The (In)Visibility of Visually Impaired People in Science, Technology, Engineering, and Mathematics: Perceptions and Perspectives[1, 2]

A (In)Visibilidade de Pessoas com Deficiência Visual nas Ciências Exatas e Naturais: Percepções e Perspectivas

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ABSTRACT: In this paper, of a qualitative approach, we sought to adduce aspects of the (in)visibility of visually impaired people in Science, Technology, Engineering, and Mathematics (STEM). The invisibility in these courses, a theme poorly addressed so far, constitutes a barrier to be surpassed to assure these people admission and stay. Thus, we interviewed eight people with a visual impairment at different levels of Higher Education and courses, from different regions of Brazil, to report their perspectives and perceptions through semi-structured interviews. The data were analyzed according to the assumptions of Bardin's content analysis. We established four inter-related categories "marks of ableism in STEM", "course choice", "adaptation and accessibility", and "teachers' role and formative aspects". We concluded that the absence of visually impaired people in these courses regards how people deal with disabilities more than the ineptitudes related to vision loss.

KEYWORDS: Visual impairment. Higher Education. Special Education. Science teaching.

RESUMO: Neste estudo, de abordagem qualitativa, buscamos aduzir elementos relacionados à (in)visibilidade de pessoas com deficiência visual em cursos de Ciências Exatas e Naturais. A invisibilidade nesses cursos, temática pouco explorada até então, constitui uma barreira a ser superada para garantir o ingresso e a permanência desse público. Assim sendo, dialogamos com oito pessoas com deficiência visual em diferentes níveis do Ensino Superior, com formações diversas, de variadas regiões do Brasil, para relatar, por meio de entrevistas semiestruturadas, suas percepções e perspectivas. Os dados foram analisados de acordo com pressupostos da análise de conteúdo de Bardin. Estabelecemos quatro categorias de análise que se inter-relacionam: "marcas do capacitismo nas Ciências Exatas e Naturais", "escolha do curso", "adaptação e acessibilidade", "o papel do professor e aspectos formativos". Concluímos que a ausência de pessoas com deficiência visual nesses cursos mais tem a ver com as formas como essa condição é tratada do que com alguma inaptidão imputada à perda de visão.

PALAVRAS-CHAVE: Deficiências da visão. Ensino Superior. Educação Especial. Ensino de Ciências.

1 Introduction

The right to education is guaranteed by law, as established by the Brazilian Federal Constitution (*Constituição Federal* – 1988). Although it is a right for all Brazilian citizens, the Brazilian Law for Inclusion of People with Disabilities (*Lei Brasileira de Inclusão da Pessoa com*

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Deficiência – Law no. 13,146, of July 6, 2015) was necessary. It is destined to guarantee and promote, in equal conditions, the exercise of fundamental rights and liberties to people with disabilities, aiming towards social inclusion and citizenship (p. 8). Regarding Higher Education, visually impaired people have been facing uncomfortable, non-inclusive situations. It is still a challenging task for a visually impaired person to enroll in an undergraduate course, and just a few succeed in graduating (Selau & Damiani, 2016; Selau et al., 2017). Even considering the legislation advances, this situation persists as the approval of Law no. 13,409, of December 28, 2016, which established the quota for people with disabilities in federal universities, resulting in a rise in registrations (Pereira et al., 2020).

Thinking about the difficulties of visually impaired students in universities, Selau et al. (2017) present a set of hurdles, including denial of their ability to learn scientific content, absence of teacher-student communication, and lack of interest in working pedagogically with them. This scenario worsens if we consider Science, Technology, Engineering, and Mathematics (STEM) courses, in which visually impaired people are even rarer. Data from the Higher Education Census of Brazil (*Censo da Educação Superior*) indicates that approximately 20% of them are enrolled in these courses (National Institute for Educational Studies and Research 'Anísio Teixeira' [INEP], 2019). Additionally, studies point to the urgency of carrying out discussions about the inclusion of visually impaired people in Higher Education in the context of STEM (Camargo, 2012; Silva & Camargo, 2018). Accordingly, the reviews of Neres and Corrêa (2018), Santos et al. (2020), Silva and Bego (2018) and Uliana and Mól (2017) corroborate the incipience of studies focused on understanding leading to these subjects' invisibility in those courses, thus justifying our inquiry.

