por sua vez, pauta-se nos fundamentos da Teoria Histórico-Cultural e Teoria da Atividade. Para tal, foram analisados episódios nos quais há manifestações dos professores diante de uma situação desencadeadora de aprendizagem de conceitos estatísticos. Como resultado, foi possível reconhecer que a situação, que foi elaborada considerando relações essenciais do conhecimento estatístico a

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partir de seu movimento histórico e lógico, desencadeou nos professores participantes necessidades de estabelecimento de nexos entre os conceitos da Estatística. As necessidades evidenciadas pela situação e no processo de organização da formação de forma geral desencadearam ações de pesquisa e de síntese por parte dos professores, o que revela a importância de projetos como a OPM para a formação de professores do ensino básico.

Palavras-chave: Conhecimento Estatístico; Atividade Orientadora de Ensino; Experimento Formativo; Oficina Pedagógica de Matemática.

Introduction

By treating pedagogical practice as a source of phenomena to be observed and analysed in research in the teaching area, we take the teacher's knowledge as our object of study. In this sense, this study aims to analyse the teachers' statistical knowledge from the 1st to the 5th grade of the initial years of elementary school, manifested from a situation that triggers learning presented in the Mathematics Pedagogical Workshop (Oficina Pedagógica de Matemática[5] - OPM).

By observing the different perspectives concerning the appropriation of statistical knowledge, we can see other ways of addressing the issue. One of them is by applying questionnaires to recognise the teachers' relationship with the content and evaluate their attitudes through statistical methods of analysis, as proposed by Oliveira Júnior (2018). On the other hand, based on Shulman (1987), Silva, Alves, Pietropaolo, and Amorim (2020) focus on discussing statistics in basic education from the professional skills of mathematics teachers and pedagogues who teach statistical notions. Conti, Carvalho, and Carvalho (2016) adopt statistical literacy (Gal, 2004) as a theoretical foundation to study teacher knowledge.

Other authors present different modes of study and research on teachers' knowledge. However, here we adopted the understanding of the process of teacher education and knowledge appropriation in the Mathematics Pedagogical Workshop supported by the assumptions of the teaching guiding activity (Moura et al., 2016), based on the activity theory (Leontiev, 1978).

The Mathematics Pedagogical Workshop (OPM from now on) can be understood as a process of materialisation of teaching praxis. This extension project of the Federal University of Technology of Paraná, *campus* Curitiba, aims to establish a collective work between basic education teachers working in public schools and the mathematics teaching degree undergraduates and graduate students of the teaching area. This initiative is rooted in a homonymous project that has been carried out at the University of São Paulo since the 1980s, having expanded to other institutions by members of the Study Group on Pedagogical Activity (Grupo de Estudos sobre Atividade Pedagógica - GEPAPe). According to Moura (1988), the OPM was recognised as a environment for creating materials and critically discussing the mathematics teaching organisation, seeking to engender new forms for teaching practice. Currently, the objective is to provide a teacher learning space where theory

[5] Project website: https://sites.google.com/view/opm-2019

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and practice constitute a unit supported by the teaching guiding activity as a theoretical and methodological basis.

This text is divided into the following sections, considering this formative space and the objective of analysing the manifestations of these teachers' statistical knowledge. First, it discusses the theoretical foundation of the project, the teaching guiding activity, which guided both the continuing education process and the analyses of this work. Then, we turn our gaze to the logical movement of statistics considered throughout the process. From there, we organise the actions of the Mathematics Pedagogical Workshop, analysing them as a formative experiment in the third section. Finally, the fourth, fifth, and sixth sections are dedicated to studying the data made available in the episodes highlighted.

Teaching Guiding Activity

There is a particular way of studying phenomena related to the subjects' knowledge concerning the field of statistical education, keeping in mind the competencies of literacy, thinking, and statistical reasoning (Campo, Wodewotzki & Jacobini, 2013). However, the Mathematics Pedagogical Workshop was not organised based on these competencies. The theoretical and methodological guidelines that support this extension project is based on the teaching guiding activity (TGA), which has its own way of studying knowledge appropriation and teacher education in general, and specifically, of statistical knowledge. By considering teacher and student as subjects in action, the teaching guiding activity (TGA) (Moura et al., 2016) allows us to understand their education process from the intentionality of their actions. Upon receiving contributions from the members of the Study and Research Group in Pedagogical Activity (GEPAPe/FEUSP), the teaching guiding activity is established as a theoretical-methodological basis for the understanding of the teaching-learning process from the assumptions of the historical-cultural theory (Vygotsky, 1998) and the activity theory (Leontiev, 1978).

We understand 'activity' as the unit of analysis of the psychic process revealed when the subjects' motives coincide with the object to which they are directed. In this psychic process, active individuals perform actions and operations to achieve a goal that meets one individual or a collective need. Thus, as those elements constitute the subjects' activity, they becoming structuring of the teaching guiding activity as a relationship between the teacher's activity and the students' activity.

