ACTA SCIENTIAE

ISSN: 2178-7727
DOI: 10.17648/acta.scientiae.5974

Special Education and the Teaching of Natural Sciences to Blind and Low Vision Students: Contributions of a Teacher Education Course

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Received for publication on 2 Jul. 2020. Accepted after review on 22 Oct.. 2020
Designated editor: Claudia Lisete Oliveira Groenwald

ABSTRACT

Background: the teachers' role in special education has been the subject of vigorous discussions in the face of current public policies in the Brazilian context. **Objectives**: to investigate the potentialities and limits of a teacher training with special education teachers, whose purpose was to provide reflections on the role of the special educator associated with the teaching and learning process of natural sciences in situations with blind and low vision students. **Design**: qualitative research. **Setting and participants**: seventeen teachers from the special education area of a Municipal Secretary of Education participated in the training, two of whom were blind. **Data collection and analysis**: qualitative information from the following sources was submitted to discursive textual analysis: textual productions resulting from activities carried out in the training teacher; collective virtual diary; and texts from semi-structured interviews. **Results**: the analysis revealed, for example, that the influence of the medical-pedagogical aspect is still predominant in the professional development of special education teachers, with implications for the teaching and learning process of natural sciences in situations with blind and low vision students. **Conclusions**: the results explain, to some extent, the resistance to innovative ideas addressed in the training under discussion.

Keywords: Teaching of natural sciences; Special education teachers; Blind.

Educação Especial e o Ensino de Ciências da Natureza para Estudantes Cegos e Baixa Visão: Contribuições de um Processo Formativo com Professores

RESUMO

Contexto: a atuação do docente da área da Educação Especial tem sido objeto de discussão pujante frente às políticas públicas atuais no contexto brasileiro. **Objetivo:** investigar potencialidades e limites de um processo formativo com docentes da Educação Especial, cuja finalidade era

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proporcionar reflexões sobre a atuação do educador especial associada ao processo de ensino e aprendizagem de Ciências da Natureza em situações com estudantes cegos e baixa visão. **Design**: pesquisa de natureza qualitativa. **Ambiente e participantes:** participaram do processo formativo dezessete professores da área da Educação Especial de uma rede municipal de ensino, sendo que 2 eram cegos. **Coleta e análise dos dados:** foram submetidas à análise textual discursiva informações qualitativas advindas das seguintes fontes: produções textuais decorrentes de atividades realizadas no processo formativo; diário virtual coletivo; e textos originados de entrevistas semiestruturadas.**. Resultados:** da análise se depreendeu, por exemplo, que ainda é predominante a influência da vertente médico-pedagógica no desenvolvimento profissional de professores da Educação Especial com implicações ao processo de ensino e aprendizagem de Ciências da Natureza em situações com estudantes cegos e baixa visão. **Conclusões**: os resultados explicam, em alguma medida, a resistência a ideias inovadoras abordadas no processo formativo em análise.

Palavras-chave: Ensino de Ciências da Natureza; Professores da Educação Especial; Cego.

INTRODUCTION

> The collaboration of the science teacher with the psychopedagogue and/or special education teacher in the teaching of blind and low vision children is very important. Each specialist brings their training, experience, and a particular view of the subject, but they all have to share objectives and meanings for the benefit of student learning. (Garcia, Caldera, & Jimenez, 2002, p. 33, authors' translation)

Collective work among teachers is a requirement in the face of the configuration assumed by or attributed to the contemporary school. In the case of teaching in special education, there is a set of particularities that have implications for this collective work. Silva (2016) explains that in Brazil these particularities have received an interpretation by public policies that mistakenly remove the special educator from the regular classroom, as a disadvantage to this professional's monitoring of the educational process in the context. Thus, breaking with the notion that teachers in special education are mere caregivers or responsible technicians capable of meeting the basic needs of a group of students outside the regular classroom can bring implications for the teachers' professional development[1] in the field. From a more critical perspective, it is necessary to overcome actions based on technical rationality that historically seem to permeate special education, importing to this teachers' work pedagogical actions that are apart from the classroom and from school contents that all students should access.

In facing the challenges imposed to special educators and the possibility of carrying out collective work at school, we must discuss and point out contributions to

[1] The term "professional teacher development" carries several meanings. We understand that the expression encompasses both initial and in-service education (Pimenta & Anastasiou, 2002). According to Marcelo (2009, p. 9), "the term, in some contexts, is synonymous with continuing education, in-service training, among others." In short, the term teaching or teacher professional development that encompasses the entire formative process seems to be appropriate to refer to special education teachers, especially in the Brazilian context, since they do not always have this specific training in an undergraduate course, but as a result of their degree through postgraduate courses in the special education area.

their professional development to highlight possible enrichment for the functions they are assigned. This, because it is usually possible to find teachers in the area performing tasks in which the physical care of students stands out to the detriment of the concern with the appropriation of school contents.

