The Professional Development of Special Education Teachers and the Teaching of Natural Sciences for Blind and Low-Vision Students[1]

O Desenvolvimento Profissional de Docentes da Educação Especial e O Ensino de Ciências da Natureza para Estudantes Cegos e Baixa Visão

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ABSTRACT: The objective of this research was to analyze how the potentialities and limits of a formative process involving Special Education teachers can be characterized in order to favor reflections on the performance of these Special Education teachers facing the teaching and learning of Natural Sciences involving blind and low vision students. In order to achieve this goal, we developed a formative process with 17 teachers, 2 of which were blind, who work in the Special Education field in the municipal school system. This qualitative research had as its *corpus* of analysis: textual productions of the teachers resulting from activities carried out during the formative process; records from a virtual collective diary, and texts originated from transcription of semi-structured interviews. The discursive textual analysis was chosen as the analytical procedure. From the data analysis, it was possible to find out that teachers of Special Education recognize, in parts, the limits of their performance regarding the teaching of Natural Sciences for blind and low vision students. Based on the inter-collective circulation category, derived from Ludwik Fleck's epistemology, attention was drawn to the importance of the interaction between Special Education teachers and different professionals, which might help them face the limits on their performance regarding the teaching and learning of Natural Sciences.

KEYWORDS: Special Education. Science teaching. Professional development.

RESUMO: Esta pesquisa teve como objetivo analisar como podem se caracterizar potencialidades e limites de um processo formativo envolvendo docentes da Educação Especial, a fim de favorecer reflexões sobre a atuação do educador especial diante do ensino e da aprendizagem de Ciências da Natureza envolvendo estudantes cegos e baixa visão. Para tanto, foi desenvolvido um processo formativo com 17 professores, dos quais dois eram cegos, da área de Educação Especial de uma Rede Municipal de Ensino. A pesquisa de natureza qualitativa teve o *corpus* da análise constituído por: produções textuais dos professores decorrentes de atividades realizadas no processo formativo; registros em um diário virtual coletivo e textos originados da transcrição de entrevistas semiestruturadas. A análise textual discursiva foi escolhida como procedimento analítico. A partir disso, foi possível averiguar que os docentes da Educação Especial, em parte, reconhecem os limites em sua atuação no que tange o ensino de Ciências da Natureza para estudantes cegos e baixa visão. Com base na categoria circulação intercoletiva, oriunda da epistemologia de Ludwik Fleck, chama-se atenção para a importância de interação dos educadores especiais com diferentes profissionais, que pode ajudá-los a enfrentar os limites de sua atuação relativa ao ensino e à aprendizagem de Ciências da Natureza.

PALAVRAS CHAVE: Educação Especial. Ensino de Ciências. Desenvolvimento profissional.

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1 Introduction

A collective work among teachers in times that alludes to social and educational "inclusion"[4] is an imperative situation. However, obstacles in the professional development of teachers need to be overcome so that collective work can, in fact, be experienced in schools.

To elucidate a perspective of collective work among teachers working at school is an even more significant goal in the Brazilian context from the growing number of students with disabilities, autistic spectrum disorders or high skills/giftedness in ordinary classes. In 2017, data from the School Census of Basic Education, conducted by the National Institute for Educational Studies and Research Anísio Teixeira - INEP (2018), indicated a number of 827,243 students with these characteristics enrolled in Basic Education, of which 90.9% in ordinary classes, mostly in the public network.

Working from a collective perspective in this scenario is not a triviality. On the one hand, there are teachers who say they are not properly trained to teach the target population of Special Education. In contrast, the right of students to stay in school with their educational needs met. In other words, besides the right to remain in school, there is the promotion of learning and the necessary transformation of teaching practices. To elucidate this perspective, we dialogue with authors from the area of Natural Sciences teaching (Camargo & Nardi, 2007; Gonçalves et al., 2013; Penã, 2012), who direct their discussions to the educational process and to the search for resources and strategies aiming at a more accessible teaching that favors learning for blind and low vision students. It is also worth highlighting the importance of promoting research involving the teaching of Natural Sciences and the area of Special Education, as there is little research of this nature (Lipe, 2010).

Based on the above, we present as objective of this paper to analyze how potentialities and limits of a formative process involving Special Education teachers can be characterized, in order to favor reflections on the role of the special educator in the teaching and learning of Natural Sciences involving blind and low vision students. We defend the argument that the collective work between teachers from different areas of education, including those of Special Education, is relevant to face gaps still experienced in school, favoring the educational process of blind and low vision students.

2 Professional development of special educators: interpretations based on Ludwik Fleck's epistemology

The professional development of Special Education teachers seems to be marked by "complications" regarding the attributions/functions inherent to the pedagogical practice. This aspect may be associated with governmental and political actions that seek to establish "a new landscape" for Special Education, which has been called "inclusive education and/or Specialized Educational Service (SES)" (Capellini & Mendes, 2007; Garcia & Michels, 2011).

