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Challenges and successes: online and inclusive teaching of green chemistry in Brazil in the time of covid-19

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Abstract

The year 2020 was marked by the beginning of the intense journey against Covid-19, which brought strong impacts to Brazilian education. In view of this, the educational system began to adapt to the "new normal" and, with this, problems arose in adapting to virtual education, especially in the scope of School Inclusion (SI) of the deaf public, since social distancing requires significant attention in the use of aspects of communication and online technologies. These difficulties were more prominent, especially in the discipline of Chemistry, which is not detached from experimentation. Thus, the research demonstrates the need for better approaches to SI in Emergency Remote Education (ERE), especially in Chemistry contextualized to Environmental Education (EE). This work aims to adopt Active Methodologies (AM) and it is justified in offering activities aimed at the interassociations between Chemistry and EE, through the Case Study (CS) method. These actions addressed the principles of Green Chemistry (GC) and the 6th Sustainable Development Goal (SDG) on drinking water and sanitation. The development of the work occurred remotely in an inclusive class. The results of the research demonstrated the importance of using inclusive methodologies that favor the construction of effective knowledge and enable the exchange of knowledge in a bilingual and accessible environment. Thus, the adaptation or development of new didactic methodologies can change the reality of Brazilian education.

Keywords: inclusive green chemistry; deafness; sustainability, LIBRAS.

1. Introduction

During the COVID-19 pandemic, there were many impacts in the social and economic spheres, causing all sectors of society to be conditioned to an intervention that, for the educational sphere, culminated in the closure of institutions and adherence to the Emergency Remote Education (ERE) model (Oliveira & Araújo, 2020; Souza et al., 2022), thus causing several obstacles in teaching.

In this circumstance, challenges arose in adapting to the virtual education system (Aquino et al., 2020; Lynn et al. 2020; Silva Júnior, Iran Filho, Romão & Dias, 2022; Romão & Silva Júnior, 2022; Long & Kowalske,

2022; Da Silva Júnior et al. 2022), especially in student behavior, as students often did not turn on cameras and/or audio functions during synchronous meetings, limiting themselves only to the use of *chat*, making communication and contact with teachers difficult, "dehumanizing" the learning process (Ferreira, 2021).

This scenario contributed to many teachers assuming the position of "depositing" information, since the absence of direct interaction brings the idea of a banking education, in which knowledge is transmitted unilaterally and mechanically (Freire, 1997). These problems occurred mainly in the discipline of Chemistry, which, for Tavares (2022) is an entirely practical and interactive science, which is not detached from experimentation, which ends up being a difficult process also due to social distance.

In accordance with the impasses exposed, it is possible to affirm that these educational challenges were intensified within the scope of School Inclusion (SI), especially in the care of the deaf public. As Lynn et al. (2020) and Santos (2019) discuss, an effective implementation of work with deaf students in this context of social distancing requires significant attention in the use of aspects of communication, education and technologies in an online space, so that the bad work of SI can result in the evasion and/or demotivation of these students.

Evidently, this atypical scenario exposed the unpreparedness of many teachers regarding SI, since the advance of the pandemic suddenly accentuated the use of Digital Information and Communication Technologies (DICTs), such as digital platforms, software, and Virtual Learning Environments (VLE), which, in many cases, have a lack of accessibility (Amorim, 2020; Chahini, Mendes & Silva, 2020; Lemos & Chahini, 2020).

Amorim (2020) highlights among these limitations, the absence of the Brazilian Sign Language (LIBRAS). The author argues that this problem extends from the lack of a simultaneous translation in synchronous classes, the insufficiency of videos in LIBRAS present in the didactic resources made available by the platforms, to the "absence of a more specialized pedagogical look that meets the needs of the deaf" (Amorim, 2020, p. 22). In addition to these limitations, many teachers understand the inclusion of the deaf public as the mere presence of a Sign Language Translator (SLT) (Santos & Oliveira, 2016).

