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Artificial intelligence as an assistive educational tool for the inclusion of the hearing impaired and deaf people in professional and technological education

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ABSTRACT
Professional and technological education (EFA) in Brazil has a history marked by advances and setbacks, reflecting the different political, economic, and social conjunctures of the country over decades, as well as the teaching of Libras and the regulation of the profession of translator and interpreter of Libras.

Keywords: Artificial intelligence, Professional education, Inclusive education.

INTRODUCTION

Professional and technological education (EFA) in Brazil has a history marked by advances and setbacks, reflecting the different political, economic and social conjunctures of the country over decades, as well as the teaching of Libras and the regulation of the profession of translator and interpreter of Libras.

The first records of vocational education in Brazil date back to the colonial period, when technical training courses were offered to workers in the mining and agricultural areas. In the nineteenth century, with industrialization, vocational education gained greater relevance, so technical and vocational training courses were created to meet the demands of the labor market.

In 1857, parallel to the context of professional education, the Imperial Institute for the Deaf and Dumb was also created by Emperor Dom Pedro II, which currently became the National Institute for the Education of the Deaf - INES.

At the beginning of the twentieth century, vocational education began to be organised on the basis of three levels: primary, secondary and tertiary. The primary level was focused on the basic training of workers, the secondary level on technical training, and the higher level on technological training.

In 1931, the Organic Law of Industrial Education was created, which established guidelines for vocational education in the country. The law defined that vocational education should be offered through industrial and technical schools, and that it should be articulated with regular education.

In 1961, the Law of Guidelines and Bases of National Education (LDB) was created, which also established guidelines for professional education. The LDB defined that vocational education should be offered through technical schools, agrotechnical schools, trade schools and social service schools.

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In 1971, Law 5.692/71 was passed, which reformed education in Brazil. The law defined that secondary education, now called high school, should lead the student to the completion of a professional qualification.

In 1996, Law 9.394/96 was approved, which established the new LDB. The LDB of 1996 maintained the guidelines established by the LDB of 1961, but reinforced the importance of vocational education for the development of the country.

It was only in 2005 that Decree No. 5,626 came to regulate Law No. 10,436, of April 24, 2002, which provides for the Brazilian Sign Language - Libras, and article 18 of Law No. 10,098, of December 19, 2000, made the teaching of Libras mandatory in higher education courses in the training of teachers and speech therapists.

> Art. 3 Libras should be included as a mandatory curricular subject in teacher training courses for the exercise of teaching, at the secondary and higher levels, and in Speech Therapy courses, in public and private educational institutions, in the federal education system and in the education systems of the States, the Federal District and the Municipalities.
> § 1º All licentiate courses, in the different areas of knowledge, the normal high school course, the normal higher education course, the Pedagogy course and the Special Education course are considered training courses for teachers and education professionals for the exercise of teaching. (BRAZIL, 2000)

In 2008, Law 11.741 was approved, which introduced important changes in chapter III of title V of the LDB, which now deals with "Professional and Technological Education". The law defined that EFA is an integral part of basic education and higher education, and that it must be organized at two levels: technical and technological.

In 2015 the Brazilian Law of Inclusion - LBI, presents itself as the Statute of the Person with Disabilities, this law determines that governments offer bilingual education, with Libras as the first language, L1, and the written modality of the Portuguese language as a second language, L2, both in bilingual schools and classes as well as in inclusive schools in general.

EFA in Brazil has been undergoing a process of expansion and diversification in recent decades. Currently, it is estimated that there are more than 2,000 vocational education institutions in the country, which offer courses in various areas, such as industry, commerce, services, agriculture, health, and education.

Vocational and technological education (EFA) is an important field for the training of qualified professionals for the job market. However, people with hearing impairment (AD) still face accessibility barriers that can hinder or prevent their access to this type of education, as is already the case in schools in general. Accessibility barriers can be physical, such as the lack of architectural accessibility, or they can also be communicational, such as the lack of sign language interpreters. These barriers hinder people with

AD from accessing information, resources, and learning opportunities at virtually all educational levels and areas, whether within or outside the EFA context.

According to surveys by the National Institute of Educational Studies and Research Anísio Teixeira - INEP, the School Census revealed that, of the 47.3 million students in basic education, 61,594 have some disability related to deafness, the statistics were collected in the 2022 School Census, the last edition of the survey with published results, which revealed that the number of enrollments in special education in common classes totals 1,372,985, Within this universe, except for other disabilities, in particular 37,625 are students with hearing impairment and 17,141 are students with deafness; Of a total of 154,809 students enrolled in special education in exclusive classes, excluding other disabilities, 2,642 are hearing impaired and 3,558 are deaf.

In view of these data, this study is justified in the sense of intending to collaborate with a study on the social and educational inclusion of the hearing impaired and Deaf people, which it considers important in the promotion of their autonomy and independence, which can be conquered in particular by an inclusive technological professional education that is increasingly adapted and that uses, in the teaching and learning process, of collaborative technological resources of AI - Artificial Intelligence. This list includes applications, *software*, and any other digital pedagogical resources and/or artificial intelligence platforms that allow the use of avatars, translators/interpreters of Libras or even augmented reality (AR), virtual reality (VR) and/or *metaverse*, which is a type of 3D reality, and other contributions of promising quantum computing.

> It is important to highlight that education is directly related to the various aspects of human life. Among them, the possibility for a better job, knowledge for decision-making, autonomy, initiative, capacity for reflection, formation of critical thinking, among others, are considered. Therefore, if education corresponds to a precious commodity in different dimensions, it is essential to investigate how it is or is not being democratized for the hearing impaired. (CAVALCANTI, 2022, p. 9)

The applications/*software* that allow the use of Libras translator/interpreter avatars are the result of an emerging technology that is believed to be able to contribute, as it already occurs in special education, to the educational inclusion of people with AD and Deaf people in EFA. These applications allow users to use personalized avatars that can interpret, translate, and communicate in text, video, and sign language format.

OBJECTIVE

The general objective of this study is to know and analyze the potential of applications/*software* that allow the use of Libras translator/interpreter avatars as educational accessibility resources for the hearing impaired and Deaf people in EFA and, thus, to gather information to answer the following

research problem: what are or could be the contributions of applications and other artificial intelligence tools that use avatars Libras translators/interpreters to assist professional Libras translators/interpreters, or even teachers in general, in the process of content mediation and, as well as for AD and Deaf students in the teaching/learning process, in the context of EFA.

The specific objectives are: To identify the variety of applications that allow the use of Libras translator/interpreter avatars; Characterize the functionalities of these applications; Investigate the advantages and disadvantages of using these apps in EFA education; Discuss how these apps can, or could, contribute to the educational inclusion of people with AD and Deaf people in EFA.