[4] As it is a strong polysemic expression, we therefore chose to use it in quotation marks throughout the text, when it was preferably not possible to avoid it - for example, if it is linked to a cited reference. There is a significant discussion about what the term "Inclusive Education" or "School Inclusion" is all about. Among the many authors who have sought to explain the polysemy mentioned, we can highlight Camargo (2017), Januzzi (2012) and Mantoan (2003).

This change points to the need for readjustments of theoretical and methodological bases in the professional development of special educators. Here we opt for the concept of professional development, which is in agreement with Pimenta and Anastasiou (2002), who include not only initial but also in-service training. Thus, considering also the peculiarity of the professional constitution of the Special Education teacher, as foreseen by the Brazilian legislation, the concept of professional development was interpreted as more adequate than the one of formation.

In Brazil, undergraduate courses in Special Education are rare. According to the study conducted by Oliveira and Mendes (2017), there were 11 courses[5] belonging to eight different institutions until the year 2014. Thus, there is an indication that a significant portion of teachers of the Special Education area has their development based on the provisions of the National Guidelines for Special Education in Basic Education (Resolution no. 2 of September 11, 2001). According to the document, Special Education teachers are those who have graduated in different areas of knowledge to work in Elementary and High School, and who have accomplished complementary studies or graduate studies in specific areas of Special Education, a reality that necessarily needs to be problematized in the country.

Such characteristics of the professional development of special educators, interpreted here as "complications," lead us to believe that Ludwik Fleck's epistemological reflections can make important contributions to the teaching of natural sciences to blind and low-vision students. In 1935, Fleck published the book *Genesis and Development of a Scientific Fact* (Fleck, 2010), which presents important assumptions for an understanding of the processes of knowledge construction and dissemination. From this work, the epistemologist is recognized as a pioneer in the studies of scientific knowledge based on a sociological approach (Delizoicov, 2009).

In the book, a series of categories are presented, which may base reflections on the problem in the current panorama of the professional development of Special Education teachers. Among the Fleckian categories, we present: thought style; thought collective; intra and intercollective communication of thought and practices; complications. Gonçalves, Marques and Delizoicov (2007) favorably articulate the Fleckian epistemology with science teaching research, since Fleck himself recognizes the potential of his epistemology to interpret the process of knowledge construction that is not restricted to that of Natural Science. The author briefly defines thought style as a directed perception with corresponding mental and objective processing. This style is marked by common characteristics of problems that interest a thought collective (Fleck, 2010, p. 149).

When a thinking style is shared by a group of people, this group can be called a thought collective. Cutolo (2001) and Santos (2005) explain that a thought collective is a social unit. It is considered the "community bearer of the Thought Style" (Santos, 2005, p. 73). Fleck (2010) explains that the composition of the thought collective occurs on two sides,

[5] It is fair to note that among the courses identified by Oliveira and Mendes (2017) are those constituent of the National Program for the Training of Basic Education Teachers (known as PARFOR - *Programa Nacional de Formação de Professores da Educação Básica*), which has as one of its objectives to encourage the offer of free undergraduate courses to teaching professionals in Basic Education of the public network without the proper training to do so. This means that they are very recent courses in the history of the formation of special educators in Brazil. In this context, they assume a vanguard position basically the Special Education Degree courses of the Federal University of Santa Maria and the Federal University of São Carlos.

namely: The constitution of a small esoteric circle that stands out from the uninitiated in their area produces a first identity nucleus of the thought collective. Around it lies a great exoteric circle, within which the "educated laymen" participate in scientific knowledge (Fleck, 2010, p. 26).

Therefore, we can consider that Special Education teachers who enact as mediators in the teaching of Natural Sciences, for example, by developing accessible pedagogical materials in this area for blind and low vision students, make up the exoteric circle relatively to Natural Sciences teachers. Although the former are specialists in one area of education (Special Education) they are not specialists in another (Natural Sciences), which puts them in a relatively exoteric circle. Thus, Special Education teachers belong to the esoteric circle when we refer to the teaching of Special Education. Knowing how the circulation of theoretical and practical knowledge between the two groups can happen becomes important. According to Fleck (2010), it is from this circulation that the "complications" can be faced.

Gonçalves, Marques e Delizoicov (2007, p. 6) explain that "Fleckian complications are associated with limitations of thought style to face a particular problem". Therefore, we understand that the professional development of Special Education teachers is characterized by elements associated with a complication to be solved.

Regarding intracollective circulation, there is a tendency for dependence among peers in a scientific community. In this sense, a certain "solidarity" of thought is invoked around an idea (Fleck, 2010). Intracollective circulation is essential to the extension of thought style – intracollective dynamics are those that occur within a thought collective. It is through it that the formation of the components of the thought collective is established. Intercollective circulation, according to Gonçalves et al. (2007), can provide the signaling of new facts and potentialize new research. More than that, it is through it that the thought collective can become "aware" of the complications of thought style. In addition, Lorenzetti, Muenchen and Slongo (2013) explain that "the intercollective circulation of ideas occurs between two or more thought collectives, contributing significantly to the transformation of the thought style" (p. 183). This is one of the aspects of Fleckian epistemology that can most contribute to interpret the problem presented and discussed in this paper.