Given this, the advance in the adoption of new technological resources in the ERE has made the learning process based on inclusion, accessible and inclusive, given that the virtual space has benefited the Deaf Community (DC) throughout history (Tavares, Ferraz, Silva Júnior, Souza & Figueirêdo, 2022a; Gori, Corrêa & Galon, 2019; Lynn et al. 2020; Souza, Figueirêdo, Silva Júnior, Ferraz & Tavares, 2022; Long & Kowalske, 2022; Da Silva Júnior et al. 2022).

However, the lack of knowledge of such innovations, due to the lack of disclosure "makes essential research that seeks to contemplate the particularities of each individual, paying attention to the authoritative universal design" (Tavares et al., 2022a, p. 11569). Thus, it is understood the need for improvements in approaches to SI in the ERE, Tavares et al. (2022a, 2022b) suggest as an alternative to the impasse, the intensification of teaching mediation between the deaf student and the contents, through the adoption of Active Methodologies (AM) and contextualized with current and everyday issues.

In this sense, Environmental Education (EE) related to the discipline of Chemistry can contextualize the theme. As pointed out by the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2021), EE should be included in the basic education curriculum by 2025, thus the urgency at the junction between the

didactic practices applied in school institutions with the topics of Sustainable Development (SD) is noticeable (Da Silva Júnior & Figueirêdo, 2017; Nascimento et al. 2018, Figueirêdo et al. 2022). Still within the context of teaching Chemistry and EE it is worth emphasizing Green Chemistry (GC), as reported by Anastas and Warner (2000), Marques et al. (2020), Tavares et al. (2022c) and Da Silva Júnior, De Jesus & Girotto Júnior (2022), GC focuses on carrying out chemical processes that are harmless to human and environmental health. In this sense, the teaching of GC involved with SD can be understood as a means to promote good practices for life in society, so these multidisciplinary fields should also be worked on in an inclusive way.

However, according to Ramos (2009), the implementation of GC and the Sustainable Development Goals (SDGs) in regular education ends up being hampered by educational impediments resulting from the scarcity of references.

According to Silva Júnior (2017), this combination of "insufficiency" is considerably more aggravating in the approaches to the inclusion of deaf people, as little is discussed about the creation of accessible methodologies regarding GC and SDGs for the mentioned public. These adversities in deaf education can be understood as resulting from the immense gap of inclusion in the daily life of schools (Silva, 2021; Lynn et al. 2020; Long & Kowalske, 2022).

In this sense, this article is justified in the offer of teaching activities focused on the interassociations between Chemistry and EE, together with the application of an AM: the Case Study (CS) method. In these actions, discussions were addressed regarding the principles of GC and the 6th SDG (drinking water and sanitation), together with the integration of the SI guidelines for an inclusive class. This article seeks to present strategies in the development of accessible methodologies for deaf and hearing students in the ERE and assist in the process of school and citizen education of the research subjects.

2. Methodology

The development of the research relied on methodological approaches of a qualitative and participatory nature, since these methods of scientific basis unite, through the construction of knowledge, the researcher to the phenomenon investigated, considering the perception of all components of the situation studied (Faermann, 2014; André & Gatti, 2011).

The researchers in this study were three professors of Chemistry, three SLT and three undergraduate students in Chemistry at the Federal Institute of Education, Science and Technology of Paraíba (IFPB), Brazil. The follow-up analysis and validation of this pedagogical intervention aimed to verify the functionality of expanding inclusive methodologies in the ERE. In this context, the application of the research took place in 2021, remotely, in a third-year class of the Technical Course in Environmental Control Integrated to High School of the Federal Institute of Paraíba - IFPB, João Pessoa campus, Brazil. The research was attended by 9 (nine) students, of whom 8 (eight) were listeners and 1 (one) was deaf. In addition, throughout the development and application of the work, the SLT of the educational institution were present. The work was divided into 3 (three) moments, as shown in Table 1.

Table 1. Research Methodology Moments.

