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ARTICLE

The Teaching of Botany in a Portuguese–Libras Bilingual Context Based on Historical-Cultural Theory

Gustavo Fernandes Rodrigues[1]
https://orcid.org/0009-0006-1229-8256

Lidiane de Lemos Soares Pereira[2]
https://orcid.org/0000-0002-8471-7169

Anna Maria Canavarro Benite[1]
https://orcid.org/0000-0002-8750-7319

ABSTRACT:

This article, grounded in Historical-Cultural Theory, investigates the conceptual appropriation of deaf students in a bilingual environment, with a focus on the teaching of Botany. To this end, a didactic sequence composed of four pedagogical interventions was developed and implemented in 2023. The research employed questionnaires, image-based activities, and video recordings as data collection instruments, which were analyzed through conversation analysis. The results indicate that visual pedagogical strategies enhance the learning and development of deaf students, as they function as mediating signs in the process of knowledge construction. Experimentation, by promoting social interaction and observation of natural phenomena, supports the appropriation of scientific concepts. However, the study also highlights linguistic barriers and the limited stimulation of language, which hinder the acquisition of spontaneous concepts and compromise the development of scientific knowledge.

Key words:
Botany; Deaf; Vygotsky

O ensino de Botânica em contexto bilíngue Português-Libras a partir da Teoria Histórico-Cultural

RESUMO:

Esse artigo, fundamentado na Teoria Histórico-Cultural, investiga a apropriação conceitual de alunos surdos em um ambiente bilíngue, com foco no ensino de Botânica. Para isso, foi elaborada uma sequência didática composta por quatro intervenções pedagógicas, aplicadas em 2023. A pesquisa utilizou questionários, atividades imagéticas e a videogravação como instrumentos de coleta de dados, analisados por meio da análise da conversação. Os resultados indicam que estratégias pedagógicas visuais potencializam a aprendizagem dos surdos e seu desenvolvimento, pois atuam como signos mediadores no processo de construção do conhecimento. A experimentação, ao proporcionar interação social e observação de fenômenos naturais, favorece a apropriação de conceitos científicos. No entanto, a pesquisa também aponta barreiras linguísticas e o pouco estímulo à linguagem, fatores que dificultam a aquisição de conceitos espontâneos e comprometem a elaboração de conhecimentos científicos.

Palabras-clave:
Botânica; Surdos; Vigotski

[1] Federal University of Goiás (UFG), Goiânia, Goiás, Brazil.
[2] Federal Institute of Education, Science and Technology of Goiás (IFG), Anápolis, Goiás, Brazil.

La enseñanza de Botánica en un contexto bilingüe Portugués-Libras desde la Teoría Histórico-Cultural

RESUMEN:

Este artículo, basado en la Teoría Histórico-Cultural, investiga la apropiación conceptual de estudiantes sordos en un entorno bilingüe, con un enfoque en la enseñanza de Botánica. Para ello, se elaboró una secuencia didáctica compuesta por cuatro intervenciones pedagógicas, aplicadas en 2023. La investigación utilizó cuestionarios, actividades visuales y grabaciones en video como instrumentos de recolección de datos, analizados mediante el análisis de la conversación. Los resultados indican que las estrategias pedagógicas visuales potencian el aprendizaje y desarrollo de los estudiantes sordos, ya que actúan como signos mediadores en el proceso de construcción del conocimiento. La experimentación, al permitir la interacción social y la observación de fenómenos naturales, favorece la apropiación de conceptos científicos. Sin embargo, la investigación también señala la existencia de barreras lingüísticas y una escasa estimulación del lenguaje, factores que dificultan la adquisición de conceptos espontáneos y comprometen la elaboración de conocimientos científicos.

Key words:
Botánica, Personas Sordas; Vygotsky

INTRODUCTION

The Brazilian Sign Language (Libras) was recognized as a legal means of communication and expression for the deaf community in Brazil by the Law No. 10,436/2002. This legal milestone consolidated Libras as a language with its own grammatical structure, ensuring linguistic and educational rights for the deaf community. Although it is not considered one of the country's official languages (Bueno, 2019), Libras is recognized as the language of identity for the Brazilian deaf community, which represented a significant advancement in the inclusion and accessibility of this population.

Based on this legislation, several regulations were enacted with the aim of ensuring access to bilingual education, in which Libras is established as the first language and Portuguese, in its written form, as the second. Among these regulations, Decree No. 5,626/2005 stands out, as it regulates the teaching of Libras, the training of professionals qualified to work in Deaf education, and the mandatory inclusion of Libras as a subject in teacher education programs. Furthermore, Law No. 14,191/2021 reinforces the bilingual nature of education for the Deaf, ensuring specific measures to promote learning in Libras and the development of accessible teaching materials.

Despite legislative advancements, the implementation of bilingual education for Deaf students still faces significant challenges. Studies indicate that the inclusion of Deaf students in regular education without proper curricular adaptation and without appropriate bilingual methodologies has resulted in largely ineffective educational processes (Souza, 2020; Vieira-Machado & Costa-Júnior, 2018; Ferreira & Chahini, 2024). The mere presence of Libras Translators and Interpreters (LTIs) in the classroom, although essential, is not sufficient to ensure the full participation of these students, as linguistic accessibility goes beyond simple translation and requires specific pedagogical strategies that support the teaching and learning process. In light of this, researchers and the Deaf community advocate for the creation of bilingual schools as the most effective alternative for the education of this population, providing an environment in which Libras is the primary language of instruction.

The education of Deaf students in Brazil has historically been marked by oralism and total communication, methods that, despite criticism for disregarding Libras as the natural language of Deaf individuals, still persist in some educational practices. These approaches, by prioritizing speech and lip-reading, often result in barriers to the linguistic and cognitive development of Deaf students (Goldfeld, 2002).

Currently, the schooling of the Deaf population takes place both in bilingual schools—where Libras is used as the first language and Portuguese, in its written form, as the second—and in inclusive classrooms within regular schools (Strobel, 2008). In the inclusive model, Deaf students have the legally guaranteed right to the presence of an ESLI, regardless of the educational institution. This right is ensured by Law No. 10,436/2002, regulated by Decree No. 5,626/2005, which establishes the mandatory presence of interpreters in public schools whenever necessary.

