INTERNATIONAL JOURNAL FOR INNOVATION EDUCATION AND RESEARCH
ISSN: 2411-2933

Journal URL: https://scholarsjournal.net/index.php/ijier

DOI: https://doi.org/10.31686/ijier.vol11.iss1.4043

Creation and Validation of Bilingual Educational Videos about Environmental Education, Green Chemistry and Sustainable Development Goals for Deaf People in Brazil

Maria Caroline Santos Velozo[1], Carlos Alberto da Silva Júnior[2], Márcio Jean Fernandes Tavares[1], Júlia Maria Soares Ferraz[1], Niely Silva de Souza[3], Alessandra Marcone T. Alves de Figueirêdo[1]

[1] Department of Chemistry, Federal Institute of Paraiba (IFPB), João Pessoa, Brazil
[2] Department of Chemistry, Federal Institute of Paraiba (IFPB), Sousa, Brazil
[3] Department of Chemistry, Federal Institute of Paraiba (IFPB), Cabedelo, Brazil

Abstract

This work aims to create and validate a Bilingual Video Material (BVM), supported by the concepts of Environmental Education (EE), Green Chemistry (GC) and Sustainable Development Goals (SDGs) in an inclusive class of the high school level in Brazil, thus enabling the inclusion of the deaf in a more accessible way, based on the cultural artifacts of the Deaf Community. Therefore, through a qualitative and participatory research, it was possible to verify the efficiency in the adoption of the bilingual teaching methodology. This didactic strategy proved to be a great ally of accessibility (in Portuguese and in Brazilian Sign Language - LIBRAS) for the inclusion of deaf people, especially when based on the contextualization with EE, GC and SDGs in an interdisciplinary approach.

Keywords: deafness; inclusion; sustainable; sing language.

1. Introduction

In recent years, environmental problems have been highlighted in the media. For example, the tragedy that occurred with the collapse of the dam in Brumadinho, in the state of Minas Gerais, Brazil(Oliveira et al., 2019), which led us to a greater reflection on the human impacts on the environment. In this reflection, the 17 Sustainable Development Goals (SDGs) can be addressed in the Chemistry classroom(Tavares et al., 2022), mainly in accordance with the International Year of Basic Sciences for Sustainable Development, celebrated in 2022 (IYBSSD, 2022; Figueirêdo et al. 2022).

As recommended by the National Common Curriculum Base (BNCC) and the National Curriculum Parameters + (PCN+), having access to chemical concepts and knowledge: “must enable the student to understand both the chemical processes themselves and the construction of scientific knowledge in close relation to technological applications and their environmental, social, political and economic implications” (BRASIL, 2002, p. 87). These documents guide the approach to Transversal Contemporary Themes, such as

the Environment, of which Green Chemistry stands out in Chemistry Teaching (Ballard & Mooring, 2021; Grieger & Leontyev, 2020; Sousa et al., 2020).

According to Da Silva Júnior, Jesus and Girotto Júnior (2022), the SDGs can be introduced in the classroom in a critical and reflective way. According to the authors, different themes in the discipline of Chemistry with a focus on Environmental Education (EE), such as the principles of Green Chemistry (GC), can help in this approach. QoL creates, develops and applies chemical products and processes aimed at reducing or eliminating the use and generation of substances harmful to the environment and man(Anastas & Warner, 2000). Thus, AS and GC help the educational process in the formation of responsible individuals and with a citizen, critical and socio-environmental awareness (Da Silva Júnior et al., 2022)

In Brazil, many teachers of Natural Sciences disciplines (Biology, Chemistry and Physics) still make great use of traditionalist methods, without contextualizing the contents with EE, GC and the reality of students, making them mere recipients of fragmented information that is transmitted by the teacher (Sousa, Cruz, Santos & Cândido, 2018). This problematic factor establishes barriers in the educational process of students, such as demotivation and lack of interest in studies, since the "contents reach students in a way labeled by the disciplines" (Diniz et al., 2021, p. 2).