This study aims to adduce and analyze elements related to the (in)visibility of visually impaired people in STEM courses, under the perspective of eight visually impaired subjects in different Higher Education stages, with a broad spectrum of formations obtained in different regions of Brazil. We consider that the idea of (in)visibility refers to a myriad of situations that make the subjects "invisible", ranging from lack of identification, knowledge about who they are, what are their demands, how to assist them, if they have their rights are assured, to their absence in these courses (André & Ribeiro; Capelli et al., 2020). We highlight, through our research, aspects not so far addressed in the scope of STEM, seeking the overcoming of deeply-rooted ableism postures. Ableism is, according to (Vendramin, 2019), a reading that someone does about people with disabilities, assuming that their corporal condition is something that, naturally, defines them as less capable (p. 17). These excluding postures may hinder the permanence and, in parallel, the interest of visually impaired people for these courses.

2 Method

In order to answer the research question, namely: How do visually impaired people apprehend their absences in STEM courses? we opted for the qualitative method, since it encompasses the complexity and singularity of this study. By itself, the nature of the emphasized object alludes to the appreciation in the apprehension of the phenomena, taking as a starting point the meaning attributed by the participants (Chizzotti, 2014).

Our research was approved by the Ethics Committee (CAAE: 94734418.0.0000.5531) and carried out in the Federal University of Bahia (*Universidade Federal da Bahia* – UFBA), in collaboration with the Brasília University (*Universidade de Brasília* – UnB) and with the Nucleus to Support the Inclusion of Students with Special Needs (*Núcleo de Apoio à Inclusão do Aluno com Necessidades Educacionais Especiais* – NAPE-UFBA). We based our interviews on a previously elaborated questionnaire, with seven questions about three topics: participant profile, experience in Higher Education, and absence of visually impaired people in STEM. Three interviews were carried out in person (before the COVID-19 pandemic), and five were conducted remotely because of the pandemic. All interviews were individual and last an average of one hour.

We focused mainly on reports of the participants of STEM-related undergraduate courses. In due time, we seized the perceptions of participants to investigate the reasons why they did not choose to pursue careers in the areas of STEM. In addition, these subjects hold impressions about STEM course even without taking them, commonly due to their experiences. All subjects already presented visual impairment before starting in Higher Education.

The participants were referred to by fictitious names, established in alphabetical order. Their lines were registered with an audio-recording device and transcribed by a combination of two computer programs (Google Docs® and VB-CABLE Virtual Audio Device®). We made the necessary reviews and corrections in the transcripts due to the automated method's imprecision, looking to preserve the meanings and colloquial speech inherent from orality.

We examined the data according to Bardin's (2011) assumptions of content analysis, both for the pre-analysis of the transcriptions and for the exploration and interpretation of the rising themes. We considered elements such as frequency, favorable, neutral, and unfavorable directions and the presence of two or more register units in a given contextual unit (concurrence) to establish the categories. Categories 1, 3, and 4 rose from the floating reading of the transcripts. Category 2 was determined aprioristically because of the questions and, accordingly, their subjects, which redimensioned interest aspects.

2.1 Meeting the participants

According to their reports, we contemplated the type of visual impairment and its stages for the participants' characterization. So, we considered how they identify themselves (blindness or low vision), in addition to the cause of their acquired conditions, since their experiences manifest in different ways. Concerning blindness, if it is congenital, the experiences are not based on vision. In contrast, those who became blind hold memories of their experiences from when they could see (Almeida & Araújo, 2013; Fernandes et al., 2017).

Another aspect about the participants is their condition and how their visual impairment is experienced since their social, psychological, and familiar contexts influence behavior due to the disability. Even if we can identify common features between visually impaired people, especially regarding their perceptions, each individual's development is singular, as they are for sighted persons (Nunes & Lomônaco, 2010). The participants' profiles are summarized in Table 1.

