(Auto)Biographical Narratives and the Professional Development of Mathematics Teachers who Teach Probability and Statistics

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ABSTRACT

Background: Investigating narratives from the (auto)biographical perspective has expanded the possibilities of research in mathematics education, in the personal and professional aspects of the individuals and their choices during professional development. **Objectives:** This article aims to analyse (auto)biographical narratives of mathematics teachers who teach stochastics in basic education and their teacher professional development processes. **Design:** It is qualitative research, from the (auto)biographical perspective. **Setting and Participants**: The lexical corpus is composed of ten narratives by teachers from the states of São Paulo and Espírito Santo, Brazil, participants of a continuing education course offered in a virtual learning environment. **Data collection and analysis:** For the textual and lexical analysis of the content, the IRaMuTeQ software and its respective analysis resources were used: word cloud technique, similarity analysis and the descending hierarchical classification (DHC). **Results:** From this analysis, four thematic categories emerged: initial education, professional challenges, school practice, and continuing education. **Conclusions:** We concluded that school practice is directly related to initial education and the challenges the mathematics teacher faces. Second, only by reflecting on their practices can the teacher be convinced of their need for updating in continuing education.

Keywords: Professional development; IRaMuTeQ; Descending hierarchical classification (CHD); narratives; (auto)biographical research.

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Narrativas (auto)biográficas e o desenvolvimento profissional de professores de matemática que ensinam probabilidade e estatística

RESUMO

Contexto: As práticas de pesquisas narrativas na perspectiva (auto)biográfica tem ampliado as possiblidades de investigações no campo da Educação Matemática, tanto nos aspectos pessoais, profissionais do sujeito e de suas escolhas ao longo do desenvolvimento profissional. **Objetivos:** Esse artigo tem por objetivo analisar narrativas (auto)biográficas de professores de matemática que ensinam probabilidade e estatística na educação básica e seus processos de desenvolvimento profissional docente. **Design**: Trata-se de uma pesquisa qualitativa, na perspectiva (auto)biográfica. **Ambiente e participantes**: O corpus lexical é composto por dez narrativas de docentes, oriundos dos estados de São Paulo e Espírito Santo, Brasil, participantes de um curso de formação continuada, ofertado em um ambiente virtual de aprendizagem. **Coleta e análise dos dados**: Para as análises textual e lexical do conteúdo, utilizou-se o software IRaMuTeQ e seus respectivos recursos de análise: técnica da nuvem de palavras, análise de similitude e a Classificação Hierárquica Descendente (CHD). **Resultados:** Desta análise, emergiram quatro categorias temáticas: formação inicial, desafios da profissão, prática escolar e formação continuada. **Conclusões:** Conclui-se que prática escolar possui relações diretas na formação inicial e nos desafios enfrentados pelo professor de matemática, e que somente a reflexão dessas práticas é capaz de convencer o professor sobre a necessidade de atualização na formação continuada.

Palavras-chave: Desenvolvimento profissional; IRaMuTeQ; Classificação Hierárquica Descendente (CHD); narrativas; pesquisa (auto)biográfica.

INTRODUCTION

The initial and continuing education of mathematics teachers and their reflections have been a theoretical field broadly studied by several researchers (Imbernón, 2010; Ponte, 2002; Tardif, 2002; Moura, 2005; Nóvoa, 1995; Marcelo García, 1999; Lopes, 2012; Fiorentini, 1995; D'Ambrosio, 1986). Those studies have drawn particular attention to the transformations that society inflicts on teachers. Therefore, in the face of those changes, the study of teachers' professional development requires necessarily giving the teacher a word and a voice to reflect and (self) educate through written narratives.

Indeed, the teaching profession is undergoing a process in which the transmission of academic knowledge has become obsolete due to the complexity enforced by scientific, social, and educational structures (Imbernón, 2011). Thus, new perspectives on the mathematics teacher have allowed us to

understand how those teachers expand their professional development and what feelings and emotions they carry along this process.

Understanding and reconstructing the individual/collective space of education, surrounded by experiences, emotions, and feelings that occurred throughout a teacher's professional trajectory, constitutes the domain of (auto)biographical research (Rocha & Sá, 2019). Therefore, in this context, the narratives produced by those teachers justifying their professional trajectories are fundamental and underlie the choice of (auto)biographical research as a research method and the narratives as a data collection instrument.

Thus, the main objective of the study is to analyse the (auto)biographical narratives of mathematics teachers who teach probability and statistics in basic education and their processes of teacher professional development. Indeed, looking at the past, taking (auto)biographical narratives as a resource is a good alternative to understand their paths, which play a crucial role in this rescue of the past with reflections on the present and projection for the future (Nacarato & Passeggi, 2013).

Thus, those narratives of their educational memorials can be analysed through qualitative data analysis software. Those qualitative analyses have been the object of studies by several researchers (Johnston, 2006; Camargo & Justos, 2013; Marchand & Ratinaud, 2012; Reinert, 1990). IRaMuTeQ software has been widely used in Brazil since 2013, and Tinti et al. (2021) discussed its application in the analyses of (auto)biographical narratives. In this study, the authors expanded the analysis of (auto)biographical narratives, allowing the researcher to have a more comprehensive look at scenarios that were often unknown due to the number of narratives available.

We understand that using IRaMuTeQ allows the researcher to verify possible categories that emerge directly from the narratives. The possibility of combining the researcher's theoretical knowledge with the results presented by the software can broaden the look at the narratives to delve into the analyses. It is worth mentioning that the results of the analyses do not impair the researchers' movements but rather help them make decisions.

Therefore, we understand that the fundamental contribution of this article is to broaden views on how the professional development process of those teachers takes place by looking into their narratives, and to expand on how using qualitative analysis software can be valuable in identifying the elements that make up the teachers' professional development through their (auto)biographical narratives.

Considering this article and its purpose, we have organised it into five sections that point to the professional development of the mathematics teacher who teaches probability and statistics. Then, we deal with the methodological aspects and present an analysis of the narratives written through the resources made available by the software: word cloud, similarity analysis, and descending hierarchical analysis (DHA). Finally, we present the discussed results and end with some final considerations.