In the context of the teaching of natural sciences, Silva, Gonçalves, and Marques (2015) draw attention to the collective work between the special education teacher and the regular teacher, responsible for the class in the initial years of elementary school. According to the authors, sometimes, instead of developing interactions between the blind and the sighted students, the special education teacher enhances segregation, therefore minimising the learning associated with the contents of the natural science. The pedagogical work with the blind or low vision students is sometimes done apart from the other students, including in different physical spaces, which hinders the implementation of a perspective that values, in fact, diversity in school, in general, and in the classroom. On this element that is still so strongly present in the work of the special education teacher, Silva (2016) states that the students can characterise:

> [...] the care received in the SR [resource room] as a support to the activities developed in the regular classroom, giving relevance in its teaching-learning process [...] regarding the fact that the **resource room is an environment where they carry out tasks, works, i.e., the activities requested by the teacher [...].** (p. 121, emphasis added)

The emphasis on the work carried out in the multifunctional resource room, which should be done in collaboration with teachers of several curricular components, expresses an understanding that it has been designed for school reinforcement, and the special education teacher, in most cases, is not qualified to teach school contents.

In general, when it comes to natural sciences teaching, there are indications that research is dedicated to discussing more the actions and understandings of teachers qualified in natural sciences than the actions and understandings of special education teachers. This is notable in works such as Silva (2016), Silva, Gonçalves, and Marques (2015), Anjos and Camargo (2011), and Camargo and Nardi (2008).

Therefore, the purpose of this research is to analyse how the potentialities and limits of a training process involving special education teachers can be characterised to favour reflections on the role of the special educator in the teaching and learning of natural sciences involving blind and low vision students. We anticipate that the analysis presented here complements a previous publication (Voos & Gonçalves, 2019).

We believe that the teaching of natural sciences to blind and low vision students, as a content of the professional development of special education teachers, can contribute to handling educational barriers that may appear in the educational process offered them. However, it is necessary to clarify that natural sciences teaching has particular aspects

that need to be mediated by professionals trained in the area, and that here we advocate a collective work with the participation of both professionals.

We agree with Capellini and Mendes (2007) when they emphasise that it is not a matter of making special education teachers specialists in the different areas of teaching, nor of making them assume regular classrooms. It is increasingly evident in the school that special educators must understand and appropriate knowledge of the curriculum so that, in the dialogue with teachers from different areas, they can have their voices heard and suggestions accepted, which may benefit blind and low vision students.

Considering the importance of the above, we present below a discussion on theoretical and methodological trends that are active in the professional development of teachers in the area of special education.

FROM THE MEDICAL-PEDAGOGICAL TO THE "INCLUSIVE" TREND: POSSIBLE INTERFERENCE IN PROFESSIONAL DEVELOPMENT OF SPECIAL EDUCATORS

The professional development process of special educators in Brazil seems to be much influenced by the different educational trends experienced by special education. Untying the pedagogical practices performed to date by special educators from the influences exerted by the educational trends, or movements, especially the medical-pedagogical one, seems to be inappropriate. Therefore, we will rescue trends to understand how they may still be influencing the professional development of special educators. For this, we will bring the theoretical contribution of authors such as Januzzi (2004, 2012), Borowsky (2010), Vaz (2013), and Vaz and Garcia (2015).

The medical-pedagogical trend seems to be strongly present to date. It appeared at a time when special education had significant influence from medicine. For Januzzi (2012), this movement is more present than would be desirable. For the author, after the first medical professionals qualified in Brazil, they started preparing other professionals in the education area, usually focused on hygiene and public health services. This approach gave rise to special classes, and the professional qualification for work in that space, which was linked to the understanding that if education and health they worked together, they could *regenerate* the country.

Another aspect that strongly marked the period was eugenics. Although historical records indicate that such practice was more directed at people with intellectual disabilities, there are also records of eugenics at the Imperial Instituto de Meninos Cegos, created in 1854, as physician José Francisco Sigaud, one of the creators of the institute and also a member of the Medicine Society, participated in movements to disseminate prophylactic ideas related to intellectual disability (Januzzi, 2004).