The articulation proposed by the research is precisely in the "awareness" of Special Education teachers about the gaps in the area. Among them we highlight the issues of "persistence" in the maintenance of practices, as commonly perceived in the area of Special Education, similarly to what Camargo (2017) explains. Fleck (2010) points out that by establishing a structured and defined system of opinions, with details and relationships, the tendency towards a process of resistance to everything that can oppose it is built. It also elucidates that a great effort is made to explain the exceptions so as not to contradict the established system. This is where the harmony of illusions that cannot be resolved at all within the limits of a particular thought style is established (Fleck, 2010), a fact that points to the persistence of the dominant vision.

Special Education teachers need to be "aware" of the limits of their education, particularly as regards the teaching of Natural Sciences, as well as the development of accessible materials in this area of education. However, it seems that Special Education teacher trainers

and those involved with curricular organization in initial training courses also need to be "aware" of certain issues so that they can contribute to addressing them more assertively.

The professional development of Special Education teachers needs to be the object of reflection. The pedagogical practices that end up segregating the student with blindness and low vision, in SES spaces often performed in a disjointed way in the classroom, need to be constituents of this reflection. This is not to point out that SES is unnecessary to meet student specificities; however, if we are looking for a school that assists all with quality and equal education processes, we can no longer accept that the teaching of these students is relegated exclusively to Special Education professionals.

As we ponder these concerns, we realize that Fleckian epistemology can indeed contribute to such analyzes. For all the elements listed in the area of Special Education that has been presented, we can understand that the intracollective and intercollective circulations, as categories, can collaborate to interpret the professional development of teachers active in the process of teaching and learning of Natural Sciences. for blind and low vision students, without the elaboration of materials of these curricular components in isolation.

Intra and intercollective circulations can therefore be important categories for interpreting the interactions established by Special Education teachers. Interactions can determine the "awareness" of elements of the "complications" that exist in educational processes for blind and low-vision students, becoming considerable elements in breaking down the educational barriers possibly experienced at school.

3 Methodology: the way towards interlocation with special education teachers

This is a qualitative study with Special Education teachers who worked in activities related to the educational processes of Natural Sciences with blind and low vision students. The study was submitted to the Ethics Committee and approved under Consent Opinion No. 1,076,627.

Among the research actions, we highlight the training process carried out with teachers. Seventeen teachers participated, from which two were blind. Most of them reported that they had a degree in Pedagogy and only had a teaching degree in the area of Natural Sciences. Most of them reported having done graduate studies in Psychopedagogy and Specialized Educational Service. It should be noted that some of them worked without having an undergraduate or graduate degree in the area of Special Education. They recorded the length of service in Special Education, including the development of accessible teaching materials. Working time in the Special Education area ranged from three months to 32 years. Only one of the participants reported having already participated in a formative process with the theme Teaching of Natural Sciences and Special Education. Most participants showed professional experience with blind and low vision students. Participants were nominated throughout the research by the abbreviations A1, A2, A3, ..., A17. Table 1 provides the information in more detail.

Sex of the participant	Degree	Working time in Special Education	Graduate studies	Have you ever participated in Natural Science teaching training for the blind and low vision?
F	Pedagogy	8 years	Specialization in Psychopedagogy	No
F	Pedagogy	Not informed	Not informed	No
F	Pedagogy / Special Education	29 years	Specialization in Specialized Educational Service	No
F	Pedagogy	9 months	Specialization in Psychopedagogy	No
F	Pedagogy	15 years	Specialization in Specialized Educational Service	No
F	Pedagogy	Few months	Specialization in Inclusive Education	No
F	Pedagogy in progress	3 months	____	No
F	Pedagogy / Special Education	32 years	Course in teaching	No
F	Pedagogy / Special Education	26 years	Specialization in Specialized Educational Service	No
F	Pedagogy	Not informed	Specialization in Literacy	No
F	Pedagogy	4 years	Specialization in Literacy	No
F	Pedagogy / Special Education	8 years	Specialization in Psychopedagogy	No
F	Pedagogy / Special Education	9 years	Specialization in Psychopedagogy	Yes
F	Pedagogy	5 years	Specialization in School Practice for early grades of Elementary School	No
M	Pedagogy	10 years	Specialization in Specialized Educational Service	No
M	Pedagogy	10 years	Specialization in Early Childhood Education and early grades of Elementary School	No
M	Teaching degree in Biological Sciences	3 months	Specialization in Educational Informatics	No

Table 1. Characteristics of the research participants.
Source: The authors.

The training process was part of the training program regularly offered to education professionals of the municipal network in which the research participants belonged and took place in the teachers' work environment. The participants were chosen by the management

team of the municipal network and the selection was based on the fact that the professionals work in activities aimed at blind and low vision students.

