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The professional development of elementary and middle-basic school teachers: an analysis of a remote training process on statistical concepts

El desarrollo profesional de los docentes de primaria y secundaria básica: un análisis de un proceso formativo a distancia sobre conceptos estadísticos

Le développement professionnel des enseignants du primaire et secondaire: une analyse d'un processus de formation à distance sur des concepts statistiques

O desenvolvimento profissional de professores do ensino fundamental: uma análise de processo formativo remoto sobre conceitos estatísticos

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Abstract

This article aims to analyze elements related to the teacher professional development presented in a remote training process on statistical concepts during the pandemic. This exploratory qualitative research comprises 29 teachers who teach mathematics in elementary and middle school in seven municipalities, partners of a research network. With the following research question: What elements related to teacher professional development are presented by participants of a remote training process on statistical concepts, carried out by a research network in the pandemic period? To implement it, during the COVID-19 pandemic, a remote training process was developed, supported by digital tools, and organized into four modules, with the methodology of the flipped classroom and the RePARe spiral. Statistical concepts were selected using the PPDAC methodology, from the perspective of equity. In data collection,

teachers answered an online questionnaire. Content analysis was adopted to read the data, and professional development emerged as a category of analysis. The thematic axis supporting the reflection was the “Training Process”, presenting elements that professional development is continuous, showing that teachers still have conceptual and pedagogical practice formative demands. Among the most mentioned factors was time, with discussions related to school, profession, the person, and the family. Finally, the internalization of research and the experience of teacher education in mathematics was promoted, especially in Brazilian Northeastern institutions. Thus, the work carried out provided equity for mathematics education.

Keywords: Teacher professional development, Elementary and middle school, Remote training process, Statistical concepts, Pandemic period.

Resumen

Este artículo tiene como objetivo analizar elementos relacionados con el desarrollo profesional de los docentes presentados en un proceso de formación a distancia sobre conceptos estadísticos durante el período de pandemia. Se trata de una investigación cualitativa exploratoria, con 29 profesores que enseñan Matemática en la Escuela Primaria y Secundaria Media de siete municipios, socios de una red de investigación. Con la siguiente pregunta de investigación: ¿Qué elementos relacionados con el desarrollo profesional de los docentes presentan los participantes de un proceso de formación a distancia sobre conceptos estadísticos, realizado por una red de investigación en el período de pandemia? Para la realización se desarrolló un proceso de formación a distancia, durante la pandemia del Covid-19, con apoyo de herramientas digitales, organizado en cuatro módulos, con la metodología del aula invertida y la espiral RePARe. Los conceptos estadísticos fueron seleccionados utilizando la metodología PPDAC, desde la perspectiva de la equidad. En la recolección de datos, los docentes respondieron un cuestionario en línea. Se adoptó el Análisis de Contenido para la lectura de los datos, emergiendo el desarrollo profesional como categoría de análisis y el eje temático que apoyó la reflexión fue el “Proceso de Formación”, presentando los elementos que el desarrollo profesional es continuo, mostrando que los docentes aún tienen demandas formativas de un orden conceptual y prácticas pedagógicas. Entre los factores más mencionados estuvo el tiempo, con discusiones relacionadas con la escuela, la profesión, la persona y la familia. Finalmente, se promovió la internalización de la investigación y la experiencia de formación de profesores en Matemática, especialmente en las instituciones del Nordeste de Brasil. Así, el trabajo realizado proporcionó equidad para la Educación Matemática.

Palabras clave: Desarrollo profesional docente, Escuela primaria y secundaria media, Proceso de formación a distancia, Conceptos estadísticos, Período de pandemia.

Résumé

Cet article vise à analyser des éléments liés au développement professionnel des enseignants présentés dans un processus de formation à distance sur des concepts statistiques en période de pandémie. Il s'agit d'une recherche qualitative exploratoire, auprès de 29 enseignants qui enseignent les mathématiques au primaire dans sept communes, partenaires d'un réseau de recherche. Avec la question de recherche suivante : Quels éléments liés au développement professionnel des enseignants sont présentés par les participants d'un processus de formation à distance sur des concepts statistiques, réalisé par un réseau de recherche en période de pandémie ? Pour la réalisation, un processus de formation à distance a été élaboré, pendant la pandémie de Covid-19, avec l'appui d'outils numériques, organisé en quatre modules, avec la méthodologie de la classe inversée et la spirale RePARe. Les concepts statistiques ont été sélectionnés à l'aide de la méthodologie PPDAC, du point de vue de l'équité. Lors de la collecte de données, les enseignants ont répondu à un questionnaire en ligne. L'analyse de contenu a été adoptée pour lire les données, et le développement professionnel a émergé comme une catégorie d'analyse et l'axe thématique qui a soutenu la réflexion était le "Processus de formation", présentant les éléments que le développement professionnel est continu, montrant que les enseignants ont encore des exigences formatives d'un ordre conceptuel et des pratiques pédagogiques. Parmi les facteurs qui se sont le plus imposés, il y avait le temps, avec des discussions liées à l'école, à la profession, à la personne et à la famille. Enfin, l'internalisation de la recherche et de l'expérience de la formation des enseignants en mathématiques a été promue, en particulier dans les institutions du Nord-Est. Ainsi, le travail réalisé a assuré l'équité de l'enseignement des mathématiques.

Mots-clés : Perfectionnement professionnel des enseignants, École primaire et secondaire, Processus de formation à distance, Notions statistiques, Période pandémique.

Resumo

Este artigo apresenta a análise de elementos de desenvolvimento profissional de professores que afloraram durante um processo formativo remoto sobre conceitos estatísticos, durante o período pandêmico. Trata-se de pesquisa qualitativa de caráter exploratório, com 29 professores que lecionam matemática no ensino fundamental em sete municípios, parceiros de uma rede de pesquisa, com a seguinte questão de pesquisa: Que elementos relativos ao desenvolvimento

profissional dos professores são apresentados por participantes de um processo formativo remoto sobre conceitos estatísticos, realizado por uma rede de pesquisa no período pandêmico? Para sua concretização, desenvolveu-se um processo formativo remoto, durante a pandemia de covid-19, com o suporte de ferramentas digitais, organizado em quatro módulos, com a metodologia da sala de aula invertida e o espiral RePARe. Selecionou-se conceitos estatísticos com a metodologia do PPDAC, na perspectiva da equidade. Na coleta de dados, os professores responderam a um questionário online. Adotou-se a análise de conteúdo para a leitura dos dados, e o desenvolvimento profissional emergiu como categoria de análise e o eixo temático que subsidiou a reflexão foi o "Processo Formativo", apresentando os elementos de que o desenvolvimento profissional é contínuo, evidenciando que os professores ainda possuem demandas formativas de ordem conceitual e de práticas pedagógicas. O tempo foi um dos fatores mais mencionados, com discussões relativas à escola, à profissão, à pessoa e à família. Por fim, promoveu-se a interiorização da pesquisa e da experiência de formação docente em matemática, sobretudo em instituições nordestinas. Assim, o trabalho realizado oportunizou equidade à educação matemática.

