International Journal of Advanced Engineering Research and Science (IJAERS)
ISSN: 2349-6495(P) | 2456-1908(O)
Vol-8, Issue-2; Feb, 2021
Journal Home Page Available: https://ijaers.com/
Journal DOI: 10.22161/ijaers
Article DOI: https://dx.doi.org/10.22161/ijaers.82.37

Signs in Libras for inorganic compounds as a translator of scientific concepts: a prospection in bibliographic databases

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Received: 27 Oct 2020;

Received in revised form:

05 Jan 2021;

Accepted: 13 Feb 2021;

Available online: 27 Feb 2021

***Keywords*— chemistry, libras, scientific terminologies, signs, teaching materials.**

***Abstract*—** *We live in a technological society whose development is directly linked to advances in scientific knowledge. Thus, learning science at school today is of fundamental importance for students to be able to understand its concepts, as well as to apply them. However, due to the lack of methodologies as regards Teaching Chemistry to deaf alumni and the scarcity of scientific terminologies in this area, which impact on the learning of this science, many authors point out the need for research involving chemical signs in Libras. In this sense, this article aims to make a mapping to know if there are Signs in Libras for inorganic compounds in audiovisual format, as material to aid the translation of scientific concepts. The methodology was based upon a qualitative approach of exploratory nature, with data collection via bibliographical research. The prospecting was accomplished on CAPES portal, Google Scholar and SciELO, there resulting in 6,476 documents. After filtering strategies, we found that none was identical to the desired product. We therefore identified that there are no articles, dissertations and theses, up to this research date, addressing to the theme of Libras for inorganic compounds and that their creation is of fundamental need for understanding the chemical concepts and, consequently, as a tool to support the chemistry teaching-learning process.*

I. INTRODUCTION

Chemistry is present in our lives from the most elementary to the most complex things like medicines. And when it comes to education, it is essential to reflect on the relevance of teaching science today, especially the Teaching of Chemistry, as we live in a technological society, the growth of which is directly linked to advances in scientific knowledge and vice versa. It is then necessary to scientifically train up literate citizens.

When considering the importance of learning Chemistry, one has to keep in mind that it studies matter and its transformations, having two distinct concerns: one focused on contents and scientific concepts, the other focused on the education of the citizen (Krasilchik, & Marandino, 2007). On the other hand, the scientific language of Chemistry uses terms such as functions, reactions, bonds, atoms, ions, among others, which are symbolic and abstract, sometimes transforming the learning in this area of knowledge into a complex task for any student, either normal or deaf, making them unmotivated (Lucena, Benite & Benite, 2008; Pereira, Benite & Benite, 2011).

When one thinks of the Teaching of Chemistry at school, he takes into account that education is everyone's right - according to the article 205 Federative Republic

Constitution of the Federative of Brazil (1988). However, despite the Constitution establishing this right, the access to knowledge is not guaranteed to all students on equal basis. Although there has been an evolution of legislation to guarantee the improvement of the teaching-learning process of the deaf, in practice these educational proposals are not satisfactory. And due to a series of restrictions and gaps in structural, methodological and pedagogical orders, these students have more learning difficulties in Chemistry than those who can hear.

Thus, in the perspective of a quality scientific education that includes deaf students, some pedagogical measures need to be adopted. That is why many authors point to the need for more research involving scientific concepts in Libras and its dissemination to education professionals. Because, in addition to the lack of methodologies in the teaching of Science for the deaf, there is a shortage of specific terminologies in this area (Carvalho, 2017; Fernandes, 2016; Ferreira, Nascimento, & Pitanga, 2014; Gomes, Souza, & Soares, 2015; Oliveira, 2014; Quadros, & Karnopp, 2004; Saldanha, 2011; Sousa, & Silveira, 2011). About this, Barral, Pinto-Silva and Rumjanek (2012) understand that a vicious circle has been created, *i. e.*, there are no scientific signs, teachers have difficulty in teaching Science, interpreters have difficulty in conceptualizing and deaf students are increasingly excluded as regards Science.

In this context, this article aims to make a mapping to know if there are already Signs in Libras for inorganic compounds, in audiovisual format, as material to aid the translation of scientific concepts.