In addition to these regulations, documents such as the National Policy on Special Education from the Perspective of Inclusive Education (2008) and the National Common Curricular Base (NCCB) discuss the importance of valuing Libras in the schooling of Deaf students, as well as the need to respect their linguistic particularity. However, debates persist regarding the effectiveness of these policies, highlighting the importance of understanding the relationship between language, linguistic expression, and access to knowledge in order to assess the impact of different educational approaches.

In light of the above, it is pertinent to question how education for Deaf students in different areas of knowledge is being carried out. To raise this discussion, we present research within the field of science education, with an emphasis on Botany.

Researchers such as Pereira (2020), Santana & Sofiato (2018), and Picanço, Andrade Neto & Geller (2021) emphasize in their studies that the education of Deaf students within the field of natural sciences is still incipient. In general, research has focused on the production of didactic materials, the development of differentiated methodological strategies, teacher training, and the creation of Libras sign glossaries. However, it is essential that researchers seek to understand how aspects inherent to language impact the learning and development of Deaf students.

Although not specifically addressing the teaching of Botany to Deaf students, Salatino & Buckeridge (2016) point out that the insufficient training of many teachers in this field results in a lack of enthusiasm for the subject, directly impacting their ability to motivate students to engage with it. This lack of interest among students perpetuates a harmful ongoing cycle, as future teachers become less likely to develop an appreciation for Botany, thereby maintaining the lack of enthusiasm in teaching this discipline.

Furthermore, the teaching and learning process of Botany takes place mostly through textbooks and theoretical lessons, often disconnected from the everyday experiences of students in basic education (Leite & Meirelles, 2021). To reverse this scenario, it is essential to implement pedagogical practices that contextualize botanical knowledge, bringing students closer to the environment and making learning more engaging (Silva et al., 2021).

Some authors have undertaken the task of introducing Botany to Deaf students while valuing their specificities, for example, Rodrigues et al. (2020), who, in collaboration with the Deaf community, created 50 sign-terms to represent botanical concepts; Pizzolatto (2021), who developed a blog with e-books, video lessons, and supplementary materials for both Deaf and hearing teachers and students on Botany content; and Silva & Santos (2020), who proposed teaching Botany through visual pedagogy. In this context, grounded in Vygotsky's Historical-Cultural Theory, this article aims to investigate the conceptual appropriation of Deaf students in a bilingual environment, with a focus on Botany, using strategies such as visual resources and experimentation.

DEVELOPMENT AND LEARNING OF DEAF STUDENTS FROM VYGOTSKY'S PERSPECTIVE

For Vygotsky, language is not merely a means of communication, but an essential tool for organizing thought and internalizing knowledge. Although Vygotsky passed away at an early age and his research did not specifically address sign language in a complex way, he was able to demonstrate through his writing that the development of Deaf individuals, when compared to that of hearing individuals, occurs in an equal manner, with social aspects being the distinguishing factor. For this reason, he played a pioneering role in recognizing the importance of language and social interactions in the education of Deaf individuals. His theoretical approach

provides a solid foundation for bilingual pedagogical practice, promoting full development and access to knowledge for Deaf people.

For Vygotsky (2008), the origins of higher psychological functions must be found in the social relationships that the individual establishes in contact with the external world. For him, cultural integration fosters development in such a way that "the true course of the development of thinking is not from the individual to the socialized, but from the social to the individual" (Vygotsky, 2008, p. 24). Therefore, it is through interaction that cognitive development occurs.

Signs are crucial elements in Vygotsky's theoretical framework and in the understanding of human development. Vygotsky (1998) understands signs as essential mediators between the individual and the surrounding social and cultural world. These signs are systems of tools, including language, writing, numerical systems, and other conventional symbols created by society. They serve as a kind of bridge between individual experiences and shared cultural heritage, allowing individuals to develop culturally and reach more complex levels of thought and learning. By using these signs, people are able to communicate, plan, reason, and solve problems, transcending the boundaries of purely sensory and immediate thinking.

Vygotsky was one of the first researchers to dedicate himself to the study of the development of people with disabilities. Tunes & Prestes (2021) highlight that Vygotsky was always interested in studying the development of individuals with disabilities, and his concern was to uncover the internal essence of the pathology, that is, how the disability impacts development and how its resulting effects interfere in a human being's life. According to Vygotsky (2021), compensatory processes constitute the key to understanding the cultural development of people with disabilities.

Vygotsky (2021) argues for the idea of compensation from a social perspective, for him, "the feeling or awareness of insufficiency, which arises in the individual as a result of the defect, is the evaluation of their social position and becomes the main driving force of psychic development" (p. 56). Thus, he makes it clear that the education of people with disabilities must be based on the fact that, simultaneously with the disability, compensatory possibilities for its overcoming are also given, and this should be included in the educational process as its driving force.

Vygotsky (2008) also stated that the main means by which individuals' appropriate scientific knowledge is through school. In the schooling process, teaching should revolve around that which is not immediately present—thus, it goes beyond immediate experience, which refers to direct and sensory interaction with the environment without the mediation of tools or signs. In this context, the author argues that valuing spontaneous knowledge and concepts—which are ideas and understandings formed intuitively through direct experiences, without reflection or systematic elaboration—is essential, but that at the same time, these must be transcended in order to reach greater conceptual complexity and generalization.

According to Vygotsky (2008), when a child enters school, they have already formed spontaneous knowledge and concepts. However, in the case of Deaf children, this situation is different. According to the findings of Santana (2007), 90% of Deaf individuals are born to hearing parents, and this has an impact on the lives of Deaf children, as they receive limited language stimulation and enter the school environment with a deficit in the formation of these concepts (Dalcin, 2006; Moura, 2013).

This lack of language stimulation can lead to emotional, social, and cognitive consequences, even if the individual later learns a language (either Libras or spoken Portuguese). These languages are often imposed inappropriately due to various social and historical factors. Thus, "due to the difficulties caused by language issues, it is observed that Deaf children are behind in terms of schooling, lacking adequate development and possessing knowledge below what is expected for their age" (Lacerda, 2006, p. 165).

The issue outlined above can limit the Deaf student's access to scientific concepts. For Vygotsky, scientific concepts are elaborated forms of knowledge that go beyond immediate experience and are constructed through tools and symbolic mediation, such as language and culture, allowing for a more advanced understanding of the world. He argues that scientific and spontaneous concepts must interact and converge in order to form scientific concepts that are meaningful to the individual (Barbosa, 1997). Furthermore, according

to Vygotsky, the sign is the word, and, at first, it functions as a mediator in the formation of a concept and later becomes its symbol. Signs guide human behavior in the process of concept formation (Oliveira & Benite, 2015).