Palavras-chave: Desenvolvimento profissional do professor, Ensino fundamental, Processo formativo remoto, Conceitos estatísticos, Período pandêmico.

The professional development of elementary and middle-basic school teachers: an analysis of a remote training process on statistical concepts

This article presents a research work that discusses teaching professional development and teacher education and their contributions to teaching-learning, specifically in statistics education. This study is part of broader research entitled "Desenvolvimento profissional de professores de matemática e o ensino de estatística no ensino fundamental" [Professional development of mathematics teachers and the teaching of statistics in elementary education] within Rede Educação Matemática Nordeste (REM-NE) and involved researchers and students from Brazilian public universities in the states of Bahia (UESC, UNEB), Ceará (UFC, UFCA), Pernambuco (UFPE, UPE), Rio Grande do Norte (UFRN) and São Paulo (UNICAMP). Research actions are systematized by centers geographically distributed in each state that is part of the research network, with the participation of partner public schools in each location. Thus, teachers who teach different primary and middle-basic grades (henceforth, elementary school) can collaboratively experience training.

The Lemann Foundation and Teachers College, Columbia University, New York, USA, funded the research. Its actions were designed to be carried out over the 2019-2021 triennium, having been approved by the ethics committee for research with human beings of its promoting institution, the State University of Santa Cruz (Universidade Estadual de Santa Cruz - UESC). In 2020, with the spread of the coronavirus pandemic and the consequent suspension of in-person activities at partner schools, REM-NE needed to adapt to the new reality that Brazil and the world were experiencing. Therefore, it adjusted the project's actions to a remote format and organized a training process for basic education teachers of the Rede, based on a collaborative perspective, entitled "Matemática #COmVIDa."[1]

Therefore, the training was organized into modules, focused on statistical concepts necessary for teaching practice in elementary school, on theoretical studies on equity and investigation in mathematics classes, and, finally, on the elaboration of teaching sequences, taking the PPDAC investigative cycle as the theoretical framework (Wild & Pfannkuch, 1999). The objective was to establish a formative process that could plan teaching sequences to be developed in mathematics (statistics) classes with basic education teachers –partners of REM-NE– by inserting local and global issues linked to the COVID-19 pandemic.

[1] Note: The title results in a triple wordplay in Portuguese: *Mathematics with life*, *Mathematics invites*, and *COVID Mathematics*

Each module presented synchronous and asynchronous moments mediated by subgroups that helped teachers by encouraging them to debate and supporting them in the activities. In small groups, the exchange of experiences, suggestions, and recurring discussions strengthened the collaborative nature proposed in the project. In this sense, Santana et al. (2021) emphasize that collaborative constructions can favor the teacher's professional development, as people involved in the same project share their experiences and knowledge and seek to find methods that favor their teaching work and enable students to learn.

At the end of the training, the REM-NE team organized feedback with the participants through an online questionnaire to collect their perceptions, criticisms, and suggestions about the formative path and get their views of the model, its organization, and their involvement and learning.

Therefore, this article describes the analysis of the elements found in the assessment of the teacher education course developed remotely by REM-NE during 2020 and reflects on some factors that contributed to the professional teaching development of participants. Based on the above, we formulated our research question: What elements related to the teacher professional development participants manifested during a remote teacher education course on statistical concepts carried out by a research network during the pandemic?

Teacher professional development and teacher education

The theme *teacher education* is one of the most explored in research on education and teacher education, public policies, teaching-learning, pedagogical practice, and professional development due to the need to train teachers for the various demands and numerous types of knowledge required. Initial, continuing, in-service, and in-context training are some categories present to define how teaching-learning experiences are processed. In this article, we turn our attention to a type of training that occurs when the teacher is already working and uses their own practice as a reference. However, with our training intervention proposal, we intended to go further and promote shared reflection on peers' collaborative practice and professional development.

Research such as those developed by Baptista (2010), Formosinho (2009), Gatti and Catalano (2015), Guskey (2002), Imbernón (2011), and Ponte (1994) discuss professional development from the perspective of education as a continuous process of reflective practice. In Brazil, researchers such as Behrens and Carpim (2013), Lima (2012), Libâneo and Pimenta (2011), and Passos et al. (2006), among others, argue that the concept of professional development is not synonymous with education, although they may be linked. For these

authors, treated as a reflective practice, teacher education can promote teacher professional development. Whether through continuing education or professional development, teachers are expected to give new meaning to their practice (Wengzynski & Tozetto, 2012) and their education.

Discussions about teacher professional development are also situated in the teacher education field. As mentioned, although distinct, the processes of continuing education and professional development are related since the second cannot be restricted to the first (Imbernón, 2011). Professional development experiences go beyond education because they are not just connected to a specific moment or aspect or knowledge of teaching practice. This perspective emphasizes continuing education as part of professional development when reference is made to the teaching work. And the starting and ending point is the teacher's action and reflection on their practice, thus demonstrating a movement of coming and going as a continuing education process through professional development.

Thus, for the action and reflection of practice to occur at school and with peers, it is necessary to have *time* allocated to organize activities at school and in the personal field. Such actions are objective and subjective because they demand constant support and monitoring from the school community and follow-up of expectations, professional representations, and experiences constructed individually and collectively. In schools' structure and organization, school time is bureaucratic and sometimes embarrassing for teachers' lives, as it is planned to follow an abstract cycle, not always considering teachers' and students' learnings. School time is also a social, affective, and administrative time imposed on professionals in the form of class hours, planning, and training; it is a forced time, "a time in which the actors invest body and soul; hence, it does not count: the work goes beyond useful time, extends into the night, weekends, etc. It is always lacking, always insufficient" (Tardif et al., nd, p. 42).