PROFESSIONAL DEVELOPMENT OF THE MATHEMATICS TEACHER WHO TEACHES PROBABILITY AND STATISTICS.

In this direction, Tancredi (2009, p. 15) states that one learns to be a teacher before one chooses one's career, when one is still a student, and one builds an idealised image of what to be a teacher is. In this sense, the author argues that learning to teach begins long before entering a degree course and extends throughout life. For Fiorentini (2013, p. 161), it is a "continuous process that extends throughout the person's professional life and begins before he or she gets their degree". Thus, Tancredi indicates that teaching goes through stages, and this perspective allows us to perceive that, for each stage, teachers have different educational needs.

Considering Tancredi's study (2009), we can indicate the following stages that make up the learning to teach: 1st stage: Idealisation of teaching; 2nd stage: Initial education; 3rd stage: Initiation into teaching; 4th stage: Continuing education and 5th stage: Retirement.

The first stage shows that the learning-how-to-teach process begins long before a person enters a specific course for teacher education; it begins when the idealised scenario of the profession is very noticeable. This first stage is vital because it relates to personal construction and the first signs of professional choice.

About this stage, Tinti (2012) points out that, if we go back to a teacher's individual trajectory, we will certainly realise that the period was remarkable for him/her since, at this stage, "being a teacher" is conceived as a game, without opposing or complicating aspects involved. In this scenario, the author indicates that we will certainly be able to identify the presence of the "model teacher" who inspired the "playing at being a teacher", in which it is

possible to reproduce the most significant or expressive actions and even awaken the "enchantment for the profession".

As this enchantment evolves, the desire to become a teacher becomes latent. Then, the search for a legitimate locus of professional qualification begins, i.e., the individual looks for a degree course.

After entering the degree course, here called Initial education, the teacher begins another stage of the learning-how-to-teach process, which we will call the second stage. Until recently, having a teaching degree obtained at high school or a degree (higher level) was considered sufficient to be a teacher. However, this is a reductionist view of education, since knowledge is dynamic and, therefore, requires teachers to be constantly studying to meet the educational needs of society at each time. In this sense, "it is not possible to intend that initial education offers finished products, but rather to understand that it is the first phase of a long and differentiated process of professional development" (Marcelo García, 1999, p. 27). Therefore, continuing education that prioritizes reflective and critical environments is important so that beliefs and conceptions developed during initial education and gaps arising from them can be re-signified.

Although undergraduate courses seek as much as possible to enable learning how to teach along the period that comprises the entry and completion of initial education, Mizukami et al. (2002, p. 23) point out that we must have in mind that:

> [if] initial education alone cannot be responsible for the entire task of qualifying teachers, as the supporters of technical rationality want, it is also true that it occupies a very important place in the set of the total process of this education, if viewed in the direction of practical rationality.

Costa & Oliveira (2007, pp. 28-29) corroborate this idea by believing that we need to understand 'learning how to teach' as "a process that does not end with initial education but takes place throughout life, which mobilises different knowledge and experiences and involves personal and professional dimensions".

For this reason, Tancredi (2009) lists the third stage: the insertion in the school context, the return to school, now no longer as a student or as a pre-service teacher, but as a teacher qualified for professional practice. In this way, Rocha and Fiorentini (2009) understand that this is a significant step in the

professional development of mathematics teachers, as it constitutes the transition from student to teacher.

Huberman (1992) understands the initiation into teaching as the first stage of the teachers' life cycle. For him, this stage corresponds to the first two or three years of teaching – and is characterised by aspects of survival and discovery, generally lived in parallel, considering that, in this period, many dilemmas could have been mitigated if, during initial education, this young teacher experienced and reflected on them.

Thus, the initiation into teaching can be seen as one of the most critical stages in the process of learning to be a teacher. It is undoubtedly a stage permeated by challenges that the initial education course may not have prepared the teacher to face. Consequently, at the beginning of their careers, the teachers face a reality shock to establish their professional and personal identity, a principle of survival that allows them to experience a moment of professional socialisation (Marcelo García, 1999; Zaragaza, 1997; Simon Veeman, 1984).

Tancredi (2009) and Huberman (1992) also indicate that a great challenge for young teachers is to realise that their professional development is directly related to the institutional context in which they are inserted, i.e., to collective work. Thus, according to Imbernón (2010, p. 47)

> Another aspect that should be introduced in the concept of professional development is the collective or institutional, i.e., the development of all personnel working in an educational institution. The professional development of all teaching staff in an educational institution integrates all the processes that improve the working situation, professional knowledge, and workers' skills and attitudes, among others. Therefore, this concept would include management teams, non-teaching staff, and teachers.

Consequently, faced with the many challenges emerging from everyday school life, beginning teachers realise that they must continue their education to handle them. "And this is how the learning process of being a teacher takes place throughout one's career (and life)" (Tancredi, 2009, p. 16). This is the fourth stage of the learning-how-to-teach process, called continuing education - often called in-service education or training.

Finally, for Tancredi (2009, p. 17), the last stage of this education cycle is retirement. Nevertheless, the author believes that even with retirement, the

teacher continues to learn; after all, "learning includes professional growth and personal growth".

Given the above, research in the field of statistics education has pointed out the need for studies in the initial and continuing education of mathematics teachers who teach probability and statistics (Batanero, 2019; Batanero et al., 2011; Batanero & Díaz, 2010; Lopes, 2003; Scarlassari, 2021; Barbosa et al., 2021; Pfannkuch & Ben-Zvi, 2011). Thus, the need for continuing education for mathematics teachers who teach probability and statistics is an object of interest for researchers in the area of statistics education since, from the perspective of mathematics teachers in basic education, such courses "have not prepared those professionals to the theoretical-methodological domain of statistics education and many other fields of mathematics education" (Lopes, 2014).

Souza (2006) points out the importance of using methodologies, such as (auto)biographical research as a resource to understand the process of formation and knowledge on topics such as professional development from the perspective of teacher identity in the context of continuing education.

For this reason, proposing spaces for a continuing education that allows for a new dynamic in the "[...] adequate combination between the knowledge of the subject to teach and the pedagogical and didactic knowledge of how to teach" (Marcelo García, 1999, p. 88) and the adoption of methodologies in which teachers can narrate their life stories —full of subjectivity— is an important strategy to understand the professional development process of the mathematics teacher who teaches probability and statistics, at the same time that it gives them a voice and a leading role.