METHODOLOGY

This study was carried out through an exploratory qualitative research. Data collection was carried out on *Google* Scholar, Scielo and other repositories of academic institutions, through a literature review of dissertations, articles, monographs, websites and, when possible, through access to AI tools, platforms, applications and *software* that promote the use of Libras translator/interpreter avatars. All other documents and digital pedagogical resources, related to the theme and eventually used, were duly cited and referenced.

DEVELOPMENT

In this study, we will not delve in depth at the conceptualization or historical evolution of Technological Professional Education (EPT), or the profession of Libras translator/interpreter, much less on the concepts of hearing impairment or deafness itself and its levels or degrees. Much less do we intend to reinvent the wheel of what AI - Artificial Intelligence is, since other works have already done it widely and brilliantly, which I consider true masterpieces and are included in the references. In the same sense, we will not dedicate ourselves to raising the conceptualization and historical evolution of special education aimed at the Deaf in Brazil, all these conceptualizations and historical evolutions can be verified in depth by consulting the bibliographic references that we point out in this study.

Rather, we intend to be more direct to the point about studies that allow us to identify applications, *software* or online or *offline* platforms that provide the use of avatars translators/interpreters of Libras, even in the context of Augmented Reality - AR, Virtual Reality - VR, Mixed Reality - RM, quantum computing or *metaverse* and other 3D technologies, although this literature and technologies are still incipient. However, some studies have pointed out the potential of these tools for the educational inclusion of people with AD - Hearing Impairment and Deaf in the context of special education, in which, at least, analogically, we believe that they have the same positive application in the context of EFA.

In his thesis on the literacy and writing of sign language for Deaf children, Stumpf (2005, p. 27), who analyzed *SignWriting*, recognizes the importance of technologies as a pedagogical support:

> Communications, with the advent of information technology, are being totally modified and the school is trying to adapt by introducing the computer. The new technologies associated with the computer bring advantages to the deaf because they are predominantly visual in nature. As participants in the educational process, we felt that it was necessary to seek a new pedagogical posture that would combine the use of technologies with the construction of knowledge. (STUMPF, 2005, p. 27)

A study conducted by (SCHNEIDER, 2008) evaluated criteria for the animation of gestures in Libras, taking into account a dynamic enunciation space. To do this, it analyzed all the parameters that make up the standard signal, seeking a greater proximity between the virtual and the real signal.

> The main contribution of this work is in the evaluation of criteria for animation of gestures in LIBRAS, taking into account a dynamic enunciation space. For this, it was necessary to analyze all the parameters that make up the standard signal, always seeking a closer proximity between the virtual (humanoid) signal and the real (human), which is a complicated task, since many parameters must be combined. As the space of enunciation must be dynamic, it can undergo transformations in its direction or in its size, and the gestures must adapt to these changes. If there is a change in the direction of the humanoid's body, automatically the space also undergoes this transformation, since the space is part of the articulated body. (SCHNEIDER, 2008, p. 63)

A model of a humanoid, avatar, was created in the *Blender software*, with joints that respect the limits defined by biomechanics. The model was exported to an XML file, which was used by a tool to generate the gestures. The gestures are composed of poses, which are defined by the tool and stored in a database.

The humanoid, avatar, generated is used to render the scene of the animation module, so that once an expression (or word) is entered for the animation, the poses are treated according to the given enunciation space and are animated in the correct order.

> First, a model was developed in Blender whose joints have limits defined through research in the area of biomechanics. This model was then exported to an XML file (XMLScene), whose description is in accordance with the parameters defined in V-ART. It is then used to generate the gestures through a tool developed for this purpose (Action Generator). The result of this application is an XML file (XMLAction), with all the parameters for generating the animation (duration, speed, position of the joints, etc.) defined. The gestures are made up of poses, all of which are defined through the action generator and archived in a database. The generated humanoid is also used in the rendering of the animation module scene (Human LIBRAS). Once an expression (or word) is entered for the animation, the treatment of the poses is done according to the given space of enunciation and they are animated in the correct order. Some attributes, such as the speed of the movement and its duration, can be modified via the animation module through functions already existing in the VART library. Thus, if it is desirable for the humanoid to perform a certain action faster (indicating anger, haste, etc.) there is no need to regenerate the action, but only to modify these attributes in the application. (SCHNEIDER, 2008, p. 64)

It should not be forgotten that facial animation, as far as facial expressions are concerned, is important for gestures to be more realistic and better understood. However, it was evidenced that it is a challenge because it is a very complex process that deserves a further study separately, since for the facial animation to be more realistic, it is necessary to dedicate to the mesh of the face so that it is possible to observe the modifications of poses and expressions.

> Facial animation is of utmost importance, aiding in the semantics of sentences. However, it was not analyzed in this work, because it is so complex as to deserve a separate study. Thus, in order for the gestures to become more realistic, there is still the need to define a facial animation technique, fixing which points of the face mesh should move, what are the limits of the movements, how the mesh will be deformed so that the modifications of the poses can be clearly observed, etc. It is also interesting that the model's mesh can be deformed in order to reduce irregularities at the moment when A joint moves, causing holes to appear in the fitting of body parts. (SCHNEIDER, 2008, p.65)

Although the profession of Libras translator/interpreter has already been regulated, and there are laws that guarantee the right of this professional to be available to assist the Deaf person in their daily lives, it is a fact that the number of professionals is still insufficient in the face of the current demand.

> A communication barrier can be experienced by individuals belonging to linguistic minorities, such as deaf people. A series of historical movements [10, 15] characterized the exclusion and/or inclusion of deaf people in society, from segregation, through oralism, to total communication to the current bilingualism, which officializes Brazilian Sign Language (Libras) as the mother tongue of the deaf person [5]. The difficulty of communication between deaf and hearing people, due to language barriers, especially in the perspective of a society that proposes to be inclusive, ends up being an obstacle in the socialization and development of the deaf person [30]. Although there are also regulations in Brazil regarding the spaces and activities in which the deaf are guaranteed the right to translation services by a human interpreter [6], it is known that these professionals are still not present in most situations in which they are needed. It is in this context imperative for the inclusion of people with disabilities in all social environments [34, 26], for the adoption of Libras as the mother tongue and the main language of the deaf and disabled in the provision of translation services through human interpreters that are delineated favorable spaces for the development of applications that are capable of mediating the relationships between deaf and hearing subjects and/or with environments and supports supported by the use of language oral and written (SANTAROSA et al, 2014, p.172).

At first, the technological advances in relation to assistive solutions contemplated only the teaching of Libras itself and specific issues in helping the daily life of the members of the Deaf community, a posteriori, had their application also expanded to the educational environment.

> It was found that one of the alternatives may be the use of assistive technologies during classes, due to the fact that they would help in the limitations of deaf subjects. Thus, facilitating and enabling communication between deaf and hearing subjects not only in higher education institutions, but also in other environments and situations. (TOSO et al., 2018, p. 1077)

Therefore, this explains why, even in the face of so many advances and legal guarantees, the high unmet demand on the part of professional translators/interpreters of Libras naturally forced the interest

and search for new solutions and innovations, especially in the field of assistive technologies, especially in the field of AI - Artificial Intelligence itself.

