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ARTICLE

CHEMISTRY TEACHING AND DEAF INCLUSION: THE CONCEPTION OF COLLECTIVELY CONSTRUCTED LEARNING[1]

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ABSTRACT: Contemporary school dialogues with plurality and diversity. In this scenario, deaf students are included in regular classrooms and need to access curricular components in their first language, Libras (Brazilian Sign Language). These students have some noticeable difficulties, such as many chemistry concepts. Thus, this work seeks to identify these difficulties and how to transform them. This study emerged from a research with several investigation phases. In this text, we present part of the interviews conducted with Chemistry teachers and three deaf students who were High School seniors at an inclusive private school in the metropolitan region of São Paulo. As a result, the investigation identified the role of the Libras interpreter and his partnership with the teacher in this process, the perception that inclusion is a movement that requires the commitment of all those involved to resignify the process, and the need for adequate visual strategies for deaf students to understand chemistry.

Keywords: deaf inclusion, chemistry education, accessibility.

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O ENSINO DE QUÍMICA NA INCLUSÃO DE SURDOS: A CONCEPÇÃO DA APRENDIZAGEM CONSTRUÍDA COLETIVAMENTE

RESUMO: A escola contemporânea dialoga com a pluralidade e a diversidade. Nesse cenário, alunos surdos são incluídos em salas regulares e precisam ter acesso aos componentes curriculares em sua primeira língua, a Libras. É perceptível que para esses alunos a aprendizagem de algumas disciplinas, como a química, se apresenta como um desafio. Assim, este trabalho busca identificar quais são essas dificuldades e como transformá-las. Este estudo emergiu de uma pesquisa que contemplou outras fases de investigação, porém, aqui, será compartilhado um recorte das entrevistas realizadas com professores de química e com três estudantes surdos do 3.° ano do ensino médio de uma escola inclusiva da rede particular de ensino da região metropolitana de São Paulo. Como resultados, a investigação viabilizou a identificação do papel do intérprete de Libras e de sua parceria com o professor nesse processo, a percepção de que a inclusão é um movimento que requer empenho de todos os envolvidos para a ressignificação do processo e, ainda, a necessidade de estratégias visuais adequadas aos alunos surdos para a compreensão da química.

Palavras-chave: inclusão de surdos, ensino de química, acessibilidade.

LA ENSEÑANZA DE QUÍMICA EN LA INCLUSIÓN DE SORDOS: LA CONCEPCIÓN DEL APRENDIZAJE CONSTRUIDO COLECTIVAMENTE

RESUMEN: La escuela contemporánea dialoga con la pluralidad y la diversidad. En este escenario, estudiantes sordos se incluyen en aulas regulares y necesitan tener acceso a componentes curriculares en su primer idioma, Libras. Llama la atención que para estos estudiantes el aprendizaje de algunas asignaturas, como Química, se presenta como un reto. Así, este trabajo busca identificar cuáles son estas dificultades y cómo transformarlas. Este estudio surgió de una investigación que incluyó otras fases de investigación, sin embargo, aquí se compartirá un recorte de las entrevistas realizadas con profesores de Química y con tres estudiantes sordos del 3° año de la enseñanza secundaria de un colegio privado inclusivo de la Región Metropolitana de São Paulo. Como resultado, la investigación permitió identificar el rol del intérprete de Libras en colaboración con el profesor en este proceso y la percepción de que la inclusión es un movimiento que requiere el compromiso de todos los involucrados por la resignificación del proceso y también por la necesidad de estrategias visuales adecuadas a los estudiantes sordos para la comprensión de la química.

Palabras clave: inclusión de sordos, enseñanza de química, accesibilidad.

INTRODUCTION

The main objective of this research was to investigate difficulties in learning chemistry observed in the daily school life of deaf students, included in regular schools, based on the premise that all participants in the teaching-learning process share responsibility for its success. It is believed that the success and failure of the school performance of these students should be shared by teachers who work in inclusive education, by sign language interpreters, and, obviously, by the deaf students themselves. In this sense, Oliveira and Ferraz (2021), in research with a deaf student from a regular school in a science class, found that the leading cause of the student's learning difficulties is the insufficient training of professionals – teachers and interpreters. We understand that one of the significant challenges of the era of school inclusion is the unintentional disregard for the real needs of everyone involved in the process.