Table 1
Profile of the visually impaired (VI) participants

Name	Type of VI	Cause	Course and stage
Amarante	Acquired blindness	Glaucoma	Cultural Production (in progress)
Bebeto	Acquired blindness	Glaucoma	Museology (in progress)
Cícero	Acquired blindness	Glaucoma	Social Sciences (in progress)
Daniela	Congenital low vision	Congenital glaucoma	Biology (finished)
Ellen	Acquired blindness	Retinitis pigmentosa	Chemical Engineering (finished)
Fábio	Acquired blindness	Accident	Social Communication (finished)
Gabriel	Congenital low vision	Congenital cataract	Industrial Chemistry (in progress)
Henrique	Acquired blindness	Chronic uveitis	System Analysis, Masters in Natural Sciences (in progress)

3 Results and discussion

The critical analysis of the data is divided into four categories, presented sequentially: (i) marks of ableism in STEM, (ii) course choice, (iii) adaptation and accessibility, and (iv) the role of teachers and formative aspects.

3.1 Marks of ableism in stem

Due to their lack of eyesight, the perception that visually impaired people would be "less capable" to attend STEM courses predominates in these areas' collective imagination, even without questioning or a reflection of why this is so naturalized. If this kind of thought comes from the professor, it can lead visually impaired people to not look for these courses (Regiani & Mól, 2013), in other words, to a segregationist behavior. This situation is exemplified by a report of Ellen, which mentions that "the professor does not accept the presence of visually impaired people in some courses, especially in some exact and engineering courses, it is a surprising amount of people […], they do not hide this opinion really well". Gabriel also states that visually impaired people are not encouraged to act in these areas:

> The disabled [sic] are not encouraged to act in the exact area. For example, I speak for myself; I have to study twice, further on to get good grades, to prove for the subjects that do not know me that I am capable. (Gabriel)

Considering Chemistry as an example, Regiani and Mól (2013) reason that this scenario would be linked to the assumption that to "be a chemist", the visually impaired student must be skilled in the lab, even to learn some scientific concepts. This attitude is endorsed by Ellen's narrative, who heard from a professor that "a person who cannot do a given procedure in the lab, obviously, would not be able to be a chemist". Because of excluding postures like that, she was forced to change her Chemistry course to Chemical Engineering.

The "inability" attributed to visually impaired people not only conditions them to choose specific courses but also induces them to believe that they are "less capable", and this condition comes to be seen as a disadvantage, as highlighted by Fabio's testimony:

> Besides people that don't believe [in our potential], there are still some others with disabilities that are repeatedly hearing: "Oh, you can't handle this", "oh, you can't do that", people keep putting those thoughts in their minds, and there is, possibly, a reason for not having so many people with visual impairment in the Natural Science areas. (Fabio)

Adverse conditions, not rarely also experienced outside of the university, result in the partial or total withdrawal from the courses. These events are not an uncommon situation among the participants. Almost all of them have had to move away from their lectures for some time. This is the case of Gabriel, which had to stop attending the classes for a while: "I live in a student environment, as I said before, and I am not from the capital. Together with the university's pressure, the out of the home environment, without family support, everything has contributed [for the course's partial withdrawal]". Gabriel mentions issues that are, sadly, recurring, as the lack of familiar support, financial conditions, and emotional pressure due to the stress of attending an undergraduate course.

Excluding postures, mainly in the laboratory classes, are also assumed by colleagues, for instance, when they do not accept to work in pairs (or in-group) with blind or low vision students or when they do accept and not allow the visually impaired students to carry out the experiments. Tutors help in other ways to run the lab activities. However, not rarely the tutors have their issues: lacking a degree, they are undergraduate students without preparation, which frequently have not to deal with these situations, obstacles also reported by Fernandes and Costa (2015). Furthermore, they are experiences reported by Mariano and Regiani (2015), as well as by Ellen and Henrique, who illustrated the behavior of colleagues and tutors in practical classes:

> If I hadn't had the help of a friend who volunteered, in fact, offered to be a tutor of the class in general, basically helped me in almost all the experiments, I possibly would not have succeeded in this course, not because I didn't know the principles, […], but because of this [the lack of access to conducting the experiments]. (Ellen)
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> They got a student who volunteered and gave her the scholarship to be my tutor, but she was attending the same class. So, this also posed some difficulties because, at the same time that she was helping me, she was paying attention to her own studies, as well. I consider that this was not the most suitable solution. (Henrique)

Amarante emphasizes that "the prejudice said to these [visually impaired] people: 'how can you work in a laboratory?'". Ellen also reports that: "it was progressively clearer that the lab experiments were impossible for me". Cícero said: "I, specifically, do not see any conditions in which a person without vision will perform in a science laboratory".