Hospital Neuropsiquiátrico Infantil (Neuropsychiatric Children's Hospital) - Bourneville Ward - was created in 1904. It started to offer pedagogical guidance services

with an emphasis on sensory pedagogical practices. This aspect is quite present in the education of blind and low vision students to the present day (Januzzi, 2004).

Later, around 1929, physician Ulysses Pernambuco de Melo Sobrinho advocated medical-pedagogical care, and founded the Instituto de Psicologia (Psychology Institute) in the city of Pernambuco (Januzzi, 2012).

Januzzi (2012) points out that the exchange of experiences and knowledge between professionals in the areas of health and education is old and has caused the influence and intertwining of various theories.

The main characteristic of the medical-pedagogical aspect is the focus on the "defect", which has implications for the teachers' work. Borowsky (2010), when analysing official Brazilian documents of curricular orientation, highlights the appreciation of techniques that should be applied by special educators at school, indicating the strong influence of the medical-pedagogical trend. Vaz (2013) reinforces this idea by explaining that the medical-pedagogical model continues to influence the performance of special education teachers, or, as she calls them, a multisensory teacher. Or, as Borowsky (2010) and Michels (2011) show, a teacher who works prioritising methods and techniques to teach at the expense of theoretical issues. It is in this line that the case of the specialist teacher becomes evident. He/she is the one who masters techniques to serve students (Vaz, 2013).

Another aspect is the psycho-pedagogical line, which, for Januzzi (2012), displaces the axis from the medical to the psychological model. The creation of psychometric tests, the development of methods and processes to catalyse the education of the supposedly less favoured were episodes that marked education in this aspect.

Several teacher education schools acted under the psycho-pedagogical line (Januzzi, 2012). We observe here an alarming period for special education. For example, teachers that applied psychometric tests and classified children as "abnormal," enrolling them in selected classes, assisted by specialised teachers. To work in those classes, teachers should have "great scientific knowledge and a great power of intuition" (Januzzi, 2012, p. 46), essential for diagnosis.

The psycho-pedagogical dimension also has a strong influence on the education of blind and amblyopic people. From 1940 to 1970, at the Benjamin Constant Institute, the qualification of teachers to work with those students was based on notions of the psychology of the blind (Januzzi, 2012).

During the period marked by the psycho-pedagogical trend, the teachers themselves would carry out the tests in school and give the diagnosis. Although today the teacher is no longer responsible for the diagnosis, it seems that there are still valuable prerogatives on this aspect, and they continue to act as if they could "detect anomalies easily" (Januzzi, 2012).

Later, around the 1970s, the influence of a new educational aspect emerges in Brazil: the well-known period of integration or normalisation (Januzzi, 2012). During this period,

the work focused on student learning was evidenced. The person necessarily needed to be educated to be "normalised," to look like the other members of society.

The year 1980 is marked by the International Year of Disabled Persons, coordinated by the United Nations. This event echoed in Brazil. The motto of the event was "Full participation and equality," and was the kick-start for the emergence of numerous organisations that took shape and integrated with international movements, such as the Association for the Blind that linked to the World Blind Union (Januzzi, 2012).

Finally, we present the "inclusive education" trend. It is characterised by the displacement of the special education teacher from a parallel teaching modality to act within the typical schools. In this period, the controversy launched on the area was remarkable and expressive. On the one hand, the advocates of special education as parallel care. On the other, those who fight for all in regular schools. This controversy reflects in part on the professional development of special educators and their performance, now, as a teacher in the multifunctional resource room[2] performing specialised educational care[3].

There is an urgent need for attention to the professional development process of special educators. This teacher is expected to be the "expert" in the area. It seems that instead of advancing on issues pertinent to the conjecture expected by current educational policies - a regular school for all – we fall back in the way we think and plan the professional development of this teacher.

We may have remnants, concerning the professional development of special educators, of the medical-pedagogical, psycho-pedagogical and integration/normalisation trends, although the discourse presented by the inclusive education trend points to the appreciation of education for all.

METHODOLOGICAL TRAJECTORY

This qualitative study was carried out with special education teachers who were working, at the time of the research, with blind and low vision students in the public school system. The teachers carried out pedagogical activities focused on the production of accessible materials for natural sciences for those students. The study was submitted to the Ethics Committee of the authors' institution of origin and approved under Opinion No. 1.076.627.

Seventeen basic education teachers, two of whom were blind, participated in the training process planned by the authors - who acted as trainers. The initial education of the

[2] Multifunctional resource room is a physical space implemented by a Federal Government programme. This space is endowed with resources and aims at specialised educational care, among other services. We aim to reflect on the teachers' performance, often limited to this space and service (Vaz, 2013).