Several works in statistics education have used the (auto)biographical method to understand teachers' education process through their life stories. Therefore, written and oral narratives have become a strategy for a broader view of teachers' professional development, as it places them as knowledge producers.

When analysing the narratives of two teachers and their professional development processes in statistics education, Lopes (2014) claims that using written narratives to understand this process was fundamental for teachers to reflect on their produced texts, giving meaning to what they lived. This movement marked by (re)construction and (re)appropriation of knowledge makes teachers the protagonists of their professional development processes. In short, for the author, when teachers tell their stories in written narratives,

they reconstruct their experiences and change their ways of acting and thinking throughout their professional development process.

For Scarlassari and Lopes (2019), the discussion about aspects of the trajectory of three mathematics teachers who teach probability and statistics through their (auto)biographical narratives reveals that the socialisation of their professional practices, diversity of opinions, multiple perspectives, and different contexts as part of continuing education helped them improve and resize their practices, also revealing evidence of their technical and didactic productions. According to the authors, those collaborative environments value the teachers' voices, put them in the centre, provide an exchange of experiences through the activities developed throughout the course, and give tthem opportunities to expand professional development by relating their practices to their interests, beliefs, and previous knowledge of the teaching of statistics and probability in basic education.

Conti et al. (2016) point out the importance of using narratives to understand the process of the professional development of teachers and prospective teachers of early childhood education and early years of elementary school from the perspective of statistical literacy. In one of the passages, the authors, supported by Passos et al. (2009, p. 148), conclude that when analysing the narrative writing process, "processes of becoming aware of their knowledge" are revealed in a continuous movement, which begins in the teacher's trajectory as a student and follows until her professional autonomy.

In short, using (auto)biographical research in the educational field is essential to understand the process of professional development capable of translating the paths taken during the formation process, revealing the teachers' feelings, listening to their voices, and inserting them as protagonists of/in their education process.

METHODOLOGY

This article aims to analyse (auto)biographical narratives of mathematics teachers who teach probability and statistics in basic education and their professional teacher development processes. For that, we chose the qualitative approach (Creswell & Clark, 2013; Minayo, 2010) and the (auto)biographical perspective (Nacarato & Passeggi, 2014). The sample consisted of ten teachers from a continuing education extension course entitled "Práticas pedagógicas para o ensino da estatística" [Pedagogical Practices for the Teaching of Statistics] offered by the Center for Research in Mathematics

and Statistics Education (Centro de Pesquisa em Educação Matemática e Estatística - CEPEME) in partnership with the Cruzeiro do Sul University (UNICSUL) and with the São Paulo Regional of the Brazilian Society of Mathematics Education (Sociedade Brasileira de Educação Matemática - SBEM/SP).

The training space of the extension course was remote and developed through the Blackboard virtual learning environment. The Blackboard was chosen because the teacher educators and teachers-students can easily manipulate and is already inserted in the academic routine of UNICSUL. Furthermore, it is a simple structure to operate, with support for web conferences (seminars with several researchers from different parts of the country), discussion forums, chat, and the creation of collaborative groups.

This fact directly contributes so that the teacher/teachers can share, reflect, and dialogue about the practical and theoretical activities of the course, promoting intense interchange in an environment where everyone can hear and be heard. This extension course was structured into three modules divided into four weeks, which dealt with theoretical and practical aspects of statistics education. At the first moment of the course, the teacher-students were asked to provide an (auto)biographical narrative taking into account the most significant aspects of their personal and professional life trajectory, with the first activity of the course as the first scenario for article analysis. Those data produced by the teachers-students through the (auto)biographical memorials make it possible to understand that:

> The lived experiences are unfolded and, therefore, the narratives produced bring not only the meanings that each one attributes to them but also the history of a community, the ideas of a collectivity —in this case, of the collective of the educational actors, especially the teachers (Nacarato & Passeggi, 2013).

The teachers-students will be named fictitiously from P1 through P10 to preserve their anonymity. In addition, all teachers-students authorised the researchers to use the data for academic circles registered in the free and informed consent form.

The IRaMuTeQ (*Interface de R pour les Analyses Multidimensionnalles de Textes et de Questionnaires*) software assists in data processing and analysis. It is free and has an interface with the R software, allowing the performance of statistical analyses on textual corpus generated

through text segments. This feature also allows different types of analysis, such as classic textual statistics, word cloud, and similarity analysis, which will be used in this article.

Word clouds, similarity analysis, and the descending hierarchical classification (DHC) were used to analyse the textual contents, i.e., the narratives. Chosing these techniques allowed a more precise, faster, and more oriented organisation of the vocabulary used in the narratives (Ratinaud, 2009; Camargo & Justo, 2013), which, in a way, allows the researcher to advance in qualitative and quantitative analyses to minimise the subjectivity. However, using the DHC technique requires a percentage of retention of text segments above 75% so that the results can be reliable, which this article fulfilled. Furthermore, in the DHC analysis, IRaMuTeQ uses the chi-square ($X2$) statistical test to measure the strength of the association between the words found in the written narratives.

Given the above, we present the results of the analysis of the textual corpus of the narratives produced by mathematics teachers who teach probability and statistics in basic education through the IRaMuTeQ software.

ANALYSIS OF (AUTO)BIOGRAPHIC NARRATIVES THROUGH WORD CLOUD, SIMILITUDE ANALYSIS, AND DESCENDING HIERARCHICAL ANALYSIS (DHC)

The descending hierarchical classification analysis connects text segments according to their vocabulary according to their frequency and locates and quantifies them through statistical procedures. This analysis aims to find similar and different vocabularies within the segments analysed. In this way, a dendrogram is displayed through the DHC with its respective classes.

It is important to note that, for the use of DHC-type analyses, minimum retention of 75% is required to adequately adjust the model (Salvador et al., 2018; Camargo & Justos, 2013). Thus, in this article, the percentage of retention was 83.42%, which, in fact, fosters an adequate analysis of the textual corpus formed by the teaching professional trajectories.