The lack of reflection about the dependence on vision in these courses, including the exclusion of visually impaired people in laboratories and the discriminatory stance of some professors and colleagues, are indicatives of ableism. Since Elementary School, the professors' discourse and actions in classrooms resulted in a false notion of inclusion success regarding people with disabilities in the educational system, disregarding retention and withdrawal (Camargo & Paes de Carvalho, 2019). Ableism is a subject that has been barely approached in

STEM courses so far, even though it is already incorporated in professors' speech and actions. A search in the main science teaching journals of Brazil (*Investigações em Ensino de Ciências; Ciência & Educação; Revista Pesquisas em Educação em Ciências; Ensaio: Pesquisa em Educação em Ciências*; and *Alexandria*) showed the absence of articles that address this theme.

The ableism phenomenon derives mainly from the concept of social normalization that imposes a notion of homogeneity of bodies. In other words, that the subject cannot clash with the others (Camargo & Paes de Carvalho, 2019; Mazzotta & D'antino, 2011), the historic of eugenics and, recently, neoliberalism. People rely on appearance to label visually impaired people as "less human and less capable" beings and, thus, segregate them. It is common for visually impaired people to feel invisible in some situations (Selau et al., 2017) or a moment of a STEM course, as stated by Gabriel (and by other participants): "in some moments, I am an invisible subject there in the university's center of technology". This invisibility often results from indifference, as Cícero emphasizes: "the colleagues' indifference, the lack of bringing up a subject, a conversation, an interaction".

According to Vendramin (2019), people with disabilities are usually treated with attitudes based on invisibility and hypervisibility. This practice reduces them to socially-built, stigmatized stereotypes. Consequently, they are addressed to as the overcoming (hero) and charity recipients (underdog). By invisibility, the author considers actions such as ignoring or disparaging people with disabilities, often because they cause discomfort in those who behave this way. These situations are also dealt with in this study. On the other hand, hypervisibility occurs when the disability overcomes the personal identity features, and the person is better known as "the blind person" rather than by his/her qualities. The permanence of visually impaired students in STEM undergraduate courses is marked by invisibility. The choice for these careers is linked to the idea of overcoming, as we discuss below.

3.2 Course choice

Regarding the choice for a given course, we noticed that it is not related to visually impaired people's condition. Two reasons commonly justify it: the excellent performance in high school courses, for instance, led Ellen to choose Chemistry as an undergraduate course (a common situation even for sighted people), or they mirror the trajectories of successful visually impaired people. Hence, we emphasize the importance of representativeness in STEM careers. In this context, Cícero reports: "Until then, I didn't know of anybody in my condition, as a person without sight, carrying on with these activities [in the laboratory]". Fábio follows in the same direction: "I was very influenced by colleagues [with visual impairment] that became teachers. For example, others who became psychologists, and so on, that 'gave me gas', and I thought: if they succeeded, why can't I?".

If a visually impaired student does not find or never knows about blind or low-vision scientists, how he/she will think about the possibility of following these careers? In the same way, how will professors believe that visually impaired people can be scientists? Contemporary cases, such as the Puerto Rican astronomer Wanda D. Merced and the Brazilian Physics professor Eder Pires de Camargo, and history episodes, as Johannes Kepler (1571-1630) and John Dalton (1766-1844), can be explored to discuss the trajectories of visually impaired scientists, providing an incentive to visually impaired students to attend and stay in these areas, additionally helping to break stereotypes.

Daniela poses an essential question about the interest in sciences: "If a person does not have access, how will he/she know that this is the topic that he/she likes?". This question suggests that these professions' invisibility is closely related to the lack of access due to inexistent adaptations and specific support for science courses. These issues can be linked to the absence of preparation from teachers and schools.