II. CHEMISTRY AND THE DIFFICULTIES IN LEARNING SCIENTIFIC CONCEPTS

Chemistry is an investigative science that lives in a continuous process of construction. We understand that its learning allows the student to be able to interpret scientific concepts and articulate them with practical applications because,

> it is a question of training the student-citizen to survive and act in a responsible and committed manner in this techno-scientific society, in which chemistry appears as a relevant instrument of investigation, production of goods and socio-economic growth, interfering directly in the daily lives of people (Martins, Santa Maria, & Aguiar, 2003, page 18).

In contrast, learning this Science is a complex task for any student, be him deaf or hearing. According to Gabel (1998), the problems to understand Chemistry can be due to two factors: the difficulties in interpreting the chemical phenomena that happen at macroscopic and/or microscopic levels, and the lack of relationship between these two levels of the subject (*Apud* Furió, & Furió, 2000).

When thinking about Teaching Chemistry at school, one – in accordance with to the article 205 Federative Republic Constitution of Brazil (1988) – must take into account that education is a right for all. Speaking especially of the deaf, it is important to understand how the teaching-learning process of this Science takes place in this community. For, they are individuals with their own culture and, therefore, knowing their aspects is of great value to substantiate the problem of this study.

We emphasize that the education of the deaf in Brazil has gained some initiatives with the objective of providing the full development of their abilities, like the Law that establishes the Guidelines and Bases of National Education (LDB) – Law nr. 9,394/1996, which won a chapter on Special Education for disabled students and recommends that it be offered in the regular school system; of the Law on the Brazilian Sign Language - Libras and other measures – Law nr. 10,436/2002, which recognized Libras as the legal means of communication for the deaf and the Decree that regulates Law nr. 10,436 of April 24th, 2002, which provides for the Brazilian Sign Language – Libras, plus article 18 of the Law nr. 10,098 dated December 19th, 2000 – Decree nr. 5,626/2005, which proposes bilingual education as well.

Although this has been an evolution to guarantee the improvement of the teaching-learning process of the deaf, in practice, these educational proposals are not satisfactory. Furthermore, some researches denounce the specific terminologies of Chemistry with a scarcity of words in Libras, as well as the few teaching materials available to assist in the translation of these terms into sign language (COSTA, 2014; Ferreira *et al.*, 2014; Quadros, & Karnopp, 2004; Sousa, & Silveira, 2011). Therefore, due to a series of methodological and pedagogical gaps and restrictions, students with deafness have more difficulty in learning Chemistry than those who can listen.

Faced with these adversities, Feltrini (2009) points out that the linguistic specificities of the deaf make their education a very complex situation, with several difficulties that decisively interfere in the construction of scientific concepts. So, in the perspective of a quality scientific education to include deaf students, some pedagogical measures need to be adopted.

A first point to be considered in the learning of students with deafness associated with chemical contents concerns Law nr. 9,394/96, in which, in its Article 58,

establishes that Special Education for disabled *alumni* be offered in the regular school system. This school model, however, does not consider that deaf and hearing people have different learning needs, and the regular school follows the common education pattern through which classes are taught in the oral language, without the option of Libras. Under this scenario, Queiroz, Silva, Macedo and Benite (2010) point out that when teachers use only oral speech and writing in the teaching-learning process of scientific knowledge, it appears that the deaf do not learn or do it poorly.

A second gap concerns the lack of clarity of the Law nr. 10,436/02, and its regulating Decree nr. 5,626/05, which contemplates the inclusion of a bilingual proposal. There is a lack of understanding of Art. 3rd, §2, when Libras becomes an optional subject for most higher and professional oral education courses. Thus, a Chemistry teacher, who should have specific training and knowledge in Libras, is only trained in his area. As for the referred article, Ferreira *et al*. (2014) claim that there is no clear definition of what the bilingual education is – within the subjects – mainly as regards the training of teachers toward understanding the scientific concepts. Therefore, according to Sousa and Silveira (2011),

> science teachers, particularly those of chemistry, who do not have the training to work with the hearing impaired, have great difficulties in dealing with the construction of scientific concepts for this particular group, which, in turn, generates exclusion and distance from deaf students in classes with this content (Sousa, & Silveira, 2011, page 38).