Following this reasoning, the study was carried out based on the observation that many deaf people have difficulties with the contents of science-related disciplines, such as chemistry. Some of the hypotheses that explain such difficulties with chemical language by these students may be related to the fact that it is an area of study full of abstractions, symbologies, formulas, calculations and the fact that many educators are still guided by orality for the dissemination of content (Miranda; Costa, 2007). This reflection has mobilized teachers, sign language interpreters, and researchers to seek pedagogical alternatives that adjust to the needs of these students (Sousa; Silveira, 2011).

It is important to emphasize that, in addition to the most recurrent difficulties observed in teaching chemistry to the deaf public – the particularities mentioned above of the area, such as the use of abstractions and symbologies – we cannot forget that, as a science, the understanding of chemistry is based on three levels of representation: macro, symbolic and submicro (Gilbert; Treagust, 2009). Deaf people, since they use a gesture-visual language such as Libras (Brazilian Sign Language) to communicate, often do not find correspondence in their language to the concepts used in this area of knowledge (Quadros; Karnopp, 2004).

As we have seen so far, the school inclusion of deaf people presupposes some specificities that differentiate it from the inclusion of students with other disabilities, as it encompasses a group that needs to have its linguistic needs met for learning to happen. It is necessary to understand that, for the Brazilian deaf, Libras is the first language of instruction, while written Portuguese is the second and the one that will be used for communication with a mostly hearing society (Gesser, 2009; Quadros, 1997).

In this sense, one of the central questions that would help us understand if there are gaps in the school inclusion of deaf people is related to considering the actions necessary for the participants in this process, what barriers are noticeable, and how to transform them. However, it is essential to define school inclusion to reach these answers.

Nowadays, it has become common to talk about inclusion. This term has been mentioned in the most diverse areas, and frequently, we have found references such as racial inclusion, social inclusion, and, more intrinsically related to this study, school inclusion. In this text, the focus was on issues involving the school inclusion of deaf people, the difficulties that emerge from this process, and the fact that inclusion is directly related to accessibility (Schuindt; Silveira, 2020).

In general terms, the school inclusion of students with special educational needs (SEN) – students with disabilities and deaf people – is a right guaranteed in Brazilian official documents. Many of these documents were created considering international protocols, such as the Universal Declaration of Human Rights (1948), the Salamanca Declaration (1994), and the Guatemala Convention (1999), which advocate conditions of equality and accessibility for all.

In Brazil, school inclusion, as we know it, is the result of actions that culminated in resolutions, norms, decrees, and laws created with the aim of including students who lived on the margins of education or were conditioned to attend special schools. It is essential to mention that the ideals present in many official documents created over the years aimed at school inclusion have been updated and reinforced by other documents. In Brazil, there are a vast number of laws that guarantee the rights of people with disabilities. There are so many of these documents that it would be unfeasible to cite them all by name. Therefore, we can focus on the Federal Constitution of 1988 itself, the Law of Guidelines and Bases of National Education (LDB) No. 9394/96 and Law No. 13,146, popularly known as the Brazilian Law of Inclusion or Statute of Persons with Disabilities, of 2015.

The Federal Constitution of 1988 governs the precepts of the universalization of education. It assigns to the State the responsibility for ensuring "[...] specialized educational assistance to the disabled, preferably in the regular school system" (Brazil, 1988). The LDB of 1996 was a milestone concerning people with disabilities, as special education is no longer formally considered an education apart from regular education, constituting a single education aimed at all students (Mattos, 2017). In turn, the Brazilian Law of Inclusion or Statute of Persons with Disabilities provides a new look at people with disabilities because, in addition to unifying the existing precepts in previous documents, it offers an essential contribution to the dissociation of these people from the idea of disability that for many years was linked to them.

In this context, the contemporary discussion revolves around the school as a democratic space capable of minimizing differences and maximizing entry opportunities for all students without distinction (Araújo, 1998). Following this reasoning, we idealized a school where ethnic, social, and cultural diversity is not more important than the possibility that everyone learns and has their rights guaranteed, regardless of whether the student has some disability, is deaf or hearing (Sánchez, 2005).