According to Veras & Daxenberger (2017), Vygotsky demonstrated an evolution in his understanding of the issues surrounding the development of Deaf individuals through language. At first, he was favorable to oralization, which coincided with the height of oralism—a movement intensified after the Milan Congress in 1880, which banned the use of sign language. In a later phase, Vygotsky (2011) changed his perspective by stating that "speech [...] can be carried out through another system of signs, just as writing can be transferred from the visual path to the tactile one" (p. 868). He further emphasized that "only the great cultural experiment that proved it is possible to read with the fingers and speak with the hands reveals to us the full conventionality and flexibility of cultural forms of behavior" (p. 868).

Vygotsky (2021) also mentions mimicry and different forms of language as important tools for the development of the Deaf individual. It is important to note that sign language had not yet acquired linguistic status at the time, a recognition that only occurred in 1960 with Stokoe's studies on American Sign Language. The fact that Vygotsky considered mimicry as a linguistic resource for Deaf individuals broadens the educational perspective toward them, contributing to their access to language.

In this context, bilingualism—a proposal grounded in the creation of a bilingual environment in which both sign language and the country's majority language are used to promote the linguistic and cognitive development of Deaf individuals—emerges as a response to the Deaf community, as it recognizes their natural language and brings forth elements of Deaf culture and identity.

METHODOLOGICAL PROCEDURES

This research is grounded in historical-dialectical materialism (HDM). HDM was developed by Karl Marx (1818–1883) and Friedrich Engels (1820–1895), and it constitutes a theory aimed at analyzing social, economic, and political structures from the perspective of class relations, class struggle, and historical development. In a similar vein, the Cultural-Historical Theory (CHT), as proposed by Vygotsky, is a psychological and educational approach that focuses on the influence of social and cultural contexts on human development, learning, and behavior. Therefore, we maintain that Vygotsky and his CHT permeate the entire discussion proposed in this study, which aligns with the HDM method (Duarte, 2000).

Dialectics makes it possible to understand the relationship between subject and object, as well as the formation of the human being based on lived reality, since the human being is both a product of society and an agent in its construction. According to Malinski (2012), dialectics implies a continuous and evolutionary movement, in which contradictions are resolved and overcome, leading to new stages of development. This process is cyclical and unfolds throughout history, aligning with the premises of action research, which was adopted as the foundation for the experience described. In the words of Tripp (2005), "educational action research is primarily a strategy for the development of teachers and researchers, so that they can use their research to improve their teaching and, consequently, student learning" (p. 445).

In this sense, we proposed an action research cycle that considers the teacher as the one responsible for the action, which must be planned, developed, and evaluated in an attempt to address an initially identified issue. Therefore, we understand the action research cycle as a spiral, since it never returns to the same point at which it began.

The initially identified issue consisted in answering the following question: How can Botany be taught considering the specificities of Deaf students? Based on this issue, the bilingual teacher-researcher (hereinafter referred to as TR1) and the bilingual Chemistry, Biology, and Science teacher (hereinafter referred to as TR2) planned a didactic sequence composed of four pedagogical interventions (PI), presented in Chart 1.

Chart 1 – Themes and Objectives of the Planned Didactic Sequence.

PI	Themes of the PI	Objectives
1	Presentation / Beginning of the Experiment	Present the project and the group involved; answer the questionnaire (Q1) and deliver questionnaire (Q2) for students to take home to their guardians; assess students' prior knowledge and begin scientific experimentation with planting beans.
2	Fundamentals of Botany	Introduce plant anatomy and morphology by recognizing and identifying parts and functions of plants.
3	Importance of Plants	Recognize the implications of plants in the economy, health, culture, and biodiversity.
4	Evaluation / End of the Experiment	Assess knowledge acquisition and observe the scientific experiment.

Source: Research data.

The didactic sequence presented in Table 1 was carried out at the *Centro Educacional Bilíngue de Surdos* (Bilingual Educational Center for the Deaf) – CEBS in Goiânia (Goiás State, Brazil) during the first semester of 2023. In addition to TR1 and TR2, the didactic sequence involved two teacher educators (hereafter referred to as TE1 and TE2), one guest teacher (GT), four in-service teachers undergoing continuing education (CET1 through CET4), eighteen Deaf students (S1 through S18) enrolled in the three grades of high school, and sixteen students' guardians (SG1 through SG16). It is important to emphasize that ethical considerations in research were respected; therefore, all participants were invited to take part in the study, and those who agreed signed the Informed Consent Form.

The data that enabled the evaluation of the didactic sequence were collected through a questionnaire answered by the students (Q1) and their guardians (Q2), the visual activities used, and the translated and transcribed discursive interactions captured through video recordings of the PIs. It is important to note that the action research cycle reported herein fostered new discussions, which subsequently led to the planning of further actions that initiated new cycles throughout the year 2023.

Data analysis was conducted through conversation analysis. According to Marcuschi (1988), conversation arises from the social nature of human interactions. The author defines conversation as “a focused interaction, involving at least two interlocutors who take turns speaking, each taking the floor at least once, with the communicative event occurring within a shared temporal framework” (p. 319-320). Furthermore, the author understands communication as a combination of verbal (gestural) elements, as well as the nuances that surround it, such as context, intonation, and many others.

Based on the aforementioned assumptions, we understand that conversation analysis, as proposed by Marcuschi, offers an enriching perspective for understanding verbal interactions, highlighting the complexity of dialogue in the production of utterance and counter-utterance. This methodology goes beyond a purely linguistic scope, incorporating an in-depth analysis of the social elements that permeate everyday interactions.

RESULTS AND DISCUSSION

Participant Profile

According to Strobel (2018), Deaf culture is the way Deaf individuals understand the world and adapt it to become accessible and livable through their visual experience and their language. The author states that Deaf culture contributes to the definition of Deaf identity. According to Perlin (2004), Deaf identities are formed based on how an individual relates to Deaf culture. If someone is deeply involved in Deaf culture, learning sign language, participating in events, and interacting with other Deaf people, their Deaf identity may be strengthened. On the other hand, if someone feels excluded or does not identify with Deaf culture, their identity may be less influenced by it.

It is within this context of the multiple identities of Deaf individuals that the questionnaires for students and their guardians were designed. Many of the questions were intentionally repeated in the questionnaire. The goal of the questionnaires was complementarity, that is, when a student was unable to answer a question, their guardian could contribute with a response.