Still in the perspective of bilingual education, in the absence a teacher of Chemistry who has knowledge in Libras, the Libras Translator and Interpreter (TILs) will translate the contents. Under Art. 17th of the afore mentioned Decree, the formation of TILs will take place through a higher degree in Translation and Interpretation, with qualification in Libras-Portuguese language. Thus, in a translation of the chemical contents for the deaf, the interpreters have their difficulties with regard to chemical symbology, using signs of their own understanding of the contents (Sousa, & Silveira, 2011). In view of the above, Quadros (2004) recalls that, historically, the education of the deaf has always been focused on linguistic issues, specifically on the teaching of the oral Portuguese language and the use of Libras, with little being discussed in the teaching of other areas of knowledge.

As a third constraint, some researches – including those of the authors Costa (2014) and Sousa and Silveira (2011) – signal the specific terminologies of chemistry without correspondence with Libras. These studies report that, as this Science uses specific symbols to represent functions, reactions, bongs, atoms etc., which do not have vocabulary in Libras, there is a difficulty in explaining the chemical phenomena on the part of teachers and understanding by deaf students, which can lead these students into school failure.

As a fourth point, we mention the works of Ferreira *et al.* (2014), Costa (2014), Sousa and Silveira (2011), and Quadros and Karnopp (2004) that reveal the few materials available to assist in the translation of specific terms from Chemistry to Libras. These studies point out that the shortage of these materials is usually considered one of the main problems in the learning of chemical contents by the deaf.

Therefore, in circumstances in which there is a difficulty in learning the chemical contents and consequently the investigative knowledge, recreating didactic materials and disseminating them in various educational contexts – such as the Signs to translate the technical-scientific language to Libras – is of fundamental importance to support the teaching of that Science.

III. SIGNS IN LIBRAS AS SUPPORT MATERIAL FOR TEACHING CHEMISTRY

As seen, deaf students have difficulty learning chemical concepts and, consequently, building their specific practical applications. This is due to several factors that range from methodological-pedagogical restrictions and gaps, passing through specific chemistry terminologies and, finally, the few materials available to assist in the translation of these terms to Libras. As for this difficulty, Quadros and Karnopp (2004) claim that the lack of these materials interferes in the negotiation of meanings of scientific concepts by teachers, students and interpreters, making science teaching and learning difficult.

With the advancement of Information and Communication Technologies (ICTs), the insertion of technological digital resources and the use of new media in schools become increasingly necessary; because the facilities of digital technologies have popularized access to knowledge, leaving traditional practices outdated. In view of this reality, for Silva (2013),

> science education is becoming more and more outside school walls, getting installed in spaces such as magazines, newspapers, videos on the internet, for example, reflecting a popularization and diffusion of science previously restricted to academic institutions. Hence the relevance of the

> creation of cultural artifacts of communication and information as pedagogical instances, being able to produce meanings, values and behaviors in different contexts – beyond school spaces (Silva, 2013, page 57).

Good experiences have emerged in Brazil, there involving the deaf and didactic material that uses digital technologies on the Web. For these students, these tools represent an inclusive, visibly attractive and very easy to understand medium, through which they learn by interacting and communicating, then leading Rosa and Cruz (2001) and Souza, Aguiar and Pinto (2003) to point out that

> the use of the *Internet* constitutes another tool that enhances the deaf in their relationship with the world as it has presented positive points such as – for instance – cognitive changes favored by technologies, incentive to search and acquire knowledge, establishing affective relationships while allowing the deaf to demonstrate their feelings and emotions without being excluded, and social through interaction and relationship with other people, deaf or hearing (Rosa, & Cruz, 2001; Souza, Aguiar, & Pinto, 2003).

As deaf students need visual memory, the utilization of means that use vision as a channel of communication has contributed greatly to their educational progress. When preparing this type of material, therefore, the work – based on visual pedagogy, as a field for learning – must be taken into account, since these students apprehend information through vision (Ribeiro, & Silva, 2017; Ferreira *et al*., 2014).

In addition, according to Rosa (2013, page 61) "sign language has a *visuospatial* modality because it is articulated in space and is apprehended visually, *i. e.*, linguistic information is received by the eyes and produced by the hands." In view of this statement, the following parameters should be used in the construction of signs: hand configuration (HC), articulation point (AP), movement (M), hand orientation (Or), facial and body expressions (FBE) (Vargas, & Gobara, 2015). It is noteworthy that these combined patterns form the signals. Figure 1 exemplifies the elaboration of signs taking into account the parameters described above.