The teaching activity is, in this sense, the psychic process of the teacher who faces the need to organise teaching. It "is a human creation to develop the human way of appropriating knowledge necessary to insert new subjects in collective activities that aim to satisfy historically developed needs [...]" (Moura, Araújo & Serrão, 2019, p. 416). Assuming that the process of organising teaching is intentional, we understand that the teaching activity requires teachers' constant study, analysis, synthesis, and reflection on theory and practice. The teaching activity "forms [the teacher] to the extent that he/she plans the initial action and must remain in a process of continuous evaluation of the actions developed in class so that

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the objective proposed is achieved" (Moura, 1996, p. 42).

In this movement of organising teaching, seeking to enhance the students' development, we realise that the teacher's actions are intended to trigger the learning activity. For this, we expect that the students' reason to be in school is to appropriate knowledge (Moura et al., 2010). Thus, "theoretical knowledge is both the object and the need in the learning activity" (Moura et al., 2010, p. 215). This type of knowledge is appropriated by theoretical forms of thinking.

Davydov (1988) considers empirical and theoretical forms of human thought, both supported by abstractions, generalisations, and deductions. Empirical thinking is based on the objective-sensory reality of the subject, while theoretical thinking operates on concepts. "The concept intervenes here as a form of mental activity through which the idealised object and its system of relations are reproduced" (Davydov, 1988, p. 300, our translation). [VERIFICAR ESTA TRADUCAO]. According to Kopnin, "theoretical thinking reflects the object in the aspect of internal relations and laws of its movement, cognisable through the rational elaboration of empirical knowledge data" (1978, p. 152). Therefore, theoretical thinking derives from the relationships between the concepts idealised by the subject and the data of the objective reality, understood as internal and external conceptual nexuses.

The recognition of internal conceptual nexuses occurs through the study of the historical-logical movement, which is seen as the process of recognising the needs that triggered a certain form of knowledge in the historical movement of human experience, as well as the nexuses between the concepts that constitute this knowledge. Those relationships between concepts shape the logical aspect that "reflects not only the history of the object itself but also the history of its knowledge" (Kopnin, 1978, p. 186).

In the process of organising teaching, the teacher proposes situations that trigger in students the need for theoretical knowledge, known by the TGA as "situations that trigger learning" (Moura et al., 2016). To create a triggering situation, the teacher's conscious recognition of the theoretical knowledge to be conducted is necessary. In other words, the teacher must recognise the internal and external conceptual nexuses of the area of knowledge that he/she intends to teach — here, the conceptual nexuses of statistics.

Considerations about the logical and historical movement of statistical knowledge and its conceptual nexuses

The study of the logical and historical movement of knowledge and the unveiling of conceptual nexuses are part of the organisation of teaching based on the TGA. It is characteristic of this study the recognition of the needs that resulted in some way in the objectification of the concepts, which, in this study, are the statisticians. Thus, we had to research historical sources that deal with the development of statistical science.

When bringing considerations about the logical and historical movement of statistics, Moura et al. (2019) present the possibility that the rock engravings of the Paleolithic Period

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are forms of pictographic representations aimed to share information with their collectivity. This consideration reveals two essential aspects for the development of statistics: the transformation of raw data (nature) into data thought, i.e., those that have already undergone some type of analysis or treatment; and the production of means to represent information.

Poubel and Sad (2014) report that statistical science "was, at first, practised empirically through quantitative counts, but slowly involved professionals, until it became the method for the analysis and study of social phenomena, systematised numerically" (p. 21). By observing the origin of the word of statistics, Memória (2004) attributes the emergence to the Latin word *status*, state, because it was the only source of collection, study, and presentation of quantitative data for a long time. However, Memória (2004) points out that,

> In fact, its essential feature is that of being a set of methods (statistical methods), especially appropriate, in the words of George Udny Yule (1871 – 1951), to the treatment of numerical data affected by a multiplicity of causes (Memória, 2004, p. 10).

Lopes and Meirelles (2005) understand statistics as "the art and science of collecting, analysing and making inferences from data" (p. 3). From the perspective of Wild, Utts, and Horton (2018), statistics is a way of "thinking how to think about data" (p. 7), projecting a perception of the real world, and affirm that being able to learn how reality operates with the use of data, considering its levels of uncertainty, is a fundamental human necessity.

Even though authors can modify their considerations about statistics, the importance of data is a core issue. In other words, statistics teaching that seeks the theoretical formation of concepts (Davydov, 1988) has as one of the objectives to highlight the need for data, which are meaningful only when collected and possibly analysed.

> The current scope and intellectual content of statistics result from evolutionary processes involving both slow progress and leaps forward due to the *insights* of intellectuals giants and visionaries, all affected by the intellectual climate of their day ang the recognized challenges in the world in which they lived. But it has not reached some fixed and final state. It continues to evolve and grow in response to new challenges and opportunities in the changing environment in which we live now (Wild, Utts & Horton, 2018, p. 10).