Changes in the educational scenario have required educators to be prepared to deal with the diversity, plurality, and heterogeneity that the contemporary school concentrates on (Carvalho, 2002). These differences transform the school into a favorable space for the exchange of experiences, but they require, especially from teachers, the use of didactic strategies to reach all students (Araújo, 1998). Thus, it can be emphasized that it was in this inclusive environment that the premises of this research were conceived, as it is perceived that even in the face of broad legislation aimed at serving students with disabilities and deaf people, many educators felt and still feel, insecure about the most effective way to serve these students (Lima, 2006).

When attention is turned to the training of teachers who work with the inclusion of deaf people, a gap is identified that is difficult to fill. Many report that they needed specific training to serve this public, neither at the university nor in their work institutions (Lima, 2006). On the other hand, it is essential to mention that since 2005, according to Decree No. 5,626, of December 22 of that year, in Chapter II, article 3, "[...] Libras should be inserted as a mandatory curricular subject in teacher training courses for the exercise of teaching, at secondary and higher levels, and in Speech Therapy courses". Still to the inclusion of Libras as a mandatory subject, when thinking specifically about the professional performance of specialist teachers in the most diverse areas, paragraph 1 of article 3 of this Decree emphasizes that "[...] all licentiate courses, in the different areas of knowledge, the normal course of secondary level, the normal higher education course, the course of Pedagogy and the course of Special Education are considered training courses for teachers and education professionals for the exercise of teaching" (Brazil, 2005).

If Libras is obligated to be a subject in teacher training and licensure courses, why do many teachers still feel unprepared to serve deaf students? First, as Oliveira *et al.* (2011) point out in a review of the training of science teachers, there was a gap in the teaching degree courses in natural sciences – chemistry, physics, and biology – concerning inclusive education. In addition, the explanation may lie in the fact that many of the Libras courses offered in universities are focused on essential content, often provided in the distance learning modality, and with little emphasis on theoretical issues capable of making teachers aware that there is uniqueness in the process of inclusion of deaf people. In short, they have access to essential Libras content that will hardly be used because they forget the basic vocabulary learned over time, lack practice, or have interpreters in their classes in the inclusive education model. In this sense, Pereira and Catão (2020) state that it is vital for the teacher to have a basic knowledge of Libras that enables communication with the deaf student. However, possibly due to the teacher's work overload, achieving minimum fluency is not often possible, making the teacher less comfortable interacting with the student.

Thus, an issue that can impact the inclusion of deaf people is the fact that teacher training courses, which should promote the teaching of Libras and prepare them to teach all students, may not be achieving their objectives since many of these educators do not feel prepared to serve the deaf public. In this scenario, this study seeks to take responsibility for those involved in the inclusion process: the teacher, the Libras interpreter, and the deaf student.

In the inclusive education model, the Libras interpreter plays a fundamental role, as he is the professional responsible for promoting accessibility to deaf students included in the regular classroom and for mediating the relationships between these students, teachers, and hearing colleagues who do not know sign language (Góes, 2000). When performing such a relevant function, it is expected that the Sign Language Interpreter Translator (TILS) is a qualified professional to perform this work and who, preferably, has extensive experience and training in their area of expertise.

Following this line of reasoning, TILS needs to invest in its career, providing quality services appropriate to the needs of the deaf students they serve in the educational field. When attention is drawn to the challenges experienced in the interactions in an inclusive classroom and, more specifically, in disciplines that present themselves as a challenge for deaf students, such as chemistry, these professionals need to bring together translation and interpretation techniques that favor learning for these students. It is important to emphasize that studies of sign languages are more recent than oral ones. Therefore, the vocabulary in Libras is constantly evolving (Quadros; Karnopp, 2004).

This discussion aims to reinforce that as much as the challenges presented so far are recurrent in the school daily life of an inclusive school, the TILS must make full use of the possibilities that its performance offers, including in science classes, such as pointing to the visual resources that are presented by the teachers on the blackboard, researching if there are signs in Libras for the content covered, spelling concepts that may be required in tests, among others. It is worth mentioning that the performance of the Libras interpreter often requires that decisions related to interpretation be made without the possibility of prior study, and regardless of the skill or creativity of this professional, it can result in significant challenges (Lacerda, 2013). Deaf students have the same responsibilities that are required of other students: to pay attention to classes, take personal notes, carry out the proposed activities, and ask questions about the content learned.