Luz (2013) understands this process as *appearance*, that is, "to assume oneself among others as someone who embodies the singularization of all humanity" (p. 33). Indeed, we understand that many of the students (if not all) have not yet fully achieved this appearance, as they are still unable to narrate their own life stories. In this sense, the use of both questionnaires allowed us to discuss recurring aspects in the life trajectories of Deaf students, especially regarding schooling and the acquisition of Brazilian Sign Language (Libras).

The total number of participating students was 18, and all of them responded to Q1. The total number of questionnaires answered by guardians (Q2) was 16, as students S17 and S18 were over 18 years old and did not wish for their guardians to complete the questionnaire. Among the 18 students, 9 were over 18 years old and 9 were under 18. Their average age was approximately 16/17 years. All students were enrolled in high school, with 4 in the first year, 5 in the second year, and 9 in the third year.

Out of the 18 students who answered the Q1 questionnaire, only 2 stated that they were not born deaf. 11 students said they did not know the cause of their deafness, while 7 provided some reason—among these, only 2 gave more detailed answers; the others mentioned vague reasons such as "got sick" or "was born [this way]." There was a contradiction in the responses from the guardians of three students (S2, S6, and S10). These students said they were born deaf, while their guardians stated that they were not.

In this regard, Strobel (2018) highlights the family as one of the cultural artifacts of the Deaf community. The author explains that the biggest challenge for Deaf individuals with hearing families is the lack of dialogue, understanding, and awareness of Deaf culture. Along these lines, Sacks (1998, p. 38) warns us that "Deaf children need to be exposed first to people who are fluent in sign language, whether they are their parents, teachers, or others."

Of all the guardians, only 1 (one) is Deaf. Moura (2013) states that the majority of Deaf children are born into hearing families, which often results in an environment where sign language is not naturally used. The exception to this rule are individuals whose family members are Deaf or have knowledge of sign language, thus providing a more favorable environment for linguistic development.

Due to the lack of early exposure to sign language, Deaf children often acquire this language later in life, meaning that the school environment is frequently their first point of contact with sign language. However, even in this context, the quality of that contact may be precarious, as not all schools are adequately prepared to meet the needs of Deaf students. This means that, while being introduced to sign language, Deaf students are also being exposed to new, systematized knowledge that is part of school culture. This complex situation has a profound impact on the learning process of Deaf students. The late acquisition of sign language and the precarious provision of education can create significant challenges, making learning more difficult and, in some cases, resulting in educational delays (Moura, 2013).

Regarding the cause of deafness, we observed from the responses of the guardians that the factors range from premature births, malformation, cerebral palsy, side effects of antibiotic use, genetic factors, and lack of oxygen. In the cases where the cause is unknown, it either remains unidentified or has never been discovered.

In relation to the beginning of learning Libras and the schooling process, among the 18 responses from the students and their guardians, 7 showed significant discrepancies concerning the age at which the students began learning Libras, when compared to their guardians' (SG) answers. According to the guardians, out of the 18 students, 2 learned Libras at the same time they started school, while 10 learned Libras after having already started their schooling.

Regarding the knowledge of Libras by the students' guardians, SG14 stated not knowing Libras, yet reported being able to communicate with S14. SG9, SG13, and SG15 said they knew only a little Libras. Trindade (2017) points out that psychology recognizes communication as mediated by language; however,

many parents of Deaf children do not have knowledge of Libras. The author further adds that for Deaf individuals to communicate effectively and achieve full development, it is crucial that their families, friends, and others within their social circle are proficient in sign language – Libras. Nevertheless, this challenge persists for many families, making it difficult to maintain effective communication with their Deaf children.

Of the 18 students, only S8 attends specialized services (speech therapist), and 6 (S1, S2, S4, S6, S10, and S12) receive additional support during the opposite school shift to learn Portuguese as a second language. Among the 16 guardians (SG) who responded, only one is male; however, he is not the student's father, but the grandfather. All other participants are female, the vast majority being the students' mothers.

Based on the participants' profile data, a plurality of Deaf identities becomes evident. The research subjects are diverse, and the questionnaires suggest that students may be at different stages regarding the acquisition of Libras, as well as in their concept of self in the world, since many of them were exposed to both Portuguese and Libras at a later stage. Nevertheless, in this particular group, the guardians proved to be very present in the students' lives and showed genuine interest in learning Libras in order to communicate with them.

Analysis of the Discursive Movement in the Bilingual Classroom

The objectives to be achieved in PI1 consisted of presenting the research to all those involved, administering Questionnaire Q1 to the students and handing out Q2 for them to take home for their guardians to complete, conducting a preliminary survey of the students' prior knowledge regarding the content to be addressed, using an image-based activity, and initiating a hands-on experimental activity using beans (*Phaseolus vulgaris*).

Thus, PI1 began with the presentation of the research by TR1 and TR2. Most of the students were already familiar with TR1, as he had participated in a previous cycle of the action-research project; however, those who did not know him wanted to know where he had learned Libras. TR1 responded that he had learned it at the *Núcleo de Capacitação de Profissionais da Educação e de Atendimento às Pessoas com Surdez* (Center for the Training of Education Professionals and Services for the Deaf) – NAS, in Goiânia.

After this initial conversation, the Q1 questionnaire was handed out to all students, and TR1 interpreted each question, pausing after each one to allow them time to respond. Following this activity, TR1 distributed the Q2 questionnaire and emphasized the importance of students taking it home for their guardians to answer and returning it the following week.

Next, TR1 began assessing the students' prior knowledge about the content to be covered through an image-based activity (Figure 1).

Figure 1 – Visual activity for inicial student assessment.
Source: Author's own work.

During the activity, many students showed facial expressions of doubt. Some asked how to write certain words in Portuguese, while others asked TR1 to fingerspell—the representation of Portuguese words using the manual alphabet of Libras. TR1 explained that he could not assist at that moment and that, if they didn't know the answer, they could leave it blank. At that point, TR2 had to intervene, reiterating that the activity would not be graded and was only meant as a diagnostic assessment.

Most of the students did not spell the words *leaves*, *fruits*, *roots*, *stem/trunk*, and *flowers* correctly. The anatomical parts of the plants that showed the greatest variety of responses were *leaves* and *stem/trunk*. The other parts, *fruits*, *roots*, and *flowers* received fewer responses.

According to Vygotsky (1998), social interactions and the cultural environment directly influence language development. In this sense, social interactions established with Deaf individuals in sign language are essential for the acquisition and development of language. However, since they are part of a predominantly hearing community, it is necessary to ensure an education that also allows Deaf individuals to develop written Portuguese.