Amarante implies that the low qualification of visually impaired people may lead them not to choose STEM courses: "the low qualification, because a blind person, in average, is much less qualified considering the previous studies". For sure that, due to a set of factors, people with disabilities are in an unequal situation regarding access to education. Gabriel, in addition to mentioning the low qualification, highlights schools' and teachers' lack of preparation, as some of these factors:

> The difficulty in the educational basis, we have a severe problem in this regard. The disabled [sic] does a terrible middle school, a terrible high school because the teachers are really not prepared for this, so most [of the visually impaired people] opt-out for humanities courses, which are easier in theory. (Gabriel)

Bebeto highlighted the high competition to enroll in STEM courses, mainly for engineering courses: "I think these components are highly sought, but the score is too high to enroll", which results in the search for less competed areas. For these reasons, the quota-based policy is essential. Even with the implementation of the Brazilian Law of Quota for People with Disabilities (*Lei Brasileira de Cotas para a Pessoa com Deficiência* – Law no. 13,409, 2016), an expressive increase of enrollments in STEM courses have not been noticed, when compared with other courses. The lack of educational basis is often reported by professors of non-humanities courses (Capelli et al., 2020).

The participants attending or have attended STEM courses (Daniela, Ellen, Gabriel, and Henrique) added that, in addition to the reasons above, they feel more challenged, and they believe that they are contributing more for these areas, in the sense of making them more accessible, serving as an example for other visually impaired people, also showing the importance of representativeness:

> I am a person who strongly defends this. If we get to know people who succeeded, despite all barriers, this will motivate more people to go there, and the more people, the more we will be able to unburden the barriers. (Henrique)

The overcoming idea is inserted in the ableism. A person with a disability is seen as someone who needs to overcome the adversities imposed by the "normal" world and who can beat them is considered a hero and an example for others (Vendramin, 2019). However, we need to understand that any human being has limitations and, nevertheless, their trajectories are less admirable (Silva et al., 2018). To recognize the limits and, mainly, the potential of visually impaired people must not be confused with the overcoming or heroism myths, since there is already enough heroism in anyone's life, whether the person has a disability or not

(Silva et al., 2018, p. 65). The disability overcoming myth is rooted in the expressions of the participants. Because they think it is a more demanding challenge to be in STEM courses, many visually impaired people give up or do not even try. Of course, that representativeness is critical, but it is an end, not a mean. Thus, we must foster representativeness without falling back on the hypervisibility arguments.

3.3 Adaptation and accessibility

People with disabilities perceive their condition because of adjustments and concessions designed to adapt them and realize that the world is not made for them, affirms Vygotsky (2011). The author reasons that education comes to help, creating artificial, cultural techniques, a special system of cultural signs or symbols adapted to the peculiarities of the psychophysiological organization (p. 867). We consider that the way visually impaired people perceive their position to be inferior is due to what we currently call "adaptation".

In general, the participants report that they initially have difficulties with locomotion in the university, something comprehensible if we consider that they did not know these spaces yet. Hence, they needed to be "helped" by other students. Some institutions have specialized support centers, which provide tutors to assist in the initial process of mobility. The importance of prepared teams to provide accessibility to visually impaired people is beyond locomotion because, in the same way, it ensures that this public feels welcomed and as an effective part of the university community. This situation is illustrated by Ellen's testimony about when she started to attend the support center: "I felt, obviously, more mingled, knowing people with similar difficulties and initiatives that helped us".

André and Ribeiro (2018) warn that the absence of an accessibility culture causes the lack of specialized educational assistance in Higher Education institutions. Therefore, the visually impaired students must be recognized in all senses, even to comply with the laws, since the university's provision of specialized service is their right. For this, these students must be aware of their rights. Both Ellen and Henrique reported that initial difficulties when entering the university resulted from their early age and their unawareness of their rights. Another fact reinforcing the importance of the support centers for the students with special needs is that they learned about their rights through these centers.