Some authors, such as Bernstein (2018) and Tabak (2004), point out that Johan Graunt (1620-1674) is one of the precursors of modern statistics and responsible for estimating deceases and births considering the variables of sex, age, marital status, and religion. Tabak (2004) points out that Graunt was the first to develop analyses establishing a relation between the causes of deaths with the subjects. Bernstein (2018) states that the theorist did not demonstrate what inspired him to produce the "Mortality Tables," only that he enjoyed doing something innovative to improve the quality of the treatment of society's problems. Graunt's work was outstanding because he used a sample to estimate information for the population - even though he was not aware of it. He used a data set found in churches - even recognising that the data were not reliable. This treatment aimed to determine information for the population, the principle of statistical inference.

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> Graunt's pioneering work revealed basic theoretical concepts necessary for decision-making under conditions of uncertainty. Samplings, averages and notions of what is normal and make up the structure that would go further, harbouring the sciences of statistical analysis, putting information at the service of decision-making and influencing our degrees of belief about future events (Bernstein, 2018, p. 86).

Although his approximations were considered good at the time, some of his results were questioned. Graunt's historical episode raised the consideration for data, treating them in a revolutionary way in his time. We perceive that the knowledge developed evolved from the need to outline the reality experienced, presenting results that modified subjects' perception regarding their people.

Due to social needs, Graunt attributed meaning to his actions, which allowed him to reframe statistical analysis. This process shows how the environment interferes in personal development and, consequently, in the process of creating concepts of statistical science. However, even if Graunt's problem was of practical origin, in the case of formulating mortality tables, the results of his studies were not contained for a particular solution. Thus, it was necessary to systematise measures, outlines, and forms of representation to better describe the information obtained.

This is one of the processes that constitute the historical and logical movement of statistical science, and that helps to understand that the development of scientific knowledge can be recognised in human needs. This research requires further analysis. By studying this movement, Moura et al. (2019) present four essential relationships of statistical knowledge to be considered in the teaching process: the movement of the variability of a phenomenon in a given time and space; the perception and observation of the frequency of a phenomenon; the demonstration of regularities; and the realisation of predictions and possibilities of the occurrence of a phenomenon. Furthermore, the authors indicate that:

> Thus, the object of statistics reveals itself as a method of study on the occurrence of a given phenomenon and its objective is, perceiving its regularities or not, to establish statistical predictions and hypotheses. Therefore, teaching activities should address this objective. (Moura et al., 2019, p. 6)

These essential relationships and the historical process stated were considered for the organisation of a learning-triggering situation, which sought to establish needs close to those that tensioned humanity to produce new ways of studying the data. Hence, we prepared the situation to be presented to the teachers attending the Mathematics Pedagogical Workshop, expecting that they appropriated some relations of statistical knowledge involving the human need to observe regularities of a phenomenon and make predictions, also using notions of rates and different forms of representation such as graphs and tables. Such relationships were objectified in the formative experiment.

It is noteworthy that this historical study does not have the characteristic of a context generator, nor does it intend to review the entire historical process. By bringing the logical-historical elements, we seek to apprehend the movements to which humanity was exposed and incorporate them into a situation that triggers learning. This is considered the central

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action in the process of the teaching guiding activity, as a theoretical and methodological basis for the organisation of teaching that aims to encourage the students' creative tension, considering the movement of knowledge production close to those that humanity experienced.

Formative Experiment: the Actions in the Mathematics Pedagogical Workshop

The objective of the research presented in this article was to analyse the statistical knowledge manifested by teachers of basic education during the process of solving a situation that triggers learning in the Mathematics Pedagogical Workshop. The OPM is an extension project that has been developed at the Federal University of Techonoly of Paraná since 2015 that aims to promote the articulation between theory and praxis that underlies actions within the mathematics teaching activity among university professors, teachers of the basic education network, undergraduate students (mathematics teaching degree and pedagogy), and postgraduation.

The studies and works developed by the participants of the OPM - considered a learning space for teaching (Moraes, Arrais, Gomes, Graciliano & Vignoto, 2012; Moraes, Lazaretti & Arrais, 2019) - are supported theoretically and methodologically by the cultural-historical theory, the activity theory and the teaching guiding activity (Moura, 2010). In this sense, we understand that all OPM participants have a need (teaching organisation) and constitute a collective directed to an object (appropriation of scientific knowledge through theoretical thinking). During 2020, the OPM studies addressed specifically the process of organising teaching statistics. For the research to be carried out in this extension project, it was submitted to and approved by the institution's ethics committee. The OPM actions take place continuously, with regular meetings of the project execution team and the participants. In the first half of 2020, the team had 15 members of the executing team, four of whom were professors of higher education, five graduate students of professional master's degree, two graduate students of academic master's degree and four undergraduate mathematics teaching degree students. Other 13 teachers from the municipal education network of Piraquara who teach in the initial years of elementary school participated in the OPM.

Thus - and due to the interaction between teachers of different levels of education and training-, the OPM is seen as a favourable space for researching teacher training. We understand that such research is similar to a formative experiment, since it has a qualitative character with the active participation of researchers who are based on the observations collected for future planning aimed at teacher education (Cedro, 2008). This is due to the characteristics of the OPM itself, in which, as well as in a formative experiment, in the development of project actions, teachers "substantially appropriate a range of knowledge linked to the educational activity" (Cedro, 2008, p. 198).