In this sense, professional development involves several bureaucratic and spontaneous experiences, with learning carried out for the direct or indirect benefit of the individual, group, or school (Day, 2001). In addition to concepts, the teacher is expected to appropriate and reflect on the beliefs and characteristics of their contexts, considering the school, the community, the students, and the local culture, among others. Clarke and Hollingsworth (2002) indicate that professional development occurs through four realms, i.e.:

> (i) *external* mastery (source of information, stimulus, and support); (ii) mastery of *practice* (professional experimentation); (iii) mastery of *consequence* (in student learning); and (iv) *personal* mastery (includes the teacher's knowledge, beliefs, and attitudes). In this model, professional development will occur through processes of

> reflection and implementation or *enactment* of actions that the teacher can carry out in dialogue between realms. (Santana et al., 2021, p. 5 – authors' emphasis)

Thus, professional development is related to the learning constructed by teachers and their formative experiences. In this way, a central concept in development is reflection on the mastery of practice and personal mastery (Santana et al., 2021).

Among other aspects that characterize and promote professional development, Imbernón (2011) highlights reflection on practice that fosters the acquisition of teaching knowledge and peer exchange aiming at group development. REM-NE takes this perspective, which understands that teachers do not develop professionally alone and that their "[…] academic education depends on their personal and professional lives, public policies, and school contexts in which they carry out their teaching activities" (Santana et al., 2021, p. 87). Furthermore, in the context of the REM-NE, experiences occur through a university-school partnership to implement and maintain a continuing training process comprising a group of people who share and critically question their practices (Santana et al., 2022).

Considering that REM-NE is formed by researchers and teachers who work in several states, digital technologies can favor creating and expanding formative and professional development spaces, as they enable shared reflection through internet tools and resources. As a result, reflecting on practice no longer needs to be limited to a solitary teacher or a small group of teachers at a school. With the support of digital technologies, teachers can share and discuss their practice with their colleagues inside and outside the school, literally from anywhere in the world, in different times and spaces, reflecting on different contexts and perspectives as a professional development experience (Maia et al., 2020).

Training and continuous collaboration between teachers are no longer restricted to physical environments, such as schools or institutions that offer teacher education courses. Based on the possibilities of communication and access to the internet, one can build learning networks in which people interact, collaborate, and learn together, thus revealing the development of meaningful collaborative learning environments for innovative learning experiences of teacher education. Web resources and tools have contributed to developing activities for teachers to build concepts, solve problems, and share solutions (Maia & Castro-Filho, 2017), even well before the experiences that proliferated during remote teaching during the COVID-19 pandemic. In this context, with the support of emerging technologies, teachers now have even more valuable tools for knowledge and experiences shared between peers in a relationship without hierarchies but with shared responsibilities. This scenario is conducive to

continuing teacher education experiences, based on reflection on practice and theoretical elements shared with other teachers through the virtual environment.

Due to the COVID-19 pandemic, the REM-NE team felt compelled to implement a completely online training model that could guarantee the perspective of professional development, including promoting equity in learning statistical concepts (Castro-Filho et al., 2022). After all, the intention was to innovate in the training model and not insist on standard proposals in Brazil, which offers mathematics teaching based on pre-formatted courses outside of school and with an excessive focus on content. In partnership with school teachers, the REM-NE defended a professional development proposal that sought to explore the diversity of possibilities that digital technologies offer for exchanging experiences and interactions with different digital genres (Santana et al., 2022).

Research methodology

This research is qualitative and exploratory, as it proposed to study and contribute to creating a professional development model that seeks to investigate –through a teacher education course with teachers who teach mathematics– statistical concepts seen in basic education based on the reflection-planning-action-reflection (RePARe) spiral model (Figure 1). This model promotes planning and implementing classes through group reflection to analyze the potentialities and limits of teachers' actions and student learning (Magina et al., 2018) and study the PPDAC investigative cycle and equity in remote classes. For better understanding, Figure 1 shows the RePARe spiral model that guided the methodological actions during the formative meetings.

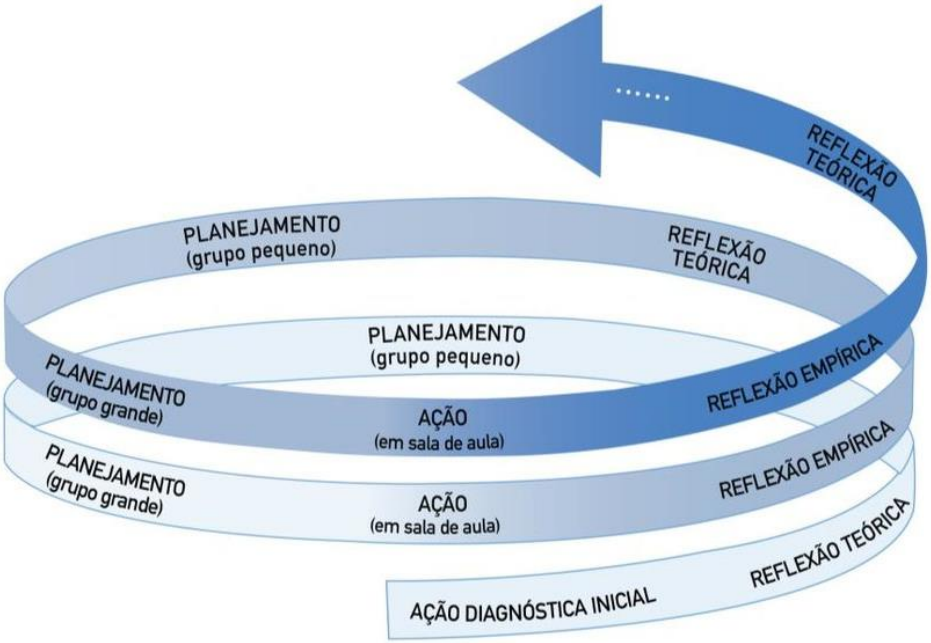

Figure 1.

RePARe Spiral Model (Magina et al., 2018)

In this sense, the study proposed a training intervention methodology with elementary school teachers, analyzing their learning for professional development and contributing to pedagogical practice with statistical concepts in an equitable way to enable students to learn.

Thus, the investigation took place in the context of a university-school partnership involving basic education teachers and higher education researchers to strengthen and foster joint efforts aiming at a collaborative process of knowledge production on teaching and learning statistical concepts, constituting a collaborative learning process based on each person's experience (Lüdke, 2001).