> In view of the weaknesses mentioned, we investigated other Portuguese to Libras translator applications that presented functionalities similar to those of the HandTalk and ProDeaf Mobile applications. In order to construct the survey of applications with the use of avatars, the following applications were identified in the Brazilian scenario of assistive technologies: Poli-Libras, TLibras, Rybená and Falibras Web. (SANTAROSA et al., 2014, p. 177)

Such search for new solutions and improvement of already established achievements has raised the level of quality of technological pedagogical tools and resources focused on Libras, so that previous problems such as those related to facial expressions have already gained new contours, thus satisfactorily expanding the capacity to use assistive tools.

> Regarding the analysis of non-manual expressions of semantic character related to expressions linked to emotions such as "fear" and "joy", changes were observed in both avatars in variables such as eyebrows, eyes, lips, head, shoulders and trunk. In this regard, the avatar of the HandTalk application was more expressive, since the alterations manifested for the signaling of such emotions involved a greater number of variables. (SANTAROSA et al, 2014, p.181)

Another study carried out by (MACHADO, 2020) designed Interlib, a kind of *online platform*, *Libras internet*, a collaborative tool that aimed to help Libras translators and interpreters learn more about the language and connect with each other. It also allowed signals to be catalogued and disseminated in areas where access to these resources is limited. In addition, Interlib was designed to respect the linguistic and regional variation of Libras, contributing to the social and digital inclusion of the Deaf community, however, the application/platform was not made available to the general public, and its use was limited to the merely theoretical field of research and development only.

> Interlib, an online platform for the deaf community, achieved the proposed objectives. The tool assists in the improvement of knowledge and interaction between professionals, allows the cataloguing and dissemination of signals in areas of difficult access, respecting linguistic and regional variation. In addition, Interlib contributes to the social and digital inclusion of the deaf community, reducing territorial barriers and integrating specialists from different areas of expertise and professional experience. (MACHADO, 2020. p. 85)

It is a useful tool for the generation of reliable gestures for Libras, the process ensures the fidelity of the gestures to the tongue, and the use of a biomechanical model allows them to be generated in a natural and realistic way.

In view of these previous considerations, we can already glimpse the relevance of the study now started, whether in special or regular education or in the context of EFA, as we intend to demonstrate, according to Pereira and Freitas (2023, p. 2): "Technological resources, if used appropriately in the

educational scenario, expand the alternatives that interpreters and Deaf people have for the complexity of learning, making the process more interactive."

Pereira and Freitas (2023, p. 3) also add that:

> There are several softwares, such as Vlibras and Hand Talk, that facilitate this communication, as well as technologies that teachers can share, being able to pass on the subject in a way that facilitates the student's understanding, overcoming these barriers and promoting good learning situations.

Other technologies that use AI - Artificial Intelligence as a basis for augmented reality - AR, virtual reality - VR, mixed reality - MR, *metaverse* and other 3D technologies have already been tested in the context of inclusion as assistive tools in support of the teaching/learning of Deaf people according to Pereira and Freitas (2023, p. 5):

> Another application developed to help with the student's writing and literacy is Storysing, an example of an application that can be beneficial in the classroom, as it uses augmented reality and artificial intelligence to assist in Early Childhood Education; By pointing your phone's camera at the text, it will work. You need a physical book to trigger the 3D character's actions and gestures. When the Libras translation is complete, the word being translated will be highlighted on the mobile screen. The detail is that the physical book translated by the app must also be made available digitally on the platform.

It is not news to scholars not only about the context of teaching, educational inclusion and the universe of interpreters/translators, as well as hearing/Deaf people, that there has always been a great barrier of communication between these various actors, with mutual and numerous difficulties and limitations, which ended up forcing us to think of joint solutions between the theoretical field of linguistics and computational and artificial intelligence technologies.

> In the case of the machine translator, interdisciplinarity occurs between the theoretical field of linguistics and the area of technology, which together offer strategies for the development of mechanisms, artifacts, solutions, among others, that minimize the communication barriers between Deaf and hearing people, that is, the translation from Portuguese to Libras performed by the 3D avatar that signs in Libras characterizes a service, whose purpose is to facilitate communication between Deaf people and hearing people. (NÓBREGA, 2021, p. 24)

Although there is still much to improve, much progress has been made in the development of technological solutions that aim to mitigate the difficulties and limitations in communication between hearing people and the Deaf community.

> From this perspective, as previously pointed out, EducaLibras was developed with the objective of assisting the Libras teacher in the teaching of this language, presenting pedagogical scenarios in which the 3D avatar acts by signaling in Libras, in order to enable visual dynamism and provide the learner with understanding and ease in learning this language. Consequently, it is hoped that it can also serve as a promoter and disseminator of Libras (NÓBREGA, 2021, p. 28).

In addition, Nóbrega (2021, p. 87) ponders that "One of the services that make up the VLibras Suite is the automatic translator that uses a 3D avatar that can be viewed and used on the Brazilian Public Software Portal."

Nóbrega (2021, p. 87) explains that "A 3D avatar corresponds to an animated agent that can emit sounds and gestures, perform movements and expressions, which can be generated through computational commands, through natural movements or very close to human movement."

In his final reflections on the use of 3D avatars, Nóbrega (2021, p. 142-143) emphasizes flexibility when using avatars, since it does not intend or does not aim to replace Libras translators/interpreters, but rather complement each other depending on choices in the pedagogical context:

> Some adjustments can be pointed out regarding the use of the 3D avatar in the context of the Digital Pedagogical Resource. For example, the expansion of activities and the possibility of using videos with interpreters instead of the 3D avatar. However, as previously stated, it is considered that the avatar does not compromise the development of this Resource, considering that the reason for its use is justified due to the low cost in its production in relation to the time required for a Libras interpreter/teacher/user to produce an intelligible video according to the parameters of LS video production. In addition, EducaLibras is flexible regarding the use of videos with an interpreter/teacher/user of Libras instead of the use of video with a 3D avatar, as suggested in some evocations by teachers.

It is very evident and easy to see the growing use of digital pedagogical resources for translators/interpreters of Libras, guided by artificial intelligence in classrooms, in an increasingly accentuated way.

> Many barriers can be broken when the teacher is able to communicate with the student, answering questions and expanding their world of knowledge. Examples of disruption happen when the teacher creates lectures, dynamics, inclusive activities or group work in which hearing and deaf students are able to communicate. There are several softwares, such as Vlibras and Hand Talk, that facilitate this communication, as well as technologies that teachers can share, being able to pass on the subject in a way that facilitates the student's understanding, overcoming these barriers and promoting good learning situations. (PEREIRA and FREITAS, 2023, p. 3)

In his studies on Digital Information and Communication Technologies TDIC's Araújo (2023, p. 23), focused on the study of some applications such as *Rybená*, VLibras, *Prodeaf* and *Hand Talk* and, during the research, he focused on analyzing more specifically the *Hand Talk* application because it is considered more complete than the others can, including capturing voice/audio and translating it into Libras.