Another common disappointment of the interviewed students refers to the delay in adapting the courses' materials, which has occurred for two reasons: the need for professors to make these adaptations or when the support centers do not have sufficient staff or appropriate assistive technologies to prepare the materials. Thereby, the student often attends the classes without reading the material, reflecting on his/her interest and performance. The situation may be even worse, as underlined by Silva and Camargo (2018). They describe how readers usually do not include audio descriptions of the images, tables, plots, models, or geometry contents, tools commonly used in STEM teaching. In view of this, we indicate: to hire audio description-trained tutors or trained professionals to transcribe the materials or to look for other means to promote teaching mediation, without depending on adapted materials, as suggested by Henrique:

> Actually, it is a description summarized on a diagram or model; in other words, first it is a description, totally conceptual, then thinking of a sighted person, someone decides to create a diagram to represent a whole idea. Thus, it makes much more sense to those who can see it, but for those who cannot, the description is much more suitable than that image, that diagram. (Henrique)

The heavy use of visual representations in STEM courses classes leads the professors to think that this is the only way to teach those contents. They do not contemplate that these representations are produced to facilitate a sighted student's learning and, not necessarily, that they must be adapted for a blind student. As Henrique explained, before they were translated into models or diagrams, they were conceptual descriptions, which depend on the scientific language.

The major dilemmas are concentrated in practical classes because they stage multiple clashes to the inclusive processes, mainly concerning the adaptation and accessibility to both audiences (blind and low vision). Ellen mentions that, due to her condition, she did not execute most of the laboratory activities: "I was not dismissed from the classes, I had to stay there, but practically all experimental classes I didn't do so much […])". Gabriel also explains that he goes to the lab but does not run the activities.

> I have to do all the experiments by myself, then when I say that I have a problem, everyone panics: "he's gonna break a glassware", which makes a guy shy. And then usually the reports are in a group, they put my name there, and everything goes fine, but this doesn't seem right. (Gabriel)

So, they are in the environment, but they do not consider themselves as part of it. They feel excluded from the practical laboratory activities. The absence of full and equal access to these spaces, in comparison to sighted students, harms the visually impaired students' formation, as pointed out by Mariano and Regiani (2015).

In view of these factors, there are countless possibilities for including visually impaired students in the practical classes. It is only necessary to have some direction in this sense. The use of audible thermometers, buttons adapted for Braille, change of visual for audible signals, and multisensory methodologies are strategies that can be adopted to make these spaces more accessible. Nowadays, we see that most of the work done in labs is automated due to the improvement and evolution of the analytical techniques and equipment (Eichler et al., 2018). Additionally, scientists do not work alone, which opens possibilities to include some steps and scientific activities aimed at visually impaired people.

Another feature of STEM courses is the mathematical language. The belief that visually impaired people struggle with math is based on prejudice. The interviewed students attending STEM courses all stated that they never had any math problems. As Daniela said: "Genetics, that is almost the math in health areas […], I have always done really well. I do the calculations in my head". The difficulty is centered on the adaptation of calculations. Even the participants that do not act in these areas admit that the challenges with math are due to the lack of accessibility and attitudinal barriers, as Fábio denotes: "In my High School when I had to study some math subject, I faced some serious issues". According to him, these problems were not caused by calculations: "calculations, in comparison to the lack of accessibility and the incomprehension of the teacher, are smooth".

Carvalho et al. (2018), anchored in Vygotsky (1997), suggest that the use of the conventional mathematical language may harm the mediation process since the symbols are not understandable for the different screen reader software, which can result in a "failure" feeling and discouragement for the students. However, the accessibility cannot be understood "as a guarantee of success for the comprehension mechanism, but an important step towards the 'super comprehension'", as stated by Carvalho et al. (2018, p. 430). The authors recommend the LaTeX language as a potential tool to promote accessibility, considering the knowledge that depends on mathematical calculations. This resource is not restricted to visually impaired people since it was already used by sighted people, manifesting a dialogical feature, thus favoring students' relations.