The formative process

The proposed formative process aimed to "plan teaching sequences to be developed in mathematics classes." The study included 29 basic education teachers from seven municipalities (Fortaleza/CE; Brejo Santo/CE; Natal/RN; Ilhéus/BA; Itabuna/BA; Teixeira de Freitas/BA and Campinas/SP), partners of REM- NE (Figure 2), through the insertion of local and global elements linked to the COVID-19 pandemic in the classroom to "facilitate the link between theory and teaching practice" (Marcelo-Garcia, 1999, p. 180). It is worth highlighting the internal nature of the research in Brazil since most of the cities covered are in the countryside (Figure 2).

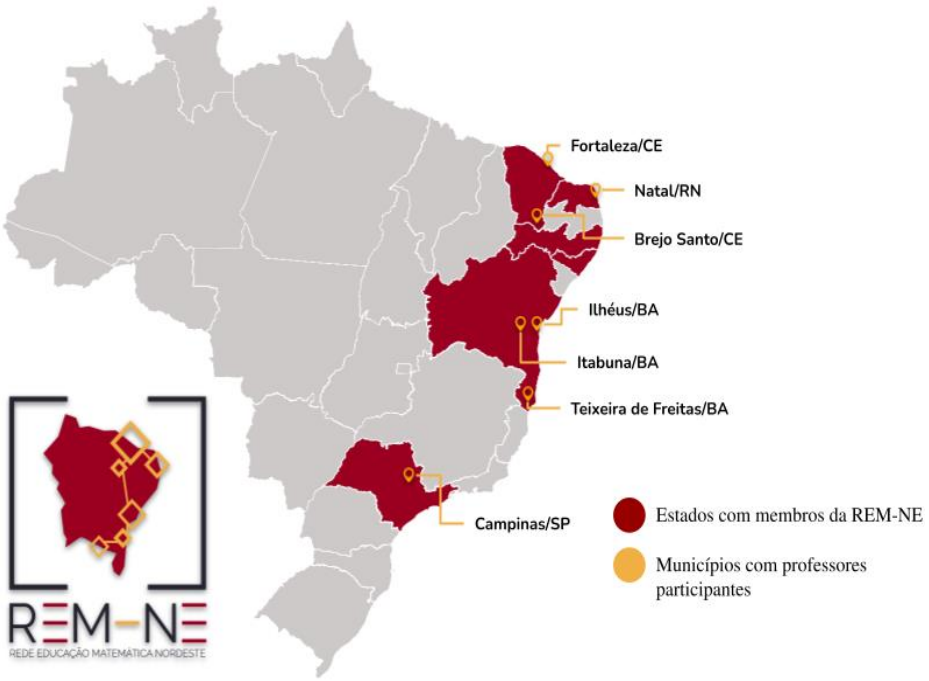

Figure 2.
Brazilian states and municipalities that have REM-NE members

The training process took place remotely from September to December 2020 due to the COVID-19 pandemic, using tools provided by G Suite for Education. We created a class on Google Classroom to post study material, videos, and activities. Google Meet and Google Classroom were used for synchronous meetings and asynchronous activities, respectively. Furthermore, the Telegram instant messaging application increased constant contact between researchers and teachers.

Regarding content, the researchers asked several questions before developing the training process. Vaillant's (2009) studies helped us arrive at the following reflections: (i) What should be taught about statistical concepts? (ii) What is needed for teachers to learn? (iii) How can we ensure the training process is not based on content transmission? Based on these discussions, the training process was organized into four modules, as detailed in Table 1.

Table 1.

The organization of the training process

Module	classroom hours	Duration	Concepts Studied
1 – Statistics concepts	25 h	Six weeks	Population, sample, phenomenon and statistical variable Frequency distribution table (FDT) and dual entry table (DET) Graphs for quantitative variable Graphs for qualitative variable

Module	classroom hours	Duration	Concepts Studied
2 – Equity at school	15 h	Two weeks	Equity in school and learning
3 – Investigative cycle	20 h	Three weeks	Investigation methodology PPDAC investigation cycle Classroom development
4 – Reflections on the investigation cycle	20 h	Three weeks	Teaching sequences Teaching sequences with the PPDAC investigation cycle

The total workload was 80 hours, spread over fourteen weeks. The actions of the modules were supported by digital technologies, mainly because of the pandemic, which required social distancing. Thus, each module's activities were planned based on "what is known as blended learning, with the flipped classroom as one of the modalities implemented in basic and higher education" (Valente, 2014, p. 82) and teacher education processes.

During the training, we created teaching material in digital format and posted it on Google Classroom so that teachers could have access to study and carry out activities according to their organization and availability of time and space. We prepared the material with the concepts learned and the activities and guidelines for each module. In module 2, we suggested studying equity through an article focused on the social role of mathematics, supported by the critical mathematics education approach. Modules 3 and 4 were grounded on Wild and Pfannkuch's (1999) work on the PPDAC investigation cycle and Santana and Cazorla's (2020) on the teaching sequence.

The flipped classroom model is based on the report of *Flipped Classroom Field Guide* (2014), with the following possibilities:

> 1) classroom activities involve a significant amount of questioning, problem solving, and other active learning activities, requiring the student to retrieve, apply, and expand material learned online; 2) students receive feedback immediately after carrying out face-to-face activities; 3) students are encouraged to participate in online and in-person activities, which are counted in the student's formal assessment, that is, they are worth a grade; 4) both the material to be used online and the classroom learning environments are highly structured and well planned. (Valente, 2014, p. 86)

Thus, in the flipped classroom, "the student studies before class, and the class itself becomes a place for active learning, where questions, discussions, and practical activities are held. The teacher works on the students' difficulties instead of presenting the content of the subject" (EDUCAUSE, 2012, as cited in Valente, 2014, p. 86). The flipped classroom model can be carried out in basic and higher education and in training processes, as developed here.

Planning of the training process for teachers' mobilization of statistical concepts from a professional development perspective took place in this movement.

We organized 16 asynchronous moments with the following actions: (i) activities – asynchronous in groups and individually for study, discussion, and exchange of experiences; (ii) research – participating teachers studied and carried out activities on the content of the module; and (iii) connecting concepts – participating teachers were organized into groups, according to the school grade they teach, to study the concepts approached in each module, under the guidance of REM-NE researchers.

There were ten synchronous moments, planned and implemented according to the training schedule, with the following actions: (i) meeting between researchers and teachers in small groups for study, discussions, and preparation of activities; (ii) meeting between all researchers and teachers in the large group to present the studies in the module, the activities, and to institutionalize the concepts studied.