Eight face-to-face meetings were organized with a total of 32 hours, which took place fortnightly; and four distance meetings, totaling 8 hours, that occurred with reading and writing activities in a collective virtual diary. The face-to-face meetings had the following activities: a) directed study of texts on Natural Sciences Teaching for contexts with blind and low vision students; b) analysis and elaboration of proposals for experimental activities in textbooks of curricular components of the area of Natural Sciences; and c) "problematizations" about the role of the special educator regarding the content "Teaching of Natural Sciences with blind and low vision students". The contents of the training process are included in the above activities and were defined based on the professional activities performed by the participants. The training process aimed to reflect on the performance of the special educator in the process of teaching and learning of Natural Sciences.

In the first face-to-face meeting, participants were presented with some activities that would be developed throughout the meetings. Participants were invited to participate in the research and all who accepted signed the Informed Consent Form (ICF). Afterwards, the trainers advised about the registration in MOODLE[6] - which included the collective virtual diary of access to all participants. In the second meeting, there was the debate guided by the trainers about previously indicated texts. Notes in general and negative aspects in the papers were listed by the participants. In the next meeting, there was a discussion about a text (Gonçalves et al., 2013) previously available, which addressed the elaboration and development of an experimental Chemistry activity in a High School class with the participation of a blind student. There were interventions and suggestions from participants with alternatives to the experimental activity in order to qualify it. In the fourth meeting, the participants, divided into small groups, received proposals for experimental activities from Natural Science textbooks of Elementary School and, after analysis and discussion in the large group, they drafted a proposal for an accessible experimental activity for a class with blind or low vision students. In the next two meetings, the groups presented their proposals in the large group. The discussion was mediated by the trainers - authors of this paper. Also in the sixth meeting, the groups received a proposal for an experimental textbook Chemistry activity and repeated the proposal. In the seventh meeting, the groups presented the proposals for experimental activities elaborated. In the eighth and last face-to-face meeting, a space for dialogue was opened, and participants were invited to report on their participation in the training process, to evaluate it and to evaluate themselves.

As already expressed throughout the training process, activities were developed in the collective virtual diary. This resource was used by researchers such as Gonçalves, Fernandes, Lindemann and Galiazzi (2008) and Benite, Batista, Silva, & Benite (2014), who explored it online in teacher education courses and indicated that it is a significant resource for the exchange of experiences among teachers. Gonçalves et al. (2008) explain that the collective dimension is one of the possible aspects and can contribute to the professional development of

[6] It is a virtual environment used to support the teaching and learning process.

educators, highlighting the written narratives and the problems experienced and not discussed in school daily life.

In our study, the collective virtual diary served as a timely space and time for sharing experiences and sharing understandings between teachers and trainers. The discussions of the texts, as well as the questions listed, encouraged the participants' exposition of ideas. The collective virtual diary was divided into four parts, executed in MOODLE. The parts were previously planned and were made available after the face-to-face meetings. In part 1, the trainers asked: "Fill out in this space doubts and initial impressions about the text proposed for reading by your group". Many participants presented ideas, criticisms and suggestions about the texts. Questions were being added by one of the trainers to foster discussion.

In part 2, the trainers began by urging participants on the following reflection: "Fill out, in this space, doubts and comments for discussion regarding the text read. If you want to point out limits and potentialities identified by you as important in the performance of the Special Education teacher with the blind and/or low vision student in the Natural Science classes". In this part, the participants were less expressive.

In the third part, participants were encouraged to reflect on: "In this space we will discuss and exchange experiences about our understanding of the role of the Special Education teacher in adapting experimental activities in Nature Science classes for blind and/or low vision students". It was evidenced that the presence of a special educator in the school was essential and that he should build a relationship with the teacher of the area of Natural Sciences, in order to talk about the planning of accessible materials and experimental activities.

Finally, in the last part, we started the debates with the following provocation: "For this space we propose to establish discussions about the easiness and/or difficulties found in the adaptations of the experimental activities that we performed during the course". This was proposed due to the fact that participants shared activities that had as proposal the accessible planning for experimental activities found in Chemistry and Natural Sciences textbooks.

After the training process ended, we invited eight teachers to participate in a semi-structured interview, of which six accepted. The interviews took place through the digital Skype tool. The selection criteria for the choice of the eight guests were: having participated in all face-to-face meetings and making contributions to the Collective Virtual Diary, this does not mean that only these eight participants were in this condition, but we opted for a sample of 50% of participants.

The qualitative information obtained was analyzed according to the discursive textual analysis procedures (Moraes & Galiazzi, 2011). Such analysis consists of three steps: unitarization, categorization and communication. For Moraes and Galiazzi (2011, p. 11), the discursive textual analysis "implies examining the texts in detail, fragmenting them in order to reach constituent units, statements referring to the studied phenomena". In the phase of unitarization, the researchers insert themselves in the corpus with the disassembly of the texts in units of meanings. In categorization, units of meanings are grouped according to semantic criteria giving rise to categories. Finally, in the communication, descriptive and interpretive texts are produced in each category. Next, we present the analysis resulting from a mixed categorization process (a priori chosen categories and emerging categories/subcategories).

