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INCLUSIVE TEACHING MATERIALS IN CHEMISTRY TEACHING: a literature review study

MATERIAIS DIDÁTICOS INCLUSIVOS NO ENSINO DE QUÍMICA: um estudo de revisão de literatura

MATERIALES DIDÁCTICOS INCLUSIVOS EN LA ENSEÑANZA DE LA QUÍMICA: un estudio de revisión de la literatura

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Abstract
This study is part of a Postdoctoral research and aimed to outline how the production of inclusive teaching materials for teaching Chemistry is presented in the CAPES Theses and Dissertations Bank and in the Digital Library of Theses and Dissertations within the time frame of 2015-2024, based on the combination of descriptors. To this end, we used qualitative research, of the literature-review type. We found a total of 64 works, after refinement, we were left with 17 productions for analysis, all of them resulting from master's research, that is, dissertations. The analysis was based on a thematic axis. The works repeatedly indicated the importance of developing inclusive resources for teaching Chemistry. The study revealed interesting but still unmotivating data and made it clear that despite the existence of laws that guarantee the right to equality and inclusion for people with disabilities in education, the topic is still little discussed, as we can see in the number of publications found. The findings also show the need to expand research to include disabilities beyond visual and auditory disabilities, and also to look at inclusive education from the perspective of Universal Design for Learning. This means thinking about learning resources in a way that makes them accessible to everyone who participates in the educational process.

Keywords: Chemistry Teaching. Inclusive Education. Teaching Material

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Resumo
Este estudo é parte de uma pesquisa de Pós-Doutorado e teve como objetivo delinear como a produção de materiais didáticos inclusivos para o ensino de química se apresenta no Banco de Teses e Dissertações da CAPES e na Biblioteca Digital de Teses e Dissertações dentro do recorte temporal de 2015-2024, a partir da combinação de descritores. Para tanto, utilizamos uma pesquisa qualitativa, do tipo revisão de literatura. Encontramos um total de 64 trabalhos. Após refinamento, ficamos com 17 produções para análise, todas elas resultantes de pesquisa de mestrado, ou seja, dissertações. A análise se deu a partir de um eixo temático. De forma recorrente, os trabalhos indicaram a importância da elaboração de recursos inclusivos para o ensino de química. O estudo revelou dados interessantes, mas ainda pouco motivadores e deixou claro que apesar de existirem leis que garantam o direito de igualdade e inclusão para pessoas com deficiência no ensino, o tema ainda é pouco discutido, como podemos ver nos números de publicações encontradas. Os achados mostram também a necessidade de ampliar as pesquisas para deficiências além da visual e auditiva e, também de olharmos para a educação inclusiva sob a perspectiva do Desenho Universal da Aprendizagem. Isto significa pensar os recursos de aprendizagem de modo a torná-los acessíveis a todos que participam do processo educativo.

Palavras-chave: Ensino de Química. Educação Inclusiva. Material didático

Resumen
Este estudio es parte de una investigación postdoctoral y tuvo como objetivo delinear cómo se presenta la producción de materiales didácticos inclusivos para la enseñanza de la Química en el Banco de Tesis y Disertaciones de la CAPES y en la Biblioteca Digital de Tesis y Disertaciones en el período 2015-2024, a partir de la combinación de descriptores. Para ello se utilizó una investigación cualitativa, del tipo revisión de literatura. Encontramos un total de 64 trabajos, luego de la depuración, quedaron 17 producciones para análisis, todas ellas resultado de investigaciones de maestría, es decir disertaciones. El análisis se basó en un eje temático. Los trabajos indicaron reiteradamente la importancia de desarrollar recursos inclusivos para la enseñanza de la Química. El estudio reveló datos interesantes pero aún poco motivadores y dejó claro que a pesar de que existen leyes que garantizan el derecho a la igualdad e inclusión de las personas con discapacidad en la educación, el tema aún es poco discutido, como podemos observar en la cantidad de publicaciones encontradas. Los resultados también muestran la necesidad de ampliar la investigación para incluir discapacidades más allá de las visuales y auditivas, y también de considerar la educación inclusiva desde la perspectiva del Diseño Universal para el Aprendizaje. Esto significa pensar en los recursos de aprendizaje de tal manera que sean accesibles a todos los que participan en el proceso educativo.

Palabras clave: Enseñanza de la Química. Educación inclusiva. Material didáctico.

Introduction

The teaching of Chemistry involves numerous challenges, and some of these are related to the lack of adequate educational resources for the learning of content that requires a certain degree of abstraction by students. We can say that these

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challenges are further compounded when teaching these abstract concepts to students with disabilities, as the level of abstraction impedes the inclusion process. This necessitates a focus on language tools and pedagogical models that facilitate understanding for students with disabilities.