The synchronous meetings took place under two conditions: (i) with the participation of all teachers enrolled in the training process and researchers (meetings with dates scheduled in advance, according to the schedule), and (ii) with the participation of teachers "with different levels of knowledge" (Valente, 2014, p. 89) organized in small groups, under the mediation of a researcher –a teacher educator (meetings with flexible dates and times agreed between members, according to the formative process schedule). This condition helped "value interpersonal interactions and be complementary to online activities, providing a more efficient, interesting and personalized teaching and learning process" (Valente, 2014, p. 84). The time for discussion, presentation, socialization, and institutionalization of the concepts studied took place as the teachers asked.

In asynchronous moments, organized in small groups, the participants met with a teacher educator to study for activities that would be posted on Google Classroom.

Considering the nature of a flipped classroom, the training modules were planned with the following actions (Table 2):

Table 2.

The movement and planning of actions in the training process

Actions	Activities carried out
Orientation (synchronous moment)	In the first online meeting, we presented the course proposal and welcomed teachers in an initial conversation. The schedule was also explained with dates and times of meetings, proposed content, posts, and guidance for installing Telegram and accessing Google Meet and its tools for developing actions. Everyone was invited to answer the TCLE and a diagnosis of statistical knowledge, both via Google Forms. They were instructed to complete a survey of teaching working conditions during the COVID-19 pandemic, constituting a first database for our analysis. In all modules, teachers received guidance on dates, times, content, and activities to be carried out.
Activities and Tutoring (asynchronous moments)	Monitoring of statistical contents to be studied. Preparing tutorials with guidelines for accessing Google Meet and Google Classroom, recording and posting videos and activities.
Research (asynchronous moments)	Reading, questioning, raising hypotheses, discussing, and carrying out activities on the concepts studied.
Connecting concepts (synchronous and asynchronous moments)	In groups, teachers studied the concepts proposed in each module and carried out activities (video recording and written activities). Teachers presented their questions about the content reviewed, aiming to consolidate statistical concepts.
Presentation (synchronous moments)	Organized into groups, the teachers presented the recommended activities and reflected on the institutionalization of the concepts studied.

Data analysis procedures

The data were produced from an online questionnaire the participating teachers answered at the end of the training. Available on Google Docs, the questionnaire was prepared with ten questions to evaluate the training model in terms of the relationships between the teacher educator and course participants or between course participants and their involvement during synchronous meetings or training groups, involvement in asynchronous moments, and the teacher educators, the organization of studies, and learning. The teachers signed the Free and Informed Consent Form (TCLE) and were identified with pseudonyms to have their identities protected.

Data analysis was founded on the theoretical and methodological assumptions of content analysis (Bardin, 1977), defined as:

> [...] a set of communication analysis techniques aiming to obtain, through systematic procedures and description objectives of the message content, indicators (quantitative

> or not) that allow for the inference of knowledge related to the production/reception conditions (inferred variables) of these messages. (Bardin, 1977, p. 42)

This technique was organized in phases: in the first, we read briefly the corpus, i.e., the teachers' answers in the questionnaire to appropriate the content. In the second, we identified the context and registration units to understand and grasp the meaning of those responses. Next, through a thorough interpretation procedure, we chose the thematic axes (Rodrigues, 2019) resulting from articulations between the context and registration units (Rodrigues, 2019). After selecting the registration unit, we identified the thematic axis. From the material produced, we identified the thematic axes –*training process* and *teacher learning*, thus emerging the category *teacher professional development* (Table 3). In the third and final phase, the categorization and analysis of the data made it possible to make inferences to communicate the contributions of the training to the professional development of teachers as elements previously unnoticed. In this article, we will only emphasize the analysis of the thematic axis relating to the training process to identify the teachers' perception of the course model.

Table 3.

Movement towards the formation of the analysis category

Actions	Activities carried out	Category
Online model Time Role of the teacher educator Participant protagonism Personal issues Expectation with practice Interaction between participants Interactivity	The formative process	Reflections on teacher professional development
Pedagogical knowledge Content cnowledge Technological knowledge Learning	Teacher learning	

Reflections on professional development emerged as a category of analysis of the material produced in the research, and the thematic axis that offered us subsidies for reflection was the formative process. However, to understand this process, the elements presented in the teachers' responses are organized into the eight record units highlighted: (i) online model, (ii) time, (iii) role of the teacher educator, (iv) participant protagonism, (v) personal issues, (vi)

expectation with practice, (vii) interaction between participants and (viii) interactivity, which favor our discussion to understand teacher professional development.

Initially, we worked with the questions individually to capture the context and registration units, the thematic axes, and, finally, the category of analysis. Thus, we organized the answers into registration units, after which we identified the categories. Another article will be produced with an analysis of the *teacher learning* thematic axis based on its registration units.

The training process and professional development of teachers: an analysis based on registration units

This section presents the analyses of each registration unit that makes up the thematic axis related to the formative process. From it, we could infer how the teacher education process occurred considering different dimensions explained in the recording units. We confronted the evidence identified in the corpus –participants' answers– with our theoretical framework to understand the impact of the training offered.

Online model

The training was entirely online during the pandemic, with synchronous and asynchronous moments (Tables 1 and 2). Considering the flipped classroom model (Valente, 2014) proposed for the process, teachers were first invited to deal with other possibilities of digital information and communication technologies (DICTs) in their learning. The pandemic revealed social and technological inequalities in the country. At first, only students and families from the popular classes were cited, but the formative process demonstrated that schools and teachers also experienced problems with technologies and participation in remote training, as teachers needed a cell phone (to download the Telegram application) and a computer or smartphone (to access the Google Meet Platform and its tools) to access the course material and carry out and post the activities. This situation was present in the teachers' narratives. To participate in the synchronous moments, they revealed that:

> The fact that it was online made it difficult. (Care Q2, 2020)
> The internet connection jeopardized our work. (Jean Q2, 2020)
>]We had] difficulties with technology/fear of making mistakes. (San Q2, 2020)
> For a few moments, it was [sic] confused. Meeting longer than 3 hours (wear and tear.) (Cris Q4, 2020)

But, regardless of the synchronous and asynchronous moments, teachers characterized the online model as follows.