> In view of the above, it is evident that the tools still need improvement and that, so far, they are not capable of replacing the professional interpreter, but they can contribute, even with their failures, at the moment when this professional is not available. Because, after performing all the tasks performed by the TILSP, this application performed well. (ARAÚJO, 2023, p. 59)

It should always be noted that, in the universe of Artificial Intelligence focused on education, we have the important contribution of the so-called Augmented Reality - AR, which consists of a tool considered promising for the inclusion of deaf students in Technological Professional Education - EPT. By overlaying virtual elements onto the real world, AR can offer visual and interactive resources that facilitate learning and communication for this community.

> SENAI has been adapting its technical courses for the development of a new professional for the job market, developing and including new technologies and teaching methodologies such as the use of Augmented Reality. In this new context, some specialists from the National Department of SENAI, together with scholars of innovations for industries, have been studying and disseminating a new concept called Industry 4.0. The concept of Industry 4.0 encompasses the main technological innovations in the fields of automation and information technology, applied to industrial production by cyber-physical systems, internet of things and artificial intelligence, making production processes increasingly efficient, autonomous and customized. Industry 4.0 is changing the way we produce and relate to the environment in which we live. This new industrial revolution is promoting the fusion of technologies and the interaction between physical, digital and biological domains, enabling the production of mass customization. (SOUZA & LORENÇATTO, 2019, p. 5)

AR can be defined as the integration of virtual elements in real time into the physical environment, usually through mobile devices such as *smartphones* and *tablets*. This technology uses resources such as motion sensors, *GPS,* and cameras to map the environment and insert digital elements that integrate with the user's reality.

> The technological resources available in Augmented Reality can currently assist in the performance and absorption of most varied educational activities, and as listed in the course of this work, for the case of deaf or hard of hearing students. The AR tool not only provides the execution of tasks in a traditional way, but also privileges the visual experience, thus making classes more interesting and accessible. (OLIVEIRA, 2022, p. 30)

In view of the studies that have been carried out so far, it would already be possible, in an analog way, to state that if assistive technologies such as applications, augmented reality, virtual reality, mixed reality, *metaverse* and other *software* based on quantum computing, artificial intelligence and 3D animated avatars translators/interpreters of Libras, have already been incorporated as support tools with considerable success in the academic and educational environment as a whole, in this way, it would allow us to infer that they would also, without a doubt, have a similar application in an equally satisfactory way for interaction with AD and Deaf students in Technological Professional Education – EPT

Stumpf (2005) in his thesis presented at the Federal University of Rio Grande do Sul, with the objective of achieving the title of Doctorate in Education, studied the learning of sign language writing by the *SignWriting* system: sign languages on paper and on the computer, that is, a way of writing sign language, through the design of other signs, with the use of specific symbols of a written sign language, signs and symbols that correspond to a certain sign language with sign signs, and may even correspond to Libras. Thus, it contributed little to our study, since it dealt only with a specific writing of symbols and

their sociohistorical, didactic, pedagogical and technological contextualizations, aimed at the teaching of Deaf people.

Schneider (2008) in his dissertation to obtain the degree of Master in Computer Science, intended the creation of a *software* with animation of virtual humans applied to Brazilian Sign Language, obviously respecting the phonetics, syntax and semantics of Libras, but with special attention to a construction that would provide the approximation of biomechanical physiology, with a gesture in a smooth and understandable way, as well as the ability to reproduce the joints of flexion, extension, rotation and spatial amplitude, by means of avatars. In his studies, the use of specialized knowledge focused on the programming and configuration of supporting computational technological tools, through algorithms, as well as knowledge and application of inverse kinematics and kinematic chain techniques, is remarkable. However, this study did not show any progress regarding the possibility of its use in the capture of signs and gestures and its translation into Libras, nor was it mentioned regarding its use in traditional or special educational environments or even in the context of EFA.

> The main contribution of this work is in the evaluation of criteria for animation of gestures in LIBRAS, taking into account a dynamic enunciation space. For this, it was necessary to analyze all the parameters that make up the standard signal, always seeking a closer proximity between the virtual (humanoid) signal and the real (human), which is a complicated task, since many parameters must be combined. As the space of enunciation must be dynamic, it can undergo transformations in its direction or in its size, and the gestures must adapt to these changes. If there is a change in the direction of the humanoid's body, automatically the space also undergoes this transformation, since the space is part of the articulated body. With regard to size, the rearrangement of the gesture occurs through the modification, in the standard gesture, of the positions and orientations of certain joints, positions that are calculated through inverse kinematics. (SCHNEIDER, 2008, p. 63)

Santarosa *et al.* (2014) who, in their article, analyzed the non-manual expressions in avatars who translate from Portuguese to Libras, basically about the variables eyebrows, lips, head, shoulders and trunk. In the process of evolution of technologies, in the improvement of 3D technologies with the use of avatars, mainly, the improvement of non-manual expressions, body and facial, are considered fundamental, since they are very relevant requirements in the understanding by people with hearing impairment and Deaf, basically with regard to expressions of questioning and negation. In their studies, it was demonstrated that the Hand *Talk* and *ProDeaf* Mobile applications, despite being deficient in the signaling of non-manual elements, with total absence or with the presence of a deficient way with regard to facial expressions in the translations performed, still proved to be the most indicated, in this study, to be used in the teaching-learning process. With regard to assistive technologies, the following applications: Poli-Libras, TLibras, *Rybená* and Falibras *Web*, were also analyzed, however, these analyses were, according to the authors, inferior so that they concentrated and focused on the analyses of *Hand Talk* and *ProDeaf* Mobile, since both also make it possible to translate from Portuguese to Libras, either from texts or audios, in addition to being considered more user-friendly for use in mobile applications.

In their paper, Toso *et al.* (2018), studied about assistive technology in higher education and reflections on its use for hearing, hearing impaired and Deaf students, in view of which they intended to describe how *cyberculture* can be a triggering element for the production of assistive technologies for AD and Deaf students. Priority was given to information and communication technologies aimed at assisting communication between Deaf and hearing subjects present in higher education institutions. The results described that the access to Information and Communication Technologies - ICT's, by Deaf people or people with various disabilities, is a resource that triggers social transformations, in addition to changes in the way knowledge is constructed, however, it was concluded that such access to this technological resource partially meets the limitations arising from, in particular, hearing impairment and only minimizes the difficulties in communication between hearing and Deaf people without, however, completely solve this challenge. Although the study highlighted the importance and positive impact of the use of assistive technologies in the educational context as a whole, it did not study or point out any specific tool and its characteristics for the purpose of bilingual communication between Deaf and hearing people, not even in the context of higher or special education, nor in the field of professional and technological education - EFA.