Moments	Description
Moment 1: Verification of the previous knowledge of the class through the application of a Survey Questionnaire (SQ).	SQ was applied with the use of *Google Forms*. The first question was: *1) Do you know Green and Sustainable Chemistry? Options: a) Yes, I have studied Green and Sustainable Chemistry; b) No, I have never studied Green and Sustainable Chemistry; c) Maybe, but I'm not sure*. The second question was: *2) What relationship can exist between sustainability and environmental control?*
Moment 2: Explanation on the 12 principles of Green Chemistry and the Sustainable Development Goals, focusing on SDG 6.	In this class, the teachers explained the socio-scientific importance of Green Chemistry, highlighting its recurrence in the National High School Exam (ENEM), after all the students were in the 3rd year of High School. It is noteworthy the growing presence of GC in the last ENEM events. Also in this class, there was the presentation of the 17 Sustainable Development Goals, highlighting the 6th SDG: drinking water and sanitation. In this context, there was also the use of the virtual simulation device, through free software "*Mozaik education&quot"* with simultaneous translation in LIBRAS for the exposure of the steps in water treatment.
Moment 3: Application of a Case Study with the participation of the Inclusive Class.	Students were presented with a case study called "Contamination of water as a barrier to fishing". This activity aimed to foster the active participation of the students participating in the research, through the contextualization with their daily lives. The students developed the answers to the case among themselves. To validate the action, an observational analysis was performed in the class during all moments of the application.

It should be noted that this research project was considered and approved by the Research Ethics Committee (CEP) of IFPB, according to the number of Certificate of Presentation of Ethical Assessment (CAEE): 50914521.8.0000.5185, as regulated by Resolution No. 466 of December 12, 2012 (Brasil, 2012), of the National Health Council in Brazil.

3. Results and Discussion

3.1 First Moment: Verification of prior knowledge of the class

Regarding the first question of SQ, 78% of the students in the Environmental Control class never studied about GC, while 22% stated that they were not sure. This was already an expected result, considering that GC is not

yet a widespread theme within classrooms in Brazil (Da Silva Júnior, De Jesus & Girotto Júnior, 2022).

Dwelling on the second question, all the answers obtained were cohesive and related to scientific knowledge. It is inferred that the knowledge acquired during the Environmental Control course may have influenced this result.

One student said, "*Yes. It is very important to have at least basic knowledge, because in everyday life, we go through many situations where reactions occur between substances and everything else, things that can often be dangerous reactions or toxic substances. Having a prior knowledge of chemistry makes it easy to even understand that we may be dealing with something dangerous, even if we don't know what it is*." This statement demonstrates the importance given to the Chemical and Environmental content that would be taught later.

These results in the survey encouraged the team responsible for the application, after all, the answers demonstrated a domain on the part of sustainability, while GC would be a new and exploratory content, transforming it into an experiential, relational and interactive context.

3.2 Second Moment: Explanation on the 12 principles of Green Chemistry and the 17 Sustainable Development Goals

Nowadays, GC is more frequent in the High School Nacional Exam, in Brazil (Da Silva Júnior & Lopes, 2021).

In this second moment with the class, there was the presentation of the 12 principles of GC and the 17 Sustainable Development Goals, which were presented in a didactic way, especially considering the quality of the DICTs, avoiding very technical words, since there is still little technical vocabulary in LIBRAS, in addition, pauses were made in orality, for better understanding and translation.

Knowing that the class is composed of a deaf student, it had become unfeasible to exclude the SLT or even impose on the student in focus the choice between visualizing the visual resource or the interpreter. Therefore, the use of "OnToReplica" was adopted, a free software that overlaps images in the background, making it possible to simultaneously view the SLT in the material (Figure 1).