The discussion undertaken by Góes (2012, p. 4) indicates that the schooling of Deaf students, particularly in terms of written production, "tends to be constituted by rather limited experiences, which create learning conditions that are not very conducive to mastering the Portuguese language." The author adds that learning tends to explore written language very little, especially in the early grades, and that there is an emphasis on grammatical rules, which are not mastered by the students.

Furthermore, Vygotsky (2004) emphasizes that the development of written language does not depend on the development of speech, therefore, the writing process is not built during the early years of schooling, but rather throughout the student's life. In this case, we can infer that if the students had been asked to identify the

parts of the plant only in Libras, their responses would likely have shown greater accuracy compared to their responses in Portuguese.

Right after conducting the students' prior knowledge assessment, we began the practical, experimental activity, which consisted of planting beans. This activity was chosen because it allowed us to address several core and related concepts of Botany, which would be explored in the upcoming PI. The planting took place during PI1, and throughout PI2, PI3, and PI4, the observed changes were discussed. This strategy proved to be relevant, as when asked if any student had previously conducted bean planting experiments at school, only 2 (two) students said they had.

Among the materials used for the practical activity were disposable plastic cups, commonly used for serving broths, which were pierced to allow water drainage; soil rich in humus; cotton; pens; and beans. Each student received two disposable cups—one with three holes and another with two. The cup with three holes was to be filled with soil, while the one with two holes was to be filled with cotton. With these two types of planting, we aimed to gather enough observations to understand the differences between the cups with cotton and those with soil.

TR1 demonstrated how to proceed with the two cups, showing the amount of soil and cotton to be used and how to place the beans in each case. Then, he handed out the cups to each student, asked them to write their names on both cups using the pens, and allowed them to carry out the entire process on their own. The students were excited about the activity and began to engage in dialogue with each other, trying to help one another with the quantities and procedures.

These dialogues were frequent throughout the four PI, occurring naturally in Libras, without interference from TR1, and often referred to experiences from the students' family environments and the use of spontaneous concepts. This highlights that the students were engaging in a peer-based learning process and that spontaneous concepts play an important role in the development of scientific concepts.

According to Vygotsky (2008), the learning of scientific concepts takes place at school through cultural and social tools that mediate the interaction between the individual and the world around them. Teachers and more experienced peers play a crucial role as mediators, providing support and guidance to foster cognitive development.

It is worth noting that the questions the students discussed among themselves during the bean planting activity guided TR1's actions in the following PI. Thus, at the end of the practical activity stage, the students placed their pots in an appropriate location with access to sunlight. TR2 explained that since classes would take place only once a week, she would water all the pots on alternating days.

PI2 aimed to elucidate the morphological parts of plants, from the macroscopic to the microscopic level, as well as to explain their physiological functions. To diversify the approach and provide students with a visual and real-life experience, various types of plants were collected near TR1's home and displayed on a table. Figure 2 shows the collected plants.

Figure 2 – Plants collected for student analysis.
Source: Research data (2023).

That day, the students were excited to see the progress of the beans; however, TR1 told them they would check them at the end of the lesson. TR1 then asked the students to observe the plants displayed on the table and began a dialogue by asking about their characteristics and whether they were familiar with them. Most students recognized only two of the plants: mango and aloe vera. The mango was identified by S9 when TR1 held up a small branch with leaves and he said, "*Mango! Very tasty.*" Aloe vera was recognized by S7, who said, "[...] *my grandma has one at her house*," by S9, who said, "*My mom and my aunt use it [aloe vera] on their hair, they've even used it on mine,*" and by S11, who said, "*I think it smells bad, I don't like the smell.*" These statements once again reveal how spontaneous concepts manifest themselves in the school environment.

According to Vygotsky (2008), spontaneous concepts are acquired informally through everyday social interactions and reflect children's practical and intuitive knowledge about the world around them. In this sense, when S9 shared that his mother and aunt use aloe vera on their hair, he was drawing from his memory and practical knowledge about the plant displayed on the table. TR1 then followed up by explaining that aloe vera is used to moisturize hair and is also an ingredient in the production of shampoo, soap, and makeup.

However, it is important to emphasize that, for Vygotsky, the acquisition of scientific concepts from spontaneous concepts is not a passive process. Instead, he highlights the importance of educational mediation and the Zone of Proximal Development (ZPD). The ZPD "defines those functions that have not yet matured but are in the process of maturing, functions that will mature, but are currently in an embryonic state" (Vygotsky, 1998, p. 113). In this context, mediators—whether teachers or more experienced classmates—play a vital role by providing the support and challenges necessary to help students develop a more advanced and scientific understanding of the concepts.

Next, TR1 began teaching the scientific concepts related to the parts of the plant (leaves, trunk/stem, root, fruits, and flowers), using the classifier (CL) for the noun *tree*, as shown in Figure 3. It is important to highlight that the CL was used even to address the concepts of *fruit* and *flowers*, for which specific signs exist independently of the CL. The strategy of using the CL aimed to help students relate the specific concepts (the parts of the plant) to the general concept (plant/tree).

Figure 3 – Classifier used for the noun “tree”.
Source: Authors.

The excerpt 1 below illustrates, as an example, the approach to teaching the scientific concept of *leaf*. In this excerpt, we observe the hypotheses formulated by the students regarding the function of leaves in plants.

Excerpt 1

TR1: And what about the leaf, guys? What do you think is the function of the leaves? Come on! It’s your turn to speak without fear.

S9: I think they do the breathing.

S7: The cows eat them.

S3: To protect from the sun.

[...]

TR1: Yes, leaves have many, many functions, but the main one is photosynthesis. They receive energy from the sun, and there is a gas exchange between CO_2 and O_2. That’s why plants are so important—they produce oxygen. They also contribute greatly to air humidity, and thanks to plants, the air becomes easier to breathe […]. Plants can also use leaves to store energy—many animals eat plants, including us.

The 3rd-grade students were generally more participative. S7, S9, and S11, for example, were 3rd-grade students, and their active involvement can be observed throughout the excerpts. In this case, as Vygotsky emphasizes, these students can be considered by their peers as the more experienced ones. On several occasions, it was possible to see the other students observing them attentively and giving credibility to their hypotheses about the phenomena being discussed.