In their article on Interactive Technology with the Use of Augmented Reality for Technical Courses: a case study at SENAI Tubarão, Souza & Lorençatto (2019) aimed to promote the inclusion of new digital technologies, which were available to SENAI teachers, as well as to evaluate their use in pedagogical practice regarding the acceptance by students involved in the teaching/learning process. To this end, it was also sought to evaluate the benefits identified by students in the use of tools with interactive and immersive technologies, especially for vocational education. The researchers presented the complete project of the SENAI RA - Computer Networks application, which included 26 AR objects, which worked on the contents of the technical course and its curricular units. Despite the positive result, the study did not present a direct relationship with the context of inclusive teaching aimed at the teaching/learning of Deaf students, allowing us only to infer that its use in this context would be equally satisfactory.

Machado (2020), in his master's thesis in applied computing, when developing *Interlib*, integration-interactivity between translators and interpreters of Libras, as a possible collaborative tool to assist translators and interpreters of Libras, in the teaching-learning process, delved into a more technical way in the creation of a collaborative tool with the use of *software* engineering, which required advanced knowledge in programming languages, such as XML, HTML, CSS, *Javascript* and other native, hybrid and cross-platform technological tools.

Nóbrega (2021) in his doctoral thesis focused on studying the teaching of Libras, basic, intermediate and advanced levels, through the pedagogical technological resource EducaLibras, the

qualitative approach was chosen, to understand the look of the Libras teacher, his impressions, his points of view, his opinions, his possible potentialities, his adjustments. This research was of an empirical nature, having as an instrument the semi-structured interview applied to the teachers of Libras, which was organized in two parts: part I refers to the profile of the interviewee and part II deals with the inducing stimuli: EducaLibras as a digital resource; methodologies for the use of EducaLibras; o EducaLibras as a Pedagogical Resource. The collected responses were submitted to Bardin's Content Analysis (2016), which had five Libras teachers as a sample. The results revealed that Libras teachers showed enthusiasm when they learned about a resource that uses a 3D avatar. Thus, this research did not advance to the field of Professional and Technological Education, it was limited only to investigating its application purely and simply in the teaching of Libras, even so it signaled positively as a technological pedagogical resource for the interaction between translators and interpreters of Libras and students.

In his article on education for the Deaf and the teaching of Libras to elementary school students, Cavalcanti (2022), in addition to scrutinizing and conceptualizing deafness and hearing impairment, their levels and degrees, resumed part of the history of inclusive education, as well as concluded that there is still a need for a better and greater appreciation of both teachers and professional interpreters who translate Libras. However, in the search for teaching methodologies for the Deaf, it did not address any type of application, it was considered that regardless of the methodology, the context of the classroom should be as welcoming as possible, otherwise no methodology will succeed if the environment is not properly designed for inclusion.

In his Final Paper, Barreto (2022) studied the production of bilingual educational software in Brazil, whose results pointed to a deficit in the production of tools with these characteristics of bilingualism, which has sign language as the main language, L1, and Portuguese as the secondary language L2.

Barreto (2022) mentions some applications such as Palavreando and Q-Libras, however, they did not go beyond the planning and execution phase only in the scope of development, they were not made available to the general public. The Bilingual ContaKg application, aimed at teaching mathematics, probability and statistics, is available at the http://bit.ly/contakgbilingue address. Another application pointed out was Alfalibras, used to assist in the bilingual literacy of the Deaf. All of them with pre-prepared content, do not include real-time translation, so, despite the bilingualism presented, the author considered that, even so, there is a deficit in relation to the existence of applications that satisfactorily meet the demand. It should also be noted that the applications mentioned do not have the use of avatars.

In addition, in his research, Araújo (2023), when evaluating applications such as *Hand Talk*, *Rybená*, *Prodeaf* and Vlibras, Librol, Elan, Poli Libras, highlighted the use of the Hand Talk translation application because he considers it more complete given that it is capable of capturing audio and

translating in real time using signs for Portuguese/Libras and also because it is the best known and most popular among the available applications. The tools Vlibras and *Prodeaf* ranked second and third, respectively, in terms of popularity among respondents.

In Pereira and Freitas (2023) in their article on the contributions of information and communication technologies in the teaching and learning processes of Deaf students, it aimed to analyze how ICTs could help Libras interpreters in the mediation of content in the classroom, as well as identify *software* that could help Deaf students. They consider that not only the sending, by Libras translators and interpreters, of videos explaining the subjects or even sending PDFs directed to these students, are great examples of the use of technologies in the classroom that can contribute by facilitating understanding, but also, on the part of teachers, when they use various *software*, such as Vlibras and *Hand Talk*, which facilitate this communication, in addition to technologies that teachers can share, being able to pass on the subject in a way that facilitates the student's understanding, overcoming barriers and promoting satisfactory learning situations. Although they looked at a few apps, they didn't point out any that they liked as being the best or the most complete, or the most affordable or the most popular.

We can anticipate that the study that came closest to our objectives, focused on EFA, was Araújo's master's thesis (2023), which was dedicated, through an experimental study of a qualitative nature with the application of a semi-structured questionnaire to explore a set of tools of Digital Information and Communication Technologies - TDIC's, and its impacts on the processes of translation and interpretation from Portuguese to Brazilian Sign Language (LIBRAS) for Deaf users who are part of professional and technological education (EPT). This study was based on the following problem: what is the feasibility of using these Portuguese/Libras translation tools in the context of professional and technological education?

In his research, Araújo (2023, p. 9) pondered that "Studies have pointed out that in the absence of a professional Libras interpreter, it is possible to use these tools to resolve doubts in administrative sectors.".

> Finally, it was found that these tools have great potential in the translation of short texts in the educational area, with more positive points than negatives. Some implements are suggested for improvement and thus serve the educational public, whether deaf or hearing. (ARAÚJO, 2023, p. 9)

The *ProDeaf app* emerges as an innovative tool to promote accessibility for the Deaf community. Through the automatic translation from Libras to Portuguese and vice versa, the application seeks to facilitate communication between Deaf and hearing people in different contexts. When analyzing the positive and negative points of *ProDeaf*, considering its potential impact on the life of the Deaf community, we have that as positive points we can highlight the autonomy and independence that it allows, since *ProDeaf* grants Deaf users greater autonomy and independence in communication, reducing

the dependence on human interpreters/translators in everyday situations. such as doctor's appointments, work meetings, and social interactions.

Another positive point to be pointed out concerns amplified accessibility, given that the application expands access to information and communication for the Deaf community, allowing Deaf people to participate more actively in different social and educational contexts, combating isolation and social and educational exclusion.

Still on its positive points, the promotion of inclusion can be highlighted, since *ProDeaf* contributes to the social inclusion of the Deaf community, promoting the breaking of communication barriers and sensitizing society about the importance of Brazilian Sign Language - Libras.