Reflecting on the role played by professionals involved in the school inclusion of deaf people reinforces the idea that only with the commitment and effective participation of all inclusion can become a reality. In the context of this research, in which the actions necessary for chemistry teachers, Libras interpreters, and deaf students in the panorama of an inclusive classroom were investigated, the Universal Design for Learning principle can be a very effective resource (Bracken; Novak, 2019). In this way, what would Universal Design for Learning be, and how can applying its precepts contribute to including deaf people in chemistry classes and other school curriculum subjects?

Universal Design for Learning or Universal Design for Learning (UDL) is a concept that arose from the idea of Universal Design, which in the original proposal emerged from architecture and advocated that physical spaces be accessible to all people without the need for subsequent adaptations. The area of Education incorporated this concept since teachers influenced by this movement felt impelled to think of strategies so that their classes became increasingly accessible, breaking with the paradigm of homogeneous classes and, in turn, serving all students, regardless of the differences presented (Bracken; Novak, 2019).

Given the specificities that permeate the school inclusion of deaf people, it is likely that the UDL guidelines can offer significant contributions to educators regarding the most appropriate care for these students. However, its benefits are not limited to this audience since this approach extends to other students without exception. To exemplify, one can reference that deaf people have a unique "visual experience" and, therefore, teachers must use mechanisms that can benefit them in this field (Alberton, 2015). Working on visuality in the classroom requires teachers to use didactic strategies that favor the learning of deaf students based on what can be understood visually, such as, for example, the use of images, drawings, graphics, and games, among other resources (Alberton, 2015; Campello, 2008). In this context, it can be concluded that using visual resources during classes favors the learning of deaf students and benefits those who are not deaf.

Thus, it is essential to reiterate that the simple recognition that the teaching-learning process of chemistry can be challenging for deaf students is insufficient, as much more is needed than that. Chemistry teachers and Libras interpreters must establish a working partnership in which the experiences lived by these professionals can be added, making it possible for the classes and materials used to be, in fact, accessible to deaf people. Aware that there are difficulties regarding the learning of deaf students and mindful of the responsibility that falls on each one of those involved in the daily school life of an inclusive classroom, the following question is asked: what are these difficulties, and how can we deal with them? The presentation so far contemplates the challenges from the conception described by the professional Libras Translator Interpreter, but what do chemistry teachers and deaf students think about these issues?

METHODOLOGICAL APPROACH

This research encompasses the excerpt from a master's dissertation in which the researcher focused on investigating the difficulties inherent to the teaching-learning process of chemistry in the school inclusion of deaf students. As research, it can be characterized as a case study and has a qualitative character (Stake, 2011; Yin, 2005).

The research was carried out in a private school during the 2019 school year, with three deaf students fluent in Libras from the 3rd year of high school. Its starting point was the chemistry content entitled "intermolecular interactions", contemplating four stages (Chart 1):

Chart 1: Research stages.

Stage	Action taken
I	Development and application of a metacognitive activity with deaf students about the researched content.
II	Observation of a specific chemistry class about the researched content.
III	Diverse insights gained during regular chemistry classes throughout the school year.
IV	Semi-structured interviews with chemistry teachers and deaf students participating in the research.

Source: Prepared by the authors

The stages of the research (Chart 1) were developed throughout the year. Stage I comprised two investigative classes on intermolecular interactions (one hundred minutes) in the after-hours, only with deaf students. In stage II, there was a fifty-minute observation class with the hearing and deaf students – and the chemistry teacher addressing the same theme. In stage III, some situations perceived in chemistry classes during that school year were noted. Finally, stage IV, the excerpt in the presentation established in this text, considers the participation of chemistry teachers and deaf students investigated throughout the process. The participants answered some questions formulated by the researcher through individual semi-structured interviews (Minayo, 1993). For this, a script was elaborated with objective but open questions, allowing non-programmed questions that added value to the research to be equally considered. The interviews were conducted through the *Google Meet* platform and recorded for later records and transcriptions. For the interviews with the deaf students, the researcher, a Libras interpreter, had the support of a professional colleague, who interpreted the dialogues, allowing the first to focus exclusively on the questions and the answers obtained. The interviews were proposed because they were intended to investigate, directly with the participants, their perceptions about the difficulties and/or barriers observed in the teaching-learning process of chemistry by deaf students in an inclusive classroom.