Turning to Brazilian legislation, the Federal Constitution of 1988 stipulates that the State has the duty to provide an integral education for all, guaranteeing specialized educational services to people with disabilities, preferably within the mainstream school system (Brazil, 1988). It is understood, therefore, that it is indispensable to incorporate teaching strategies that may contribute to the comprehension of knowledge addressed in the school context, particularly subjects that are difficult to assimilate and are abstract, as is the case with certain content in Chemistry, within the inclusion process.

Promoting education for all within the mainstream school system with inclusion necessitates the pursuit of means and resources that accommodate the diverse natural learning styles inherent to all individuals (Carvalho, 1998). Within the field of inclusive education, it is necessary to foster capabilities and possibilities rather than limitations. In this scenario, varying teaching approaches through the use of attractive, dynamic, and interesting methodologies and didactic materials can foster the development of diverse students' abilities and lead to more effective outcomes.

The Salamanca Statement (Brazil, 1994), a key document addressing the educational process for Persons with Disabilities (PwD), presented several ideas for inclusive education. This document states that PwD must have access to mainstream schools, and that these institutions must adapt and provide pedagogical practices and didactic materials to guarantee their rights. In this sense, this study recognizes the necessity of considering the adaptation and development of didactic resources to promote inclusive education in Chemistry teaching.

According to Souza (2007), a didactic resource is any material used that is relevant to the student's teaching-learning process. Films, games, experiments, music, and other instruments of interaction and entertainment can be considered resources when they are directed toward teaching.

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Didactic resources can promote interaction, foster inclusion, motivate students, and enable effective learning. Selecting the most appropriate didactic resource for each student constitutes one of the most relevant aspects of Inclusive Education (Tarouco, 2004). Teaching Chemistry is already a challenging task, regardless of whether the student has a disability or not. Therefore, it is essential to examine the didactic resources used and implemented in Chemistry teaching for Inclusive Education to target both the limitations and potentialities of students.

Based on this understanding, this study is justified by the need to explore and update the relationship between Chemistry teaching, the production of inclusive didactic materials, and Inclusive Education in order to provide a current overview of academic publications. Thus, our objective was to outline how the production of inclusive didactic materials for Chemistry teaching is represented in the CAPES Theses and Dissertations database and the Digital Library of Theses and Dissertations within the time frame of 2015–2024. From this objective, we formulated the following research question: What has been presented regarding the production of inclusive didactic materials for Chemistry teaching in the CAPES Theses and Dissertations database and the Digital Library of Theses and Dissertations?

To answer our inquiry and achieve our objectives, we structured our text as follows: the first section presents a brief discussion of the introductory aspects of the study; the second section discusses Chemistry teaching and didactic resources for Inclusive Education. Next, the methodological design of the study is presented, followed by the research results, concluding with the final considerations.

1 Development

1.1 Teaching Chemistry and Didactic Materials for Inclusive Education

Reflecting on inclusive education, as well as the tools this education requires, is more than necessary in the current scenario. Pedagogical inclusion is established in official documents and is characterized by laws that aim at the acceptance of individual differences, the appreciation of each contribution, collaborative learning, and coexistence within human diversity in mainstream educational institutions.

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The Salamanca Statement of 1994 (Brasil, 1994) initiated discussions from the perspective of inclusive education, aiming to ensure that everyone attends mainstream schools, has access to, and appropriates the knowledge taught therein. The national policy on Inclusive Education ensures everyone's right to education. All students have the right to access education in an equitable and equal manner. It is the duty of the State to guarantee full access to education with equal opportunities, regardless of people's conditions.

The right to access does not imply permanence, and in this sense, a closer look at the school environment as a space of experiences and practices that effectively promote inclusion is urgently needed, in the sense of "[...] moving towards rethinking the school so that it abandons a script that considers everyone in a homogeneous manner and starts to consider the existing heterogeneity" (Fernandes e Reis, 2017, p. 187).

Costa and Turci (2011) argue that by segregating students with disabilities from the company of other students, they are deprived of social contact, stigmatized, and perceived as incapable of exercising their autonomy with dignity. This, in turn, goes against the principles that defend the right to education for all without distinction.

Inclusive Education is a social issue and is based on the principle of legitimizing a more just and equal education. All people have the right to belong to a school context, participating and learning collectively, regardless of their difficulties and limitations.

For Mittler (2003, p. 25), "in the field of education, inclusion involves a process of reform and restructuring of schools as a whole, with the objective of ensuring that all students can have access to all educational and social opportunities offered by the school." In this sense, education that aims at the inclusion of people with disabilities is understood as a process that aims to provide opportunities for everyone to have access to teaching, supported by didactic resources that respect differences and diversity, promoting the construction of knowledge and the insertion of these learners.