It is also worth pointing out as one of its positive points the ease of use, given that the intuitive interface of the application facilitates its use by people of different ages and levels of familiarity with technology, making it an accessible tool not only for the Deaf community, but for everyone who uses it.

As negative points, we can make reservations about the accuracy of the translation, because the automatic translation from Libras to Portuguese, and vice versa, still has flaws and inaccuracies, especially in complex sentences or with linguistic nuances specific to Libras.

Another possible problem is related to possible technological dependence, since the use of the *ProDeaf* application can create an excessive dependence on technology for communication, distancing users from the direct experience with Libras and the Deaf community.

The issue of acquisition cost is another factor that proves to be a barrier since the full version of the *ProDeaf* application is paid, which can limit access for some users, especially those with limited financial resources.

Regarding legal and ethical issues, it is always good to remember that the use of the application in professional or legal contexts requires caution, as machine translation does not guarantee the fidelity of the original message and can generate interpretation problems.

In this way, the *ProDeaf* application has enormous potential to promote accessibility and inclusion of the Deaf community. However, it is important to recognize its limitations and use it consciously and critically. The combination of *ProDeaf* with other communication tools and the active participation of the Deaf community are essential to ensure effective and inclusive communication.

It is recommended, in the case of *ProDeaf,* to improve the quality of machine translation, especially in complex sentences and with linguistic nuances of Libras.

It is also recommended to offer accessibility options for users with different levels of familiarity with technology and reading and writing skills.

Implement measures to reduce the cost of acquiring the app, such as discount programs or even free admission for specific groups.

Establishing guidelines for the responsible use of the app in professional and legal contexts, ensuring the fidelity of the original message and the protection of the rights of the Deaf community, is another recommendation.

With regard to the translation of Libras to Portuguese with *ProDeaf* we have some challenges and opportunities, as in other applications, challenges in the sense of translation accuracy, since the automatic translation of Libras to Portuguese still has flaws, especially in complex sentences, idiomatic expressions and slang. Lack of context and ambiguity of language can lead to misinterpretation.

As for facial and body expressions, *ProDeaf* does not recognize facial and body expressions, which are essential elements of communication in Libras. The translation can miss important nuances of the original message, such as emotions, intentions, and irony. Regarding regional signs, it is known that Libras has regional variations in terms of vocabulary and grammar. The app is not yet adapted for all variants of the language, which can make it difficult for users in specific regions to communicate.

On the other hand, there are opportunities to improve technology with the development of more advanced algorithms and the use of artificial intelligence and quantum computing can significantly improve the accuracy of machine translation from Libras to Portuguese and vice versa.

Integration with additional resources is another possibility of integrating *ProDeaf* with sign language dictionaries, grammar tools, and context resources that can help in understanding the original message and reducing interpretation and/or translation errors.

Another possible linguistic richness would be the adaptation to regional variations through the creation of versions of the application for different regions of the country, which could ensure that the interpretation/translation would be more accurate and appropriate for all Libras users at the national level.

Thus, *ProDeaf* proved to be a promising tool for the interpretation/translation of Libras into Portuguese, with the potential to improve the lives of the Deaf community. However, as with other applications, there are still challenges to overcome to ensure the accuracy and quality of interpretation/translation. The continuous development of the app, the integration with additional resources, and the adaptation to the regional varieties of Libras are essential for *ProDeaf* to become an effective and inclusive communication tool.

VLibras, in turn, emerges as an innovative tool to democratize access to technological professional education for the Deaf community. Through automatic translation from Libras to Portuguese and vice versa, with artificial intelligence resources and animated avatars, VLibras opens doors to a more inclusive and promising future.

Regarding the aspect of bidirectional translation, which VLibras offers, it is observed that it allows Deaf people to understand content in written or spoken Portuguese and to express themselves freely in Libras. It is believed that this functionality greatly contributes to ensuring the inclusion of Deaf students,

not only in general or special education, but also in professional and technical courses, promoting equal opportunities and effective learning.

With regard to artificial intelligence, which is the background that drives, or at least is believed to drive, several inclusive applications and also VLibras, improving its real-time translation accuracy and adapting it to the different nuances of Libras, for the effective recognition of signs, facial and body expressions that ensure fluid and natural communication between Deaf and hearing people.

The 3D animated avatars present in the app represent users in Libras, making communication more interactive and engaging. This technology makes it easier to understand the original message, conveying emotions and intentions with greater clarity.

In the scope of Technological Professional Education, we can highlight that VLibras can become a powerful tool to promote the inclusion of the Deaf community, since through innovative resources, the application opens doors to even *online* courses, so that Deaf students would be able to participate in professional and technical courses on equal terms with the hearing.

Accessible teaching materials, since the automatic translation of teaching content into Libras ensures understanding and effective learning.

Communication with teachers and classmates is facilitated with interaction between Deaf and hearing students, promoting collaboration and teamwork.

It is possible to prepare assessments and exams, since the application allows Deaf students to take assessments and exams in Libras, ensuring a fairer and more accurate adapted assessment.

Thus, it is possible to conclude that VLibras represents a milestone in the search for a more inclusive and accessible technological professional education for the Deaf community. The combination of machine translation, artificial intelligence, and animated avatars opens doors to a promising future where deafness is not a barrier to learning and professional development.

It is also recommended, in relation to VLibras, to expand the sign database, as well as to increase the number of signs and expressions of Libras in the system to ensure a translation that is both more accurate and comprehensive.

Thus, it would be good to develop specific resources for technological professional education, with tools that assist in the translation of technical terms and specific content from the most diverse professional areas.

In addition, however, it should also promote the training of teachers/educators/trainers and other education professionals, interpreters/translators, with training on the use of VLibras and how best to use it in different educational contexts.

Encouraging research and development of new technologies through investments in research to improve the automatic translation of Libras and develop new accessibility tools for the Deaf community is expected to operate for all applications.

On the other hand, *Hand Talk* applications also have great potential to promote inclusive education in EFA, offering several features that can be used to translate content in real time and thus facilitate the comprehension of content in Portuguese by Deaf students and vice versa.

It enables the promotion of communication between Deaf and hearing students, facilitates the interaction between these students in the classroom in educational environments, presents itself as a satisfactory tool to support the learning of Libras, encourages hearing students to be interested in and learn Libras and communicate with Deaf students.

It allows the creation of a more inclusive learning environment, promotes the participation and engagement of Deaf students in the educational context. However, the *Hand Talk app,* like the others, also has some limitations that need to be considered.

Like the other apps, *Hand Talk* has flaws in machine translation, since machine translation is not always accurate, especially for complex sentences or those that require the application of idioms or facial and body expressions.

Another factor is the need for *internet*, due to the fact that the application needs *internet* to work, which can be a problem for students who do not have access to the world wide web in their homes or schools.

Another risk common to all applications and which also presents itself refers to the possible dependence on technology, since the excessive use of the application, as well as the excessive use of other applications, can lead to dependence and a decrease in social interaction between Deaf and hearing students.