4 Analysis of qualitative information

The intercollective and intracollective circulation was selected as a priori category and the subcategories/categories emerged from the analysis: a) the performance of Special Education teachers and the teaching of Natural Sciences; b) the relations between teachers of Natural Sciences and Special Education; and c) resistances to pedagogical work in the Natural Sciences.

4.1 Intercollective and intracollective circulation: the performance of Special Education teachers and the teaching of Natural Sciences

The performance of the Special Education teacher seems to be based on knowledge that involves empirical actions, such as providing resources for students and performing SES. This helps, to some extent, to keep this professional in parallel teaching, indicating a more "technical" performance (Vaz, 2013), providing support to those who need it on specific subjects, such as Braille and the accessible computer.[7]

Throughout the training process, the teachers explained their understanding of the role of the Special Education teacher in the Natural Sciences educational process for blind and low vision students in tune with this more technical performance:

> The role of the SES teacher is to present all the new symbology in the unit/content being used by the teacher, as well as to use resources and adaptations so that the student understands the proposed activities in the classroom. (A9).

We identified among teachers, therefore, the understanding that their role in school is to "support" classroom teachers, to provide resource needs and to teach the use of technological resources and Braille symbology.

When referring to the Natural Sciences classes - usually taught with exploration of the sense of sight - the need to replace visual information with tactile information, for example, seems to become even more obvious. Of the participants, only one mentioned the need for the special educator to learn, throughout professional development, about school content in order to qualify the relationship between teachers. Glat and Pletsch (2010) explain that Special Education teachers must be inserted in training processes that aim to build strategies that envision knowledge that goes beyond how to do it.

Teachers also explained their understanding of working together, which may be one way to break the boundaries of the profession of special educators:

> In my view, the Special Education teacher has the role of working with the class teacher, *developing learning* strategies that enable the blind student to acquire knowledge. (A3, emphasis added).

An understanding of teachers about their professional performance that went through the training process is that a joint work between the special educator and that of the regular class can constitute a possible solution for problems experienced in the schooling of blind and

[7] It is important to highlight that there are other Assistive Technology resources relevant to blind and low vision students in Natural Science classes, such as screen reader software (NVDA, Jaws, etc.), electronic magnifying glass, 3D tactile materials, thermometers with Voice, voice scanner. However, these features did not need to be used in the research by the blind participants.

low vision students. Hence, the teachers give signs of appreciation of the development of a work in "partnership". However, even so, we allude that the relationship established and the interpretation given by the professionals seems focused on a work that aims at the "development of strategies", valuing the resources and the performance of the special educator as those who have certain knowledge that is needed so that the work of the other teacher can occur, a work with "technical" aspects - an aspect to be explored in the next category.

In fact, it seems that the professional development of Special Education teachers has contributed to reinforcing this image of a professional who acts as an "expert" in certain subjects and as a "technician" who makes available and teaches the use of resources. These are actions that seem to impoverish the social interactions that are imperative to the teaching and learning processes. Participants strongly indicated that there is a need to interrelate with teachers in the fields of Natural Sciences in order to contribute more significantly to the teaching of this curriculum component for blind and low vision students, as A13 explained:

> I understand that the partnership should not be for guidance only. It should not be just…It should not be without classroom entrances for you to really understand what the student is, how his learning process is, how he understands the concepts, the contents. It is necessary to be closer, it is necessary to attend this student, both in the classroom and in extra hours. (A13).

The participant explains that there is a need for dialogue between teachers. Such points are based on the understanding that interactions, translations and cooperation between different social worlds favor the establishment of more solid and sound studies for the school community and society (Araújo, 2002). The establishment of the intercollective circulation of knowledge can contribute to addressing gaps still present in the teaching of Natural Sciences with blind and low vision students.

Although the participants indicate signs that they realize the need to establish moments of dialogue with professionals from different areas of the school curriculum, it is necessary to discuss the teacher's interpretations of a more interactive work, since, at times, they seem to reflect little about the meaning of "working together". In the participants' speeches, there is a certain understanding about the problem that is created by the individualized performance of the Special Education professional, and there is the understanding that the education of blind and low-vision people increasingly demands to be interpreted under different perspectives. Participant A17, on this aspect, pointed out:

> I think the important thing is the partnership, the teacher dominates the content and the special education assistant will come with his daily experience, adaptation, description of the image, as teachers in other areas did not have this training, did not have this education. So it's an *exchange*. I can't say that you can handle everything alone, it is not possible, because you can't handle the subjects, because no teacher will be able to answer all the questions of blind students. A *partnership*, *an integration*, *a joint planning* is necessary. (A17, emphasis added).

It can be noted that participant A17 highlights the need for knowledge of each area and how they should articulate. He expresses some understanding of the role of the special educator in classroom mediation. Although he speaks of "exchange, partnership, integration

and joint planning", he seemed inclined to the idea of a curricular fragmentation, in which the Special Education teacher holds knowledge that the Natural Sciences teacher does not have. Such understandings can hide a process of resistance to interaction between teachers.