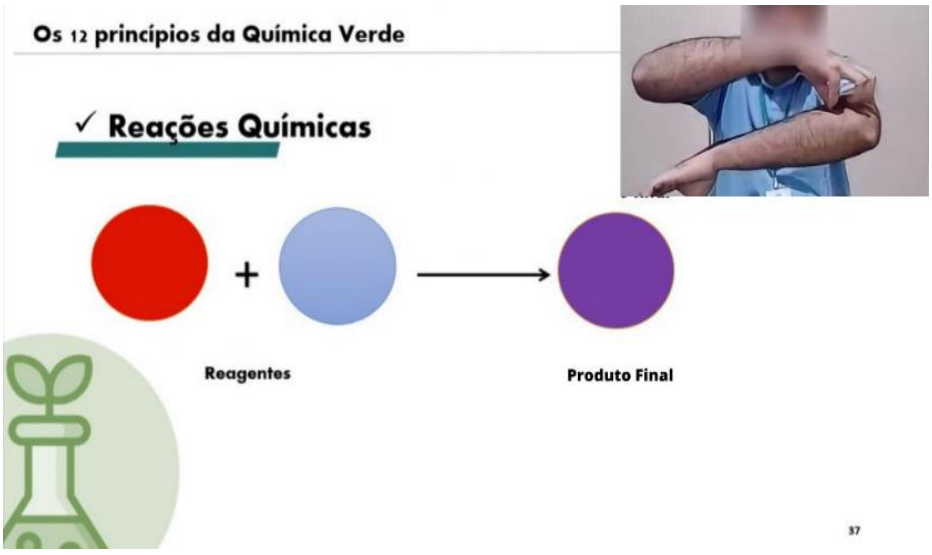

Figure 1. Using the "OnToReplica" software to overlap SLT in remote classes.

Throughout the application process, the active participation of the student with plausible positions was noticed, mainly with comments stating the importance of the action, as well as the following speech pronounced by a student through the video call *chat*: "*This is important, the less dangerous products, the better*", which demonstrates the effective participation by the student.

It is noteworthy that one of the tools used in the application for permanence and participation of students was the material presented, both in terms of content and the quality of visual resources presented.

The absence of visual pollution facilitated the interpretation of the SLT (which had prior access to the material), as well as focused students' attention on a specific point. The lack of excessive texts combined with agile language, bringing technical sayings closer to colloquial communication (to explain technical language), increased participation and interaction. In a qualitative approach, it is inferred that all participants showed to be participatory and responsive regarding the stimuli offered.

Always aiming at the integration of the knowledge taught by teachers and those obtained by students in the Environmental Control course, space was given for inquiries from them at opportune times, always valuing favorable information, such as the importance of providing an adequate process of sanitation and water treatment for the population, especially in the region in which they live. This region has a source of income more concentrated in fishing practice, thinking about it the entire teaching process of the 6th SDG kept this focus.

Students were also presented with the main contextualization resource, the wastewater treatment plant simulator, obtained through the free software "Mozaik education", being of paramount importance to adapt the content presented to the student's experience, as can be seen in Figure 2.

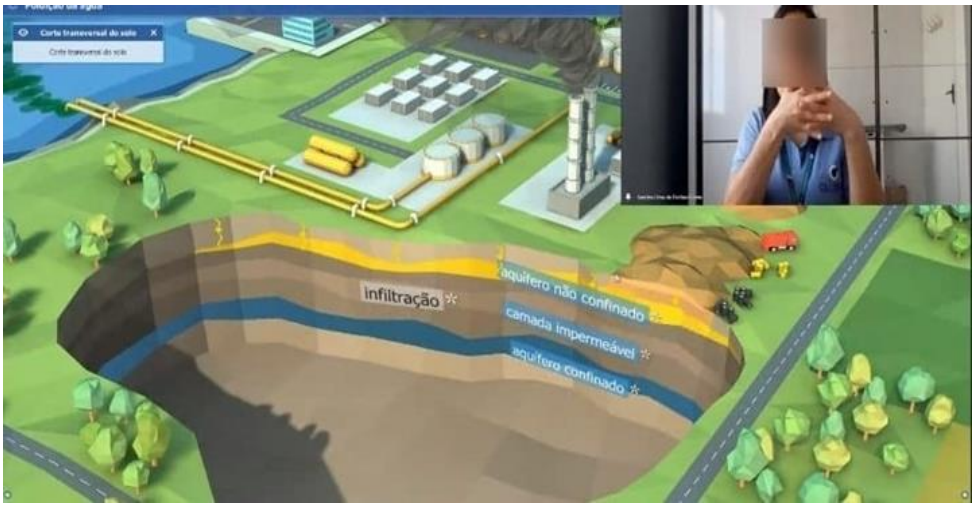

Figure 2. Use of the simulation software of a water treatment plant.

During the exemplification of the treatment process, a student reported: "That is why a well-made treatment is important", referring to the last treatment plant, in which case the waste disposed of in the waters would not be treated effectively, pollution would occur, which depending on the intensity or time, could become irreversible.