In the specific case of the concept of leaves, we observed that it is intrinsically linked to the concept of photosynthesis. Therefore, it was important for the students to understand that photosynthesis is a chemical reaction involving the substances carbon dioxide (CO_2) and oxygen (O_2), which raised a concern for TR1 about whether he would be understood when signing the molecules. Despite TR1’s concern, when he signed the gas molecules, the students understood what was being presented. It is important to highlight that TR2 has a degree in Chemistry and is also the students’ Chemistry teacher, so they had already internalized the symbolic language (CO_2 and O_2), which represent the molecules of carbon dioxide and oxygen, respectively—key components in the process of photosynthesis.

One strategy to help students represent the concepts (parts of the plant) through writing in Portuguese involved TR1 and TR2 repeatedly using fingerspelling for the structures as they were introduced, asking all

students to practice together. They would fingerspell the words *fruit*, *flowers*, *root*, *leaves*, and *stem/trunk*, letter by letter. Our intention was that the words which did not appear in the activity during PI1 (transcribed into Portuguese) could be learned by the students in future sessions. At the end of this part of the instructional period, as an evaluative activity, each student was guided to freely choose one of the parts and explain it in Libras.

Before wrapping up PI2, we retrieved the small pots with the planted beans and brought them to the table. The students were asked to first look at them for three minutes and analyze what they were seeing. Most of them were excited to see that the beans were growing and began discussing among themselves the appearance and the initial separation of the cotyledons. The goal at that moment was not to discuss the experiment, but rather for them to notice and mentally record the observed changes, as these transformations would be discussed in PI4.

Between PI2 and PI3, there was a three-week break due to the academic calendar, spanning the last week of March and the first two weeks of April 2023. As a result, there was concern that some activities could be compromised, such as the development of the beans that had been planted.

The objective of PI3 was to demonstrate that plants are distributed across different spheres and are important for biodiversity, the economy, and industries, but they also hold cultural value and are present in our daily lives. Salatino and Buckeridge (2016) point out that the teaching of Botany faces a concerning scenario both in Brazil and in other countries. This issue originates from insufficient teacher training, which leads to a lack of interest in the subject and directly impacts their ability to engage students in learning about it. As a result, this lack of motivation perpetuates a negative cycle, in which students who will eventually become teachers tend not to develop an appreciation for Botany, contributing to the ongoing devaluation of this area of teaching.

In an attempt to address the importance of plants to society, PI3 was divided into an exploration of the significance of plants across various sectors, including: pharmaceutical, food, decoration, clothing, cosmetics, construction, air and water, biodiversity, industry, and culture. At all times, the students brought up examples from their daily lives, and TR1 consistently drew on these experiences to help build their scientific understanding.

At the end of this PI, the students went to check on the beans. They were not very satisfied with what they saw, as most of the beans had not germinated as expected. Among the reasons, the main one was the rain, during all the PIs, it had rained heavily in Goiânia. However, with the three-week gap between PI2 and PI3, the students had not maintained routine care regarding the bean planting, and the place where they had been kept was damp due to the rain. Nevertheless, TR1 asked them to observe as many details as possible about the process, since the evolution of the planting would be discussed in PI4.

PI4 aimed to assess the content covered and was divided into three stages. The first consisted of drawing a plant and labeling its structures. The second involved an oral evaluation, and the third consisted of a group discussion about the bean planting experiment.

Thus, blank sheets of paper were first handed out to the students, and they were asked to freely draw a tree—it could be any type of tree—and to write the parts of the plant that we had covered in the previous PIs. In Figure 4, we can see two of these works.

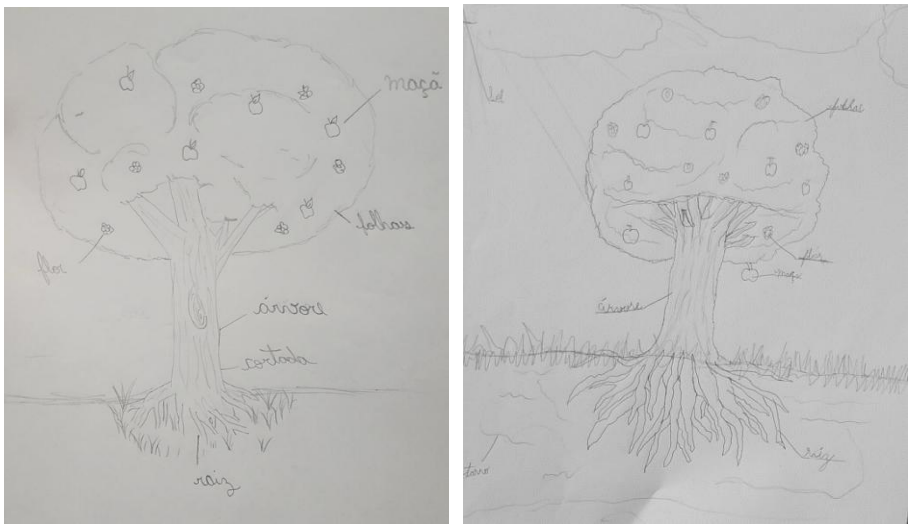

Figure 4 – Images drawn by S2 and S5, respectively.
Source: Research data (2023).

As it can be observed in Figure 4, the drawings correctly represent the parts of the tree, although the names were not written correctly, such as *apple* (for fruit) and *tree/cut* (for trunk/stem). According to Ferreira (2005), when a drawing acquires figurative characteristics that allow it to be interpreted as a representation of reality (as seen on the images in Figure 4), it becomes considered a sign.

According to Oliveira (1998, p. 30), signs "can be interpreted as representations of reality and may refer to elements that are absent from the present space and time." Thus, the relationship mediated by signs (such as the drawings by S2 and S5) allows for a representation of elements from the world, freeing students from the need for concrete interaction with the objects of their thoughts.

We emphasize that the assessment strategies planned for this PI4 were based on the discussion of evaluation from an inclusive perspective. Thus, although the fingerspelling of the plant structures was repeated several times, our intention with the first activity was not for students to produce a literal transcription of the words, but rather to write letters that, in some way, referenced the structures. We agree with Fernandes (2007) that literacy for Deaf individuals involves "the appropriation of reading and writing through meaningful practices, in order to meet different social demands" (p. 5). The author also points out that it is not only Deaf individuals who have difficulties in understanding messages. According to her, many literate people, although able to meet the requirements of school text exercises, are incapable of understanding instructions or writing an argumentative text, and this is related to their form and condition of literacy.