[3] "The specialised educational care identifies, develops, and organises pedagogical and accessibility resources that eliminate barriers to the full participation of students, considering their specific needs. The activities developed in specialised educational care differ from those carried out in the regular classroom, not replacing schooling. This service complements and/or supplements the students' education with a view to autonomy" (Brasil, 2008, p. 16).

majority was in pedagogy, and only one of the participants had completed an undergraduate degree in the area of natural sciences. All of the participants registered service time in special education and are called in the research as A1 through A17. All participants who agreed to collaborate with the research signed an informed consent statement.

The training process consisted of 32 hours of face-to-face meetings and eight hours of activities in the distance mode. This process was part of the continuing education program of the municipal education network to which the participants belonged. In the face-to-face meetings, the activities carried out were: a) study of texts on the teaching of natural sciences for contexts with blind and low vision students; b) analysis of experimental activities in textbooks of curricular components of the area of natural sciences; c) elaboration, from the preliminary analysis, of proposals for experimental activities accessible to blind and low vision students; and d) "problematisation" related to the performance of the special educator in the context of teaching natural sciences with blind and low vision students.

The activities in the distance modality consisted of reading texts pre-selected by the authors and discussing them later in face-to-face meetings and in narratives written in the collective virtual diary - class[4] diary- inserted in *MOODLE*[5]. Research conducted by Gonçalves et al. (2008) and Benite et al. (2014) used the class diary collectively in teacher education courses. Both indicated that this is a very expressive resource, especially with regard to the exchange of experiences, expectations, and narratives among teachers. Zabalza (2004) explains that writing diaries helps teachers reflect on their performance, becoming aware of the standards adopted in the teaching process. Regarding the collective attribute, Gonçalves et al. (2008) state that the collective dimension is of fundamental importance so that the teachers, from the place they occupy, can see what they may not identify, which may favour teacher learning.

In the scope of our research, the collective virtual diary was explored from activities previously organised by the trainers, and based on the reading of references on the teaching of natural sciences for contexts with blind and low vision students. The participants were instructed on how they could register their ideas about what they had read, their doubts and, from the above, share professional experiences and discuss with the other participants and trainers. The collective virtual diary was, in fact, explored by the participants and one of the trainers was responsible for adding considerations and problematisations based on what was registered periodically. Thus, the participants could express themselves on the role of special education teachers in the educational processes of natural sciences for blind and low vision students, and the limits and potentialities of this role.

[4] The class diary is too polysemic an expression. This characteristic, according to Alves (2004) and Zabalza (2004), is directly linked to the different ways to exploit this resource. Both consider it a relevant resource that can also contribute to obtaining information in a research. However, for this work we use Zabalza's (2004, p. 13) understanding that the meaning of diary must be "[…] voluntarily opened to contain the various types of diaries, both by the content that collects the notes and by the way the process of collection, writing, and analysis of information is carried out."

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

From the description of the activities, we infer the contents of the training process, namely, the teaching of natural sciences to blind and low vision students, the experimental activities for contexts with blind and low vision students, and the role of the special educator regarding natural sciences teaching.

In short, the training process was supported by theoretical and methodological assumptions, as follows: a) understanding the teacher as a subject possessed of knowledge and unfinished; b) associating theory and practice as a way to foster theoretically grounded reflection on practice and as a potential to overcome the myth of a predominantly instrumental didactic that sees in the field of techniques and decontextualised methods of practice the solution to educational problems, which is very strongly present among special education teachers; c) problematising as a form of "reflection that someone exercises on a content, the fruit of an act, or on the act itself, to act better with others in reality" (Freire, 1977, p. 82-83).

After the training process, semi-structured interviews were carried out through the digital tool, *Skype*. Six out of the eight teachers invited agreed to participate. Two teachers declined the invitation because, according to them, they had enormous work demand for the period of the interviews. The invitation was conditioned to the following criteria: a) participation in all face-to-face meetings, and b) writing in the collective virtual diary. All interviews were transcribed. Besides the semi-structured interview, the textual productions[6] from activities carried out in the formative process and the collective virtual diary were the instruments through which qualitative information was obtained.

The information collected was exposed to the procedures of discursive textual analysis that consist of three stages: unitarisation, categorisation, and communication (Moraes & Galiazzi, 2011). In the first, the *corpus,* consisting of the sources given above, was submitted to disassembly in units of meaning, according to the objective of the research. In the second stage, these units were grouped according to semantic criteria, to originate the categories that in this work were characterised as *a priori*- defined from the theoretical approach explained previously – and emerging (Moraes & Galiazzi, 2011). In the communication stage, descriptive and interpretative texts were produced in each category and will be shown below. This step reinforces the understanding that the researcher needs to act explicitly as an author of the written production, articulating theoretical knowledge already disseminated in the literature with his/her new theoretical creations.