The research was carried out by a Brazilian Sign Language interpreter as a participant observer (Marconi; Lakatos, 2003) in a regular private school in an inclusive classroom. The deaf students included in this institution, for the most part, are scholarship holders, except for those who can afford the tuition fee. They are part of a schooling program that begins in a bilingual school for the deaf belonging to the same sponsor. These students attend the bilingual school for deaf students from kindergarten to the 5th year of elementary school, being included in regular school from the 6th year onwards and accompanied by sign language interpreters until the end of high school. In the school where this research was conceived, students begin to study chemistry as a curricular subject in the 1st year of high school.

The researcher interviewed two chemistry teachers: a man and a woman. In that order, they work at the school referenced as full professor and support teacher. Both are 35 and have been working at the school where the research was conducted for eight and four years.

In addition to the teachers, three deaf students were interviewed and are characterized as follows: two boys and a girl, aged 17 and 18 years, enrolled in the 3rd year of high school. These students entered the bilingual school for deaf students in early childhood education, remaining there until the 5th year of elementary school, and were included in the regular school from the 6th year onwards. It is important to emphasize that the teachers and the deaf students described were invited to participate in this research. Their adherence occurred voluntarily, in compliance with the ethical principles established by the National Health Council (CNS), as governed by resolution no. 466/2012.

In this context, it is necessary to emphasize that by the researcher's choice and to preserve the anonymity of the participants, their names will not be exposed. On the other hand, the following designations will be used: P1, for the full professor of chemistry; P2, for the chemistry support teacher; A1, for the first student; A2, for the second student; A3, for the third student, and I1, for the Libras interpreter, researcher, and interviewer. The answers reached throughout this research led to the emergence of four categories, which, according to Bardin's (2011) assumptions, enabled the analysis of the data obtained by I1.

Semi-structured interviews with teachers and deaf students

The interviews with the chemistry teachers were conducted individually on different days and times. Five objective questions were asked, but spontaneous manifestations not in the draft were considered. The interviews with the deaf students were designed individually on different days and times. Five objective questions were also asked, and spontaneous manifestations were widely considered (Chart 2).

Chart 2: Questions asked to teachers and deaf students.

	For teachers	For deaf students
1	You were one of the professors participating in the research on the difficulties of deaf students in chemistry. What was it like to participate in this research?	You were one of the participants in the research about the difficulties of deaf students in chemistry. How do you evaluate your participation in the study?
2	Do you remember when you started interacting with deaf students, and what were your most significant difficulties related to the group's specificities?	Why do you think chemistry is such a difficult discipline?
3	Do you currently teach the deaf student? (reference month: April 2019) If so, what is your perception of these students' learning with chemical language?	Of the school contents present in the chemistry discipline, which did you have the most difficulties?
4	In your opinion, what are the main difficulties that deaf people have with the chemistry discipline?	In your opinion, what strategies could teachers use so that deaf students better understand chemistry content?
5	As a chemistry teacher, what strategies do you believe could be used in classes with deaf students to favor the learning of chemistry for these students?	Do you believe specific training in chemistry is necessary for interpreters to interpret appropriately?

Source: Prepared by the authors.

RESULTS AND DISCUSSION

The discussions about the difficulties of deaf students with learning chemistry presented in this study brought the characters involved in the inclusion process to the established debate. A Libras interpreter conducted the research; however, the questions, expectations, and perceptions of the other participants investigated were added: deaf students and chemistry teachers. This triad comprises the three fundamental characters in the school inclusion of deaf people defended here in this article.

The discussion shared here is the outcome of a study that contemplated other stages of research, and, in this context, the interviews were the means chosen to consider the narrative presented from a collective perspective. Discuss the importance of the leading players involved in the teaching-learning process of deaf students (Pereira; Catão, 2020), meet several movements that seek to rescue the history of the groups investigated, breaking with paradigms that tell the story and analyze it from a single point of view, silencing those who have experienced or constantly experience the issues discussed. Oliveira *et al.* (2011) corroborate this idea, understanding that inclusion is not restricted only to the participation of the deaf student, and it is also necessary for the other participants – teacher and interpreter – to be willing always to reflect and modify their behaviors when necessary. As an example, the observations found by Oliveira and Ferraz (2021) and Pereira and Catão (2020) about the teacher's difficulty in being able to communicate with the deaf student and the interpreter in presenting problems with the signs of scientific concepts (Oliveira; Ferraz, 2021).