Considering the above, Figure 1 shows the dendrogram given by the DHC analysis that demonstrates the classes/categories coming from the content divisions, from left to right.

Figure 1

*Dendrogram of the descending hierarchical classification on the analysed textual corpus.*

The dendrogram in figure 1 was divided into two corpuses and one subcorpus, sufficient for analysing the similar vocabulary in the analyses involving the DHC. In the first subcorpus, classes 4 and 3 correspond to 58.3% of the total. In addition, class 3 was subdivided into a subcorpus, composed of classes 1 and 2, corresponding to 45.2% of the total analysed. The words within each class are directly linked to their representativeness by the chi-square value in a descendent way.

Figure 2 groups occurrence trees through similarity analysis, whose function is to organise frequencies and their relationships so that the central

axes presented are the words with the highest chi-square value indicated by the classes constructed by the DHC.

Figure 2

Similarity analysis of the words with the highest chi-square value originated from the classes constructed by the DHC.
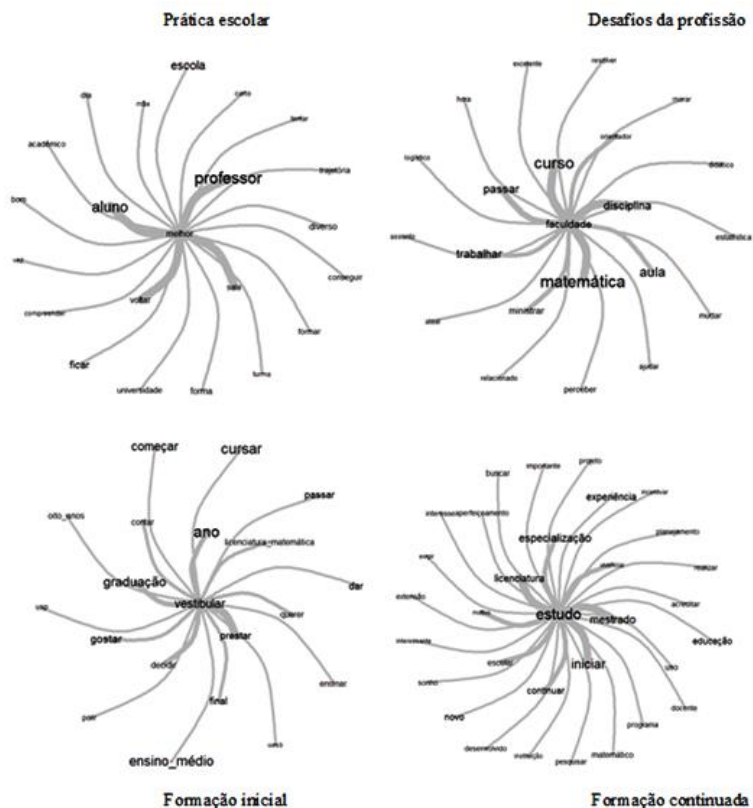
The central axis of the occurrence tree in Figure 2, in the school practice class, emphasises that teachers seek to improve their practices and interactions in the classroom. For example, the central word *melhor* [best] has a significant relationship with the words *aluno* [pupil] and *professor* [teacher], which can be seen in the excerpt from the teachers' narratives.

Thus, Figure 2 presents a similarity analysis based on the words of the categories evidenced by the DHC and their connections with the other words in the group. Those connections satisfactorily reflect the denominations for the generated classes and mainly on the intensity of those words with their connections. This type of exam also allows us to advance more deeply in the analysis of each class. However, so that the work does not become too big, we chose to comment only on the class called *formação continuada* [continuing education], which we will analyse in-depth in the following topics.

Indeed, continuing education is an essential pillar for the professional development of mathematics teachers, as it allows "[...] expand and diversify their knowledge for teaching, transforming their practices according to this reality and the contexts of action, helping students to take full advantage of the benefits that schooling can provide" (Tancredi, 2009, p. 14).

This expansion and diversification during professional development are seen in the excerpt from P5's narrative. Thus, innovation, critical thinking, and "theory" are important elements of a "reflective" practical teacher, who can understand their reactions and those of their students, modifying them in favour of their objective (Tardif, 2002).

DHC interpretive analysis

Continuing education - 4th stage

Category class 4, shown in Figure 1, which we call continuing education, is the most significant within the classes generated on the textual corpus of professional trajectories narrated by teachers. The most representative words according to the chi-square value (X2) were: *estudo, conhecimento, software, especialização, mestrado, iniciar, propiciar, usar, licenciatura* and *aparecer* [study, knowledge, software, specialisation, master's degree, start, provide, use, degree, and appear]. These words also show that elements associated with teacher improvement, whether at extension levels and even master's/doctoral degrees, are present in the teachers' narratives, which shows a constant concern for improving their practices and a willingness to learn.

> *P7: [...] in December 2017, I completed my <u>master's degree</u>, which contributed immensely to my professional and academic formation and maturation, providing me with many reflections*

and new knowledge. (P7's narrative, the first half of 2020, emphasis added)

P1: Since 2014, I have taken several continuing education courses at the Education Center [...] Last year, I started a blended <u>specialisation</u> in education and technologies at UFSCar. (P1's narrative, the first half of 2020, emphasis added)

The recognition that professional development is a continuous, unfinished, and everyday process is present in the ideas proposed by Scarlassari and Lopes (2019, p. 220) when they state that: "Continuing education, therefore, is a phenomenon that occurs throughout life and that takes place in an integrated way with the social practices and everyday school life of each one, gaining intensity and relevance in some of them". In addition, continuing education programmes that value reflection and teacher participation can expand professional development, effectively reducing the gap between academic knowledge and school practice (Selles, 2000).

However, for Nóvoa (1995), teacher education cannot be linked only to the accumulation of course knowledge. For this author, there must be a reflective and critical work of their practices and permanent (re)construction of their identity as teachers. These and the other narrative excerpts from the teachers-students increasingly show that teachers must be critically reflective about their pedagogical practices in the classroom, know how to work in collaborative environments, and understand that teaching is a complex, essential task that requires continuing education. Furthermore, teaching is an action that anyone can perform whenever they feel necessary, which does not mean being a teacher (Marcelo García, 1999).