This formative movement of the OPM is revealed in the different actions of all participants. The characteristics of this movement are fluency - everything changes at all

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times — and interdependence - everything is related to everything (Caraça, 1978). The fluency and interdependence of teachers' continuing education phenomenon are revealed in several participants' relationships, for example, their relationship with each other; those with the object of knowledge (statistics); with the theoretical-methodological basis that organises the actions of the project (TGA); with the format in which the project is occurring, via virtual platforms, due to the pandemic moment experienced; with the school environment, etc. These relationships influence the formative process that takes place in the Mathematics Pedagogical Workshop.

In the impossibility of covering and explaining this formative movement, we isolated a part of the research (Caraça, 1978) to enable a better analysis of the phenomenon, which, in this work, refers to the statistical knowledge manifested by teachers of the early years in the OPM movement. Thus, the isolate chosen to be analysed was the manifestation of this phenomenon in the teachers' movement in response to the problem presented by the learning-triggering situation *The Bubonic Plague Diary* (*O Diário da Peste Bubônica*) (Silva et al., 2020). This situation was elaborated by the OPM execution team to be presented to the other project participants who teach in the early years of basic education.

Those isolated excerpts presuppose an initial error in the sense that they are separated from the system of relationships in which they are found. Thus, when analysing the teachers' statistical knowledge as they solve a situation in the OPM movement, it is separated, for example, from the previous formative movement experienced by this teacher, or from other statistical knowledge appropriation that this teacher may have experienced and that may influence his/her actions in the OPM.

The situation *The Bubonic Plague Diary* presents the character Augusta who, in the pandemic context of France in 1720 and 1721, recounts in her diary the difficulties faced during the plague and gives information on the numbers of the deceased and the survivors of the outbreak. It is a virtual story written with fictional characters who experience a problem of social isolation at the time, which can be assumed also in the current era of the covid-19 pandemic. Quantitative information is gradually presented as excerpts from the diary are brought, as shown in Figures 1, 2, and 3.

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Gazzete de

20 de dezembro de 1720

Interdiction de circulation

Rei Luis XV indicou o fechamento das cidades para diminuição do contágio da Peste Negra. Também indicou que as pessoas evitassem a circulação pela cidade. Segundo as autoridades locais, a cidade de Arles declarou mil mortes. Já na cidade de Provença foram declaradas trezentas mortes.

Figure 1 - First excerpt from Augusta's diary
Source: Silva et al. (2020, p. 6).

Gazzete de

30 de janeiro de 1721

Cinq mois de terreur!

A população de Arles cai de 23 mil para 20 mil habitantes em apenas 5 meses de peste! A nova estratégia do governo é o isolamento domiciliar para tratar os infectados. Total de infectados já chega a 3 mil em Arles.

Figure 2 - Second excerpt from Augusta's diary
Source: Silva et al. (2020, p. 6).

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Gazzete de

15 de junho de 1721

6 mille morts!

Arles já chegou ao oitavo mês de isolamento. Até o momento, foram registrados 6 mil mortes em Arles contando com 8 mil infectados.

Figure 3 - Third excerpt from Augusta's diary
Source: Silva et al. (2020, p. 7).

To solve the situation, the participants are expected to organise the data presented in the diary in tables or otherwise. The information in the diary just allows us to create the register shown in Table 1, and the hidden data are treated as unregistered (NR).

Table 1 - Quantitative data present in the situation

	Dates	12/20/1720	01/30/1721	02/01/1721	06/15/1721	08/20/1721
Total deaths recorded in cities	Arles	1000	3000	NR	6000	NR
	Provence	300	NR	2000	NR	6000

Source: Adapted from Silva et al., 2020

At the end of the situation, the characters have a problem to solve regarding whether they should keep isolation in which they are, in which they ask themselves: "What can we do with so the many numbers that the government sends us through the newspapers?"

We expected that from reading the situation and the triggering problem proposed, teachers would discuss the data organisation, statistical analysis from the variables (number of deaths, number of patients and number of recovered), the perception of regularities, and be able to propose a collective solution. In this movement, we expected to enhance forms of theoretical thinking and recognition of the conceptual nexuses of statistics presented by Moura et al. (2019).

The OPM participants discussed this situation during two two-hour meetings. The situation was forwarded in advance for them to solve and present an individual solution at the first meeting, identified as E1. During the occasion, the solutions the teachers presented were discussed in search of a collective solution. At this time, the concepts of rates, variables, and forms of data organisation were also discussed, as well as the presentation of a table with the data accumulated in the two cities after the outbreak of the disease and the number of inhabitants in each location. For the second meeting, identified as E2, teachers should review

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the individual solution from the new data presented and establish an articulation with TGA elements from a previous reading, recognising needs and actions triggered by the situation, and the statistical concepts discussed. To analyse the data of the solutions, we used E1 and E2 for the meetings, PA, PB, PC, PD, PE, PF, PG, and PH, for the teachers and indicated the type of register (video or written register).