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For this to occur, it is necessary that all those involved in the educational process are aware of the importance of their participation. Therefore, it is essential that not only the teacher is committed to the development of the learner, but also the entire school unit, the family as the first educational space for individuals, teachers adequately prepared to meet the specificities of different students, and, finally, society in its various areas and services (Mantoan, 2003).

Chemistry teaching needs to be dialogical and developed from a perspective that does not merely show relationships between atoms and molecules or formulas. Methodologies and resources must facilitate the learning of Chemistry for all learners, regardless of their conditions. They must be designed in such a way that they can be used both by those who have specific needs and by those who do not; otherwise, exclusion occurs, not inclusion. According to Mantoan (2003), inclusion is our ability to understand and recognize the other and, thus, to live and share with people who are different from us.

Santos *et al*. (2020) point out that new teaching strategies aimed at incorporating students with disabilities have been developed with the objective of ending existing discriminatory behaviors, increasing the flexibility of the educational system. Oliveira (2021) adds that educational institutions are gradually adapting to receive students with special needs, making the school structure viable to suit the different needs of each student. He also emphasizes that the teaching staff has been seeking training and specializations to adapt methodologies and didactic materials that can be appropriate for all students in the classroom, whether they have special needs or not.

Considering methodologies that can be effective for all students within the classroom involves reflecting on which didactic resources should be used. For Cerqueira and Ferreira (2000, p. 1), didactic resources are:

> [...] all physical resources, used with greater or lesser frequency in all disciplines, areas of study, or activities, regardless of the techniques or methods employed, aiming to assist the learner in achieving their learning more efficiently, constituting a means to facilitate, encourage, or enable the teaching-learning process (our translation).

The didactic resource must include all students, with or without disabilities.

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Selecting the most appropriate resource for each student constitutes one of the most relevant aspects of Inclusive Education. Therefore, it is essential to examine the didactic resources that will be used in Chemistry teaching for and within Inclusive Education, focusing on both the limitations and potentialities of students.

2 Methodology

This study is characterized as qualitative and bibliographic research, specifically a literature review. According to Fonseca (2002), bibliographic research is conducted through the survey of previously analyzed and published references, with the objective of obtaining information or prior knowledge about the problem for which an answer is sought. We understand, therefore, that such research is based on the study of already published theory, which enables the researcher's appropriation of the domain of reading and systematization of the material being analyzed.

The study was conducted in the databases of the CAPES Theses and Dissertations Catalog (BDC CAPES) and the Brazilian Digital Library of Theses and Dissertations (BDTD), with a publication timeframe of ten years, that is, scientific productions disseminated between 2015 and 2024. This temporal delimitation was based on the year 2015, when the Brazilian Law for the Inclusion of Persons with Disabilities (Statute of the Person with Disability) was enacted, reinforcing that education constitutes a right for this portion of the Brazilian population. The year 2024 is the year prior to initiating the survey of works to be integrated into the corpus of our study.

The CAPES BDC makes works defended in Brazilian postgraduate programs available year by year. It functions as a platform that aims to facilitate access for the entire community to productions from master's and doctoral programs in the country, through specific descriptors such as keywords, fields of knowledge, evaluation area, year of publication, among others. The Brazilian Digital Library of Theses and Dissertations (BDTD) encompasses the existing thesis and dissertation information systems in Brazilian educational and research institutions and stimulates the registration and publication of theses and dissertations in electronic media, thus providing greater visibility to national scientific production.

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The criteria adopted for inclusion and exclusion in this literature review were, respectively, the proximity and distance from the study's object. The search was performed using the following descriptors: teaching materials, production, chemistry teaching, inclusive education, inclusive didactic resource, inclusive didactic material, development, teaching, chemistry, assistive technology AND chemistry teaching, and their associations with Boolean operators.

The analytical strategy used was Bardin's (2016) Content Analysis, which consists of a methodology for analyzing qualitative data, aimed at producing new understandings about phenomena through categorization.

3 Results and Discussions

3.1 Selected Works in the CAPES Theses and Dissertations Catalog (BDC CAPES) and in the Brazilian Digital Library of Theses and Dissertations (BDTD)

For the search, we used the following descriptors: teaching materials, production, chemistry education, inclusive education, inclusive didactic resource, inclusive didactic material, development, and assistive technology, combined using Boolean operators. The subsequent stage after the initial survey involved an abstract review to determine the inclusion or exclusion of the identified publications. Table 1 below presents the number of studies located across the two databases.

Table 1 - Number of studies per descriptor in the Capes Theses and Dissertations Database.