These barriers of traditional education intensify in the context of Inclusive Education (IE), especially for the deaf public, due to the lack of school actions that effectively insert these students. Christino and Böck (2019) indicate that this factor is the result of the troubled discriminatory, segregating and capacitating scenario in which the Deaf Community (DC) developed, in which Sign Language (SL) was criminalized and prohibited for many years, and deaf people were forced to communicate through speech [Oralism] (Souza, Figueirêdo, Da Silva Júnior, Ferraz & Tavares, 2022).

The history of struggle and empowerment of DC, along with the emergence of bilingualism, was enabling the right to communication via SL, the most legally recognized in Brazil is the Brazilian Sign Language (LIBRAS) (Alves & Frassetto, 2015; Reis et al. 2021). Thus, the education of the deaf began to be understood by the principles of school inclusion and communicative and linguistic accessibility, indicating that deaf students should share, in an equitable way, the same environment and set of opportunities as listeners. According to Leal and Guimarães (2019):

"the bilingual philosophy is incorporated within Inclusive Education, in which deaf students attend the same classes as hearing students in regular schools, both public and private. In the regular school, the deaf student comes into contact with the scientific knowledge presented to him by the teacher, in Portuguese. As the deaf student does not communicate and does not perceive assimilation as the listeners, since their communication occurs more visually, he needs the performance of a LIBRAS interpreter" (p. 73).

It is necessary to understand the cultural artifacts of the deaf people, such as the visual experience and linguistic aspect (Strobel, 2008). The first artifact discusses the way in which the deaf public absorbs their knowledge and exercises their communication, being the channel through which they access the world. The second (linguistic) artifact brings the idea of valuing LS that makes the deaf person have access to information and knowledge (Guimarães, Aquino & Fernandes, 2017; Chahini, Mendes & Silva, 2020; Souza et al., 2022).

Thus, the development of teaching actions should consider these factors in a didactic systematization that guarantees students a more meaningful and accessible learning. As Ambia and Rahman (2021) indicate, the Inclusive Educational Policy needs to be presented to teachers from the training period in the bachelor's degree courses, to minimize the aforementioned challenges in regular education institutions.

In the literature on Inclusive Chemical Education, chemistry teachers have recently highlighted the use of Digital Information and Communication Technologies (DICT) as an alternative for teaching deaf students(Aljedaani et al., 2022; Clark et al., 2022; Long & Grunert Kowalske, 2022; Lynn et al., 2020; Souza et al., 2022). Regarding the theme in Green Chemistry (GC), Brazil was a pioneer in the development of accessible, didactic and inclusive resources for deaf students(Beyond Benign, 2022).

Chemistry teachers need to be aware of the specificities of students so that they can provide them with specific, adequate and inclusive care, as provided for in Brazilian legislation (Brasil, 1999). Specifically in the deaf community, it is necessary to corroborate with Strobel (2009, p. 159) when stating that "far from being considered as a group of people marked by disability and by the desire for healing and normalization, these students with special needs are characterized by their own elements that mark their difference".

In this context, this work was configured from a question: What didactic resources could be developed to facilitate the access of hearing and deaf students in this theme? The answers to this question are important, since the school needs to promote actions that develop the skills and abilities necessary to preserve the environment and improve the quality of life in an inclusive way. This work aimed to develop and apply accessible teaching materials that contextualize the teaching of Chemistry and EE, valuing the visuality of students, through a Visual Pedagogy (PV) (Campello, 2008), supporting the bilingual ideal and adding the use of technology in its favor.

2. Methodology

The methodology of this research is a pedagogical intervention applied in a post-pandemic context. According to Zanella (2011, p. 23), "research essentially aims to produce new knowledge and aims to seek answers to problems and theoretical and practical questions". Therefore, we developed a qualitative approach of a participant nature, in order to obtain a meaningful evaluation.

According to Martins (2004), one of the main characteristics of the qualitative methodology is flexibility, since

this method allows an intensive examination of the data, analyzing each research process. In turn, Zanella (2011, p. 121) states that "in participant observation, the observer is part of the observed group and is confused with it, directly experiencing the observed situation". Therefore, this approach presents a greater interaction between the researcher and the object of study (Günther, 2006).