Thus, given the teacher's professional development scenario, we selected some excerpts that allow us to broaden the view on the importance of continuing education for mathematics teachers who teach probability and statistics.

P2: [...] In this course, I learned about <u>new teaching methodologies</u> that are essential for teacher education. Soon after, I entered my second lato sensu specialisation in higher education teaching. [...] this course provided me with vast knowledge about learning theories and expanded my knowledge of constructivist pedagogy [...]. (P2's narrative, the first half of 2020, emphasis added)

> *P8: [...] Today I seek <u>knowledge</u> to contribute to teaching and researching on this topic. (P8's narrative, the first half of 2020, emphasis added)*

The search for an education that can (re)create their practices and expand their knowledge in learning theories for teaching mathematics/statistics is evidenced in the P2's and P8's excerpts. We also believe that, when narrating their history, teachers can reflect on how they became teachers and the paths taken in life-education during their professional development (Sousa & Almeida, 2012). In this sense, we understand that this search for knowledge and new methodologies drives the professional development of the teacher

In the case of teacher P2, the reflections highlight the importance of innovative teaching-learning methods in a clear desire to migrate from teaching to learning. This migration gives teachers and students opportunities to demonstrate skills, repetitions with interaction, and more effective communication between them (Souza et al., 2014). From this perspective, the search for new teaching methodologies probably originated from challenges observed during their school practice or even from examples they experienced during their initial education in university, a fact that induced teachers' reflections and (self)training. This movement depicted in P2's narrative excerpt points to a rupture between innovative practices for mathematics teaching and traditional teaching strategies based mainly on the "exercise paradigm" and algorithmisation (Skovsmose, 2001)

The analysis of the narratives revealed that the search for spaces for continuing education is motivated by the desire to remedy gaps that came from initial education, and overcome some challenges experienced in school practice, and mainly, in recognising a "hidden" statistics educator among the mathematics "I-teachers".

School practice - 2nd- 4th stages

Class 3 category indicated in Figure 1, called "school practice", is the second most expressive within the classes generated on the textual corpuses of the professional trajectories narrated by the teachers-students. As seen in Figure 1, the words with the greatest representation included in this class, according to the chi-square value ($X2$), were: *Educação de Jovens e Adultos (EJA), anos finais, melhor, ganhar, diretor, convidar, aluno, ficar, voltar* and *participar* [youth and adult education, final years, best, earn, principal, invite, pupil, stay, come back, and participate]. These words indicate the teachers' association

with their school practice, present in many of the analysed narratives. Thus, some excerpts from those trajectories help us to understand in an illustrative way the content of the analysed class and its context.

> *P2: […] I started working with mathematics for <u>youth and adult education</u>, always in high school. I came across the great difficulty adults have with mathematics, but their strong interest in learning was motivating. (P2's narrative, the first half of 2020, emphasis added)*

> *P4: […]. In the meetings with the teachers, I <u>learned</u> many diversified activities focused on mathematical modelling. (P4's narrative, the first half of 2020, emphasis added)*

> *P6: […] contextualising, problem situations, illustrations, applications in everyday life, social reality, all these terms had to be learned during my professional activity because they <u>never appeared</u> during my degree. (P6's narrative, the first half of 2020, emphasis added)*

> *P1: In 2010, I took a pedagogy course to <u>improve my practice</u>. (P1's narrative, the first half of 2020, emphasis added)*

The narrative excerpts presented specify strong motivations for teaching probability and statistics in the classroom and portray the contribution of teacher education spaces. In addition, they configure an understanding that the act of teaching is complex and essential and requires permanent construction and reconstruction, i.e., it requires an investment in their professional development.

The construction and reconstruction are pointed out in teacher P2's narrative, who talks about a challenge imposed on her when teaching probability and statistics/mathematics classes to a youth and adult education class (EJA). The teacher reveals in her narrative that she had numerous difficulties teaching probability and statistics. However, her students' motivation to learn in the face of all the barriers imposed on EJA students was encouraging and essential element for her learning in probability and statistics, which promoted further her professional development. The teacher also reports that the first steps towards teaching probability and statistics to her students were marked by discoveries and learning for all, her and her students, especially during programmed practical activities. Indeed, this led the teacher to dedicate more to conducting the classes. Furthermore, the fuel of the teachers' intrinsic

motivation to continue teaching and learning directly reflects their students' learning (Lortie, 1975; Marcelo García, 1997).

For Morales (2011), teachers' relationship with the students clearly influences professional satisfaction and is a determining factor for the goals set by teachers. This satisfaction is directly proportional to P2's learning in the teaching of probability and statistics because, for her, even having taken a statistics course at graduation, everything was very new in that context. Furthermore, this rupture and this discontinuity that occurred during the practices with the teaching of probability and statistics were important factors for professional development, as they require that the teachers reflect on the new in their school practices.

Knowledge in learning to teach and its reflection cannot only be acquired in an initial education course or education courses in general that largely obey mechanical, linear, and decontextualised teaching. Such learning must consider the confrontations of the practical reality of the profession and the transformation into the teaching of the content learned throughout their professional path (Marcelo García, 1998; Nóvoa, 2004). Furthermore, this formation must provide students with the ability to understand changes and uncertainties within and outside their school environment.

Thus, the school practice for teachers who teach probability and statistics is a permanent demand along their professional career, because the context listed by the subjects requires from the teachers knowledge they did not get during their graduation. This appears as a challenge for them, especially when working with basic education.

Challenges of the profession - 2nd - 4th stages

Class 1 category, presented in Figure 1, which we call "Training Challenges", is the third most expressive within the classes generated on the textual corpuses of professional trajectories narrated by teachers, being a subdivision of the "School practice" class. Thus, the most representative words according to the chi-square value (X2) for this group were: *faculdade, chegar, passar, interessar, disciplina, mostrar, sair, perceber, mudar* and *didática* [college, get, succeed, interest, discipline, show, leave, perceive, change, and didactics]. Given these words, it is possible to understand the different scenarios present in the analysed narratives, such as ruptures of technical ideas, reflection and reflection-action of their practices, and adversities of the profession. The selected excerpts expand this view.