Given this study's specificity, it is vital to consider the opinions of the characters involved in the narrative being shared. From this perspective, the arguments collected during the interviews corroborate the idea that deaf students find it challenging to learn chemistry and other sciences (Paiva *et al.*, 2023; Florentino; Vizza; Locatelli, 2023; Miranda; Costa, 2007).

The categories emerging from this research are shown in Chart 3:

Chart 3: Emerging categories of the research.

CATEGORIES (C)	
C1	Barriers that limit and/or hinder the teaching-learning of chemistry for deaf people.
C2	Difficulties of deaf students with chemistry in the perception of teachers.
C3	Difficulties of deaf students with chemistry in the perception of deaf students.
C4	Chemistry teaching-learning strategies in the school inclusion of deaf people.

Source: Prepared by the authors.

The interviews showed that both for the teachers and the participating students, there are barriers (C1) that limit and/or hinder the teaching of chemistry and, consequently, the learning of this curricular component for deaf students, the first category analyzed. In this category (C1), it was possible to identify some barriers related to the actions developed by the characters in an inclusive classroom. P1 shares his personal experience from the moment he started teaching dead students when he says that

> [...]In the beginning, I spoke very fast and used some jokes involving chemistry, which made it complicated for the interpreters to do the interpretation. Over time, I learned that the deaf establish different relationships from the listeners and that phrases and songs for memorizing chemical formulas I used in class were inappropriate because they did not make sense to the deaf student.

Following the same reasoning, P2 demonstrates the importance of the records made by deaf students and concern with their organization of the blackboard, in addition to pointing out the short time of classes as a barrier (C1) to the development of more accessible actions, as an example:

> [...]My biggest challenge was the organization of thoughts. Writing on the board what I'm talking about requires much time, as a class has an average of 45 minutes, and during this time, the teacher needs to teach the contents that will be charged in the test. As I speak, the interpreter interprets for the deaf student, but I am aware that the deaf needs to have a record of the classes in the notebook, and in a class, it is very complicated to handle everything.

The teacher adds, "[...] We cannot forget that for the deaf, the blackboard must be organized with colors, differentiating processes so that they perceive what is happening". For teachers, the barriers in the teaching-learning process (C1) are related to the complexity existing in chemistry itself. Throughout the interviews, the word difficulty was very present in their statements, so much so that it was concluded that this perception for itself already configured a new category, in this study designated as C2.

When asked about the difficulties of deaf students with chemistry (C2), P1 and P2 were categorical, saying there is a perceptible barrier for these students with the contents of this discipline. P1 believes that "[...] the contents that involve symbology and chemical equations result in greater difficulties". The teacher adds, "[...] Another difficulty is related to the interpretation of graphs and tables". In the same line of reasoning, when asked about the main difficulties of deaf students, P2 believes that some contents are more challenging and cites the "[...] chemical bonds because it involves much imagination." Also, P1 and P2 emphasized that the fact that the contents and activities are presented in Portuguese, a second language for the deaf, and because the chemical language is very technical, abstract, and specific, the difficulties of these students are maximized (Quadros; Karnopp, 2004). Regarding the learning of chemistry, the student needs to enter the submicro (abstract) level, which is essential, but considered difficult for students, in addition to transiting between the macro, symbolic and submicro levels (Florentino; Vizza; Locatelli, 2023; Gilbert; Treagust, 2009; Pear tree; Cured; Benite, 2022). Also, Pereira, Curado, and Benite (2022), in a study with deaf students on the concept of chemical transformation, found that the conceptual difficulties pointed out are similar between hearing and deaf students. However, they state that strategies combining the partnership between the teacher and the interpreter and diversifying semiotic modes can contribute to deaf students' better understanding of chemistry.

The data showed that the perceptions of the deaf students interviewed concerning the difficulties presented by the group regarding the learning of chemistry are like the perceptions raised by the teachers, culminating in the creation of another category, the C3. For students A1 and A2, the abstraction present in chemical language, the excess of formulas, the use of symbologies, and the fact that it is a science that requires much imagination explain part of the difficulties (Miranda; Costa, 2007). Student A3 reports much difficulty in chemistry and adds another factor when he says, "[...] the fact that there are no signs in Libras for all concepts, symbols, and formulas makes this discipline even more difficult". This finding agrees with the idea that sign languages are considered recent when compared to oral languages (Alves; Silva, 2021), and therefore, much of the vocabulary is under constant construction (Quadros; Karnopp, 2004).