Thus, the second stage consisted of an assessment strategy in which the students had the opportunity to argue, in their natural language — Libras — the importance of plants in society. It is important to emphasize that this topic was addressed in PI3. Entering into the second stage, we recorded videos in a separate area within the classroom. At that time, the pairs would approach, and TR1 would ask a question that each student answered individually. The question was: *Of the ten reasons why plants are important, which we covered in the previous lesson, choose two and explain them.* The answers are presented in Extract 2 below:

Excerpt 2

S1: Plants are important because we eat them – they help us get strong and *avoid getting sick.* And plants are also used to make makeup, to clean the body, clean hair, and make things smell nice. That's it.

S2: Plants are important for building things, like tables, chairs, houses, ships, and the boats the Indigenous people use for fishing. And plants help *us not get sick* – we have to eat them well to *stay healthy.*

S5: They are used to make the clothes we wear, shirts, skirts, blouses, many types of clothing. And *they're important for our health.* We have to eat a lot of them to stay healthy.

S7: We need to eat plants, vegetables, greens to be healthy and not go to the hospital – *they're good for your health*. And they're also used to make medicine, to make tea, to apply to wounds, and to drink to get better, that's also for good health.

S8: Plants are important so we can eat and have a good diet, grow strong and *healthy*. And they're also important for hygiene and cleanliness, like soap, lotion, lipstick, makeup, and cleaning the house.

S10: Plants can be used as decoration – to make the house beautiful, and also to make the city beautiful. And they are used for our health, to eat well, grow, and *develop in a healthy way.*

S12: Plants are important for us to breathe. We breathe because plants help with the air, producing oxygen – breathing clean air that's good to breathe. And I also choose this: plants are important for our health, to eat well *and stay healthy without getting sick* or weak.

S13: Plants are important for our nutrition, so we don't get weak, so we can grow strong and well – stronger and resilient, *and healthy*. Plants are also the homes of many animals, like birds and monkeys that we have here. Plants are their homes and protect them.

S14: Plants are important for building houses, they are strong and resistant and last a long, long time, making houses strong. And we also need to eat plants to have very good *and strong health*, to grow and develop well.

S15: Plants are important in difficult moments like grief – we can give them to the family. But also on happy days like Valentine's Day, Mother's Day, Father's Day – they can be gifts [she shares a personal story]. And they're also important for protecting the forest. We shouldn't burn or throw trash on flowers so we don't pollute the soil and water.

S16: Plants are important for our nutrition, everyone needs to eat them, even animals, dogs, and cats, they need to eat *to grow strong and well.* Plants are also used to make our clothes, this one I'm wearing now, and other clothes too.

Among the responses, we noticed a predominance of the theme of food, as out of the eleven students present in this PI, only one did not mention food as one of their two answers. Luria (1991), a disciple of Vygotsky, refers to the evaluative process described in Extract 2 as a mnestic activity, that is, an activity in which the subject is tasked with memorizing and reproducing material. Based on the author's perspective, we can say that the students carried out a mnestic activity using a type of memory classified as verbal memory, since TR1 addressed the importance of plants during PI3, and in PI4, asked students to recode the content. According to Luria (1991), this process is "linked to the abstraction of secondary details and the generalization of the central elements of information" (p. 67), which allowed students to retrieve the most important aspects of the discussion. These aspects required more time and emphasis during PI3, namely, the importance of plants in the context of nutrition.

The third stage of PI4 consisted of a discussion about the bean planting experiment. First, we retrieved the bean containers that had been stored at the back of the cafeteria and brought them to the table. Each student brought their two containers, one with the beans planted in soil and the other in cotton. The students observed that, out of all the containers on the table, only three had shown noticeable growth and were green and healthy, as we can see in Excerpt 3.

Excerpt 3

TR1: Now let's talk about the bean plant experiment. What can you notice by looking at them?

S8: Mine is dead, it didn't grow.

S7: Mine didn’t either.

S5: Mine grew, here it is, look!

[similar responses]

TR1: Yes, that’s true. But why do you think not all of them grew? What happened?

S15: I think the soil was weak, the beans didn’t grow strong.

S8: There wasn’t enough water. We should’ve watered them more often, it’s dry.

S1: Mine grew a little, but then it stopped, I think.

TR1: There can be many reasons why the beans didn’t sprout or died, but let’s look around us… What’s been happening a lot lately here in Goiânia? *(TR1 pauses for the students to respond)* It's been happening a lot.

S14: I don’t know.

S8: Raining? The rain?

TR1: That’s right! It’s been raining a lot! Do you think rain is good or bad for beans?

S7: Good! Rain is water, and plants like water, right?

TR1: Yes, they do, but it depends on the timing, the beans were just starting to grow, starting to sprout, and too much rain gets in the way, it makes the soil too damp, too wet. What do you see when you look at the soil, does it seem dry?

S15: My soil has some white stuff on top, I don’t know what it is.

S10: My bean plant is black, small and black.

S8: True! The soil isn’t dry, it’s wet, I think.

TR1: Damp soil with too much water can make the plant die and rot. Those white things on top are fungi, fungi that are eating the plant *(TR1 asks TR2 for the sign for "decomposition")*. The fungi are decomposing the plants. This process is natural and very important. [...] What else did you notice? You saw that each of you has two containers — can you see any difference between the one with soil and the one with cotton?

S10: I don’t know.

[similar responses]

TR1: Do you think one grew more than the other?

S8: Both of mine died, both.

S5: The one in soil is green, but the one in cotton doesn’t have any leaves anymore.

S12: Mine are alive. The one in cotton is bigger – much bigger than the one in soil.

S7: I don’t see anything in the soil one, but I can see that the cotton one started sprouting, though I don’t know if it’ll keep growing.

[similar responses]

TR1: Exactly, the ones in cotton start sprouting faster because there's nothing on top, no weight, and the light gets in directly, and the water stays trapped in the cotton, helping the bean to sprout more quickly than in soil. And it grows faster because it's searching for light. The one in the soil takes longer to sprout, but it becomes strong and resilient because the soil has nutrients and minerals that cotton doesn't. If it hadn't rained so much, what do you think would've happened? Which one would sprout first?

S8: The ones in cotton.

S5: That's why in the second lesson we saw the cotton one already green.

[similar responses]

TR1: Yes, and the one in soil would survive longer. We only have three living plants, S5's, S12's, and S2's, and they're all in soil.