Tight time. (Tina Q1, 2020)
Reconcile time between activities. (Joas Q2, 2020)
Time. (Eme, Cis, Ance Q2, Tina Q3, Ilda Q4, 2020)
Time limitation. (Ance Q5, 2020)
Time with other activities. (Go Q6, 2020)
Time to respond to activities. (Adria Q7, 2020)
The number of activities. (Care Q7, 2020)
Time to balance work and studies. (Joas Q7, 2020)
Time and remote classes at college. (Nio Q7, 2020)
Reconcile group study schedules. (Sila Q7, 2020)
Time and completion of proposed activities. (Gean Q7, 2020)

Due to teachers' emphasis on the time element for the online training based on the flipped classroom, with synchronous and asynchronous activities, we explain this category in the following section.

Time

Concerning asynchronous moments, those that the teacher chose to study according to his availability, teachers mentioned issues regarding the activities and time, such as: "*Activities and readings at the right time*" (Joas Q6, 2020); "*I performed most of the activities*" (Lara Q6, 2020) and I was "*participatory, attentive, and open to the teacher educator's guidance*" (Rita Q6, 2020). However, difficulties were also present in synchronous moments, albeit to a lesser extent, either as a result of the technological instrument used by the participant or due to the adequacy between the end of the remote work shift and the beginning of meetings in the large group.

In this context, it is possible to verify that *time* was configured as a challenge for participants in the formative process, which leads us to reflect on the need to rethink teacher education and public policies in the educational field that allow us to predict, within the workload of the in-service teacher, moments that corroborate their professional development.

Some difficulties also reside in the registration unit denoted in the process of analyzing *personal issues*, as they are based on the following aspects: time to develop the actions of the training process, accessibility, and knowledge of how to use digital tools.

Thus, the time was challenging in two aspects: school time and professional time. Two times that have different natures: quantitative, "in which teachers would need 'free hours'"; and qualitative, considering "that teachers can hardly disconnect from daily relationships with students, which occupy them all their time" (Tardif et al., p. 42).

Thus, regarding *time*, the participants say it is difficult for them "*to balance work and coursework*" (San Q6, 2020), "*time to balance work and studies*" (Joas, Q7, 2020), and family time to "*sharing attention with children and training*" (Gil, Q7, 2020). These excerpts indicate

“that all activities that tend to distance or divert teachers from their work with students are often seen as burdens, additions, or obstacles” (Tardif et al., p. 42).

During the pandemic, it seems that the school and education networks thought of time as linear, while the nature of time revealed by the teacher was subjective, social, and human. This condition proved challenging in terms of time for training, especially concerning the use of the DICTs and new ways of planning classes and taking care of their health and their families. Thus, time was subjective, reflecting the new expectations, representations, and experiences of teachers, management, and students.

Personal issues

Regarding accessibility and the use of digital resources portrayed in the analysis by the *personal issues* unit, the innovative aspect of participants’ use of digital tools in their educational practice was confirmed. Exploring the potential of digital technologies, especially mobile devices, gives new contours to the very culture of teacher education. As teachers already use smartphones in their daily lives, we must know whether they have also used such devices to develop their profession and how to make this connection (Maia, 2016).

To carry out the activities, it was necessary to use and access technological devices that constituted obstacles to effective participation in the formative process, as seen in the participants’ words: “*availability of the digital tool*” (Ine Q7, 2020) and having this tool with “*internet access*” (Cis Q7, 2020), a condition that would provide opportunities for contact with guidelines and the study of statistical concepts, but due to problems with the use of “*technologies (Google Meet, Google Classroom)*” (Nete Q7, 2020) and namely “*dealing with the Google Classroom platform, overcoming shyness*” (Rita 07, 2020), the participants needed monitoring by the teacher educators in the small groups in which they were inserted. In this sense, the *place* of knowledge was evident with the use of technologies and their tools, such as Google Meet and Google Classroom, recording and posting videos and activities, and being necessary “*to adapt to study schedules in the training group*” (Go Q7, 2020), to “*carry out group work*” (Juá Q7, 2020).

Expectation with practice

The unit *expectations with practice* emerged from the teachers’ narratives about the concepts worked on and their implications in teaching practices to restructure the training process in future stages. In this way, we sought to understand, through teachers’ expectations about the training, the motivation to participate, in which we found that concepts such as

numbers and their operations were indicated as an object of training interest due to the need to promote students' learning to understand other mathematical concepts. Thus, in the participants' words:

> I would prefer the topics to be even more basic, like integers, operations. Well, how will we explain so many types of graphs, tables, and percentages, if they barely know integers and their operations? (Lara Q 10, 2020)
> Certain concepts were not widely used in teaching practice… a fourth-grade student, who has not even constructed the concept of sum yet, it is difficult to imagine delving deep into graphs in teaching practice. (Care Q10, 2020)

From the excerpts, we consider that the teachers maintained a restricted vision in teaching statistical concepts, as they could not identify the possibility of working with other objects of mathematical knowledge that involve numbers and operations through activities carried out with different types of graphs.

As Clarke and Hollingsworth (2002) propose, the knowledge mobilized by teachers in this situation emerges from professional experience, constituting a domain of practice and a personal domain since the ideas expressed are based on the belief system and attitudes of teachers in the face of the demands of the educational context.

Despite the statements about the concepts studied in the formative process, other situations were revealed and are related to the external and consequence domains suggested by Clarke and Hollingsworth (2002). This is apparent in the narratives of other participants when they mention theoretical and methodological aspects that motivated them to incorporate knowledge acquired in the training process in their future mathematics classes.

> Study and understand graphics, in all situations. I will put into practice everything I studied and I intend to continue studying. The PPDAC phases only came to add, inform, and form. (Eme Q9, 2020)
> The concepts were excellent, thinking about any problem and the steps to be taken. It is a powerful research methodology for the classroom. I really enjoyed learning about the PPDAC phases and I intend to apply them with the children. (Cris Q9, 20201)

Thus, we captured in the teachers' speeches reflections that guide actions in the training process that fostered professional development, as we understand that the knowledge mobilized awakened teaching action in search of giving new meaning to their teaching practice based on significant changes in their professional performance, by developing essential skills for their improvement (Day, 2001).

The teacher educator

In the formative process, the teacher educators were the mediators between the teachers and the concepts being studied, in the conceptual support and operational discussions for the forwarding of studies, in carrying out the activities, using DICTs, and in contact with the other participants. The teacher educator was understood as "the professionals involved in the teaching-learning processes of prospective teachers or those who are already carrying out teaching activities" (Mizukami, 2005-2006, p. 3), as a continuing process developed in diverse contexts, in this case, online education, in times of pandemic, with teachers from various schools.