(AP)and (M) (FBE) (HC)

Fig. 1: Examples of parameters of Libras

Fonte: De "Desenvolvimento de sinais em Libras para o ensino de química orgânica: um estudo de caso de uma escola de Linhares/ES" (Dissertação de mestrado), de A. B. Pontara, 2017, *Centro Universitário do Norte do Espírito Santo*, p. 78.

In Chemistry as a whole, it should be noted that some research have been developed to assist the teacher when the student is deaf, as are the case of the Brazilian Sign Language by Capovilla and Raphael (2001), the Chemistry Sign Book of the Phala Institute (2013) and the Scientific Signs by Costa (2014). According to Costa (2014)

> the production of these signs is of fundamental importance to solve difficulties in the teaching and learning process and to minimize educational barriers such as chemistry, which has a and complex vocabulary in Portuguese, but is not included in the sign language (Costa, 2014, page 26).

Stumpf (2005, page 36) conceptualizes *Sinalários* as "a set of expressions that make the lexicon of a given language". According to this definition, Libras Signs can be used as teaching material. Because being a bridge between the student and knowledge, they are a visual experience that helps to explain scientific concepts. This type of resource can be an efficient didactic strategy to meet the learning needs of deaf students, especially with regard to teaching Chemistry.

Furthermore, as the main support media for the *Sinalários* (signs) are the video-sharing sites on the Web, they establish themselves as excellent means of popularizing science. Thus, "the audiovisual language allows the formation of new concepts by these students, causing the interest and internalization of concepts that – if expressed with the formalism of scientific definitions – would be incomprehensible" (Silva, Santana and Silva, Tudury, & Barros, 2009, page 2).

Given the above, it appears that the Signs in Libras are appropriate products to assist in the teaching and learning of Chemistry in various educational contexts,

through which the deaf can learn scientific concepts and use them in practical experiments.

IV. METHODOLOGY

The methodology adopted in this research was based on a qualitative approach to the treatment and analysis of information, since it aims to explore the meaning of the chemical terms translated to Libras. The type of research used can be classified as exploratory, due to the few records of scientific term in Libras in Brazil. As for data collection, the procedure was via bibliographic research, supported by search for precedence.

a. Data collection – search for precedence

The researched universe had Academic Bases, as a scope. The sample, on the other hand, was based on information contained in documents of the afore mentioned Bases, referring to chemical Signs in Libras.

Academic Bases (Google Scholar, SciELO and Capes – articles, dissertations and theses) – As a criterion for gathering information and search strategies, we used keywords: Glossary AND Libras; Glossary AND Libras AND Chemistry; Glossary AND Libras AND inorganic reagents, in which we tried to make various combinations. Instead of the word *Sinalário* (signs), Glossary was used as this is a more comprehensive synonym. As the aid tool, we used the *Boolean* operator AND in order to restrict the number of documents. Bearing in mind that the *Sinalário* we intend to develop in this work refers to an intellectual property, we – for this reason – searched only on academic bases platforms.

From the mapping of the information contained in the Academic Bases, we started with the data collection in the months of April/May 2020. Signs of inorganic compounds translated into Libras and displayed in articles, dissertations and theses were used as instrument for the qualitative analysis of the data.

V. RESULTS AND DISCUSSION

After collecting data, the presentation and analysis from the Academic Bases took place as per Table 1, basing on the chemical terms translated into Libras. Each base is divided into two fields: quantity of documents found (F) and quantity of documents identical (I) to the *Sinalários* in Libras.