3.3 Third Moment: Application of a Case Study with the participation of the Inclusive Class

In the third moment, there was the application of a Case Study entitled: "Contamination of water as a barrier to fishing practice". The CS method was chosen because it is an essential alternative for the expansion of teaching, since it is a methodology that aims to "develop higher order skills, such as decision making and the development of argumentation" (Selbach, Daniel, Ribeiro & Passos, 2021, p. 38).

In addition, the CS is still categorized as a strategy for education in times of pandemic, since this method, even not requiring experimentation, is still characterized as a practical science, and can thus motivate students to understand and explain daily events, through the participatory search for alternatives based on socio-scientific content (Silva Júnior, 2017; Selbach et al., 2021; Tomaz, Novaes, Machado, Crispim & Massena, 2019; Silva, Oliveira & Queiroz, 2011).

The case discussed the contamination of water from a river, which led to the prohibition of fishing. The story brought empathy for the class, who presented solutions to the case.

At the end of the reading and explanation of the case, it was explained that the students would have to divide into two groups, each group had a period of one week to present the response to the case study, being clarified that the teachers would be available to contact to resolve any doubts, but without pointing out the resolution of the case.

The students presented their answers to the case study in a written form, this moment was a spectacle apart, primarily due to the willingness of the deaf student to present part of the work, such action occurred widely supported by the members of their group (Figure 3):

Figure 3. Deaf student presenting the resolution of the case study.

It is worth remembering that the deaf student performed a series of care, preparing the place where he made the presentation, leaving it as functional as possible, being attentive to the lighting, framing and positioning of the camera, as well as the color of his shirt, all this to facilitate the visualization of LIBRAS and the simultaneous translation of the voice version performed by SLT professionals. His attitude was praised both by the interpreters and by the other students and professors.

The responses to the case study presented by the two teams were surprising, being also linked to the baggage acquired in the Environmental Control course. The students brought pertinent and well-placed comments throughout the presentation.

This was a satisfactory result for the researchers, since it was found that the teaching action was fundamental in the class, both for making the remote space more accessible to all the students surveyed, and for encouraging them in the field of EE.

Given the facts exposed in this research, it was found the great value of adopting interventions that minimize the lack faced by the educational sector in the pandemic period, both referring to environmental contexts and the inclusion of deaf students in regular classrooms.

Such action can occur by the interposition of methodologies that favor the construction of effective knowledge, as well as the strengthening of the interaction between hearing and deaf students, deaf and teaching students and hearing and teaching students, making it possible to exchange knowledge in a bilingual and accessible environment.

4. Conclusion

The advancement of the pandemic brought several challenges to the educational field, so the actions developed in this pedagogical intervention by the research group and the SLT, presented effective didactic strategies within the scope of School Inclusion, through the DICTs and inclusive methodologies informed in this article. The use of these technologies and didactic methods that promoted accessibility for the researched class led to new teaching practices for teachers and students, in which the active participation of these students was the main axis of the educational process.

The teaching of Chemistry, even before the pandemic, already had several challenges regarding the students' interest in the discipline, which was intensified with the ERE, which alleges the need to develop actions that overcome these problems in the learning process. The research in question suggests as a solution to the aforementioned impasse the intensification of active and contextualized methodologies linked to the SI process, this recommendation is justified in the presentation of satisfactory data of this teaching action.

Thus, the principles of Environmental Education involved with the CS method worked as an efficient alternative to the teaching of Chemistry. Thus, the discussion of environmental issues with the active methodologies and the DICTs, contribute decisively to the learning process of this discipline, making the students understand significantly and create a socio-environmental awareness from their experiences.

Thus, it is essential that the teacher focuses on the aforementioned factors in the classroom, primarily providing the inclusion of deaf students, who are often forgotten. Thus, the simple fact that the teacher proposes to adapt or develop new didactic methodologies together with the entire pedagogical team (Mwirichia, Kathuri & Mariene, 2017) can change this reality. Therefore, it is worth remembering that the consolidation of this structure helps in the preparation and composition of the teaching and learning process of the student.

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