For this work, we present the categories: 1) the role of special education teaching in natural sciences classes: influences of the medical-pedagogical trend on the "school inclusion" movement; and 2) the training process in teaching natural sciences to special educators.

[6] For example, participants elaborated narratives about their professional experiences exposing reflections concerning their pedagogical practices. This type of activity favoured the apprehension of their initial knowledge about the role of the special educator in the context of the teaching and learning process of natural sciences with blind and sighted students. They also answered a questionnaire that allowed them to express themselves about the limits and potentialities of the formative process.

THE ROLE OF TEACHING IN SPECIAL EDUCATION IN NATURAL SCIENCES CLASSES: INFLUENCES OF THE MEDICAL-PEDAGOGICAL ASPECT ON THE "SCHOOL INCLUSION" TREND

Historically, special education was marked by various trends: medical-pedagogical, psycho-pedagogical, integration, and, finally, the so-called school inclusion. They did not appear in a static manner and within rigid temporal boundaries. We add that they were influenced by political and governmental actions managed by people and events at various times, as stated by Januzzi (2004). The first three trends explicitly fostered paths of fragmentation and parallelism in the area. Such aspects may also influence the performance of special educators; they seem to influence the roles that teachers of the area "assign" themselves in today's school.

The research made it possible to interpret that special education teacher can still influence the so-called medical-pedagogical aspect in the characterisation of their role. What the participants expressed about how they understand their role in the teaching of natural sciences is associated with the knowledge that attributes more technical responsibility to the special educator than to the natural sciences teachers, with the production of accessible tactile materials, for example. One of the participants said:

> In my view, this adapted material was fundamental for this student as it would be for all other blind students. Because if you're learning visual physics, how are you going to understand it? So, if you have all this adapted material in your hand, it's a gain for this student. I'm not the one who says it, just look at the experience he has, surely he has the answer there, with this student who is learning, who is succeding from one year to the next, absorbing the subject. As I work with this, I am sure of what I am talking about in this sense, that we see the student's response advancing, the student participating. It seems that when we are inside this work, we can see it, people have no idea of the importance of a job [making the materials accessible], unless they are seeing the answer as we see it, we see here advances in all the children who appropriate it, all the adolescents who appropriate Braille, the adapted material. (A10)

We interpret that there is the appreciation of a knowledge that attributes to the teacher of the special education area a function that could be shared with other professionals, that is, to make tactile materials accessible. This aspect may indicate, to some extent, the influence of the medical-pedagogical trend that, according to Vaz (2013), Vaz and Garcia (2015), and Borowsky (2010), reinforces the performance of the special education professional as a "technician" who enhances the education of the blind and low vision students. We also understand that an exacerbated confidence in educational materials, regardless of their accessible character, can bring with it the knowledge that minimises the role of teaching in the teaching and learning process. Without denying the imperativeness of the accessible materials, they alone will not provide student learning. In fact, they can

even collaborate for the opposite, depending on their characteristics and the way they are conceived. In the context of research in natural sciences teaching, in general, the literature has long been full of examples that indicate problems in many teaching materials and the approach adopted in their use. As an example of studies that discuss, to some extent, these problems are those of Lopes (1993), Hodson (1994), Mortimer (2000), Hofstein and Mamlok-Naaman (2007), and Hidalgo et al. (2018). The confidence mentioned is consistent with a perspective that defends the parallel action of the special educator, away from the regular classrooms. In other words, given the potential of materials accessible to student learning, the presence of the special educator with other teachers and students in regular classrooms would be unnecessary.

Another knowledge related to the medical-pedagogical trend is that which understands that teachers in the special education area have better possibilities to work in teaching, if compared to other teachers:

> Also because, even though the teacher is aware of the content being explained, he/she [the special educator] has an experience that I think is much greater than the teacher. He/she can suddenly make a synthesis. Look, we had a student who had similar difficulty, and the path we found was this. Now we will sit together, and we will combine your practice with our practice, your theory with our practice [...] Of course, the special education teacher will never master the knowledge that the physics teacher has, but this way of solving, addressing in a way more focused on the issue of the visually or hearing **impaired, he/she will certainly have more experience to help.** (A17, emphasis added)