P9: [...] subjects that involved <u>didactics</u> always pleased me more, because they showed me the directions of where I wanted to go with my career. I had teachers who weren't so didactic either, but that also helped me show what I shouldn't do in my classes. (P9's narrative, the first half of 2020, emphasis added)

P5: I taught in two colleges in my city, the discipline of mathematics in the pedagogy courses. A very significant experience, which showed how "<u>scared</u>" students were of mathematics. (P5's narrative, the first half of 2020, emphasis added)

P10: Despite my short period as a teacher, I could see over these ten months the <u>dissatisfaction of teachers</u> who teach mathematics; they sometimes feel incapable because they cannot reach their students and I include myself in this team, we try in different ways to convey to the students, who, most of the time, can't understand the content, it's always a setback, but we keep doing the best we can. (P10's narrative, the first half of 2020, emphasis added)

The selected excerpts reflect on the challenges that the mathematics teacher experiences during the school practice process. Such pieces point out that the challenges begin during our initial formation, characterised by several conditions imposed on the prospective teachers even before they enter the classroom, such as mechanised teaching, the type of fear or dislike that mathematics imposes on students, and teachers' frustration in the face of the ineffectiveness of their teaching strategies, portrayed in the teachers' reflection on their practice.

Professor P9's speech highlights a problem that resists changes, and that makes him continually rethink his practices. The portrait the teacher chose to compose part of her narrative, shows that when narrating this past, a (re)signification of her practice is clearly visualised in her narrated passage. Moreover, it is possible to infer that the excerpt of her past causes changes in her present and future practices by avoiding their reproduction in the classroom. (Simas et al., 2019; D'Ambrosio & Lopes, 2013; D'Ambrosio, 1993).

The picture from P5's narrative excerpt shows that fear and aversion to mathematics are still factors that persist in classrooms and have accompanied teachers even before they decided to follow this profession. The scenario that the teacher narrated about the students' feelings of fear is recurrent within the

studies on teacher education and shows how those feelings hinder the students' development.

In addition, the first years of the teaching profession are fundamental for the development of the teacher's knowledge and identity, whose mission will fall on complex situations that, many times, will require immediate responses from this professional (Ponte et al., 2001). The teacher faces countless challenges that range from beliefs and conceptions that mathematics is very difficult to outdated methodological strategies.

In this case, the teacher must create strategies so that those harmful beliefs and conceptions about mathematics, often coming from different contexts, can be mitigated. Besides, they can expand activities that take the student's context as a reference so that creativity and cooperation can be elements of autonomy for the students in the teaching and learning process. For Cunha (2009), the methodology used in the teaching and learning process is the main link between the teacher and the students. Thus, taking methods that prioritise practice is a determining factor for students' involvement in this process and the development of the probability and statistics teacher.

Initial education - 2nd stage

As shown in Figure 1, class 2 category, which we call "Initial education", is the fourth class generated on the textual corpuses of professional trajectories narrated by teachers and a subdivision of the school practice class. As seen in Figure 1, the words with the highest representation according to the chi-square value (X^2) for this group were: *vestibular, cursar, ano, prestar, graduação, licenciatura, matemática, estágio, ensinar, decidir* and *Universidade de São Paulo (USP)* [university entrance exam, attend, year, take an exam, graduation, degree, mathematics, teaching practice, teach, decide, and São Paulo University]. Those words reveal the teachers' decision to take a degree in mathematics and the phases resulting from this choice, for example, supervised teaching practice, when teachers in initial training can experience the challenges of the profession.

> P6: *Gradually, I started to like the subjects I was studying, and by participating in projects in partnership with the municipality, I could experience the classroom even before taking teaching practice (which at this time was at the end of the curriculum). (P6's narrative, the first half of 2020, emphasis added)*

> *P₂: <u>I always liked to teach</u>, I was very patient with the students of an NGO where I was a tutoring teacher; encouraged by a teacher, I researched the available courses and decided to go straight to the degree in mathematics, I wanted something complete, so in 2015 I started my studies. (P2's narrative, the first half of 2020, emphasis added)*

The reports on the first moments of the initial training are essential for the professional development of the prospective teacher. For P_6, participation in projects and in the supervised teaching practice are important for them to experience other teachers' practices, their emotions and challenges along the teaching and learning process. In this formative space, with different levels of education, the undergraduate can experience the duality between knowledge and practice, recognise their limits and potential, and especially, the opportunity to reflect on their practices (Cyrino & Passerini, 2009). From this perspective, the teaching professional identity is taking shape through the shock of realities provided by the school environment.

In turn, for teacher P_2, [...] "I always liked to teach" [...] the teacher's role begins even before having contact with the teaching profession. For Tinti (2002), the professional choice often begins with a playful process based on model teachers whose trajectories inspired and motivated them to choose the teaching profession.

Thus, the results provided by the classes show the stages of professional development listed in Tancredi (2009). It also reveals that the reflections present in the narratives expand those teachers' professional development.

CONCLUDING REMARKS

This study aimed to analyse professional development through (auto)biographical narratives of elementary school mathematics teachers who teach probability and statistics. Thus, to understand this development, the (auto)biographical narratives proved efficient in revealing those teachers' professional development and how they direct their pedagogical practices and all their experience throughout life-education. Moreover, the importance of listening to the teachers so they can reconstruct their history is an element in an analysis based on (auto)biography research.

The teachers' narratives during the continuing education course provided the opportunity to create categories of analysis visualised from the descending hierarchical classification (DHC) and the theoretical knowledge required to name the categories within the observed results. In addition, understanding those categories and their relationships with professional development, such as continuing education, school practice, initial formation, and the challenges of the profession, are essential to broaden discussions on those teachers' professional development, their relationships and reflections along their formative experiences, their knowledge built during their practices, and how social influences impacted their choices/strategies for teaching mathematics and statistics.

The characteristics reported as the knowledge built and the reflections on their practices, and the importance of continuing education in the process of professional development were visualised through a textual analysis software. This tool enabled several analyses in the lexical corpus to understand the behaviour of those textual data within the analysed narratives, and how those words were connected in the analysed contexts, which, in a way, guided us towards a clearer view of the categorisations and their connections.