Regiani and Mól (2013) point that the inclusion process depends on each course lectures' characteristics. Some would favor inclusion, while others would not. Corroborating with this, Daniela relates that she had severe issues with the Histology and Botany classes due to the need to examine thin sections on the microscope, which were not possible, even using a magnifying glass:

> We tried to adapt also with the screen, magnifying the images. However, we could not find an adaptation that was enough for me to understand some of the stuff. I understood the drawings, but I could not identify them when the teacher showed me the thin section. Do you understand me? The same with the plants […], this reflected my interest and, consequently, my Botany grades. In Histology, it was different. In Histology, the teacher made other types of adaptations. So, she adapted the grades according to what I was able to do because I had some interest, but in Botany, I felt so frustrated, which reflected in my grades. (Daniela)

The adaptation process does not necessarily involve creating tactile models. It may be done in other ways. Although touch is an important means of information for the sightless, evidently, it is not the only one (Nunes & Lomonaco, 2010, p. 57). The adaptation may be achieved by the flexibilization of exams, as reported by Danila. Costa (2018) outlines that one of the systems for inclusion at the Higher Education level is the flexibilization of the evaluation processes and the curricular adaptations. From the participants' testimonies, we apprehend that there is resistance in STEM courses regarding the exams' adaptation, especially the ones made in practical classes. In this way, we must consider that it is solely the teacher's responsibility for these adaptations. For this, they require the best working conditions, a specific formation, and specialized educational attendance from the universities.

3.4 Teachers' role and formative aspects

The speeches of the participants reveal what they think about the role of professors and the formative aspects. As professors build up perceptions and articulate knowledge with the teaching practice, the students formulate their ideas on how the "ideal" professor should be. Ellen's testimony clarifies this practice:

> When the professor is an open-minded and receptive person and a true educator, he doesn't need to be hindered by external programs to listen to his students and try to adapt [the classes and materials]. He, in fact, seeks help for these programs [support centers]. In particular, a professor of mine sought the [support] center actively, searching for resources. For me, it was something praiseworthy. (Ellen)

One of the available resources that Ellen talks about is the support centers. They are responsible for providing specialized educational attendance in Higher Education institutions. According to the 5th paragraph of the Brazilian Decree no. 7,611, of November 17, 2011, the accessibility centers in the Higher Education federal institutions aim to eliminate physical, communication, and information barriers, that restrict the social and academic participation and development of students with disabilities. Besides breaking up attitudinal barriers, these centers' activities can bring educational support for the students, in and out of classrooms, sharing a responsibility that is often attributed to the professors.

Specific teaching knowledge must deal with visually impaired students in STEM courses (Camargo, 2012). For example, knowing how to link scientific concepts through representations that do not rely only on vision; and, as pointed out by Paula et al. (2017), to know how to work with the mathematical language; to understand how to perform activities for both sighted and visually impaired students (p. 874). The authors also conclude that the chemistry professors must discuss chemical concepts' vision dependence, which can be extrapolated to STEM.

However, the domain of these notions cannot be limited to the inclusive process, once there is a belief that professors must be prepared before beginning the inclusion process (Griboski & Alves, 2013). This issue is at least contradictory, recognizing the existence of laws that reinforce the need to train teachers for inclusive teaching (Silva & Mól, 2018). Due to this unpreparedness and knowing that inclusion is an ongoing process, we must not wait for professors or students to feel able to change. Instead, this formation must and needs to occur in parallel to classroom practices. The professional qualification regarding school inclusion requires expertise beyond scientific background because the professor often will face singularities, ambiguities, and values different from him/her know-how, demanding the development of skills to face reality from an inclusive science context.

The problem precedes these issues since the notion that learning STEM is difficult is rooted in people's minds, and the demystification of prejudices on this also depends on (in part) the professor and is related to his/her science conception (Silva & Mól, 2019). Scientific thinking believed to be neutral disregarding diversity, probably, will exclude the students with special needs. Instead, sciences are a human endeavor; thus, they are engaged in a cultural framework, and their agents are inevitably immersed in this culture.

Professors have been assuming that it is possible for visually impaired people to graduate in STEM courses (Bohnert & Mól, 2018; Mariano & Regiani, 2015; Silva & Mól, 2019; Veraszto et al., 2014). However, how to make this possible? Besides promoting changes in professors' and colleagues' science conceptions, the universities must take a series of measures, such as the implantation and operation of support centers, hiring specialized professionals, infrastructure investments (especially in labs), continuing education, and promoting programs for students. Bebeto describes an episode experienced by a blind colleague:

> I met a blind lady in the [university]. A professor said to her: "Oh, inclusion is really easy", but in theory… In practice, it is different. This comment discouraged her for real. Inside the university, I think that the experience I had on my first undergraduate course says that the maintenance of this dark trajectory, mainly in this technical course… It starts more inside the universities than outside of them. (Bebeto)

Ellen and Bebeto's testimonies suggest that the STEM courses would have their organizing structure, and most of the inclusion barriers are related to the professors' attitudes in these courses, which have postures more ableists and segregating than in other courses. Ellen reports the treatment received by students with special needs defining their future when they feel abandoned or forced to change courses, as was reported by Ellen. In this way, a STEM course would have a colder, 'darker', more technical, and competitive nature. This would make the inclusion process harder, as stated by Bebeto. Maybe, this 'cold and dark' nature can also be related to the prevailing science conception.

Ellen categorizes the professors that do not get involved with inclusive questions as "neutrals" and explains that they do not get involved because of their excessive workload. In fact, the universities' productivity demands place teaching activities on a second level (Regiani & Mól, 2013). It is implicit in Ellen's speech that this involvement is kind of "help" to the students, while it should be part of the professors' work:

> They [professors] do not deny the help but obviously want to minimize the work. If needed, they accept the university's command, but they do not search outside. Some professors, which are excellent people, actively seek to help and are interested in this subject [inclusion], face as an opportunity for learning, as a new challenge. (Ellen)

One of the biggest obstacles of learning for visually impaired students focuses on the teachers' training, which "need to have access to adapted materials, as well as physical and psychological conditions to create the adaptations needed for teaching the student" (Nunes & Lomônaco, 2008, p. 135).

Concerning the initial STEM teachers training for school inclusion, we warn guidelines and plans to execute what has been discussed and elaborated in legislation and specialized research. For instance, the Chemical Braille for use in Brazil could be a mandatory course for teachers, as Brazilian Sign Language (Libras) courses already are. Accordingly, Special Education courses could be instituted in teachers' curricula. Finally, we suggest the continued training for the inclusion of students with special needs in a STEM course, regarding the Special Education knowledge, also includes professors that have not studied to become teachers.

4 Concluding remarks

This study contributes to the literature, considering the limited amount of research that aims to discuss visually impaired people's invisibility, under the student's perspective, specifically in a STEM course. We consider that the low incidence of blind and low vision students in these areas has posed the main difficulty of developing this research and future works. The testimonies' critical analysis allowed us to identify the students' profiles who aim to follow a STEM career and the ones who not. Additionally, we reported their achievements and the main obstacle they face, resulting in withdrawals; besides, we suggested some alternatives to break these barriers.

Besides the lack of interest of visually impaired students for STEM's course, due to multiple difficulties here discussed, these courses are marked by ableism, a sociological phenomenon, so for, not approached in this scope. We noticed that in these courses, specific features affect the inclusion of visually impaired students: the laboratory is still understood as only for sighted students, causing resistance in adapting practical classes and refusal from colleagues to work with these subjects; the need of tutors, which we recommend not to be colleagues from the same class. Another systemic barrier from STEM courses is the resistance to adapting the exams.

The limitations of not doing an assignment are not inherent to the visually impaired students; they result from a society that does not provide the means for their inclusion. In fact, the students' limitations should motivate the professors to rethink strategies and not transfer their responsibilities to the students, assuming an ableist posture. It also happens when professors do not allow the students to be present in the practical classes or make them "invisible" in the laboratory without participating in the activities. Considering this problem, the support centers are vital.

We punctuate that there are other ways to facilitate the inclusive processes, besides the screen reader programs and the tactile materials, commonly used in STEM courses. Other under-explored possibilities, such as improving conceptual descriptions of scientific contents and the multisensory methods, which can be useful in lab classes, are viable and promising alternatives.

Our study shows the importance of providing public policies and institutional measures to encourage blind and low vision students to become interested, to enroll and stay in STEM courses, also serving as a stepping stone for future research. Beyond denouncing of invisibility, we contribute to the dismantling of ableist postures. Understanding visually impaired students' invisibility goes further into the comprehension of the reasons that lead to invisibility. It requires an investigation of the importance of visuals for the production of knowledge in these areas and knowing the perception of these people related to science and scientists, topics that will be covered by future work.

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