As this article aims to relate the teachers' statistical knowledge manifestations, we decided to present them through scenes that constitute the episodes, which, according to Moura (2004), "reveal the nature and quality of the actions in an isolated" (p. 273). These episodes and scenes were extracted from the discussions registered in the written and oral presentation of the teachers' solutions.

The first episode is about the needs that the situation triggered. The second episode highlights the subjects' actions during the discussion and the process of resolving the situation. In the last episode, participants' manifestations about statistical knowledge and its relationships are highlighted.

Episode 1: The needs aroused by the situation

The teaching organised from the TGA elements is centred on proposing a situation that triggers learning, seeking to generate needs for the subjects (Moura, Araújo & Serrão, 2019). However, the participants' needs were not always related to understanding the statistical concepts during the resolution of the problem. It was possible to perceive that the teachers also expressed a need to know the reality and the data collection process of the historical context presented in the situation.

Thus, the first scene of this episode unveils the teachers' attempt to understand how the historical context and tools of those times influence the data reliability, updating and dissemination. This need was demonstrated in two teachers' statements, who were curious about how the data collection was done then, and whether there was no tampering in the newspaper information. One of the teachers stated:

> I felt I needed other data, especially in relation to the research methods used at the time. How could I think of any strategy to solve the problem if 'we' did not know what the methods of research and data collection to solve this problem were [back then]? (E1, PD, video).

Another teacher (PC) indicates the possibility of conducting a local survey and verifying that the data are according to those the government reported. However, it is important to emphasise that not necessarily the number of cases and deaths are homogeneously distributed in the region. The teacher also indicates that if the local research obtains data similar to those disclosed by the government, then he could consider the government's information to be true.

But what does it mean for a data survey to be true for statistics? We can consider that this occurs when we analyse a significant sample, which results, from example, from considering the historical moment experienced by the character. As it happened in England,

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Graunt obtained data that represented information from a portion of the population, and, based on them, he extended his conclusions about the entire population (Bernstein, 2018). Even though epidemiological studies are census studies, estimating the absolute number of inhabitants and cases of a disease and its consequences, this is a distant possibility for the time narrated in the situation. So, assuming that the region of the city in which Augusta lives is not significant for the situation of the whole city, it is possible that the data collected were very different from those presented in the newspapers. So, would her research be misleading? No, it just could not, necessarily, be used to analyse the whole city's situation. Augusta would need to choose the population sample carefully.

Thus, we can see from this scene that some teachers felt needs related to the historical context and distrusted the statistical method used in the data survey, but the proposed alternative was not accurate enough for statistical analysis.

Three other teachers (PA, PD, and PE) felt a lack of numerical data, and these contributions constitute the second scene. The omission of the number of inhabitants of the cities in the diary was intentional, precisely to trigger the teachers' need for those data and show them that they must be attentive when choosing the variables to use as comparison criteria. Without information about the regional population, it was impossible to stipulate mortality rates (number of deaths per total population) and incidence rates (number of cases per total population). The analysis of mortality rates (number of deaths per number of cases) only showed how severe the disease was and that such a rate could be high even if very few people were affected. Some teachers pointed out that for every four individuals infected, three would die, however, because they did not think of the number of inhabitants, they did not compare the cities, not realising that the impact of 6,000 deaths in a city with a small number of inhabitants is very different from the impact in a large capital, with a higher number of inhabitants.

Also, teacher PF highlighted that she felt a spreadsheet with the number of infected, deceased, and recovered was missing. It is worth noting that the construction of a spreadsheet that could help Augusta to decide would only be possible with the help of statistical concepts, especially the recognition of variables and rates, since only the numerical data were not sufficient and the organisation and the two-dimensional representation of the data (whether in spreadsheets or graphs) require a preliminary analysis of what each information represents and how they relate, which would allow for the selection of the variables and rate estimation that would be relevant to solving the problem. At the end of this episode, we could highlight that the needs the subjects expressed enable us to recognise their process appropriating the statistical concepts. In this case, the following situations were observed: some teachers had not appropriated the notions of rate and variable, which was observed because they did not feel the need to identify the number of inhabitants of each city, and others did not mobilise themselves to answer the question, paying attention to social issues. Some teachers produced researched and study actions. They will be analysed in the next episode.

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Episode 2: Teachers' actions triggered by the situation

In the second episode, some actions of the participating teachers are evidenced during the analysis of the learning-triggering situation (LTS) in search of its resolution.

The first scene of this episode reveals the participants' intention to analyse the situation only with the data that were described in Augusta's diary. Realising that the data presented were not sufficient, some participants sought more information to analyse the situation according to the historical context of the time. This action was demonstrated in teacher PA's statement. She concluded that the data from the situation alone would not be enough for her to take a position regarding isolation.

> I went to the side of the information I had and what I needed to research about the disease. When I opened the diary and started reading -I really like to talk about statistics and make graphs and compare the information a lot so that I am not misled-, and I saw a lot of contradictory information (E1, PA, video).