Thus, in relation to *Hand Talk*, it is worth pointing out some recommendations, based on the results of the research, such as the need to develop resources to improve the accuracy of machine translation, invest in research and development of technologies to improve the accuracy of machine translation from Libras to Portuguese and vice versa.

Promoting the training of teachers in the use of AI technologies, with training of teachers, translators/interpreters, and other actors in the educational universe, to use AI technologies, such as *Hand Talk*, effectively including in the context of EFA, is another recommendation.

Always seeking to ensure access to the *internet* for Deaf students, in order to facilitate access, for example, through the installation of *free Wi-Fi* in schools and communities, should always be a goal pursued.

It is recommended to promote social interaction between Deaf and hearing students, in order to encourage community interaction and avoid dependence on technology and thus promote social inclusion.

Finally, Hand Talk proved to be a promising tool to promote inclusive education in the context of EFA. The application offers several features that can be used to facilitate communication, learning and participation of Deaf students in EFA as well. However, it is important to consider the limitations of the app and take steps to ensure that it is used effectively and inclusively.

TecnoSinais is a translation application from Libras to Portuguese and vice versa that uses gesture recognition. It was developed by the Federal University of Santa Catarina - UFSC, and is available for free for *Android* and *iOS.*

It features features such as real-time translation, allows you to translate conversations in Libras to written Portuguese and vice versa. To do this, the user needs to make the signals in front of the cell phone camera.

It has a sign language dictionary with more than 3,000 signs, with demonstration videos and definitions in Portuguese. It has customization tools that allow you to customize the translation speed, screen size, and other settings.

As its main advantages, we can point out gesture recognition that uses technology to translate signs into Libras, which can be more accurate than text-based machine translation.

Another advantage concerns its comprehensive dictionary, one of the most complete available in sign language translation apps.

However, it also has disadvantages, among them we can highlight the need for *internet* to work, as well as flaws in accuracy, since the accuracy of gesture recognition can vary depending on the quality of the image and lighting.

Another very common disadvantage among applications of this nature is around complex signs, in the face of which you may have difficulty translating them, or in the face of signs that require very specific facial or body expressions.

Libras Fácil, in turn, presents itself as an educational application that offers games and activities to teach/learn Libras. It was developed by the Federal University of Rio de Janeiro - UFRJ, and is also available for free for *Android* and *iOS.*

We can point out as one of its features the availability of educational games aimed at teaching/learning Libras in a playful and fun way. The games cover different levels of knowledge, from basic to advanced.

The app also offers interactive activities, such as *quizzes* and exercises, to help the user practice Libras. The Libras Fácil sign language dictionary has more than 1,000 signs in Libras, with demonstration videos and definitions in Portuguese.

Among the advantages of Libras Fácil, we can point out how much it promises to make learning Libras a fun and interactive experience.

With its comprehensive content, the app offers different levels of knowledge, from basic to advanced, with several practical tools to help the user practice Libras.

On the other hand, as a disadvantage, we can consider that Libras Fácil is not a translation application, but an educational application and its content is limited to this context, its dictionary is less comprehensive than that of other applications, so that it is not applicable as a pedagogical resource for the inclusion of AD and Deaf students in the EFA universe.

Another factor that weighs in its favor is the lack of real-time translation, since it does not offer real-time translation of conversations in Libras.

Despite the applications already designed and developed, whether they are already available or not, whatever they may be, it should be noted that the immersive technologies behind all of them, such as artificial intelligence - AI, avatars, virtual reality - VR, augmented reality - AR and mixed reality - MR, as well as quantum computing and the *metaverse* emerge as promising tools with enormous potential to promote inclusion and equity in education as a whole and also in EFA.

VR can create immersive virtual environments where AD and Deaf students can explore and interact with 3D objects and scenarios, providing a richer and more meaningful learning experience. AR can overlay digital information onto the real world, allowing students to view information and instruction in Libras or other visual aids.

MR combines elements of VR and AR, creating hybrid environments that merge the real and the virtual. The metaverse, on the other hand, is a persistent and interactive 3D virtual universe, where users can connect, interact, and perform various activities.

IMMERSIVE TECHNOLOGIES BASED ON AI, QUANTUM COMPUTING, AND THE CREATION OF THE *METAVERSE* CAN BE USED TO

Promote communication and interaction: real-time translation, avatars in Libras, *chat* in Libras and other tools facilitate communication between Deaf students and their peers, professional translators/interpreters of Libras for the Portuguese - TILSP and teachers in general;

Create accessible learning environments: immersive virtual environments and visual aids that can facilitate the comprehension of content by Deaf students;

Offer personalized learning experiences: Immersive technologies allow Deaf students to explore and learn at their own pace and according to their individual needs;

Develop professional skills: Immersive technologies can be used to simulate real work environments, allowing students with Deaf AD to practice their skills and prepare for the job market more effectively.

Immersive technologies in general and the creation of metaverses in a personalized way have the potential to revolutionize technological professional education for AD and Deaf people, promoting inclusion and equity in education. However, it is important to overcome the challenges of accessibility, cost, and teacher training so that these technologies can be fully utilized for the benefit of Deaf students.

The *metaverse*, in our view, constitutes a persistent and interactive 3D virtual universe, presents itself as a promising frontier for inclusive education. In addition to the accessibility tools mentioned above, the *metaverse* offers a vast array of opportunities to promote inclusion and equity in education for all students, regardless of their abilities or backgrounds.

WITH THE *METAVERSE* IT IS POSSIBLE TO EXPERIENCE IMMERSIVE AND INTERACTIVE EXPERIENCES

Experiential learning: The metaverse allows students to experience realistic simulations of different scenarios and environments, such as virtual labs, interactive museums, technical visits, or visits to historical sites. This hands-on experience makes it easier to grasp abstract concepts and makes learning more meaningful and engaging for any and all types of learners, and even more so for ADs and Deaf people;

Combating school dropouts: immersion in stimulating virtual environments can increase student motivation and engagement, reducing school dropout rates;

Developing social-emotional skills: The *metaverse* provides a safe space for students to interact with each other and develop social and emotional skills such as communication, teamwork, and problem-solving.

OTHER POSSIBILITIES ARE RELATED TO PERSONALIZATION AND AUTONOMY IN LEARNING

Adaptive environments: the *metaverse* allows you to customize learning environments according to individual student needs by adjusting the pace, difficulty, and level of support;

Self-paced learning: Students can explore the *metaverse* at their own pace, without the pressure of keeping up with the pace of the class;

Autonomy and self-direction: The *metaverse* can empower students to be protagonists of their own learning, setting their goals and choosing their own paths.

IN THE CONTEXT OF EDUCATIONAL INCLUSION, THE FOLLOWING CAN BE HIGHLIGHTED

Students with disabilities: The *metaverse* offers accessibility tools for students with visual, hearing, physical, or intellectual disabilities, allowing them to participate fully in education;

Students in remote areas: The *metaverse* eliminates physical barriers, allowing students in remote areas or those with limited mobility to access quality education;

Students with special needs: The *metaverse* provides safe and inclusive environments for students with special needs, not only AD and Deaf people, but also those with autism or ADHD, providing a personalized learning experience for all audiences.