Thus, although this work focused on the mathematics teachers' professional development, we do not intend to exhaust other possibilities of category analysis, i.e., the categories created in this work are just one of the several categorisations that the results of the DHC can offer. Furthermore, the results provided by the techniques and the large textual volume generated by the written narratives allow us to infer several other paths, such as the teachers' reconstruction in the statistics teaching, evidencing in their speech the learning of the contents of probability and statistics through projects with their students, the relationships of their course professors with their former educators and the way these influences determined their choices along the way and, mainly, the concern about technical rationality, whose rupture only becomes evident when there is a reflection of the practice.

AUTHORSHIP CONTRIBUTION STATEMENT

Authors SSS, GCB, DST, and CEL participated in the conception of the study idea. SSS and GCB prepared the instruments and data collection, and analyses were carried out with the active participation of the authors DST and CEL, with the first author leading the study and the article.

DATA AVAILABILITY STATEMENT

The data that contribute to this study are under the custody of SSS and can be made available to interested parties, upon appropriate request, for five years.

REFERENCES

Barbosa, G. C., Santos, S. S., Tinti, D. D. S., & Lopes, C. E. (2021). Análise de Trajetórias de Professores que Ensinam Probabilidade e Estatística com Auxílio do Software IRAMUTEQ. *Jornal Internacional de Estudos Em Educação Matemática*, *13*(4), 420–428. https://doi.org/10.17921/2176-5634.2020v13n4p420-428

Batanero, C. (2019). Thirty years of stochastics education research: Reflections and challenges. En J. M. Contreras, M. M. Gea, M. M. López-Martín y E. Molina-Portillo (Eds.), *Actas del Tercer Congreso Internacional Virtual de Educación Estadística*. www.ugr.es/local/fqm126/civeest.html

Batanero, C. & Díaz, C. (2010). Training teachers to teach statistics: what can we learn from research? *Statistique et Enseignement*, *1*(1), 5-20.

Batanero, C., Burrill, G., & Reading, C. (2011). Overview: challenges for teaching statistics in school mathematics and preparing mathematics teachers. In C. Batanero, G. Burril, & C. Reading (eds), *Teaching Statistics in School-Mathematics- Challeneges for Teaching anda Teacher Education: A joint ICMI/IASE Study* (p. 407-418). Springer.

Camargo, B. V. & Justo, A. M. (2013). IRAMUTEQ: um software gratuito para análise de dados textuais. *Temas em Psicologia*, *21*(2), 513 518.

Conti, K. C., Carvalho, D. L. D., & Carvalho, C. F. D. (2016). Desenvolvimento profissional de professores potencializado pelo contexto colaborativo para ensinar e aprender estatística. *Revista Eletrônica de Educação*, *10*(2), 155–171. https://doi.org/10.14244/198271991439

Crecci, V. M. & Fiorentini, D. (2013). Desenvolvimento Profissional de Professores em Comunidades com Postura Investigativa. *Acta Scientiae*, *15*(1), 9–23.

Creswell, J. W. & Clark, V. L. P. (2013). *Pesquisa de métodos mistos*. Penso.

Cyrino, M. C. C. T. & Passerini, G. A. (2009). Reflexões sobre o estágio supervisionado do curso de Licenciatura em Matemática da Universidade Estadual de Londrina. In: Cainelli, M. & Fioreli, I. (Org.). *O estágio na licenciatura: a formação de professores e a experiência interdisciplinar na Universidade Estadual de Londrina* (p. 125-144). [1ed]. UEL/Prodocencia/Midiograf.

D'Ambrosio, B. (1993). Formação de professores de matemática para o século XXI: o grande desafio. *Pro-posições*, *4*(1), 34-40.

D'Ambrosio, B. S. & Lopes, C. E. (2015). Insubordinação Criativa: um convite à reinvenção do educador matemático. *Bolema: Boletim de Educação Matemática*, *29*(51), 1–17. https://doi.org/10.1590/1980-4415v29n51a01

D'Ambrosio, U. (1986). *Da realidade à ação: reflexos sobre Educação Matemática*. UNICAMP.

Costa, J. S. & Oliveira, R. M. M. A. (2007). A iniciação na docência: analisando experiências de alunos professores das licenciaturas. *Olhar de Professor*, *10*(2).

Fiorentini, D. (2009). Alguns modos de ver e conceber o ensino da matemática no Brasil. *Zetetike*, *3*(1). https://doi.org/10.20396/zet.v3i4.8646877

Fiorentini, D. (2013). Learning and Professional Development of the Mathematics Teacher in Research Communities 1. *Sisyphus-Journal of Education*, *1*(3), 152–181. https://dx.doi.org/10.9788/TP2013.2-16

Huberman, M. (1995). O ciclo de vida profissional dos professores. In: Nóvoa, Antonio (org.), *Vidas de Professores*. Porto.

Imbernón, F. (2010). *Formação docente e profissional: formar-se para a mudança e a incerteza*. Cortez.

Johnston, L. (2006). Software and method: reflections on teaching and using QSR NVivo in doctoral research. *International Journal of Social Research Methodology*, *9*(5), 379-391.

Lopes, C. E. (2003). O conhecimento profissional dos professores e suas relações com estatística e probabilidade na educação infantil. Tese de Doutorado da Universidade Estadual de Campinas.

Lopes, C. E. (2012) A educação probabilidade e estatística na infância. *Revista Eletrônica de Educação*, São Carlos, *6*(1), 160-174.

Lopes, C. E. (2014). As Narrativas de Duas Professoras em seus Processos de Desenvolvimento Profissional em Educação Estatística. *Bolema*, Rio Claro, *28*(49), 841-856.

Marcelo García, C. (1998). Pesquisa sobre formação de professores: o conhecimento sobre aprender a ensinar. *Revista Brasileira de Educação*, *9*, 51-75.

Marcelo García, C. (1999). *Formação de Professores – Para uma Mudança Educativa*. Porto.

Marchand, P. & Ratinaud, P. (2012). L'analyse de similitude appliqueé aux corpus textuels: les primaries socialistes pour l'election présidentielle française (septembre-octobre 2011). In: *Actes des 11eme Journé es internationalesd'Analyse statistique des DonnéesTextuelles*. JADT: Liége, 2012, (p. 687-699).