Up to this moment we have tried to present teachers' understanding of acting in Natural Science educational processes for blind and low vision students. Such understandings seem to be linked to practices in tune with the so-called medical-pedagogical aspect (Januzzi, 2012). According to this aspect, Special Education teachers must act in a parallel and segregationist manner, so that there is a predominance of techniques over the mostly neglected school knowledge to this student public. Sometimes participants suggest some appreciation of the technique. These understandings, to some extent, seem to have coexisted throughout the formative process, thus constituting a limit of such a process to collaborate to re-signify them.

4.2 Intercollective and intracollective circulation: the relationship between teacher of Natural Sciences and Special Education

Among the participants were indicative of elements interpreted as constituting the intercollective circulation regarding the relations between teachers of Special Education and teachers of the area of Natural Sciences. We present four different types of relationships, namely: consulting, advisory, technical and interactive (interaction).

The consultancy-type relationship can be characterized by two modalities: when the Special Education teacher seeks consultancy and when he/she offers consultancy. On the one hand, the Special Education teacher faces difficulties, especially when it comes to developing accessible materials, leading him/her to consult other teachers to solve his/her problems. In this regard, a teacher took a position:

> I was studying Biology [referring to the process of transcribing the book from Biology to Braille]. And all that Biology book that's extremely visual I couldn't do all those adaptations because the ideas get so mixed, the pictures get mixed up and a blind person can't do it by only touching. So we have to call the school, ask what is really going to be used, which one is the most important, because the book is so full of images, sometimes we look for the images, but all of them are important. […]. To be able to transform this visual feature into touch material for people.... This is how we can do things by asking and choosing what is most important […]. (A10).

On the one hand, the fragment exposes that interaction occurs in the consultation of contents, but there is not necessarily the debate of ideas that may qualify the teaching of Natural Sciences. This indicates that there are limits in the understanding of what is really a work with interaction between special educators and teachers of the area of Natural Sciences. On the other hand, the Special Education teacher is interpreted as the consultant. In line with this bias, participant A8 points out that:

> Mathematics teacher, Science teacher, Biology teacher are teachers with whom we already had a moment to discuss, to see the materials they needed, to bring some materials that they adapted so that we could see together if it was viable. (A8).

The participant recognizes the importance of interaction among teachers, but is interpreted as someone who should be consulted in order to make each other's work possible. We

can see this in the highlighted speech. It seems that the special educator is the only professional who experiences daily contact with blind students and is therefore suitable for consulting.

Another form of interaction refers to advice. In this sense, the Special Education teacher is responsible for acting as one who helps other teachers. About this, one participant pointed out an aspect that he perceives that happens in the relations between teachers:

> [...] the classroom teacher says: look, I'll work with this content here. Can you *help me* adapt this material for this student? (A3, emphasis added).

Special Education professionals sometimes seem to provide an advisory service because, although they have emphasized the process of "being together," interpretations seem more closely linked to "technical service," as described by Vaz (2013). We noticed this aspect in A17's statement:

> […] the teacher alone cannot cope, especially if he is not aware of how to make this inclusion with blind students. And having someone who *gives support and technical support* as there was in that piece of news [referring to a text that the teacher trainers gave participants before the interview], in that text or being a trainee or a Special Education person who can support that teacher is important […]. (A17, emphasis added).

The participant reinforces the understanding that established relationships may be under the strong influence of understandings for which special educators are basically technicians with specific knowledge that contribute to the better execution of educational processes in the school. Although the technical design appears with emphasis among teachers, they also indicated the need and importance of doing work with interactive bias. About developing work in an interactive way and, thus, having partnerships that go beyond the school walls, one teacher explored an example about the school-university relationship, expressing another way to consolidate the intercollective circulation of knowledge and practices.

> […] the importance of management understanding and having a partnership with the university. Why does the university need to come after the school? This doesn't mean that it is not necessary, it's good that it happens reciprocally, a two-way street, and not just waiting for the university. If we there is the demand, if I need to, if we have a target population, then nothing more coherent than looking for the researchers and saying: "let's have a partnership so that both parties will benefit'". (A13).

Valle and Connor (2014) bring contributions that articulate with the participant's idea and say that when talking about an interaction work among teachers from different areas, it is not intended to indicate that they lose their professional identity, but it is important that they assume curriculum.

In short, teachers' understandings of how relationships with Natural Science teachers might be appear to be strongly influenced by the ideas of consulting and advising. The lack of "problematization" of these understandings, as they last, is recognized as a limit of the educational process promoted with special educators. Even so, it is possible to identify, as a contribution of the formative process, the clarification of an understanding that takes into consideration that relationships need to be guided by interaction in the sense exposed by

Capellini and Mendes (2007) and Garcia and Michels (2011), which was valued throughout the meetings.

So far we have sought to characterize the different types of relationships established between professionals in the role of the special educator, which signaled the intercollective circulation of knowledge and practices as relevant. However, participants were sometimes resistant to change, a subject that we will discuss next.