Table 1 – Search result of Sinalários in Libras

	G. Scholar		**SciELO**		**Capes**		**Total**
Keywords	F	I	F	I	F	I	
Glossary AND Libras	4,970	_	_	_	24	_	4,994
Glossary AND Libras AND Chemistry	1,310	_	_	_	3	_	1,313
Glossary AND Libras AND inorg. reagents	169	_	_	_	_	_	169
Total	6,449	_	_	_	27	_	6,476

Taking a look at Table 1, we can see that a total of 6,476 documents containing articles, dissertations and theses were found; 6,449 of them in Google Scholar, 27 in Capes and none in SciELO. In the first search, using the keyword **Glossary AND Libras**, 4,994 records were found; of these, 4,970 were in Google Scholar, 24 in Capes and none in SciELO. In a second search as a filter strategy, we used **Glossary AND Libras AND Chemistry**, finding 1,313 records; of theses, 1,310 were in Google Scholar, 3 in Capes and none in SciELO. And as a last filtering criterion, **Glossary AND Libra AND inorganic reagents** were adopted, obtaining 169 documents, all available in Google Scholar.

The combination of keywords that index more articles, dissertations and theses is Glossary-Libras; 4,970 for Google Scholar and 24 for Capes. This happens because this association of words is more generic, covering all areas of knowledge for Glossary in Libras. For the Glossary-Libras-inorganic compounds combination, the list of documents is small. There are 169 records, and only for Google Scholar. This is due to the fact that inorganic functions are from a specific technical area of chemistry, in which there are very rare sign-terms in Libras. Therefore, the few documents found in the literature show his term arranged throughout the text; yet, unrelated to signs in Libras for inorganic compounds.

On realizing that, for all combinations of keywords, the titles were repeated, we then took – for research – **Glossary AND Libras AND Chemistry**, since this filtering strategy contemplates more specific documents of interest for the research, while excluding the

generics. As the objective of the research was to find out which documents had sign-terms for inorganic compounds, all the titles of the 1.313 records found were analyzed. As a criterion of exclusion, only the documents that contained words in the title referring to the research objective, such as: Libras, signs, chemistry, glossary, scientific, concepts, *Sinalários*, among others remained. Thus, of the 1,313 found in Google Scholar, 28 remain; while of the 3 Capes records, two remained. Finally, the abstracts of the articles, dissertations and theses were selected, reaching 17records for final analysis; 16 in Google Scholar and 1 in Capes.

For a amore specific analysis, we present below, in Chart 1, the list of 17 titles of the articles and theses of the final analysis and their consequences.

Chart 1: Final analysis records – Google Scholar and Capes

Platforms	TITLES
Google Scholar	1. Development of signs in Libras for teaching organic Chemistry: a case study in a school in Linhares/ES, 2017, Amanda Bobbio Pontara.
	2. New signs for science: development of scientific glossary in Libras, 2011, Julia Barral Dodd Rumjanek.
	3. Construction of a glossary of signs-terms used in the teaching of chemistry, 2017, Regina de Fátima Freire Valentim Monteiro; Layce Alicy CunhaAlves Pontes.
	4. Construction of glossary on glass to give support to disabled students, 2017, Raquel Teixeira; Yuri Freitas Mastroiano; Amelia Rota Borges de Bastos.
	5. Elaboration of a glossary to support the learning of chemical concepts for deaf students, 2017, Thalita Gabriela Comar Charallo.
	6.The contribution of *sinalários* for scientific divulgation in Libras, 2018, Vilma Malacarne; Verônica Rosemary deOliveira.
	7. Libras glossary for chemistry: innovation in teaching the deaf, 2017, Nielson Firmino de Oliveira.
	8. Libras signs for experimental chemistry: building communication between teachers and deaf students, 2018, Expedito Barbosa Lages; Jhonison Lima Fernandes de Freitas; Nazaré do Socorro Lemos Silva Vasconcelos.
	9. Creation of a *Sinalário* of technical terms in Libras –Technical Course in Electro-technique, 2017, Ângela Paloma Zelli Wiedemann; Elisete Ponio Aires; Ana Lucia Berno Bonassina; Fabio Cuellar; Gustavo Elias de Brito; Marcella Jenichen Perussolo.
	10. *Sinalário* of Chemistry in the Brazilian Language of Signs (LIBRAS): lexical creation on a periodic table, 2019, Joyce Valeska Oliveira Gonçalves: Bruna Gomes Delanhese; Letícia Jovelina Storto.
	11. Sinalário of Scientific Terms in Libras and its Use at School, 2016, Geano Gustavo Geofre Paz; Bruno Gonçalve Carneiro; Roselba Gomes de Miranda.
	12. Experimentation in chemical education: elaboration of signs in Libras for laboratory practices, 2018, Geilson Rodrigues da Silva; Talina Meirely Nery dos Santos; Griscele Souza de Jesus; Lucas Pereira Gandra.
	13. Teaching of chemistry and the Brazlian language of signs – signwritting system (Libras-SW): intervening monitoring in the production of scientific signs, 2014, Edvaldo da Silva Costa.
	14. Glossary on glass: material of support to the teaching of disabled students, 2, Raquel Lopes Teixeira; Amélia Rota Borges de Bastos; Yuri Freitas Mastroiano.
	15. Production of glossary in Libras for laboratory equipment: option for chemical experimentation and inclusion, 2019, Rogério Pacheco Rodrigues; Fernanda Welter Adams; Cinthia Maria Felício; Maísa Conceição Silva; Jaliane Soares Borges dos Santos; Alessandra Timóteo Cardoso; Simone Machado Goulart.
	16. Chemical terminologies in Libras: use of signs in the learning of deaf students, 2010, Sinval Fernandes de Sousa; Hélder Eterno da Silveira.
Capes	17. Information density, phonological complexity and their implications toward organizing glossaries of technical terms for the Brazilian sign language, 2013, Janine Soares Oliveira; Markus Johannes Weininger.