Minayo, M. C. S. (2010). *Pesquisa Social: teoria, método e criatividade*. 29. ed. Vozes.

Mizukami, M. G. N. et al. (2002). *Escola e aprendizagem da docência processos de investigação e formação*. EdUFSCar.

Morales, P. A. (2011). *Relação Professor-aluno: o que é, como se faz*. Loyola.

Moura, M. O. (1995). A formação do profissional de Educação Matemática. *Temas & Debates: Formação de Professores de Matemática. Sociedade Brasileira de Educação Matemática - SBEM*, *VIII*(7).

Nacarato, A.M. & Passeggi, M.C. (2014). Narrativas autobiográficas produzidas por futuras professoras: representações sobre a matemática escolar. *Revista de Educação Puc-campinas*, *18*(3), 287-299.

Nóvoa, A. (2004). Novas disposições dos professores: a escola como lugar de formação. *Correio da Educação*, *2*(1), 7-20.

Nóvoa, A. (Org.). (1995). *Os professores e sua formação*. Dom Quixote.

Passos, C. L. B., Oliveira, R. M. M. A., & Gama, R. P. (2009). Práticas potencializadoras do desenvolvimento profissional docente: atividade de ensino, pesquisa e extensão. In: Fiorentini, D., Grando, R. C., &

Miskulin, R. G. S. (Orgs.). *Práticas de formação e de pesquisa de professores que ensinam matemática*. Mercado de Letras.

Pfannkuch, M. & Ben-Zvi, D. (2011). Developing teachers' statistical thinking. In: Batanero, C., Burrill, G., & Reading, C. (Ed.). *Teaching Statistics in School Mathematics-Challenges for Teaching and Teacher Education: A Joint ICMI/IASE Study* (p. 323-333). Springer.

Ponte, J. P., Galvão, C., Santos, F. T., & Oliveira, H. (2001). O início da carreira profissional de jovens professores de Matemática e Ciências. *Revista de Educação*, Lisboa, *10*(1), 31-45.

Ratinaud, P. (2009). *IRAMUTEQ: Interface de R pour lês Analyses Multidimensionnelles de Textes et de Questionnaires* [Computer Software].

Reinert M. (1990). Alceste une méthodologie d'analyse des données textuel les e tune application: Aurelia de Gerard de Nerval. *Bull Methodol Sociol*, *26*(1), 24-54.

Rocha, L. & Fiorentini, D. (2009). Percepções e reflexões de professores de matemática em início de carreira sobre seu desenvolvimento profissional. In Fiorentini, D., Grando, R. C., & Miskulin, R. (Eds.), *Práticas de formação e de pesquisa de professores que ensinam matemática*. Mercado de Letras.

Salvador, P. T. C. O., Gomes, A. T. L., Rodrigues, C. C. F. M., Chiavone, F. B. T., Alves, K. Y. A., Bezerril, M. S., & Santos, V. E. P. (2018). Uso do software IRAMUTEQ nas pesquisas brasileiras da área da saúde: uma scoping review. *Revista Brasileira em Promoção da Saúde*, *31*, 1-9.

Scarlassari, N. T. (2020). Narrativas de práticas em Educação Estatística e a agência profissional de professores de Matemática. 2020. 246f. Tese (Doutorado em Ensino de Ciências e Matemática) – Universidade Cruzeiro do Sul, São Paulo.

Scarlassari, N. T. & Lopes, C. E. (2019). Narrativas de professores de matemática em formação contínua. *Revista Brasileira de Pesquisa (auto)biográfica*, *4*(10), 215-229.

Selles, S. E. (2000) Formação continuada e desenvolvimento profissional de professores de ciências: anotações de um projeto. *Revista Ensaio Pesquisa e Educação em Ciências*, Belo Horizonte, *2*(2), 167-181.

Simas, V. F., Prado, G. V. T., & Segovia, J. D. (2019). Tornar-se professora: o saber da experiência na pesquisa narrativa. *Revista Brasileira de Pesquisa (auto)biográfica*, Salvador, *4*(12), 991-1004.

Skovsmose, O. (2000). Cenários para investigação. *Bolema*, Rio Claro, *13*(14), 66- 91.

Sousa, E, C. & Almeida, J. B. (2012). Narrar histórias e contar a vida: memórias cotidianas e histórias de vida de educadores baianos. In: Abrahão, M. H. M. B. (Org.). *Pesquisa (auto) biográfica em rede* (p. 29-31). UFRN, IPUCRS, EDUNEB.

Souza, A. P. G. & Anunciato, R. M. M. (2019). Aprendizagens da docência em uma comunidade de aprendizagem online: contribuições da ReAD. *Revista Brasileira de Pesquisa (auto)biográfica*, Salvador, *4*(12), 1090-1109.

Souza, C. S., Iglesias, A. G., & Filho, A. P. (2014). Estratégias inovadoras para métodos de ensino tradicionais - Aspectos gerais. *Medicina*, Ribeirão Preto, *47*(3), 284-292.

Souza, E. C. (2006). A Arte de contar e trocar experiências: reflexões teórico-metodológicas sobre histórias de vida em formação. *Revista Educação em Questão*, Natal, *25*(11), 22-39.

Tancredi, R. P. (2009). *Aprendizagem da docência e profissionalização: elementos de uma reflexão*. EdUFSCar.

Tardif, M. (2002). Os professores enquanto sujeitos do conhecimento. In: Tardif, M. *Saberes docentes & formação profissional*. 5. ed. Vozes.

Teixeira, B. R. & Cyrino, M. C. C. T. (2015). Desenvolvimento da Identidade Profissional de Futuros Professores de Matemática no Âmbito da Orientação de Estágio. *Bolema*, Rio Claro, *29*(52), 658-680.

Tinti, D. D. S., Barbosa, G. C., & Lopes, C. E. (2021). O software IRAMUTEQ análise de Narrativas (Auto)biográficas no Campo da Educação Matemática. *Bolema: Boletim de Educação Matemática*, *35*(69), 479- 496. https://doi.org/10.1590/1980-4415v35n69a22