Moreover, after the first meeting, the organisers presented a table with complete data from the two cities after the outbreak and invited the teachers to rework their responses. In this movement, two teachers reaffirmed their decisions about isolation from the concept of rate presented, demonstrating that they understood it and used it to interpret the data and make decisions, movements proper to statistical knowledge. Although many teachers did not reformulate their answers, teacher PA went further, seeking to understand more about the concept of variable, which was presented in general. She reaffirmed the definition of variables as the characteristic to be observed and presented explanations and examples of each type of qualitative and quantitative variable.

When the participating teachers were asked about the needs that the situation generated in each one and what data were still missing to reach a conclusion, PA stated that she had made a list of missing data, both the socioeconomic data of the time and the numerical data. Here, the action the teacher developed is clear – besides analysing the situation, her search for more supporting elements in the face of the situation.

The second scene reveals an articulation of the situation presented with the structure of the teaching guiding activity. A text was made available for the participants' pre-reading to get familiar with the TGA. They were requested that, based on the text, they set up a scheme articulating the situation presented with the TGA elements (motives, objectives, actions, operations, conditions). Some teachers expressed difficulty identifying the structuring elements of TGA, such as the learning-triggering situation (LTS), confusing it with mere contextualisation.

Other teachers presented reflections that are linked to the TGA principles, where the teacher, to materialise a proposal of work with students, presents the LTS as a central and mediating action between the teaching activity and the learning activity, as can be observed in the speech of one of the teachers:

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> [...] I did not have some mathematical knowledge so I had to look up a theoretical study for me to base my answers, it was exactly one of the objectives that you wanted to provide with these activities, I did not make a scheme because I find it difficult to do it on the computer, but I did it here in my notebook, and I related it like this: theoretical scientific content and, on the other side, the teaching activity; in the teaching activity, having you as the teacher, as I described in my answer, and we as the student in the teaching activity, what are we? The subject of this situation, what are our needs? Of the student, that we are to learn, and of you in this case, in the role of teacher to teach us, right, to pass on this knowledge. And the reasons, of you, an organisation of this teaching, right, to be enabling our knowledge and we, the assimilation of theoretical knowledge, at least we read, internalise and do other research to assimilate this theoretical knowledge, then we come to actions that you sat together, for sure, gathered, saw the definitions and procedures of how to work with this theoretical knowledge with us, how to ask us, question us, provoke us in relation to a knowledge, and we stay with the actions of solving the learning problem, we want to learn, but we need to come to a solution, we need to study this to reach a conclusion (E2, PA, video).

Thus, through this episode, it was possible to identify actions that were triggered by the situation proposed, both to meet the need to understand the statistical content in the process of resolving the situation and reflect on the theory from the reading performed. In the teacher's statement, we realise her awareness of her learning process and recognition of her actions. Thus, we can conclude that the situation presented aroused needs that led some teachers to be active, even if this did not occur with the other participants.

Episode 3: Manifestations of Statistical Concepts

This episode aims to reveal how teachers connected themselves to statistical concepts from the triggering situation proposed. These relations will be presented through two scenes, the first on the manifestations of concepts in the movement of the collective solution of the triggering problem, and the second on the relations established in the teaching of statistics.

The moment of resolution of the triggering problem is divided into two moments: individual solutions and discussions mediated by the organisers. In the teachers' individual solutions, it was possible to perceive that not all of them resorted to mathematical tools or statistical concepts, establishing social relationships and comparisons with covid-19 to affirm the need for isolation.

Only teacher PC sought to use the percentage as a resource, establishing the mortality rate of the disease in both cities. Other teachers constructed bar graphs, however, with different intentions: some of them sought to identify deaths over time while others sought to compare the number of deceased in the two cities. However, we should remember that bar charts do not have the function of establishing changes over time. The establishment of comparisons would not be wrong at all; however, due to the lack of information about the population, it was impossible to interpret the graph. Thus, the bar graph, when used, serve only to represent the same information as the text, without contributions to the interpretation and comparison of data.

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Teacher PG, who also felt the need to represent the data over time, used something close to the line graph (Figure 4). Nevertheless, we could not understand what made her define different concavities to connect the numbers of the deceased of the two cities. As a hypothesis, we can think that the participant was influenced by the format of exponential or logarithmic growth or was still worried about the difference in days between the data, but there is not enough information for this analysis.