Descriptors	Number of Works CAPES Theses and Dissertations Database	Refined Search CAPES Theses and Dissertations Database	Number of Works Brazilian Digital Library of Theses and Dissertations	Refined Results Brazilian Digital Library of Theses and Dissertations
"didactic materials" AND Production AND "chemical education" AND "inclusive pedagogy"	1	1	3	1

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"inclusive didactic materials" AND "chemical education"	2	1	2	0
"inclusive didactic resource" AND "chemistry education" AND "Inclusive Education"	2	1	1	0
"assistive technology" AND "chemistry education"	13	11	12	0
Development AND "teaching materials" AND education AND Chemistry AND Inclusion	9	1	19	1
Total number of works	27	15	37	2

Source: Elaborated by the authors, based on research data (2024).

A total of 64 studies were initially identified. After the refinement process, 17 master's-level dissertations were selected for analysis. The research corpus consisted exclusively of works that focused specifically on inclusive didactic materials for Chemistry Education as their primary object of study.

This limited number of publications aligns with the findings of Uliana and Mól (2017), who, upon analyzing theses and dissertations available in the BDTD from 1990 to 2014, identified 50 works in the field of visual impairment but found only one study connecting this theme to Chemistry Education. The selected studies are listed in Table 2 below.

Table 2 - Works Identified in the CAPES Theses and Dissertations Catalog

Year	Title	Author	Institution	Source	Academic Level
2019	Inclusive Education in Chemistry Teaching: The State of the Art and Our Experiences at Colégio Pedro II	Marco Antonio Batista Valente	Federal Fluminense University	BTD CAPES	Professional Master's Degree
2017	Production of Video Lessons as Inclusive Teaching Materials for High School Chemistry Teachers	Paula Rodrigues Nogueira Ferreira Paulo	Federal Fluminense University	BTD CAPES	Professional Master's Degree
2023	Chemical Braille Bricks: Pedagogical Implications for Chemistry Instruction for Visually Impaired Students	Vivian Caroline Farias	CEFET-MG	BTD CAPES	Research Master's Degree

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2017	Developing Teaching Resources for Blind Students: A Case Study in Chemical Reactions Instruction	Lais Perpetuo Perovano	Federal University of Espírito Santo	BTD CAPES	Research Master's Degree
2017	Assistive Technologies and Meaningful Learning-Based Didactic Material Development for Chemistry Instruction to Deaf Students	Ricardo Daniel Prestes Jacauna	State University of Roraima	BTD CAPES	Professional Master's Degree
2017	Utilizing Tactile and Audio-Descriptive Assistive Technologies in Chemistry Education for Students with Disabilities	Tamyla Cristina Alves de Sousa	Federal University of Acre	BTD CAPES	Professional Master's Degree
2023	Development of Video Lectures with Brazilian Sign Language Translation: Assistive Technology in Chemical Education	Isabele Fernanda Silva de Moraes	IFAM	BTD CAPES	Professional Master's Degree
2017	The Periodic Table as an Assistive Tool in Chemical Education for Blind and Visually Impaired Students	Rodrigo Pedroso da Silva	Federal University of Technology – Paraná	BTD CAPES	Professional Master's Degree
2021	Encoded-Element Periodic Table: Assistive Technology as a Tool for Chemistry Education	Lucicleide Maria de Andrade Silva	State University of Paraíba	BTD CAPES	Research Master's Degree
2020	Assistive Technology in Chemistry Teaching for the Blind: Interfaces for Building Mental Representations	Tania Silva Nascimento	Federal University of Sergipe	BTD CAPES	Research Master's Degree
2020	Cosmetics: Contextualized Experimentation via the Science-Technology-Society (STS) Approach for Visually Impaired Students in Organic Chemistry Education	Mislene da Silva Oliveira	Federal University of Goiás	BTD CAPES	Research Master's Degree
2023	Assistive Technologies in Thermochemistry Teaching from an Inclusive Perspective	Bruno Cesar Rodrigues	Federal University of Sergipe	BTD CAPES	Research Master's Degree
2023	Tab-Libras App: Interactive Periodic Table for Teaching Chemistry to Deaf and Hearing Students	Jose Carlos de Sousa Araujo	State University of Mato Grosso	BTD CAPES	Research Master's Degree
2023	Studies on Guided Participation in Chemistry	Renata de Moraes e Silva	Federal University of Goiás	BTD CAPES	Research Master's Degree

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	Teaching for Students with Visual Impairments				
2021	Chemistry Teaching for Deaf Students: Planning Didactic Materials Based on Visual Approaches	Gessiele da Silva Correa	Federal University of Pelotas	BTD CAPES	Professional Master's Degree
2020	Development of a Periodic Table Using Additive Manufacturing Applying the Universal Design for Learning Concept	Ângela Paloma Zelli Wiedeman	Federal University of Technology – Paraná	BDTD	Research Master's Degree
2018	Visual Impairment and Chemistry Learning: Reflections During the Planning and Development of Tactile Teaching Materials	Natália Pereira Marques	Federal University of Uberlândia	BDTD	Research Master's Degree

Source: Elaborated by the authors, based on research data (2024).