As this work involves the production and application of an inclusive resource, the methodology was divided into 2 (two) general steps: (I) The preparation of Bilingual Video Material (BVM); (II) The application of Bilingual Video Material (BVM) in the classroom. The preparation of the Bilingual Video Material (BVM) was subdivided into 4 (four) stages, as shown in Table 1:

Table 1. Stages of the preparation of Bilingual Video Material (BVM)

Steps	Activities
1	Capture of the contents covered in the video and Preparation of the Script.
2	Development of the visual resource (images, animations and visual effects).
3	Recording the audio.
4	Recording of the translation in LIBRAS and the insertion of the subtitle in Portuguese-Brazil.

The application of Bilingual Video Material (BVM) in the classroom was subdivided into 3 (three) stages, as shown in Table 2:

Table 2. Steps for the application of Bilingual Video Material (BVM) in the classroom.

Steps	Activities
1	Survey of the class with the application of Virtual Bilingual Survey Instrument (VBSI).
2	Display of the video for the class.
3	Application of the Bilingual Final Virtual Instrument (BFVI)

The project took place at the Federal Institute of Education, Science and Technology of Paraíba (IFPB) João Pessoa Campus, Brazil. The participating students attended the 4th (fourth) year of High School Integrated to the Technical Course in Environmental Control. This class was composed of 21 (twenty-one) hearing students and 1 (one) deaf student. The research was evaluated and approved by the Research Ethics Committee (REC) of IFPB, according to the number of Certificate of Presentation of Ethical Evaluation (CAEE): 57464422.1.0000.5185, as regulated by Resolution No. 466 of December 12, 2012, of the National Health Council (CNS) (Brasil, 2012). As members of the research team, 03 (three) professors from the Chemistry

area participated, 03 (three) students from the Chemistry Degree and 02 (two) interpreters from IFPB.

3. Results and Discussion

3.1 Elaboration of Bilingual Video Material (BVM)

The BVM is an inclusive and bilingual material, so the programs and applications used in the production of the video are accessible and have a simple and easy-to-understand interface. These characteristics are important, because during the pandemic it was observed that teachers, in general, had no experience with TDICs (Souza et al., 2021). Thus, the creation of the bilingual resource is characterized as an innovative and executable alternative, which contributes to IS.

The results in the stages of preparation of the Bilingual Video Material (BVM) are discussed in the following topics, which are divided into: i) capture of the content covered in the video and preparation of the script; ii) development of the visual resource (images, animations and visual effects); iii) audio recording; and iv) translation recording in LIBRAS and the insertion of the subtitle in Portuguese-Brazil.

3.2 Capture of the contents covered in the video and Preparation of the Script

The BVM is characterized as an educational instrument and, for this reason, it is necessary for the teacher (author of the video) to understand the importance of designing the execution for the proper functioning of the construction stage. Conceição, Santos, Moura Sobrinha and Oliveira (2019) explain that planning is defined as a means to program teaching actions, such as didactic activities and proposed objectives. Thus, the first moment happened in capturing the chemical contents addressed in the video.

The definition of the contents is a primordial phase for the conception of a project of such nature, because through it it is possible to determine a linearity and hierarchy of the subjects exposed in the video. Thus, the structuring of these items in the BVM took place in the following order: i) the principles of QoL; ii) definition of SDGs; iii) the 6th SDG (Drinking water and sanitation); iv) and the batch adsorption process, with a biodegradable adsorbent, as an alternative to water treatment. It is important to emphasize that the choice of the aforementioned contents occurred in accordance with the teacher of the class.

After defining the programmatic content of the video, the stage of development and preparation of the script was initiated. Establishing a *script* is necessary for the creation of audiovisual content of any genre, such as a didactic video. The script was also elaborated, because this script served as a guideline in the selection of visual resources, in the capture of audio and in the recording of the translation in LIBRAS.