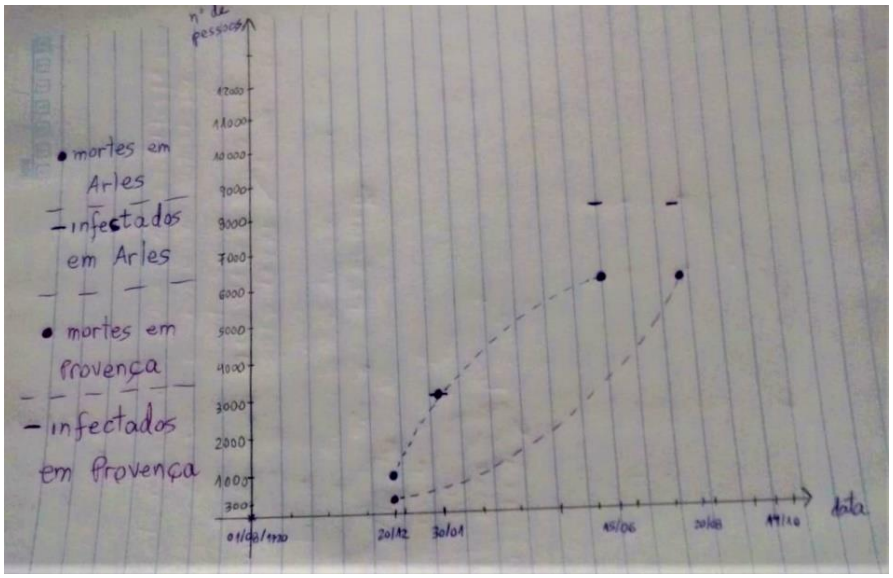

Figure 4 - Individual solution of a teacher
Source: Authors

Still trying to understand how teachers understood the movement of data in function of time, we noticed that teacher PH considered the number of deceased stable between one and the other news, that is, he considered the movement of the data survey Augusta made and not the movement (more gradual) of the disease.

Only two teachers reported in their individual solution that they felt they lacked data, but did not specify which ones. At the time of mediation, i.e., of the collective discussion, when asked which information would be necessary to relativise the data between cities, the need to know the population finally arose.

> How am I to know that 6,000 deaths in Provence is a percentage if I don't know the number of inhabitants in Provence at that time? (E1, PA, video).

From this, the mediation of the organisers turned to what to do with this information:

> [...] I do not have [the number of] recovered, but I will calculate the number of the deceased at the time, so I know the percentage of the population that was effectively dead then, but I could also be using [the data] to compare the two cities (E1, PA, video).

When asked about how to organise and interpret data from an entire region, two statistically valid possibilities emerged: adding the data and establishing the rates from the whole, or establishing an average of the data and, consequently, the average rate — a fact that demonstrates that during the discussions, teachers started to resort to statistical concepts to

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answer the questions posed.

There hasn't been much discussion about the forms of representation. Nevertheless, it is valid to highlight teacher PC's statement about how the graphs can change the view of the data:

> [...] if the newspaper put this information on a chart, it would be much scarier, because a chart significantly improves the understanding of the situation, I think also putting numbers is a strategy not to scare the population (E1, PC, video).

At the end of this scene, it is possible to conclude that the triggering situation alone did not raise the need for statistical concepts in all teachers and when this occurred, these teachers did not necessarily reflect on how the instruments they had chosen actually helped to interpret the data. Mediation, as theoretically expected, was an essential element to awaken the needs and discussions about the concepts, and it is possible to perceive that teachers began to look critically at the set of data offered in the situation.

Although we expected them to establish the conceptual nexuses of statistical knowledge and the movement of theoretical thought of the OPM participants, we must consider that a single teaching situation cannot show what is expected to be achieved throughout a process of study and training.

The second scene, about the role of statistical concepts in the teaching process, is shorter. This is because few teachers read the text indicated and that this was not the focus of the situation. Even so, after reading the text, one of the teachers (PB) made a relationship between the statistical concepts and the teaching and learning activities:

> [...] the teacher must develop the teaching capacity, in this case, the teaching activity is an analysis of statistical data, while the student, what he/she had to do, learning activity, [...] [is] understand how the reading of statistical data helps in reading, understanding and interpreting phenomena. (E2, PB, video).

Thus, it is possible to perceive that she understands that the statistical analysis is the teacher's role, and the students are responsible for reading those analyses to understand phenomena. However, it is necessary to emphasise that this view of teaching does not reflect the TGA relationships and does not develop the autonomy of the students, who would always depend on a teacher's previous action for data interpretation. Therefore, this statement allows us to realise that teachers are not familiar with learning triggering situations (consequently, with the OPM mode of action).

Final considerations

In this work, the phenomenon "statistical knowledge manifested by teachers of the early years in the OPM movement" was analysed by the isolate of the problem solving movement presented by the situation "O Diário da Peste Bubônica" (The Bubonic Plague Diary). The situation was intentionally created, taking into account essential relationships of statistical knowledge and episodes of its historical and logical movement. An excerpt from this movement was the selection of the historical register of the tensioning experienced by

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English society during the bubonic plague, when Johan Graunt's records showed a way of organising and analysing data to recognise the causes of the deaths, assisting in decision-making in the face of that problem. This episode and the conceptual nexuses established by Moura et al. (2019) were considered in the preparation of the learning-triggering situation, aiming at the development of thought in its theoretical form (Silva et al., 2020).

The data made available in Augusta's diary, which composes the situation that triggers learning, are complex and are intentionally neither complete nor present temporal regularity. This situation should trigger the students' need to recognise other more regular data, identifying them as variables to be related. From the teachers' discussions on the search for the solution to the problem proposed in the diary, we made an analysis in search of the teachers' manifestations on statistical knowledge. Thus, we understood the (re)constitution of the isolated for three episodes: needs aroused by the situation, actions aroused by the situation, and manifestations of scientific concepts.

Thus, it was possible to recognise that the situation triggered needs for socioeconomic data of the time and quantitative data of the disease, besides the need posed by the problem of making a decision with the information made available. To supply them, teachers demonstrated research and data representation actions. Another action evidenced was the relationship between the situation and the elements of the teaching guiding activity.