It is not stated that the techniques for the production of pedagogical materials embossed and written in Braille or an expanded form are irrelevant. However, the knowledge that mastering techniques is sufficient is questioned. Garcia (2013) explains that the education of special education teachers and their role as teachers have emphasised a hegemonic and specific knowledge related to their use of techniques. Pimenta and Lima (2004) highlight in teacher education, in general, the promotion of the myth of decontextualised teaching techniques that have contributed little to teaching practice. Among other aspects, because such techniques are not per se insufficient to interpret and face more forcefully the educational problems that invade the school environment. Thus, we interpret that special educators' appropriation of this myth in their professional development process may undesirably reinforce the idea that it necessarily make them more "capable" than other teachers to interpret and face the problems that affect blind and low vision students in the process of teaching and learning natural sciences.

Even when teachers explained knowledge that indicated appropriation of the knowledge addressed in the formative process, they showed the influence of the medical-pedagogical trend:

> As I already said, it was a course... where I had no idea of these experiences that the teacher did there in front [of the class] with blind people, and we saw

> that blind people can be there together [with all the others]. I also really liked it when he showed us that certain types of experiences can't be done even with the sighted students, because he showed us that there are dangerous experiences. But then, those that we did and that we can do with blind students, [they] are very valid. So, for me the course was valuable, because it brought an idea that I did not have about physics, chemistry experiences. They took those materials, they could understand [the blind participants], I found it very interesting. (A10)

It is imperative to highlight the importance given by the teacher to knowledge learned in the formative process, especially that related to experimental activities with blind and low vision students. At the same time, it is worth noting the emphasis on sensory experience and the organisation of accessible materials. This would be another aspect to be contemplated in the review of the formative process, since the focus was not the sensory dimension per se, but how much accessible experimental activities could collaborate to stop the imperative social interactions to natural sciences learning (Gonçalves et al., 2013). It is the absence of this type of consideration on the part of the participant that allows us to interpret that their placement tacitly approaches the assumptions of the medical-pedagogical aspect. We infer that the teacher seems to combine new knowledge learned in the formative process with others that are rooted in the history of the professional development of special educators. Knowledge such as this explained by participant A10 was unusual, favouring the understanding that knowledge related to the medical-pedagogical trend can exert some influence on the teachers' learning process.

Besides the participants' kinds of knowledge demonstrated throughout the formative process, others are recognised to indicate, to some extent, the potential of this process:

> [...] I see that none of them can stay out and that if we really want to include it, it is by doing a job together, all the professionals and all the people involved, blind and not blind. Everyone should be together, helping in this sense, but the teacher in the special area should be in all schools. (A10)

The emphasis on collective work suggests appropriation of knowledge addressed in the formative process, approaching what has been called inclusive education in the literature, according to a preliminary discussion. Another participant mentions inclusion more explicitly:

> [...] So we often pretend that we are, that we are including this student. And he [...] Who is in the greatest difficulty [....] Passing the difficulties and such, it is he who is at the end wanting to learn and often can't, right? But it is not his fault, it is because of this process that is there. There is a failure. I don't even know, I

> can't tell you where the end of this thread is, this whole tangle. I don't know what to say [...] (A3)

The teacher brings up a reflection on the difficulties of the teaching and learning process in this current context of the presence of blind and low vision students in regular classrooms. By recognising how vital these students are in regular classrooms, the limit of educational processes is recognised, considering the role of the special education teacher. As argued by Silva, Gonçalves, and Marques (2015), it is necessary to foster social interactions between students in the school space regarding the diversity that characterises this space. However, the authors point out that they are not any social interactions that potentially favour student learning, which also implies the relevance of interactions between teachers that can be characterised equally in different ways. Hence the need to reflect on the quality of the social interactions established in the school to promote learning and not only in the interactions themselves and in the accessible materials so necessary for the educational process.

From the analysis, it seems that knowledge acquired during the professional development of special education teachers may have lasted in the formative process. We identified the relationship between this knowledge and the one associated with the medical-pedagogical trend. As a limitation of this formative process, we recognise it is not enough to problematise some types of knowledge, such as the one associated with the medical-pedagogical trend. On the other hand, teachers also explained knowledge in harmony with those studied in the formative process, indicating, to some extent, the importance of the theoretical-methodological approach adopted.