3.3 Visual Resource Development

The second stage of the elaboration of the BVM was the creation of the visual resources of the video (images, animations and visual effects). This stage was developed by the *Microsoft Powerpointprogram*, as it is characterized as a *software* already known and used by most teachers in the preparation of slides. However,

this program is not only a Slide editor, since it has a range of tools that allow the creation of videos with animations, in addition to having a simple interface and language.

The selection of the components applied in the video was made taking into account the specificities of inclusive education(Egambaram et al., 2022). The choice of images was made in order to add didactic value to the BVM, also aiming to arouse students' interest in the discipline of Chemistry and make the content more interactive. This characteristic of exploring the sense of visuality of students, through the use of images to replace textual elements, is an action of PV indispensable for the process of cognition of both deaf and hearing students (Campello, 2008).

For the creation of a video with LIBRAS translation, it is important to pay attention to the space in which the Sign Language Translator (SLT) video box will be located, before adding any other visual elements. Thus, the other components must be inserted respecting this space, as shown in Figure 2. The demarcation of the SLT video box was developed using the "Insert>Shapes>Rectangles" functions, respectively. Strategically, the space for the translation in LIBRAS was placed at the top so that the caption was later added in Portuguese-Brazil.

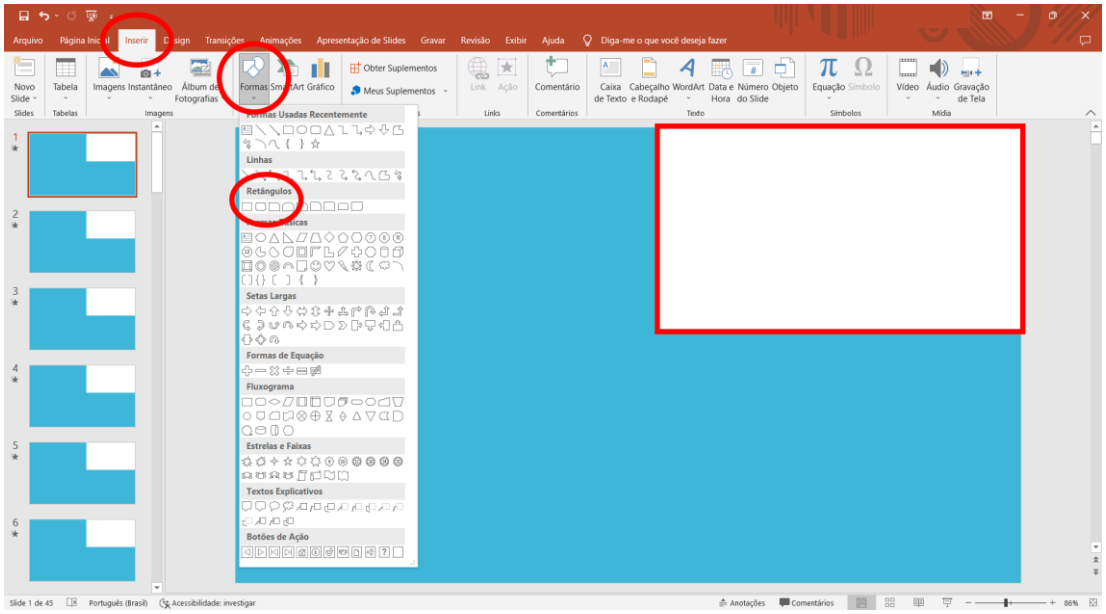

Figure 2. SLT video box.

In this sequence, the previously selected images were introduced into the bilingual material, for which the Insert>Images functions were applied. In the course of this step, it was necessary to follow the guidelines described in the script, causing the figures to be distributed on different pages of the slides according to the sequence of lines of the *script*. To add new pages to the slide, the "Insert>New Slide" functions, arranged in the Microsoft Powerpoint Tools tab, were followed.

In addition, to ensure the aspect of interactivity to the BVM, the "Animations" function was used. This feature

of the digital program enabled the use of actions and movements in the inserted images. To create animations, simply select the image and choose one or more available animations (Figure 3).