The first aspect analyzed was the annual quantitative distribution of publications, as illustrated in Graph 1 below.

Graph 1 - Yearly Distribution of Studies on Inclusive Educational Resources for Chemistry Teaching

Source: Elaborated by the authors, based on research data (2024).

Regarding the volume of publications, the first mapped works date back to 2017. This occurred two years after the enactment of Law No. 13,146/2015, the Brazilian Law for the Inclusion of Persons with Disabilities (LBI), which aims to ensure and promote, on an equal basis, the exercise of fundamental rights and freedoms by persons with disabilities, aimed at their social inclusion and citizenship.

In the following year, 2018, a decline in research output was observed, with

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only one publication. New studies subsequently appeared in 2019, 2020, and 2021, although in numbers lower than those in 2017, indicating a period of low productivity. In 2023, the number of research works returned to a level comparable to that of 2017.

These results demonstrate that this remains an area with limited specific academic output, highlighting the need for further studies on this contemporary and relevant theme for the promotion of an equitable education system. Subsequently, we sought to ascertain the academic level at which these studies were developed. As shown in Graph 2 below, the research was conducted at both academic and professional master's levels.

Graph 2 - Research Level Analysis of Publications Retrieved from the Digital Library of Theses and Dissertations

Source: Elaborated by the authors, based on research data (2024).

No studies were conducted at the doctoral level, indicating that academic production dedicated to understanding the development of inclusive didactic materials for chemistry education remains limited, and that research on this topic has not yet achieved significant depth.

Consequently, we directed our attention to the research objectives, methodologies, and findings of the selected studies. The aim at this stage was to highlight the focus of the published works, detailing key aspects of the selected publications and presenting critical reflections, following the sequence presented in Table 2 above. For this purpose, we employed the theoretical framework of Content Analysis (Bardin, 2016) and organized the mapped works into a single analytical

category, as they demonstrate substantial thematic dialogue. Through meticulous examination of the abstracts, methodologies, results, and, in some cases, the complete texts, we identified the following analytical category: Production of Inclusive Didactic Materials in Chemistry Education.

3.1.1 Production of inclusive teaching materials in Chemistry education

In his dissertation entitled *Inclusive Education in Chemistry Teaching: The State of the Art and Our Experiences at Colégio Pedro II*, Valente (2019) presents a literature review on the production of adapted teaching materials for the chemistry education of visually impaired students and describes teaching resources developed from experiences at Colégio Pedro II. The author's review highlighted that the most frequently researched topic related to inclusion is content about the Periodic Table. Furthermore, the author reflects that this underscores the importance given to this specific content and emphasizes that chemistry teaching in the first year of Brazilian high school is much broader than simply teaching the periodic table.

Following the literature review, the author presents the materials created based on his experience at Colégio Pedro II. According to him, this resulted in a collection of adapted resources for visually impaired students, designed for quick access by teachers working in the first year of high school, while also offering ideas on how to adapt teaching materials based on the provided models. The research showed that adapted materials can contribute to the socialization of visually impaired individuals, as the author argues that the lack of vision, whether total or partial, does not prevent students from understanding the proposed content. The core issue, he states, lies in adaptation, that is, in accessibility.

Paulo (2017), in a dissertation produced at the Federal Fluminense University, addressed the *topic Production of Video Lessons as Inclusive Teaching Materials for High School Chemistry Teachers*. The research focused on producing three video lessons on diverse themes, aiming to assist chemistry teachers with the inclusion process.

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The methodological approach of this study consisted of bibliographic research to identify publications in articles, journals, dissertations, presentations, videos, and tutorials on inclusive chemistry teaching in general, and specifically on inclusive chemistry teaching related to visual impairment, combined with a case study. The target audience was chemistry teachers and their relationship with inclusion. The produced videos were evaluated by 25 teachers from different fields, who assessed the content positively and suggested improvements regarding technical aspects of recording.

The focus of this work is also on the production of teaching materials for students with visual impairments. Both the studies by Valente (2019) and Paulo (2017) highlighted the need and feasibility of developing new materials and methodologies for teaching chemistry to blind individuals.

The study conducted by Farias (2023), also focused on visual impairment, investigated the pedagogical implications of using an inclusive didactic resource called *Bricks Braille Químico* (BBQ) in chemistry teaching for students with visual impairments. This work, entitled *Bricks Braille Químico: pedagogical implications for teaching Chemistry to students with visual impairments,* was based on a qualitative and exploratory research design, conducted through semi-structured interviews and two focus groups.