Souza and Silveira (2011) point out one more factor to justify the difficulty in learning chemistry, in addition to the specificity already discussed, which is the need for signs for chemical concepts in Libras. Carvalho (2017) found that good support material and scientific signs enable access and autonomy for deaf students, emphasizing the importance of these signs. However, there are few studies focused on the development of scientific signals, especially in chemistry (Carvalho, 2017; Fernandes *et at.*, 2019). In this sense, Fernandes et al. (2019) point out that the signals for scientific concepts do not vary regionally like other words and concepts. Even so, according to the authors, still "[...] there is no consensus as to the sign to be used for a given scientific term" (2019, p.32). The issue is that with the lack of these signs, the interpreters end up showing difficulty in mediating the class with the correct scientific terms, and consequently, the deaf end up having learning gaps (Fernandes *et al.*, 2019).

Another question asked to the interviewees was related to the strategies necessary for teaching chemistry with the inclusion of deaf people. This issue highlighted the importance of using a didactic appropriate to the needs of deaf students, resulting in the creation of the last category addressed in this study, C4.

The participating teachers unanimously recognized the importance of teaching strategies (C4) to make chemistry classes accessible to deaf students (Paiva et al., 2023; Shah; Silveira, 2011). P1 mentions that it is fundamental to "[...] make time available for deaf students to record the information on the blackboard, and only after that, proceed with the explanation". The teacher also emphasizes diversifying strategies, using direct commands and keywords, and avoiding distractors. The use of technology in the classroom, simulators, and games were strategies pointed out by P2 to transform chemical language into a more visual language. The teacher pointed out visualization as an essential resource in classrooms with deaf students and emphasized: “[...] I think it is essential that the teacher does not focus his classes only on theory, but that he allows students to make schemes, produce materials and do experiments".

Deaf students also mentioned the importance of teachers' use of strategies (C4) and visual resources as fundamental for their learning (Alberton, 2015; Campello, 2008; Florentino; Vizza; Locatelli, 2023; Novais; Silva, 2022; Paiva *et al.*, 2023), as can be seen in the words of A1: "[...] I can say that teaching methodologies that work on visual issues are the best for deaf students. Most of the chemistry teachers I had at school made an effort to transform the contents of the classes into visual learning possibilities." The student adds: "[...] With figures, graphs, drawings, and images, chemistry can become more real because visualization is crucial for the deaf".

Student A2 reinforced the importance of using visual strategies (C4) when he said that "[...] The teacher needs to work on visuality during classes. Using drawings, images, animations, and different colors are of great help," – which is corroborated by several researchers (Alberton, 2015; Florentino; Vizza; Locatelli, 2023; Nancy; Silva, 2022; Paiva *et al.*, 2023). For student A3, accessible classes are fundamental. The issue of visuality can be perceived in his speech in the following expression: "[...] The teacher needs to highlight the most important commands in the statements, use images, draw on the board so that the classes are more visual because chemistry is very abstract". In this sense, Florentino, Vizza, and Locatelli (2023) point out the importance of visualization precisely because of the abstract character of chemistry and, therefore, the possibility of rethinking chemical models through visual strategy. However, despite some initiatives such as the previous example, Novais and Silva (2022, our translation), in a review of the use of visual strategies for deaf students, found that "[...] Even after decades of struggle for the educational rights of deaf subjects, there are still few studies on visual teaching materials and/or visual strategies for the inclusive education of deaf students" (p.752), which is very worrying.

The categories presented were essential to identify the difficulties of deaf students in the chemistry discipline. On the other hand, it is also important to emphasize that the initial training of teachers who work with the inclusion of deaf people, in this case, was evidenced. It was noticeable that the teachers interviewed did not feel prepared to teach deaf students at the beginning of their careers, managing to develop teaching techniques only over time (Lima, 2006). P1 vented:

> [...] I believe that teacher training should contemplate more inclusion issues because much of what I learned was in day-to-day practice. I had the privilege of being surrounded by excellent professional interpreters who helped me understand the issues related to deafness, but this is not the reality of the majority.