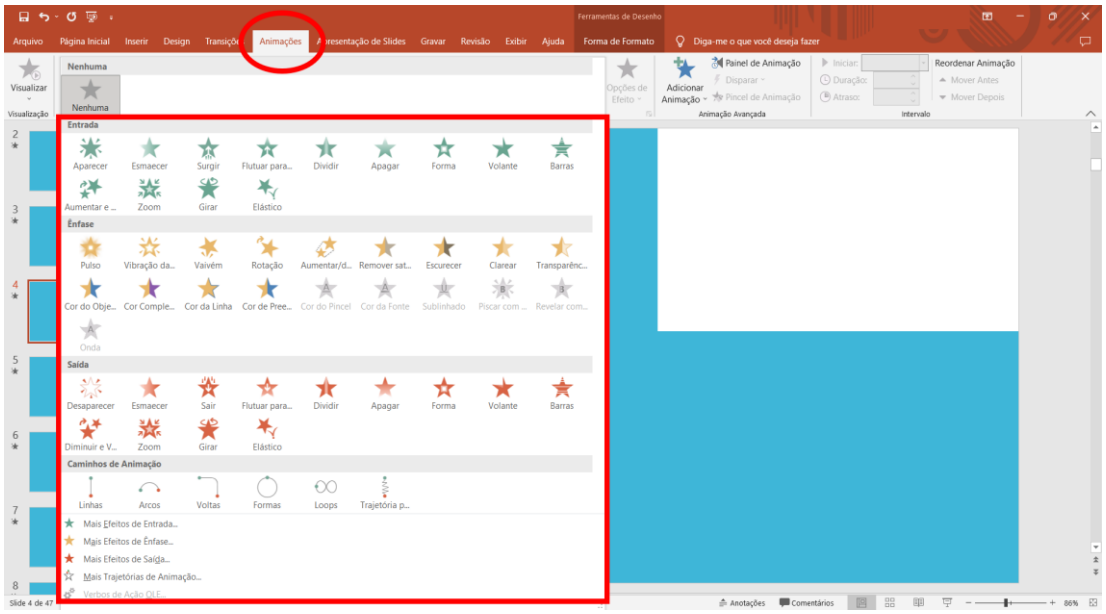

Figure 3. Animation effects.

These animations are used both to make the video more dynamic, and can also be extended in the demonstration of some chemical concept. In this video, these resources were used to explain adsorption (Figure 4). The white circle (Adsorbent) attracts the orange circles (Adsorbate). The visual representation of this physicochemical phenomenon was created through the function of "Animation> Emerging > Effect Options".

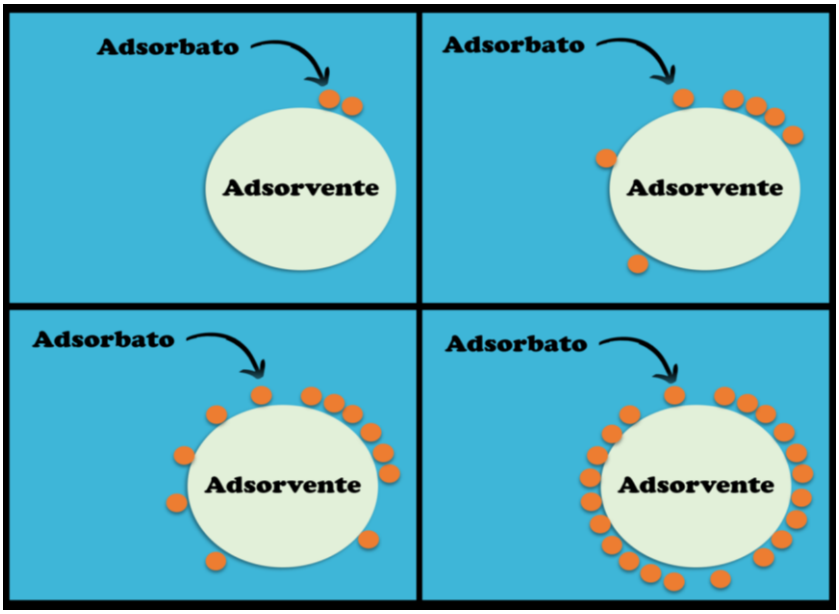

Figure 4. TILS video box.