Thus, teacher educators were considered by teachers as "*always attentive to each student's needs*" (Rita Q2, 2020), who helped them "*in group activities*" (Gean Q2, 2020), which took "*questions and protagonism*" (Tina Q2, 2020) to help them think and build their concepts. Furthermore, the course participants highlighted that the teacher educators were "*welcoming, receptive*" (Adria, Care Q1, 2020), presented "*content in a way that facilitated learning*" (Joas Q1, 2020) and did not give a ready and direct answer, but "*put themselves in the position of apprentices*" (Adria Q2, 2020), being those who instigate, question, reflect with the group to reach conclusions and, thus, build concepts, and resolve study situations. This is the teacher educators' task, to form while being formed.

The "*mastery of the topic*" (Lara Q1, 2020) being studied in the training was mentioned several times, thus demonstrating the involvement of teacher educators with the training proposal, such as educating oneself and educating others at the same time, which required a knowledge base about statistical concepts, the PPDAC investigative cycle and planning the teaching sequence for the development of training actions (Mizukami, 2005-2006). This knowledge base focused on statistical concepts, the design of an investigative class, and the elaboration of the sequence, at which time pedagogical knowledge was mobilized to give life to statistical concepts with a social function and teaching situations close to the reality of those apprentices.

So, for teachers, "*the teacher educators were always available, were attentive, maintained an interactive relationship with the culture and exchange of experiences*" (Nio Q1, 2020) and "*respect*" (Sila Q1, 2020). This is an important condition for the teacher educator, as it requires "'learning to teach' in different ways for different types of clientele and contexts" (Mizukami, 2005-2006, p. 8). However, study meetings lasting more than three hours sometimes became exhausting and tiring. The online model requires organized and flexible planning due to emerging demands in order to avoid exhausting meetings.

To meet training needs, the team of teacher educators created tutorials (Table 2) as a way of helping teachers in their learning. This action also constituted learning to use the DICTs and the statistical concepts studied. Several lessons were learned in this direction: on concepts with an investigative methodology –the PPDA– and the use of digital tools with pedagogical potential. As a result, teachers thought they were "*too many activities*" (Lara Q7, 2020) and "*in a short time*" (Mar Q7, 2020) in the same "*training process*" (Nir Q7, 2020). However, such objects of knowledge were relevant to the training process, which took place in the online model and, naturally, required DICTs and future pedagogical practices that teachers would implement in their schools, including considering the remote teaching context.

The course participant

The formation course centered on the university-school partnership constituted an environment of investigation, inviting teachers to develop research in teaching with the school reality and the methodology of the PPDAC investigative cycle. Thus, the teacher's narrative highlights the movement of protagonism in the learning process by emphasizing that "*the course favors the learning process by placing the student at the center*" (Ance Q 10, 2020).

Under these conditions, the training promoted teachers' self-regulation of learning by seeking to transcend curricular content and statistical knowledge so that they could make critical choices, be prepared to resolve challenging everyday situations, act with autonomy, and know how to manage the information. Thus, Perrenoud (1999, p. 96) conceptualizes self-regulation as "one of the subject's capabilities to manage their projects, their progress, their strategies in the face of tasks and obstacles." Thus, teachers mobilized knowledge that foregrounds aspects of self-regulation of learning, such as in the management of their projects with "*dedication and professional improvement*" (Nete Q2, 2020), at the same time as they sought strategies to solve tasks with "*effort to participate and develop activities*" (San Q5, 2020), in addition to monitoring your progress with "*responsibility and commitment*" (Nir Q2, 2020), being proactive in searching for strategies to resolve challenging situations, especially "*when an issue arose to be discussed or suggested, collaborating*" (Cris Q2, 2021) with learning from their peers.

Interaction between participants

Due to the characteristics of the formative process –professional development based on online meetings– interaction between participants was essential. To this end, despite the pandemic context, the appropriation of DICTs has become a pressing demand for teachers,

including from the perspective that understands the use beyond the mere consumption of information and content. People need to perceive the space offered by DICTs as another environment for acquiring knowledge through collaborative construction (Castro-Filho et al., 2016).

Therefore, there is still a need to invest in teacher education that fosters opportunities and encourages collaboration through DICTs. The online education model aimed at professional development required interactions to occur so that experiences could be socialized and reflected on with professional colleagues. Some teachers said these exchanges as the highlight of the formative model, either because of "*interactivity with culture and exchange of experiences*" (Nio Q1, 2020), as one of the "*conditions to expose our experiences*" (Nio Q2, 2020) in which "*the course participants interacted, showing respect*" (Juá Q3, 2020) to practice and "*shared experiences*" (Sira Q4, 2020) with "*dedication, commitment, exchange of knowledge together*" (Nete Q6, 2020), making "*Without colleagues it wouldn't be as meaningful*" (Nir Q3, 2020).

Furthermore, when we propose a training model that focuses on exchanging experiences, valuing teachers' knowledge, beliefs, and perceptions in their practice –as a demand for professional development– interaction between participants proved essential. The activities proposed by the researchers for the training included tools and actions that encouraged and provided collaboration between course participants. However, we perceived some challenges, especially in the meetings with the large group, in which they affirmed, "*maybe I could interact more*" (Mar Q2, 2020) and "*there was no relationship between the students*" (Nio Q3, 2020) due to the format of the meeting where "*there was no space for interaction*" (Adria Q3, 2020) caused mainly by "*lack of interaction, lack of time*" (Tina Q3, 2020), and "*participation*" (Rita Q5, 2020) and "*harmony*" (Sila Q3, 2020).

Although the training model integrated several communication and interaction tools, as detailed in this article, some teachers still found it difficult to interact with their colleagues. From these excerpts, we inferred that the problem of poor interaction was not linked to the possible limitations of the tools or even the activities proposed in the training process but to a change in teaching culture that went beyond the conception of individual work. For many, the appropriation of digital tools was still the "*difficulty with technology and fear of making mistakes*" (San Q2, 2020). On the other hand, the chosen means of communication aligned with what Maia and Castro-Filho (2017) proposed when they used digital tools in a formative and collaborative process of mathematical concepts within mastery and daily use of teachers. This was the case with Telegram, which teachers use daily and which we used in the formative

process, and Google Classroom and Meet, which many teachers started using, encouraged by the emergency remote teaching. It seems that, although the large group meetings allowed everyone to participate and contribute to the debates, whether by voice or even chat, teachers' individualized and passive attitudes had not yet been overcome, which locates them closer to a listener's role.