In the same vein, P2 reported:

> [...] I believe the teacher training process is flawed, as it does not contemplate the diversity of students that the school receives today. What is taught about the deaf and students with disabilities in the teaching degree courses does not prepare us to deal with these students when we are in front of them in the classroom.

Corroborating the statements of teachers P1 and P2, Bozzi and Catão (2021), researching the difficulty of chemistry teachers with the education of deaf students, found that active teachers had problems related to inclusive education in their initial training and what they learned was from experiences with other colleagues.

When asked about the interactions with the main characters in an inclusive classroom, in general, the deaf students reported that they developed a good relationship with each other, helping each other as difficulties arose. They indicated they had a good relationship with the chemistry teachers and felt comfortable asking questions during classes. Regarding the interpreters, A1 and A3 reported perceiving difficulties in the interpretation of chemistry contents by less experienced interpreters (Paiva *et al.*, 2023), and A2 criticized the relay at the end of each cycle: "[...] We have always had a nice interaction and relationship with the interpreters, but I believe that the change of interpreter in each cycle harms the students". To conclude, in the panorama that identifies the relationships developed in an inclusive classroom, the negative point raised by the three deaf students interviewed was the absence of communication with hearing students, which, according to them, is since they do not know sign language. A2 summarized this finding by saying, "[...] communication was almost non-existent."

FINAL CONSIDERATIONS

The present study proposes to investigate the challenges of the teaching-learning process of chemistry in the inclusion of deaf students in schools. The use of semi-structured interviews was a strategic choice, as it enabled the researcher to identify, in contact with, those who make up the triad of main characters in the molds of an inclusive classroom, how, when, and why the difficulties of deaf students with chemistry arise. More than that, it allowed us to list the strategies identified from the perspective that inclusion requires collective effort.

This research revealed that the difficulties of deaf students with chemical language are a reality. From the beginning, the researcher's intention, a Libras interpreter, was to ratify the hypothesis that the difficulties of deaf students with chemistry required a resignification in the way of teaching. Teaching the discipline involves using models at the submicro level, where the abstraction process is excellent, which becomes even more difficult for deaf students who rely predominantly on the visual mode to learn. The perceptions of teachers and students themselves reinforce this idea and suggest that the teaching-learning process of chemistry for deaf people needs to be discussed and rethought.

In this sense, of the many perceptions obtained, the constant reference that chemistry classes and other sciences need to stimulate visuality can be cited. Images, drawings, highlighting keywords, commands, and central concepts were pointed out as visual strategies that enable the learning of all students, especially deaf students, who are highly visual.

The participation of teachers and deaf students, as well as their positions and perceptions, revealed to the researcher that inclusion is, in fact, a movement that requires the effective participation of all those involved. It was evident that the well-established partnership between the Libras interpreter and the chemistry teacher could favor deaf students in the learning of school content. Together, they identify the problems and can collaborate to minimize the difficulties, including working with signs for chemical concepts, which can help to include deaf people in learning.

In this panorama, the attributions corresponding to the characters participating in the scenario of an inclusive classroom are preponderant. Libras teachers and interpreters need to be qualified professionals. In addition, they need to be open to correcting actions that go against the premises of a work that requires actions as unique as inclusion. Deaf students must assume their role in this process and seek alternatives to make learning meaningful. This is because although the difficulties with chemistry are not exclusive to the group, it is assumed that the attention they need to develop during classes is greater than that of the hearing students because no matter how much the classes are interpreted into their first language, the activities and teaching materials are in a language structure that is not theirs.

The study also revealed that the teachers investigated did not feel prepared, as they believed that the knowledge received in the academy was far from the reality that the performance required. In this sense, a careful look is indicated to verify the current quality of teacher training courses qualified to act in the face of the inclusion of deaf students and students with current disabilities, as the finding of this study brought evidence of this need, being our first suggestion for future work.

Finally, the results reinforce the idea that inclusion is a movement that requires commitment from all those involved. Specifically, in the context of this research, regarding the teaching-learning process of chemistry, many difficulties with the contents of this discipline by deaf students can be resolved using specific strategies, as they can mean progress for these students. As another suggestion for future work, a focus on developing visual strategies, which in the case of chemistry, are crucial and still scarce in the area, as well as support from theories in their understanding, can be recommended.

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Solange Wagner Locatelli – Data analysis, writing of the text, and revision of the final writing.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest with the present article.