The author sought to understand the pedagogical mediation enabled by the use of the BBQ in teaching practices for students with visual impairments. The didactic resource was developed through digital prototyping, using three-dimensional modeling software available at the Maker Lab of CEFET-MG. The pieces were produced using 3D printers. The research involved four groups of participants: blind teachers, science/chemistry teachers experienced in Braille, chemistry teachers unfamiliar with Braille, and blind students. The study concluded that the BBQ is an inclusive didactic resource with promising potential, offering teachers accessible material that can be implemented in pedagogical practice.

Similarly, Perovano (2017), in the work entitled *Development of Didactic Resources for Blind Students: a case study in the teaching of chemical reactions*, emphasized the scarcity of teaching materials for teaching chemistry to people with

visual impairments. In the text, Perovano (2017) cautioned that this scarcity constitutes a barrier to the teaching and learning process. The study focused on creating didactic resources for teaching chemistry, specifically chemical reactions, to blind students. The research was based on a qualitative methodology, with data obtained through observations and semi-structured interviews. The participants in this research were a blind student, her chemistry teacher, and her Special Educational Services teacher.

The results of the study indicated that the use of tangible didactic resources, combined with the mediation established with peers and the teacher, is fundamental for the internalization of the scientific concepts covered in chemistry classes for students with visual impairments.

Jacauna (2017), in his dissertation *Assistive Technologies and the Elaboration of Teaching Materials based on Meaningful Learning for Chemistry Education for Deaf Students*, proposed to evaluate the use of assistive technology in the construction of advanced organizers for the teaching of chemistry to deaf students. The author conducted her research with a deaf student in the 3rd year of high school and sought to identify the student's prior knowledge in organic chemistry and oxygenated functional groups. This was achieved using a Portuguese-to-Libras (Brazilian Sign Language) text translator application and pedagogical material based on the Meaningful Learning theory, paying attention not only to the use of assistive technology but also to the pedagogical aspect of this tool.

The author highlighted in the research results that the use of the text-to-Libras translator application, when integrated with teaching strategies that consider the specificities of these students and are grounded in an educational theory, can enhance pedagogical practices. In the conclusions, the author stated that teacher training is an indispensable factor in developing strategies and resources aimed at the cognitive development of all students, deaf or otherwise. As the dissertation resulted from a professional master's program, the author developed, as an educational product, an instructional sequence and a practical guide aimed at teachers and professionals interested in inclusive education.

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In 2017, Sousa developed her dissertation, *The use of tactile and audio-descriptive assistive technologies in chemistry teaching for students with visual impairments*, with the objective of analyzing whether the description of tactile adaptations using MecDaisy software facilitates the comprehension of chemistry content by students with visual impairments (blindness and low vision). Through a qualitative study from an action-research perspective, the author conducted workshops with resource room teachers and chemistry teachers from the participating schools. The purpose was to introduce and utilize the MecDaisy software. Following classroom observations, the adapted material was developed and subsequently tested with two students with visual impairments, two chemistry teachers, and two resource room teachers.

As a result, Sousa (2017) indicates that the use of assistive technologies combined with tactile adaptations assists visually impaired students in educational activities by stimulating their cognitive potential and fostering their socialization and learning. The study further indicates that the material contributes to a more equitable and dynamic development of the students' chemical knowledge. It also revealed that teachers recognized the need for changes in their pedagogical practices to avoid excluding students with visual impairments.

Similarly to Jacauna (2017), Moraes (2023) also dedicated her research to analyzing the use of assistive technology for deaf students in chemistry. In her study, a qualitative research with an action-research epistemological foundation, entitled *Production of video lessons with Libras translation: assistive technology in chemistry teaching*, the author sought to evaluate the use of assistive technology resources for deaf students in the context of chemistry classes by creating video lessons with translation into Brazilian Sign Language (Libras). Moraes (2023) developed three video lessons addressing the following topics: physical transformations of matter, atomic models, and chemical bonds, incorporating images and animations.

The videos were evaluated by chemistry teachers and members of the deaf community, who assessed the content positively. The author emphasizes that the deaf community unanimously expressed that the use of images and animations facilitated the comprehension of concepts in the field of chemistry. She concludes by

stating that the use of video lessons made the teaching-learning process more dynamic and engaging for students, and that these results reflect the relevance of integrating assistive technology into chemistry classes to meet the needs of the deaf community, providing an inclusive and effective approach for teaching this subject.