Chart 1 evidences that there is a similarity in all 17 recorded titles as regards the format of the document, *i. e.*, they all mention the creation of signs in Libras, mainly for Chemistry as a whole. This is due to the fact that the platforms index documents quoting the words Glossary, Libras and Chemistry, which generally refer to the assistance in contents of Chemistry. Some mention the creation of scientific sign-terms in Libras. However, when the download is carried out to allow the reading of the document, what came closest to the intended product in this work was Amanda Bobbio Pontara's master's dissertation, 2017, which proposes the "Development of signs in Libras for the teaching of organic Chemistry: a case study of a school in Linhares/ES".

In general, the product described in the dissertation is similar in form to the *sinalário* intended in this research project – as it refers to the development of signs in Libras and, in this sense, there is a similarity in the general format of the two products. However, it differs in content, since the proposed *sinalário* refers specifically to signals from the area of inorganic chemistry, while that of Pontara (2017) refers to the area or organic chemistry.

VI. FINAL CONSIDERATION

Science and technology have advanced all over the world, making societies more and more dependent upon this knowledge. In view of this reality, it is imperative to form scientifically literate citizens. As seen earlier in this specific case, deaf students have more learning difficulties in Chemistry than hearing ones. And among other reasons, this is due to what authors like Silva and Santana (2011) and Quadros and Karnopp (2004) had already noticed in their studies: the lack of scientific terminologies in Libras and the impact that the lack of these sign-terms cause to the access, the production and exchange of scientific knowledge in the deaf community. In this scenario, research on anteriority is very significant for the inclusive scientific education of the deaf; because, on the one hand, it confirms what the aforementioned researchers had already reported and, on the other hand, it reinforces the need for the development of more studies involving scientific concepts in Libras and their dissemination in different educational contexts.

Regarding data mapping, the search for anteriority resulted in 6,.476 documents containing articles, dissertations and theses: 6,449 in Google Scholar, 27 in Capes and none in SciELO. After strategies for excluding titles, reading abstracts and texts, there was only one document similar to the product intended in this project, authored by Amanda Bobbio Pontara, 2017. However, the *Sinalário* described in the dissertation is similar in form but, differs in content. The *Sinalário* we propose refers specifically to Libras signs in the area of inorganic Chemistry, while that of the researcher Pontara (2017) refers to the area of Organic Chemistry. Thus, there is a lack of specific signs of inorganic Chemistry in Libras.

Therefore, we conclude that – until the date of the search carried out in this research – there were no articles, dissertations or theses in the researched bases that addressed *Sinalários* in Libras for inorganic compounds. This factor indicates the importance of creating this instrument as a didactic material to support the Teaching of Chemistry. Because, it will firstly provide the translation of the scientific concepts in theoretical classes and, later on, their practical application in laboratory experiments, including the deaf in investigative knowledge.

It is important to show that research in Libras, in the area of Sciences, continues, and that signs can be created in order to cut off the lexical gap for a more satisfactory scientific inclusion of this community.

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