THE TRAINING PROCESS IN NATURAL SCIENCES TEACHING FOR SPECIAL EDUCATORS

This category deals specifically with participants' considerations about the formative process they took. In the search to present possibilities to overcome barriers, more than one participant signalled the importance of the formative processes analogous to that carried out in this work, but involving natural sciences teachers and special educators:

> I think the course should be extensive for science teachers. (A12)
>
> I believe that training should **include** science teachers and science lab teachers in the future, focusing on pedagogical practices. (A13, emphasis added)

Based on the above, the participants expressed an understanding that special education should not be isolated from the other areas of the school curriculum, contrary to assumptions of the medical-pedagogical and psycho-pedagogical trends. From the point of view of the participants mentioned, it is a desirable characteristic of future

formative processes the participation of teachers who teach in curricular components of natural sciences. Formative processes with those characteristics can contribute to transcend problems exposed in the literature, such as the one qualified by the presence of the special education teacher in the classroom that contributes more to segregate blind and sighted students in natural sciences classes than promote the imperative social interactions between them, necessary for the learning to happen (Silva; Gonçalves & Marques, 2015). We understand that adherence to the idea of interaction between special education teachers and teachers from other areas of knowledge that make up the school curriculum is essential also to begin a reflection on the nature of the interaction established by these professionals. The limit characterised here relative to the formative process can be construed as a contradiction to the knowledge defended throughout its development. On the other hand, the teachers' reflections reinforce the potential of the problematisation developed for the discussion on the content studied for action in a given reality.

In the participants' understanding, the formative process has another limitation: special education teachers cannot put into practice in school, with blind students, the experimental activities they planned. About this, participants A2 and A14 highlighted:

> That, as far as possible, some of the experiments presented are done in the classroom with the students. (A2)
>
> The experiments proposed in training were done in the classroom with the students. (A14)

We must consider that most participants did not work with blind and low vision students in the regular classroom, nor in multifunctional resource rooms. Their activity was focused precisely on the planning of accessible materials. However, the short duration of the formative process – a dimension that could not be avoided for different reasons - greatly contributes to hinder the direction of planned activities in this process to the classroom. The above does not mean that other practical activities cannot be jointly predicted in longer training processes to be carried out in the classroom context, on the contrary.

Other participants mentioned the need to have prior knowledge on the subject:

> I don't think there's a limit, but **you need prior knowledge** of the discipline. (A5, emphasis added)
>
> Limits – their knowledge [mentioning the special education teachers] of the physical, chemical, and biological phenomena that act interconnected. (A17, emphasis added)

We identify, from the participants' speeches, that their formations may be focusing on the specificities of deficiencies to the detriment of specific knowledge (Vaz & Garcia, 2015; Vaz, 2013; Bueno, 1999). However, we understand that the teacher is a subject

under construction. As Freire (1996 p. 50) pointed out, "teaching requires awareness of an unfinished work, " which does not mean stating that the teacher is a *tabula rasa*. As the same author emphasised in another work (Freire, 1977), it is from the notion that little is known about a given subject that a person may come to know more about it.

Other ideas were interpreted as potentialities of the formative process. For example, participant A17 highlighted that his participation in the training process enabled him to re-signify his professional attitude:

> To realise other ways of teaching and learning with a systemic vision, develop other competencies and skills [...] reframe your attitude as an educator. (A17)

The performance of the special educator in the context of the teaching of the natural sciences was one of the contents of the formative process. The teacher gave indications that he combined the contents addressed in the process with those he already had, since notions such as competencies and skills were not the objective at stake.

Other participants also registered:

> It is a very important training for teachers in this area, considering that it is a time when you stop and think exclusively in this area [...] The importance of knowledge of the whole process. (A11)
>
> It is paramount, this formative process, through it, we learn and share new perspectives and discussions relevant to the subject promoted by teachers. (A4)
>
> As learning of this teacher training process, I highlight: [one must] stop to think about the activity. (A3)

The knowledge demonstrated may suggest that the formative process contributed somehow to special educators, although we recognise there is a long way to go. From what the participants said, we can draw attention to the importance of the collective dimension: "through it, we learn and share new perspectives and discussions relevant to the subject promoted by teachers" (A4). This speech contradicts the individualistic view that often permeates learning about being a teacher. In the process developed, the social dimension of learning was valued. One learns to be a teacher also in the interaction with students in school, in education processes, and in the work environment itself by interacting with colleagues. Commitment to collective work in the institution where they work can be learning fostered by training processes. Thus, besides the contents showed and addressed in the formative process, there are others, sometimes more tacit, such as those of an attitudinal nature, that deserve to be recognised and valued in the teachers' professional development. Knowing how to work in a group, knowing how to listen, being supportive with colleagues in the institution, is also relevant for the exercise of teaching.