With the completion of the exposed steps, the last step was the recording of the visual mechanisms of the BVM. For this, it was necessary to use the functions "Record>Record>Start Recording". Then, it was necessary to convert the Powerpoint BVM model to the video format, for this purpose the functions "Record>Export to video>Create Video" were used.

3.4 Recording the audio

The third stage of BVM development was audio recording. This step is essential to make the composition of the video more complete, fulfilling the objective of bilingualism. Thus, the indicated action allowed MVB to reach the entire class, in addition to the deaf student, also the hearing students.

The recording was performed with a mobile device, in an application of the smartphone. However, if necessary, mobile virtual stores have a wide variety of applications for audio capture available for free, facilitating access to teachers interested in building similar material. The audio recording was done in a quiet place, to ensure better quality and noise free.

In this sequence, the audio was inserted into the video (visual part developed in the second moment), using the YouCut-Video Editor application. The synchronization of the audio with the video facilitated the translation step for LIBRAS. Thus, it was crucial to edit the video before forwarding it to SLT, as the visual resource with the audio ready helped synchronize the translation in LIBRAS in the Portuguese material.

3.5 Recording of the translation in LIBRAS and the insertion of the subtitle in Portuguese

Following all the steps mentioned above, the last moment of the development of the BVM was the recording of the translation in LIBRAS by SLT. In this stage, the collaborative work among all members of the group of researchers was intensified, resulting in the assembly of a didactic and accessible material.

This data corroborates directly with the idea of effectiveness in the joint work of the pedagogical team for the expansion of IS, through activities like this, teachers develop new skills and competencies assuming the role of teaching mediator, along with school support networks (Mwirichia, Kathuri & Mariene, 2017; Clark et al., 2021).

For completion, the video of the translation in LIBRAS was added in the space demarcated in the material, this step was developed by the video editor used previously, *Youcut-Video Editor.* Then, the caption in Portuguese-Brazil was added using the CapCut *application*, generating the caption automatically.

In this sense, according to Lopes (2022), the use of digital applications and platforms works as a viable, current, economic and practical strategy for teachers from different areas of science, being characterized as tools that enhance the teaching and learning process for all.

3.6 Application of Bilingual Video Material in the classroom

The results in the steps of the application of the Bilingual Video Material (BVM) in the classroom are discussed in the following topics, which are divided into: i) survey of the class with the application of the Virtual Bilingual Survey Instrument (VBSI); ii) display of the video to the class; iii) application of the Final Bilingual Virtual Instrument (FBVI).

Both evaluative questionnaires (VBSI and FBVI) followed the bilingual production line. We add a more inclusive and accessible character to the research project. The verification instruments came from *Google Forms*, in the following order: formulation of the questions; audio recording of the questions to assist the translation in LIBRAS; sending the recordings to SLT; recording the translation in LIBRAS; posting on *YouTube* to generate the sharing *link*; and the assembly of the forms with the insertion of the videos.

3.7 Survey of the class with the application of the Virtual Bilingual Survey Instrument

In the first moment of contact with the inclusive class, the IVSB was made available to students. The digital questionnaire consisted of 4 (four) questions: *I. Do you know the Sustainable Development Goal 6?*; II. *Do you know Green and Sustainable Chemistry?;* III. *What experiences in inclusive education have you had?; IV. Have you seen Green and Sustainable Chemistry and Sustainable Development Goal 6 didactic materials in LIBRAS? If yes, exemplify.*

The VBSI was shared with the students during the class, via *link* in the *WhatsApp* group of the class, before the BVM exhibition.

After an accurate analysis of the answers provided by the students regarding the first two questions of the VBSI, which dealt with the knowledge of these students in relation to the socio-scientific contents of Chemistry, present in the didactic material, it was found that: 77.3% of the members of the inclusive class did not know SDG 6, and 70.2% also did not know QoL, or had only partially heard about it.