4.3 Pedagogical work in teaching natural sciences: a trend to persistence

Special Education teachers' understandings of who is responsible for teaching Natural Sciences and the consequent accountability attributed to these professionals bring to light gaps that need to be filled. The influence of the medical-pedagogical aspect present in professional development (Januzzi, 2012) reflects the role of special educators and may contribute to the resistance in establishing interlocutions with teachers of the Natural Sciences.

The speeches analyzed allowed us to perceive the persistence of certain understandings and possibly reveals the difficulties encountered in the professional development of special educators. Here we present A11's statement:

> I don't think so, why Natural Sciences? Because if I think that I would need to do a training course, for the Natural Sciences, I would need to do it for Mathematics, for Geography, for other areas that we also produce. And we wouldn't realize it. Our education. Why wouldn't we realize that? Because you would need to be an expert in Chemistry, Biology, Geography, to be able to know all the processes that these disciplines require. We wouldn't be able to handle so much training to be able to produce the material. What I find interesting is that: there are standards, there are productions, there is Braille spelling for materials, for producing these materials. Having all that, which gives us parameters, which gives us the rules for the production of the material, the rest is the dialogue with the teacher. The rest is the conversation, because with the regular teacher and the Special Education teacher, who will tell us about the student, because each student is different from the other and has different needs, even with regard to the same content, and we do not practice experience, we do not experience, we transcribe. I think it would be megalomaniac to think of a Natural Sciences training to produce material for students. (A11).

The excerpt seems to indicate that the fact that the special educator has to approach the different curricular components that compose the school would bring an expressive weight to the teaching activities. Another point that deserves to be mentioned is the fact that it is enough to have knowledge in Braille and in norms to produce a textbook. We realized that there were few mentions made by the participants in relation to curriculum issues in the training process.

A10 refers to the production of accessible pedagogical materials and a state that calls "being together", as we described earlier, with teachers of the Natural Sciences:

> He makes the material [referring to the production conducted by the teacher of Natural Sciences], sends it to this professional [referring to the special educator], this professional analyzes it, sees if it is so. I think they should work together, because a study is for this, there are the ideas, […] comes back and remakes it, because there is this side of the experience. But of course, the professional who is already qualified for this will always be helping. I think there has to be this work together. We here at the [institution] sometimes we don't have that, we make the books,

> we send it and we often study hard to know what it's going to be like, but we don't have a return. The feedback is very important. (A10).

This excerpt mentions working together. However, we continue to realize that such insights need further reflection on what it means to "be together" in school. The interaction between teachers is present; however, it is presented unilaterally, in which one exercises the role of teacher and the other "helps". These views seem to contribute strongly to the persistence of a pedagogical work, with weak partnerships between teachers, valuing a place historically occupied and established in the medical-pedagogical aspect (Baptista, 2013).

We noted such aspect in the speech of participant A11 when he seems to evidence that the work of special educators who are in charge of making accessible teaching materials is not related to that developed in the school. It is contradictory, because if, in fact, the participant interpreted the work as collective, his view would not indicate resistance in the development of an interactive pedagogical work:

> I think the special education teacher who is there at school, who works with students every day. I think all the training that covers working with students who have this disability, I believe is really important, because the regular teacher ends up asking for guidance, help, or asking for contribution, even for this person [referring to special educator], who is the person who is asked for help in working with children with disabilities. So, this training will contribute in this sense, that when the teacher of this subject needs contribution, needs help, assistance, exchange an idea, he will be able to contribute with this teacher. So I believe it is important, yes, that he can do training in this area and others as well. (A11).

A11's statement seems to indicate that he sees himself uniquely as the professional who makes teaching materials accessible. We noted that he refers to an articulation between teachers, understands that the search for the material should be collective and considers such dialogues enriching. However, it does not deal with the school curriculum or even with the appropriation of knowledge from other areas of education. From the above, we realized that the special educator is not in the classroom and that this can reinforce stances of resistance, especially when it comes to occupying new spaces in school. Participant A11 continues:

> […] our contact is with both and because it has already happened with both professionals, both the regular school teacher and the teacher of the multimedia room. Both ways are quite enriching for our work. There is no way to measure how much better one is than the other, there really is not, the two always contributed well. In the search for material, sometimes it is the regular classroom teacher who seeks it, and these conversations that come in search of the material, this feedback that comes from the student in the classroom, it is when we have the most opportunity, because he is the one who works with the student longer than the Special Education teacher, so he brings us things from the students, the Special Education teacher doesn't bring us because he doesn't know the student as the regular classroom teacher knows because of the contact, the time. And these conversations, these dialogues with the teachers are very enriching. (A11).

It is reinforced in this excerpt that the teacher has an understanding of the special educator as that responsible professional who makes accessible teaching materials, without a permanent dialogue with the professionals who are in school. An understanding of the

pedagogical work that places Special Education, in a certain sense, as an area that acts in a parallel and segregated way is identified.

A3 points out an understanding that brings the dialogue among teachers as a point to be considered when making accessible materials, although it is perceived some influence of the assumptions of the medical-pedagogical aspect.