The *metaverse* is still developing, but its potential for inclusive education is immense, as it leverages innovative tools and resources that can revolutionize the way students learn and interact, creating a more equitable and equitable educational future for all. It is crucial to ensure that the *metaverse* is accessible to all students, whether disabled or not, with robust accessibility tools and intuitive interfaces.

Student safety and privacy in the metaverse should be prioritized, with measures in place to prevent *cyberbullying* and other online risks.

Teachers and the entire school community need to be empowered to use metaverse tools effectively in education, with a focus on inclusive pedagogy and personalization of learning.

Access to the *metaverse* can be challenging for students in areas with limited digital infrastructure or restricted financial resources.

Examples of projects that are already using the *metaverse* in inclusive education are "*Second Life*" and "*Minecraft*".

It is necessary to be attentive to the monitoring of research and developments that are underway on the use of the *metaverse* in education, looking for opportunities to contribute to this area.

It's always good to encourage participation in online forums and communities that discuss the use of the *metaverse* in education, sharing ideas and experiences with other educators and students.

The *metaverse* opens up a new world of possibilities for inclusive education, so that by tapping into and developing its potential, we can build a more inclusive, equitable, and transformative educational future for all students, whether they have disabilities or not.

In the field of innovation and promising work, we can highlight one of them that was the subject of Trindade's article (2022), referring to the work of three former students of the Social Service of Industry - SESI/Campinas Amoreiras/SP, who developed the Bilingualism application project, Lívia Yasmim, Larissa Matuo and Vanessa Mendes, who were 18 years old at that time, who designed an application that uses artificial neural networks to translate in real time the Brazilian Sign Language - Libras. T The app's differential lies in facial and body recognition, audio-to-text transcription, image translation and a mini-

dictionary, promoting effective communication between listeners and non-listeners. The challenge faced by the young women in creating the application includes the complexity of artificial neural networks, integrated into Industry 4.0.

The app seeks to address the historical exclusion in communication faced by Deaf people, highlighting the importance of bilingualism between Libras and Portuguese. The desktop version performs real-time and image translation, while the mobile version offers audio transcription and a mini-dictionary. The students, initially without programming knowledge, learned and developed the project during their time in the institution's technical course, and also created, at the same time, the Team Niobium robotics team.

Inspired by similar ones available in the industry, the young women entered higher education in computer science and currently work at the Robert *Bosch company*, where the development of the Bilingualism project contributed to their hiring. The application has received several awards at science fairs, standing out at events such as the National Science and Technology Fair and the Brazilian Fair of Application Colleges and Technical Schools.

In 2018 they reached the third position in the exhibition of projects of technical courses of the Technical College of Campinas - Cotuca of the State University of Campinas - Unicamp, and also in the Science and Technology Exhibition of the 3M Institute.

In 2021, the students obtained second place in the National Science and Technology Fair of Colégio Dante Alighieri - FeNaDante, in addition to receiving the award by popular vote and ensuring accreditation for the Brazilian Scientific Initiation Fair - FEBIC, which took place in 2022.

According to an article published by Souza (2023), the work of two other former technical high school students in Administration at the National Service for Commercial Learning - SENAC/SP, Luisa Ribeiro Teixeira and Sarah Teixeira Willig, both 15 years old at the time, deserves equal mention. The students developed the project of the Me Translate application, aimed at the rapid translation of Brazilian Sign Language - Libras into Portuguese. The project won second place in the state entrepreneurship competition at Empreenda Senac, when the students were in their first year of high school. The application uses cell phone or *tablet cameras* to capture images of the signals, performing the translation in real time.

The main objective of the students was to promote the inclusion of Deaf people in society, facilitating communication in situations such as job interviews or any others that enable the interaction of Deaf people with hearing people, given the importance of making communication easier to promote inclusion. The app has the validation of people who communicate through Libras, and incorporates suggestions, such as the addition of an emotion bar to convey facial expressions during communication in the same line as *emojis*.

In addition to assisting in communication, Me Translate can also be a sign language learning tool, providing an accessible approach for self-taught people. At that time, the students were looking for investors and *software* developers to turn the project into reality.

It is believed that Me Translate has the potential to offer more quality of life for both listeners and non-listeners.

In this way, both the Bilingualism application and Me Translate were able to collaborate, if they were developed and implemented, with the inclusion of Deaf students in the context of Technological Professional Education, since not only the teachers would be able to communicate through various applications, but also the Deaf students would be able to signal to the applications that would translate into the Portuguese.

The results of the literature review and other research carried out in this study indicate, in general, that the applications that allow the use of Libras interpreter avatars, such as *ProDeaf*, VLibras, TecnoSinais and *Hand Talk*, have the potential to contribute to the universe of education, especially to the educational inclusion of people with AD and Deaf people in EFA.

The literature review identified that these applications can be used to improve communication between people with AD or Deafness and hearing people, as well as promote their autonomy and reduce social isolation, as well as can contribute significantly to their independence.

However, it is important to note that these applications and the associated technologies are still under development, and that more research needs to be conducted to assess their potential and limitations.

Some challenges, in general, that need to be overcome in order for these applications to be most effective include:

The accuracy of translating texts and videos into Brazilian Sign Language;

The accuracy of the translation of Libras with its facial and body expressions, for the Portuguese;

The customization of avatars to meet the individual needs and preferences of each user;

The full accessibility of immersive and inclusive apps and technologies for people with hearing and visual impairments.

FINAL THOUGHTS

The results of this study suggest that the Artificial Intelligence that powers resources focused on Virtual Reality - VR, Augmented Reality - AR, *metaverse* and quantum computing will be able to improve the existing available applications that allow the creation of interpreter/translator avatars of Libras, not only for *ProDeaf*, VLibras, TecnoSinais and *Hand Talk*, as well as for all others, which are believed to be valuable tools with great potential for the educational inclusion of people with AD and Deafness in EFA. However, it is always good to remember and emphasize that innovative technologies

and applications are still under development and that more research is needed in order to expand their potential and mitigate limitations.

Thus, this study sought to contribute to the knowledge about the potential of technologies and applications and other technological resources of a nature alluding to Artificial Intelligence - AI, which could allow the use of avatars translators/interpreters of Libras as technological educational resources of accessibility and inclusion aimed at Deaf and AD - Hearing Impaired students in the context of EPT - Technological Professional Education.

Recommendations for future research include:

1. Longitudinal studies to evaluate the impact of technologies and applications on the educational inclusion of Deaf and AD people in EFA;
2. In-depth comparative studies to evaluate the performance of different technologies and applications;
3. Studies focusing on the accessibility of applications for people with hearing impairments, deaf and also visual.

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