These results indicate an intense distancing of students from the socio-environmental themes of this discipline. The application of the project was developed for high school graduating students who also attended Technical Education in Environmental Control, so this "ignorance" is worrying. Both due to the fact that the discussions related to QoL and the SDGs have been recurrently found in the tests of the National High School EXAM (ONE), and because the curriculum of courses focused on environmental demands are pertinent themes (Santos, 2018).

This contradiction can be justified by the persistence of pedagogical traditionalism. Since, in these institutions, teachers usually do not correctly contextualize the issues of EE with the teaching of natural sciences (Farias, 2021; Silva Neto & Araújo, 2021). This lack of a diversified methodology makes the process of students' cognition incomplete, dispersing scientific knowledge of their reality.

Subsequently, when asked about their experiences with IE, most of the research participants stated that they had never had an experience similar to this one. One of the highlighted responses reported the following: "*I've never had an experience like this, but I think it's necessary to be inclusive.*" From this statement, it is noted that the students themselves understand the importance of IS for a good progress of educational activities.

Thus, it is up to the pedagogical team to provide students with a more inclusive environment. As Harami (2021) informs, ensuring the vacancy of students who characterize themselves as People with Disabilities (PD) in basic education is not enough to make education accessible. In addition, it is necessary for schools to promote activities, produce teaching materials and transform the classroom into a space that satisfactorily serves all students, so that IS becomes a reality.

3.8 Display of the video for the class

After verifying the results obtained in the VBSI, there was the second moment of application of the pedagogical intervention, which was defined as the display of the MVB for the class. Thus, with the help of technological resources such as a slide projector, the video was presented to all students present in the class (Figure 6). At this stage, through the mediation of an observational analysis carried out by the researchers, it was possible to notice that the students paid attention to the moment of presentation of the BVM.

Figure 5. Display of the BVM in the class.

With the completion of this application, the chemistry teacher and students showed interest in the didactic resource, since they requested that the researchers make the BVM available for sharing, also in the virtual classroom of the class. This information, as Ribeiro (2021) indicates, demonstrates how the application of TDICs and the contextualization methodology arouse students' interest in the discipline, making the learning process more fluid and meaningful.

3.9 Application of the Final Virtual Bilingual Instrument

Moment 3 of stage 2 was the last moment of the application of the research project and, in this stage, the FBVI

was made available to the class, which aimed to evaluate the effectiveness of the didactic material developed and the level of learning of the students. The final questionnaire was shared with the class after the exhibition of the MVB and consisted of 3 (three) questions, as follows.

Analyzing the students' responses, it was noticeable to observe the effectiveness of the elaboration of the action in question, since 100% of the students positively evaluated the experience of the project. Table 3 gathers some of the data reported by the students, regarding the first question of the FBVI that asked the following question: "I. *Would you like the Chemistry classes to have this type of methodology? Why?*

Table 3. Answers to the first IVFB question

Students	Activities
A	Yes, because the format draws the student's attention.
B	Yes, because I liked it and I found the method very understandable.
C	Yes, because the material and the dialogue made with the students were extremely understandable and didactic.
D	Yes, because the methodology was interactive.
E	Yes, because it is inclusive and has the help of illustrations, providing means that facilitate the understanding of the subject.

As already discussed throughout the article, the expansion of methodological diversity in the classroom is a teaching technique that must be dominated by teachers from all teaching categories, especially at the basic level (Carvalho, 2021).

This information corroborates directly with the statements presented in Chart 1, because as the students discussed, the purpose of this project was to bring in a dynamic and inclusive way a methodology that would make the teaching of Chemistry and its socio-scientific dimensions easier for these students. That is, one of the previous objectives of the research was achieved.

In this follow-up, the second question asked: "*II. On a satisfaction scale, how do you assess that the implementation of this project has facilitated your understanding of Green Chemistry content and the sixth Sustainable Development Goal (Drinking Water and Sanitation)?".* The analysis of the results indicated that 92.6% of the students were satisfied with the methodology used and 7.4% were partially satisfied with the knowledge acquired during the application of the BVM.