It was also possible to analyse how teachers related to statistical concepts from the proposed triggering situation. Those relations were observed in the movement of the collective solution and the reflections on teaching statistics. Regarding teachers' solutions individually, it was possible to note that not all of them used mathematical tools or statistical concepts, establishing social and comparative relationships with covid-19 to reach a conclusion about isolated. Two teachers reported they felt they lacked data, but did not mention which ones. During the collective discussion and analysis of the situation, teachers started to resort to statistical concepts to formulate a position. We could grasp that the triggering situation alone did not arise the need for statistical concepts in all teachers, but that during the mediation, teachers reflected critically on the set of data presented in the situation, establishing more relationships.

Recognising, analysing and representing data are movements specific to statistics, but do not reflect the conceptual nexuses of this area. To understand how teachers confront conceptual nexuses, we sought to understand the relationship between them and the movement to solve the problem posed by the triggering situation:

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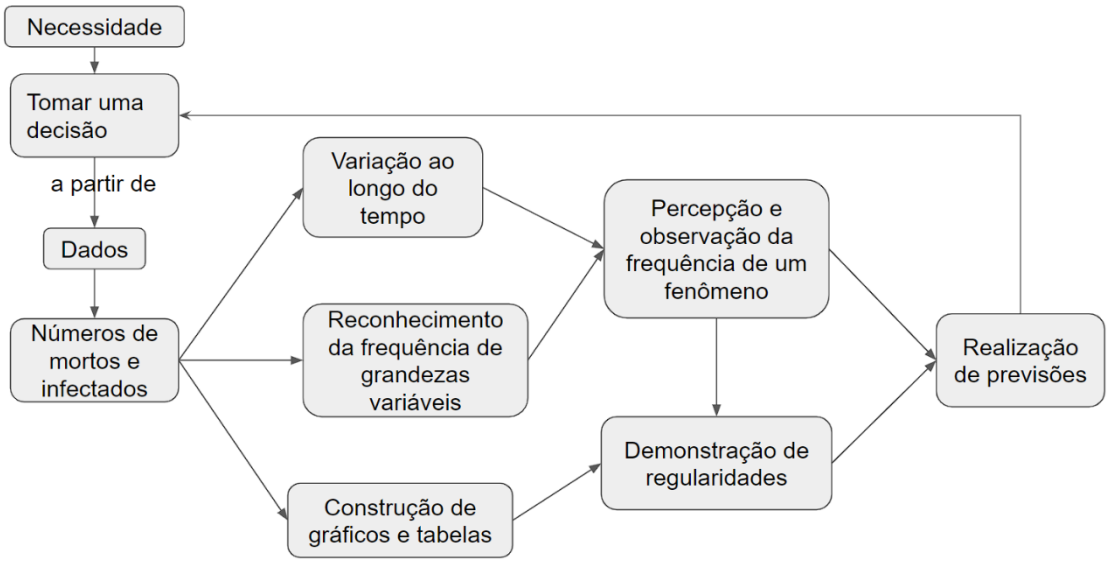

Figure 5 - Relationships between the situation proposed and the conceptual nexuses of statistics
Source: Oliveira et al., 2020, p. 164.

Thus, even if the situation was resolved with a restricted set of concepts, especially rates, variables, and graphs that did not allow teachers to recognise patterns and regularities, we can understand that it allowed analyses and discussions that reached some of the conceptual nexuses of statistics proposed by Moura et al. (2019). As this movement was not spontaneous from teachers, the importance of continuing actions such as the Mathematics Pedagogical Workshop is highlighted in presenting teachers with the historical-logical movement of the various areas of knowledge, especially statistics.

Furthermore, the role of the proposed triggering situation to trigger needs and raise the movement of statistical knowledge within the project is highlighted. We understand that this instrument enabled such discussions due to its characteristics, especially the fact that it contains a triggering problem that was planned to work understandings of the historical-logical movement (Silva et al., 2020). Although the planning of a situation does not necessarily reflect the particularities of the practice, we understand that the intentionality put into the situation and mediation is a fundamental point for the results found.

Therefore, this article presented the analysis of one of the actions of the Mathematics Pedagogical Workshop in 2020. Taking this action as an isolate, we could realise how the participating teachers relate themselves to statistical knowledge and how training movements, such as those of the OPM, are important to qualitatively modify these relationships. It is worth noting that this analysis, due to the isolated characteristic, does not propose to understand all the relationships between the teachers and statistics, but seeks to observe their manifestations in registers of two meetings of the project carried out in a virtual way and their respective tasks. Such analysis, if carried out with other teachers, another situation or under other conditions, could show different results, leaving the possibility of further investigations on the appropriation of statistical knowledge by teachers in continuing education. At the end of this study, under the conditions in which it was conducted, we could see that, although the

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formative movement of the Mathematics Pedagogical Workshop is not usual for the participating teachers, the proposed situation triggered motives and actions that enabled reflection on essential relationships of statistical knowledge.

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