> Well, I see that the special education teacher needs to be together with the teacher, working on these contents. Contents that, let's say, if he will work the issue of cell division, for example, right? That he can make this adaptation to the relief imagery, so that this student can understand what is meiosis, what is mitosis, do you understand? So if this Special Education teacher can be together, work on these contents, adapt, the class work will be much richer for this student. […]. When we work with atoms, this is in Chemistry, or Mechanics, in everything we can work together making adaptations in to the relief imagery. (A3).

This aspect seems to reinforce the ideas that Special Education teachers are affiliated to the thinking bias that values technical practices over other knowledge. Such teachers do not dispute the fact that Brazilian law assigns them so many specific functions and knowledge. Problems with training seem to be based on difficulties such as: insufficient number of educational institutions in the area, curricula that are little articulated with pedagogical knowledge and the dissemination of pedagogical practices based on practical activities (Baptista, 2013).

Participant A17 also talked about developing teamwork. For example, he explained that in order to produce accessible materials, the team would need to be made up of professionals from different areas. However, he seems to show that each one has the exclusive responsibility for his/her teaching area, without, in our interpretation, a more effective interaction:

> A teacher masters that knowledge and the special educator does not have a perception, a broad understanding, does not master all the contents of the various areas. I think it should, as has been tried by [teacher], to have people from various areas with the team to facilitate and reduce these difficulties, errors. There is no one there who understands Science, only pedagogues. It should have a multidisciplinary team supporting the team [referring to the team that produces the materials], as content support itself. "[…] how do we do it here? You have an understanding of this concept here, how can we make it easier, how do we describe it? I argue that there should be a multidisciplinary team from the areas in contact with the team, working together to clear these doubts as best they can. (A17).

It is possible to identify an understanding concerning a multidisciplinary performance with involvement of the special educator. However, once again the understanding that each professional should contribute relatively isolated in terms of professional knowledge stands out. It is necessary to recognize that resistance seems to be veiled. Such understandings point once again to the linking of the area of Special Education with the medical-pedagogical aspect and retakes the logic of providing the service to the detriment of scientific education.

Special educators working in a specialized service perpetuate insights into parallel service. Sometimes participants reduced the role of special educators to the production of accessible materials. The resistance found through the understanding of Special Education teachers has remnants of the medical-pedagogical aspect.

Thus, it should be noted that persistence to change is something that characterizes a style of thinking, although we are not in this paper seeking to define any kind of thinking associated with Special Education. The permanence of ideas like these among the participants of the above process can be considered another limit of the promoted training.

5 Final considerations

We infer from the analysis that one of the contributions of the training process concerns the valorization of a collective work as one of the ways to address the gaps that exist for the teaching of Natural Sciences to blind and low vision students. In contrast, the persistence of ideas from the medical-pedagogical side, in turn, constituted a limitation of the training process, along with those ideas that Special Education teachers provide a technical service in parallel to blind and low vision students, in detriment of the articulation with the pedagogical work done in the classroom by the teachers of the Natural Sciences. Due to the available space, it was not possible to explore other categories that signaled the potentialities and limits of the training process. Therefore, we chose to expose some issues associated with the limits of this educational process. Thus, other potentials and limits should be addressed in future publications. We understand, from this study, that one of the possible referrals to training processes, derived from what was presented here, may be the joint participation of special educators with teachers of the area of Natural Sciences. This joint participation may perhaps favor reflections on the performance of the Special Education teacher that were not expressly identified among the participants. What is most striking is that such difficulties and barriers do not seem to be part of the discussions of special educators. Thus, breaking with established understandings is a task that requires many changes, including thinking.

Another aspect of valuable importance that still seems to lack discussion in Special Education is the teachers' poor knowledge of Natural Science teaching for blind and low vision students (a factor that necessarily needs to be rethought in the professional development of special educators). Such aspect may cause a process of excessive accountability for this group of teachers, generated by different factors of which we can evidence: the belief that the special educator is characterized as the most apt to teach (belief maintained by the group itself); understand oneself as solely responsible for blind and low vision students; and understand themselves responsible for developing strategies, materials and resources almost exclusively; among other aspects. The greatest difficulty in this regard is to enhance teachers' reflections that make it possible to understand the importance of appropriating school contents, not to become specialists in Natural Sciences, nor to be responsible for teaching these contents to blind and low vision students, but so that they can enhance their performance in these educational processes and, consequently, favor the learning students in Natural Sciences.

With this, it is explicit the understanding that it is not pointed here to an exaggerated graft of curriculum components associated with specific didactics (Didactics of the Natural Sciences, etc.) in the curriculum structure of the Special Education Teaching Degrees, because, as already indicated, we understand professional development beyond initial training. We present with some urgency that the intercollective circulation among teachers of Natural Sciences and Special Education transcends the views of the medical-pedagogical aspect,

contributing to deconstruct these understandings and collaborate with the necessary resizing of the area of Special Education in the current school.

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