Compared to the VBSI data, in which a considerable portion of the students claimed to be unaware of QoL and SDG 6, it was found that the contents explained in the BVM, in a contextualized and interactive way, served as a tool to foster genuinely active learning. At this juncture, it is possible to glimpse that the association of these environmental issues with the teaching of Chemistry will assist these students both in the technical

training in the area of Environmental Control, as well as in ENEM and/or other vestibulars.

Finally, the last question of the IVFB asked the following question: *"III. Were there any technical aspects in the bilingual didactic material (lighting, caption, speed, diagramming, illustrations, audio) that you found wrong? If yes, please indicate which aspects can be improved in the bilingual teaching material."*. The investigation of the students' answers indicated that no accessibility barrier was found in the didactic material. This result is appropriate to the recommendations of Egambaram et al. (2022).

This result indicates how enriching the collaborative work between researchers and the TILS was, since they acquired the skills and competencies necessary to transform a traditional school environment into an accessible, efficient and interesting space for all research participants. As Freitas et al. (2022) cite, the mediator and qualified teacher makes education possible for all student profiles. Thus, the data from this final phase of the research demonstrate the effectiveness of the integration of IS in the teaching and learning process.

5. Conclusion

This research presented the results obtained in the production and application of a Bilingual Video Material (BVM) with deaf students and listeners of Basic Education in Brazil. The contents on the batch adsorption process, with a biodegradable adsorbent, as an alternative for water treatment were worked in an interdisciplinary way with the contemporary transversal theme of Green Chemistry, assisting in the juvenile protagonism of the class.

The production of the BVM involved four general stages: i) capture of the content covered in the video and preparation of the script; ii) development of the visual resource (images, animations and visual effects); iii) audio recording; and iv) recording of the translation in LIBRAS and the insertion of the subtitle in Portuguese-Brazil. In turn, the application of the BVM with the class involved three stages: i) probing the students' prior knowledge; ii) displaying the video to the class; and iii) applying a final questionnaire.

In total, 21 (twenty-one) students actively and voluntarily participated in the research. The involvement and engagement of the deaf student revealed that the didactic strategies used were in fact inclusive. During the Chemistry classes, it was observed that the presence of the LIBRAS interpreter and the aid of audiovisual tools helped in the teaching and learning process of the class. Thus, it appears from this research that by incorporating innovations that facilitate the understanding of the deaf, the class was also benefited, after all, inclusion is a matter of facilitating the lives of all and not just some.

It is noteworthy that the results showed the favoring of teacher-student interaction, mainly due to the effective performance of the SLT in the production of the BVM, which facilitated the interaction of the deaf student. However, the need for renewal and diversification of teaching methodologies is notable, making them more attractive, favoring teaching and learning, especially in the case of inclusive classes.

Thus, for the constant methodological advancement in Inclusive Chemical Education, it is essential to adopt a bilingual education system, such as the use of inclusive didactic resources linked to the student's experience, in line with scientific knowledge, collaborating with the permanence and success of students with or without disabilities, providing autonomy combined with technology and accessibility in sign language and Portuguese for all.

Finally, in line with the International Year of Basic Sciences for Sustainable Development, it is imperative that contemporary transversal themes, such as Green Chemistry, be integrated into the teaching of Chemistry, in a reflective and creative way. By working across the board, the principles of Green Chemistry allow the school to play its role of educating for sustainable development. In addition, the inclusion of students with disabilities in regular education is a legal provision in the Brazilian legal system. Thus, by building an BVM associated with the environmental theme, this research hopes to foster other initiatives in the area.

6. Acknowledgement

The research was financed by the Federal Institute of Education, Science and Technology of Paraiba (IFPB), Brazil. The authors would like to express their gratitude towards the IFPB for their support in making this project possible. This work was supported by Edital nº 01/2022 (Chamada Interconecta) initiated by IFPB. Further, the authors would like to thank every participant engaged in this academic research.

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