In the dissertation *The Periodic Table as an Assistive Technology in Chemistry Education for Blind and Low-Vision Students*, Silva (2017) presents an assistive resource to promote access to the periodic table for blind and low-vision individuals. The study involved a literature review of proposals for chemistry teaching resources aimed at inclusion, covering the period from 2006 to 2017. Considering the principles of Universal Design, the author systematized an adaptation of the periodic table for blind students, which was subsequently tested in the classroom. In his conclusions, Silva (2017) asserts that the use of this resource can yield benefits for the didactic practice of science teachers and for the learning process of blind and low-vision students. This has the potential to remove barriers to accessing the common curriculum, thereby fostering the possibility of a truly inclusive education.

Similarly, in 2021, Silva, in her study *Periodic Table with Encoded Elements: The Aid of Assistive Technology as a Tool for the Teaching-Learning of Chemical Content*, aimed to adapt the periodic table using QR Code and podcast resources for use in an inclusive high school classroom. Like Silva (2017), Silva (2021) considers the principles of Universal Design and seeks to cater to sighted students, as well as blind and low-vision learners enrolled in the public high school system.

The author's findings resonate with those of Silva (2017), indicating that the resources used for teaching the periodic table to students with or without visual impairments facilitate greater learning and peer interaction, in addition to prompting reflections on teaching practices regarding the use of technology in inclusive education within mainstream schooling. The author further notes a persistent lack of pedagogical materials to support chemistry teaching for inclusive education.

In 2020, Nascimento published a dissertation entitled *Assistive Technology in Chemistry Teaching for the Blind: Interfaces for the Construction of Mental Representations.* The work centers its discussions on chemistry education, visual impairment, and assistive technologies, with the overarching objective of analyzing

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the use of polychromatic tactile stickers in the study of organic functions by a student with a visual impairment. To achieve this objective, the author employed a qualitative case study methodology, with participants comprising one student with a visual impairment, three sighted students, a Braille specialist, and a person with amblyopia. The study's findings reveal a need for more nuanced reflection regarding the construction and use of teaching materials to ensure their functionality is not reduced to mere instrumentalism. Nascimento (2020) concludes that the developed and applied polychromatic tactile sticker proved to be an ally in teaching organic functions, as well as in stimulating the formation of mental imagery by the blind student.

In the work *Cosmetics: A Proposal for Contextualized Experimentation through the STS Approach for Students with Visual Impairments in the Teaching of Organic Functions*, Oliveira (2020) sought to investigate how the STS contextualization can contribute to the promotion of inclusive chemistry teaching. Through action research, the study developed pedagogical interventions for the study of organic functions using contextualization under the STS approach with the theme of cosmetics, emphasizing the social inclusion of students with visual impairments.

The results present a proposal for chemistry teaching that utilizes three principles of contextualization and five stages of the STS teaching approach. This model demonstrates a less visual-centric stance in experimentation and enables the inclusion of these students in more autonomous participation, familiarizing them with specific tools and techniques of this culture and thereby contributing to the teaching-learning process. In its conclusions, the study emphasizes that the presented proposal is not a solution to all issues related to teaching chemistry to people with visual impairments. However, it represents a starting point for possibilities and initiatives, offering relevant alternatives in developing teaching strategies that respect diversity and integrate these students into activities.

Rodrigues (2023), in the study *Assistive Technologies in the Teaching of Thermochemistry from an Inclusive Perspective*, aims to analyze the use of assistive technologies in teaching thermochemistry for the construction of chemical knowledge among students with visual impairments. To this end, the research subjects were

four chemistry teachers from the second year of high school who teach students with visual impairments (blindness and/or low vision). The study was qualitative in nature and characterized as a descriptive field-based case study.

In his results, Rodrigues (2023) highlights the scarcity of research on assistive technologies and the teaching of thermochemistry involving students with visual impairments. In his literature review, he found only two scientific articles related to this theme and no dissertations or theses on the topic. The study also identified numerous challenges and difficulties in teaching thermochemistry to this student population, such as the absence of practical training. It also found that the use of inclusive graphics associated with strong colors and language in both Braille and Portuguese can facilitate the reading and comprehension of chemical representations by students. This approach allows for the creation of mental representations that enhance communication and access to scientific language through the senses and the materials used. In his conclusions, he suggests the need for further research to foster new discussions on the training of chemistry teachers, as well as the development of inclusive educational practices.

In line with other studies, Araújo (2023), in his research *Tab-Libras App: An Interactive Periodic Table for Teaching Chemistry to Deaf and Hearing Students*, utilized a technological and assistive didactic resource to teach chemistry content in an inclusive manner. The author's objective was to contribute, through the mobile application Tab-Libras, to the teaching of chemical elements from the periodic table as a didactic-technological and assistive resource for deaf and hearing high school students. Consequently, he emphasized that the use of digital technologies and digital assistive technologies in the school environment initiates a new conception regarding the perception of unification and the creation of conditions capable of establishing new parameters for student autonomy and agency, thereby promoting equal opportunities to address the needs of persons with disabilities.