From the narratives, it is possible to verify that the intentions of the proposal were present in the training process. However, not all teachers could explore the potential. After all, the presence and support of DICTs, in this case, were –as they are in all contexts– factors to promote communication and interaction. For them to be effective, the active stance of those involved is necessary. It is essential that participants in the training process –with the learner and their experiences taking center stage– engage and collaborate, and be open to feedback, negotiate points of view, and learn together harmoniously and respectfully. These were aspects highlighted by course participants when commenting on the interaction between participants. Terms like "*partnership*" (Go Q3, 2020), "*mutual respect*" (Cris Q3, 2020), "*relaxed and light atmosphere*" (Cris Q3, 2020), "*interaction*" (Mar Q3, 2020), "rapport" (Cis Q3, 2020), "*reciprocity*" (Ilda Q5, 2020), "*collaboration*" (Ete Q3, 2020), "*dialogue*" (Cis Q5, 2020), "*collective*" (Ete Q5, 2020), which constituted some units of records identified in the teachers' narratives about interaction between participants, reinforcing horizontal learning between peers and teacher educators.

Interactivity

We also sought to identify the interactivity of the training process in the participants' assessment of their relationship with DICTs. According to Belloni (2008), interaction is the mutual and intersubjective activity between subjects that can be mediated by some communication vehicle and, in this sense, interactivity occurs from the subject's relationship with the tool that intends to establish a direct or indirect communicative process between the subjects. Therefore, in this aspect, the interactivity of participants in the formative process influenced their ways of being successful or not in active participation when "*participating and commenting in the chat*" (Rita Q2, 2020), whether due to size or exposure to the "*screen*" (Ance Q3, 2020) or when "*group members did not respond to messages on Telegram and did not participate in meetings*" (Juá Q5, 2020), because of "*time and difficulty using tools*" (Joe Q7,

2020), essential for "*exchange of experiences, enrichment of knowledge, [access to] available material: videos*" (Mar Q8, 2020).

In the questionnaire, teachers commented on factors related to interactivity that suggest positive and negative aspects of the training. Some teachers listed elements linked to skills in handling the chosen tools as an obstacle that may have influenced their lack of collaboration and/or that of their colleagues. As we highlighted, we do not attribute these difficulties to the tools but to the participants' willingness to overcome their difficulties and explore them in a training that presupposes their active participation. Furthermore, as highlighted by some, represented here by Mar, the communication means adopted in the course provided opportunities for access to information and content, besides communication with other people.

Considerations

This research unveiled that professional development involves several elements and factors in the learning experiences in the university-school articulation (Day, 200; Clarke & Hollingsworth, 2002). In addition to learning statistical concepts with an investigative class, the teacher had the opportunity to take ownership and reflect on the use of DICTs in teaching and people's lives. Thus, we perceive the presence of the four realms studied by Clarke and Hollingsworth (2002), namely external, practical, consequence, and personal.

In the first, the external mastery, the coordination of the formative process planned guidelines and tutorials for using Google Meet, Classroom, Telegram, recording videos on cell phones, etc. In the practical mastery, teachers planned activities and the teaching sequence, recorded videos, posted them in the Google Classroom, and participated on Telegram. These actions were part of new professional experiences. In the realm of consequence, teachers and teacher educators were involved in reflections on the concepts, practice, and student learning in large and small groups. Finally, in the personal realm, the construction of statistical concepts and the possibility of believing in an investigative class in mathematics were present, with problematization, discussion, reflection on the topic, and systematization of concepts. Thinking about every teacher's condition, learning factors that favor professional development emerged,

such as overcoming shyness, communication skills, and pedagogical and technical use of digital tools, among others.

Regarding the online training model with the flipped classroom, the fact that the teacher had access to the study material before the meeting presented positive points, as they could study at their own pace and try to carry out the activities proposed to develop a possible understanding. The recorded digital videos allowed the participants to watch them as many times as necessary and at their own pace and time. Teachers were encouraged to prepare for the next meeting by completing the indicated tasks. The asynchronous and synchronous activities and discussions helped them understand statistical concepts and the PPDAC investigative cycle as a possibility to build new learning. It also fostered peer exchange of experiences and knowledge in the formative course, despite the pandemic and the fact that many teachers had not met each other. Nevertheless, they learned together. Thus, a teacher education activity based on the flipped classroom methodology, theories, and active learning concepts –providing an online training model based on the participant's protagonism and collaboration with peers and researchers– is possible and promotes qualification and professional development.

In the research, the variable *time* appeared as a challenging element for teachers, as they pointed out it jeopardized their participation in the training and the attempt to reconcile school time and professional time. The nature of time revealed by the teachers was subjective, social, and human, and this condition proved to be challenging in terms of time for formation, especially concerning DICTs and new ways of planning classes, as well as taking care of their health and their families. In this sense, we understand that the REM-NE teacher education course, constituted by the university-school partnership, is relevant for teaching professional development by reflecting on teachers' daily activities inside and outside the school. Such reflections corroborate the creation of future teacher education models linked to the school reality that consider the coexistence of school time and professional time in the search for teaching development based on reframing knowledge and teaching practices.

During the analysis of the formative process, we found evidence that makes us understand professional development as something continuous, inconclusive, and articulated with the systemic educational context (Rocha & Fiorentini, 2009). It was evident that teachers

still have demands of a conceptual nature and pedagogical practices. We realize that teaching methodologies and handling DICTs require other learning besides mathematical concepts. Furthermore, the pandemic context experienced by education may have guided teachers' reflections on the mathematical content they expected to be covered since emergency remote teaching (ERT) required them to adapt their teaching practices to minimize students' gaps in learning during the period.

Finally, it is worth highlighting an additional aspect of the objectives of this work, which was to promote the internalization of research and the experience of teacher education in mathematics. In addition to broadly focusing on research and teaching institutions located in the Brazilian northeast, the most economically vulnerable region of the country, of the seven cities in which the REM-NE centers linked the participating teachers, only two were state capitals, where research is concentrated in Brazil. This characteristic meets an educational, social, and political demand by proposing an intervention with the collaboration of local participants in regions of the country and states that require even more support. We can say that this work promoted equity in research in mathematics education by socializing scientific and pedagogical knowledge of statistical literacy with teachers from upcountry, where they do not always have the same access, conditions, and opportunities for training and reflection on teaching practice compared to large urban centers. Despite the online model that enables the socialization of experiences, regardless of time and space, the fact that researchers are also linked to rural cities favors and highlights the importance of fostering research in the countryside.

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