The above brings to light the need to reflect on the professional development of special educators, make the teaching of natural sciences more emphatic, to enable teachers to circulate in knowledge and practices of other areas of education. It also may contribute to minimising the barriers that may be present in their performance. The limitations analysed need to constitute an object of reflection to be taken as a starting point in subsequent formative processes.

FINAL CONSIDERATIONS

The history of special education was mostly developed in exclusive and segregated services influenced by the ideas of the medical-pedagogical trend. This fact left marks on the roles assigned to special education teachers. In this research, we identified that this trend might influence the participants' understandings of their role, marked by the development of techniques on school knowledge. We also realised special education teachers' little comprehension that the educational needs of students in natural sciences classes, in general, exceed the teaching and mastery of language codes, tools, and technological resources and transcriptions for Braille. Although, given the ideas disseminated in this aspect, such attributions are the hallmark of the teaching role in special education.

From the analysis, we can also mention the fact that the participants show knowledge that values a more dialogic performance with teachers from various areas of education – here, the natural sciences stand out. As positive points of the formative process, the participants registered the moments of reflection through both the discussions and elaboration of experimental activities and the exchanges established between them and the teacher trainers. The notes, especially of the limitations of the formative process, also collaborates to the trainers' professional development. The interactions with the special education teachers and the analysis presented here favour the equal enrichment of the trainers' knowledge, which, in turn, will influence other formative practices in which they participate and their own research – as it has already occurred[7].

We understand that it is the nature of every training process its lacunar and procedural character, which implies the continuing need to improve the formative processes considering, for example, spaces, times, subjects, themes, and methodological procedures. In fact, this need for improvement is often shown in the literature about teacher education in general.

[7] For example, an extension project called "Experimentação no Ensino de Química/Ciências da Natureza para contextos com estudantes cegos e videntes" (Experimentation in the teaching of chemistry/natural sciences for context with blind and low vision students) is currently under development, registered at the Federal University of Santa Catarina (UFSC), Brazil, in which one of the characteristics is the constitution of formative processes integrated by researchers in teaching natural sciences, basic education teachers who teach in the area of natural sciences, and special educators, aiming to study, plan, and develop teaching and learning activities with blind and sighted students according to the need of each school context. Participation in the project is totally voluntary.

The analysis and considerations presented here, added to those disclosed in a preliminary publication (Voos & Gonçalves, 2019), can also be appreciated by educational managers who are co-responsible for the training processes. The results of this research reinforce and/or add knowledge about formative processes with teachers in the area of special education that could contribute to the school board's reflection and, therefore, to the organisation of those processes to transcend the known problems. With this, we expect to have a more positive impact on the professional development of special educators and, consequently, on the learning of students of basic education.

The analysis and considerations above do not constitute any explicit or implicit criticism to participants in the formative processes with teachers of basic education, teachers in the area of special education and educational managers. We understand that criticism out of the context of their professional development contributes little to solving ongoing problems and problems that have long been characterised. We must recognise that their performance is influenced, for example, by public educational policies, working conditions, and social contexts in which they are inserted.

It is understandable that throughout the training process, the participants presented contradictory knowledge, experiencing with them after the end of the process. Only a technicist approach in education would defend the immediate abandonment of knowledge that subjects bring with them to accommodate new knowledge (Freire, 1977). Peremptorily, it was not this defence of the technicist approach that guided the training process described.

Those elements reinforce the arguments for changes in the professional development of special educators. Such changes can contribute to bringing special education teachers and teachers of other educational areas closer to qualify the educational processes of blind and low vision students in school. This is the thesis we defend in this work, whose results presented here complement a previous publication (Voos & Gonçalves, 2019).

Those aspects indicate the necessary "reaction" of professionals, sometimes contradicting legal and historical impositions that oppress the profession, keeping it in isolation, with pedagogical practices that value the technical vision to the detriment of the improvement of relations between teachers and the qualification of pedagogical work carried out with blind and low vision students.

AUTHORSHIP CONTRIBUTION STATEMENT

The work is based on the doctoral thesis of the first author I. C. V., under the guidance of the second author, F. P. G. The version submitted and accepted for publication was discussed and revised by both authors, who contributed equally to the production of the text. The authors have made significant contributions to the article and assume full responsibility for its content. Both made important contributions to the article and were therefore named as authors.

DATA AVAILABILITY STATEMENT

According to the approval of the project by an Ethics Committee, as stated above, only the researcher and her advisor will have access to the data collected. The ethics committee approved that project based on "maintenance of confidentiality and privacy. When the results of the research are disclosed, the names of those involved will not be disclosed, using, when necessary, fictitious names. The data shall be used exclusively for scientific purposes.

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