Silva (2023) presents an account of her master's research entitled *Studies on Guided Participation in Chemistry Teaching for Students with Visual Impairments*, which aimed to reflect on the contributions of experimentation through Guided Participation in the teaching and learning process of chemistry for students with

visual impairments. The research employed a qualitative, participant methodology to develop new strategies for teaching students with visual impairments. The planned experiments were designed to utilize the students' senses of touch, smell, hearing, and taste as means for observing the experiments, enabling them to participate autonomously and independently.

Her results reveal that the use of experimentation with an investigative approach based on guided participation favored the appropriation of knowledge and the development of competencies to reduce the barriers that prevent these students from participating in practical classes, resulting in increased autonomy. Furthermore, she states that the use of guided participation in classes for the visually impaired points toward a proposal for Chemistry teaching that opens up new possibilities for more autonomous participation by these students, thereby contributing to the teaching and learning process.

The research developed by Correia (2021), in the dissertation Chemistry Teaching for Deaf Students: Planning Didactic Materials Based on Visual Elements, aims to understand the extent to which the use of a teaching proposal based on visual elements can assist deaf students in comprehending concepts, specifically changes in the physical states of water, among first-year high school students. The work involved the use of didactic material developed with visual elements, such as pictures, figures, illustrations, and the corresponding chemical terms in Libras (Brazilian Sign Language).

The research findings indicated that deaf students found it easier to understand chemical concepts when visual elements were considered. These elements included drawings, graphs, photographs, videos, models, and the corresponding chemical terms in Libras, all of which proved useful for presenting topics or content.

Marques (2018) presents another study focused on the inclusion of students with visual impairments in Chemistry education. In her dissertation *Visual Impairment and the Learning of Chemistry: Reflections During the Planning and Elaboration of Tactile Teaching Materials*, the author states that one of her objectives was the production of tactile materials to assist Chemistry teachers in reflecting on certain concepts, thereby making them more meaningful for students with visual

impairments. To achieve this goal, the author employed an action research methodology and organized an extension course for the production of teaching materials, targeting undergraduate Chemistry students, Chemistry graduates, Chemistry teachers, and postgraduates in fields related to Chemistry Education.

The results obtained by Marques (2018) indicate that teachers should pursue continuing education to feel more confident in making their classes more inclusive, thereby developing greater competence to address the specific needs of their students.

In her dissertation entitled *Development of a Periodic Table Using Additive Manufacturing Applying the Concept of Universal Design for Learning*, Wiedeman (2020) developed a periodic table structured according to the principles of Universal Design for Learning (UDL). The author utilized a project-development guidance framework for the prototype's construction. The resulting product consisted of blocks, platforms, and a carrying case. It was implemented in two integrated high school classes at the Federal Institute of Paraná, Campo Largo Campus, comprising a diversity of students without disabilities, students from special education, and students with specific needs.

According to Wiedeman (2020), the results suggest that students' specificities were accommodated within a regular classroom, enabling individual and social learning. Furthermore, the teaching of the periodic table facilitated engagement through multiple means of expression and representation.

In general, the analyzed studies highlight a scarcity of inclusive materials for Chemistry education. It is also evident that these efforts were predominantly directed toward the inclusion of students with visual impairments, with fewer focusing on deaf students. No studies were found dedicated to developing resources that consider other target groups within inclusive education, such as individuals with Autism Spectrum Disorder (ASD) and intellectual disabilities.

Conclusion

This study presented an analysis of publications on the topic of inclusion in Chemistry Education within the CAPES Theses and Dissertations Database (BDTD) for

the period from 2015 to 2024. The research revealed interesting, yet discouraging, data. Although laws guarantee the right to equality and inclusion for persons with disabilities, the subject remains underexplored, as evidenced by the limited number of publications found.

The findings also highlight the need to broaden research to include disabilities beyond visual and auditory impairments and to examine inclusive education from the perspective of Universal Design for Learning (UDL). This entails designing learning resources to make them accessible to all participants in the educational process. The diversity present in today's classrooms poses a challenge for teachers aspiring to provide inclusive education and ensure learning for all students. Addressing the specific needs of students, with or without disabilities, makes teaching more targeted and effective. Therefore, it is necessary to discuss and understand different strategies for universal teaching and learning, thereby reducing learning inequality.

Despite clear societal demand, inclusive education in Chemistry teaching remains underexplored. There are few publications addressing the development of inclusive didactic materials for Chemistry teaching, especially when compared to other themes. This result points to a need for both initial and continuing teacher training, as well as the dissemination of successful experiences. Educators must understand foundational principles to critically position themselves toward inclusive education and to design and develop inclusive teaching materials for this scientific discipline.

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