The bean plant experiment was carried out throughout all the PIs, in PI1, the beans were planted, in PI2 and PI3, the students observed the process, and in PI4, the process was discussed. One of the main goals of the activity was to introduce students to the scientific experimentation process, besides allowing the reflective process to emerge from their own experiences. Throughout the activity, aspects such as observation, hypothesis generation, as well as testing and refutation of those hypotheses, were all explored.

The experiment demonstrated that scientific experimentation is not always quick or limited to a single lesson, as this one was observed over several weeks. In order not to prioritize Portuguese and the written modality, students were not asked to take written notes of their observations. Instead, each lesson involved discussions based on the developmental process initiated with the planting in PI1. By emphasizing the visual experience that shapes Deaf individuals' daily lives and cultural expressions, our goal was to give prominence to Libras and the visuospatial modality as the primary means of engagement in our activities.

The differences observed between the soil pot and the cotton pot allowed students to understand that, even though all the beans from the packages appeared identical and were placed under seemingly similar conditions, the results could be quite different. This was evident in S5's comment: "The one in the soil is green, but the one in the cotton doesn't have leaves anymore," and also in S8's reflection: "Both of mine died, both of them," highlighting that external factors around us are not always within our control.

Relating the bean in soil and in cotton also made it possible to connect the content worked on throughout the PIs, by highlighting how each part of the plant emerges, from the leaves to the roots, and demonstrating their functions. It showed the differences in absorption and support between the roots of the bean grown in soil and those in cotton, how nourished the leaves and stems were in the different pots and served as a basis for discussing the scientific experimentation process, this enabled the learning of scientific knowledge and, consequently, the student's development. In the words of Vygotsky (2012):

> "[...] learning is not, in itself, development, but a properly organized learning process leads to mental development, activating a whole set of developmental processes that could not occur without learning. Therefore, learning is an intrinsically necessary and universal aspect for the development of those human characteristics in the child that are not natural, but historically formed." (Vygotsky, 2012, p. 115)

It is important to highlight that, when relating the bean planting in cotton and in soil based on TR1's explanation, some students were able to satisfactorily answer TR1's question: "*If it hadn't rained, what do you think would have happened? Which one would have sprouted first, then?*" For instance, S8 correctly answered "The ones in the cotton," and S5 added, "*That's why in the second lesson we saw the one in cotton already green.*" In such cases, we can infer that these students' learning enabled their development, as they reached the zone of proximal development with the support of mediators (teachers and more experienced peers) and the strategies used (visual resources and experimentation).

FINAL REMARKS

Throughout this article, we have highlighted the richness and depth of Vygotsky's contributions to the education of Deaf students. By applying his principles, teachers can not only facilitate the learning of concepts but also nurture the cultural and linguistic identity of Deaf individuals. The promotion of social interaction, symbolic mediation, and the use of sign language as learning tools have proven to be essential components in building an inclusive and effective educational environment. Therefore, the implementation of Vygotsky's sociocultural theory in education significantly contributes to the cognitive, linguistic, and cultural development of Deaf students.

Throughout this article, we have investigated the conceptual appropriation of Deaf students in a bilingual environment, with a focus on Botany and using strategies such as visual resources and experimentation. In this context, aiming to outline the path taken, we first highlighted the importance of using visual resources and the students' visual experience. This visual experience goes far beyond the visuospatial nature inherent to Libras; it is the way in which Deaf individuals experience the world, beginning with their earliest interactions as subjects at birth. Visual experience serves as the guiding instrument of their perceptions. To envision a pedagogical practice devoid of these characteristics is to promote approaches that are misaligned with Deaf culture and identity.

In the same way, the use of visual resources proved to be relevant, as they functioned as signs, essential mediators that facilitated communication, comprehension, and student learning, in addition to supporting information retention and mnemonic activity.

It is also important to consider the use of experimentation in the process of conceptual appropriation. According to Vygotsky, learning occurs through the interaction between the individual and the social and cultural environment. Thus, experimentation provided opportunities for students to actively engage with knowledge, exploring and investigating natural phenomena through observation, experimentation, and analysis.

However, it is important to highlight the limiting factors in the conceptual appropriation that enables the full development of Deaf individuals, among which we emphasize the language barrier. In this study, we observed that most participants were not exposed to early language stimulation and learned Libras belatedly, during their schooling process. This reveals a precarious foundation in the formation of spontaneous concepts, which consequently hinders the development of scientific concepts. Even though this may seem repetitive, it is impossible to overlook this conclusion, as it permeates the entire teaching and learning process, not only regarding academic or school content but also the development of the Deaf individual as a whole and appears to constitute the foundation of the challenges faced by this community.

Given the precarious development of spontaneous concepts and the resulting difficulty in forming scientific concepts, we highlight the need for careful planning of experimental activities so that they truly foster the observation of phenomena throughout the experiment. Our research presented limitations regarding the germination process of the beans, and we understand that, had germination occurred without setbacks, it could have significantly contributed to the acquisition of scientific concepts by the Deaf students.

Once again, we turn to Vygotsky, who emphasized the complexity of social relationships and how these relationships mediate our development. Considering individuals who are socially excluded and marginalized, such as the Deaf, and depriving them of a basic right that everyone should have, the right to communicate, to understand themselves in the world, to build relationships and transform their surroundings, this is not possible without language. That said, we advocate for and encourage research in the field of inclusion, as well as public policies that value Brazilian Sign Language (Libras), along with the use of visual resources and experimentation.

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Gustavo Fernandes Rodrigues

Ph.D. candidate and master's in science and mathematics education. Holds a Bachelor's degree in Biological Sciences and is currently pursuing a degree in Linguistics (Languages), all at the Federal University of Goiás (UFG).
E-mail: gustavofr@discente.ufg.br

Lidiane de Lemos Soares Pereira

Ph.D. in Chemistry and master's in science and mathematics education, both from the Federal University of Goiás (UFG). Professor at the Federal Institute of Education, Science and Technology of Goiás (IFG), Anápolis, Goiás, Brazil.
E-mail: lidiane.pereira@ifg.edu.br

Anna Maria Canavarro Benite

Ph.D. and M.Sc. in Science/Chemistry, both from the Federal University of Rio de Janeiro (UFRJ). Full Professor at the Federal University of Goiás (UFG), Goiânia, Goiás, Brazil.
E-mail: anna@ufg.br

Editor Responsável

Vanessa Cappelle

Contact

Center for Science and Mathematics Education of Minas Gerais – CECIMIG
School of Education – Federal University of Minas Gerais
revistaepec@gmail.com

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