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A state of knowledge: The interaction between teacher, Sign Language Interpreter (TILS), and deaf student in Physics classes and its implications for teaching and learning[+][*]

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Abstract

This study investigated the dynamics among the physics teacher, the Sign Language Translator and Interpreter (TILS), and the deaf student, focusing on their interactions, difficulties, and potential within the school context. Because effective bilingual education that recognizes and prioritizes Libras as the first language of the deaf community remains absent, the TILS plays an essential role in the classroom and must coordinate with the physics teacher to promote inclusive educational processes. However, school practices revealed challenges that compromised this coordination. This qualitative and bibliographic research relied on a State of the Art review of Brazilian theses and dissertations addressing physics education from an inclusion perspective. The review sourced data from the repositories of the Digital Library of Theses and Dissertations and the CAPES Catalog, covering the period from 2010 to 2024. The analysis, performed using Atlas.ti software, indicated a scarcity of signs and technical vocabulary in Brazilian Sign Language (Libras) for Natural Sciences and Physics content. Furthermore, the results identified barriers such as a lack of knowledge regarding Deaf culture, unfamiliarity with Libras as a first language (L1),

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a poor understanding of the specific needs of deaf students, limited time for pedagogical planning between the TILS and teachers, and the heavy workload teachers face when planning inclusive lessons. These factors hindered effective inclusion, resulting in the physical presence of deaf students in the classroom without their active participation. Additionally, teachers and TILS exhibited insecurity, as their initial training often left them unprepared to work in inclusive settings. Consequently, continuing education policies must urgently promote inclusive pedagogical practices tailored to the linguistic and cultural specificities of the Deaf community.

Keywords: *Physics Teaching; Inclusion; Deaf Students; Difficulties in Inclusion.*

I. Introduction

Before discussing the challenges and dynamics of the teacher-Sign Language Translator and Interpreter (TILS)-deaf student triad in physics education, we emphasize that this study did not seek to hold the involved professionals responsible for the difficulties faced in deaf education. Rather, it aimed to promote awareness and foster reflections that enable the development of strategies to overcome or mitigate these difficulties. Inclusion is particularly relevant given the number of students with disabilities enrolled in Basic Education.

According to the School Census of the Anísio Teixeira National Institute for Educational Studies and Research (INEP), special education enrollment reached approximately 2.1 million in 2024, a 58.7% increase from 2020, demonstrating exponential growth in Brazil's special education target audience. In high school, the focus of this study, this growth was even more pronounced, rising from 30,152 enrollments in 2010 to 262,243 in 2024. This scenario highlights the need to deepen the discussion on inclusive physics education, which presents distinct challenges, particularly for deaf students.

Analyzing the teacher-TILS-deaf student triad is fundamental to understanding the processes and barriers permeating physics education within inclusive settings. As Quadros (2006) and Strobel (2008) noted, recognizing Libras as the first language of deaf individuals and appreciating their cultural identity require bilingual pedagogical practices grounded in a perspective that extends beyond simple content translation. However, as Skliar (1998) highlighted, the bilingual teaching model still faces structural, political, and pedagogical obstacles that hinder its consolidation in Brazilian schools.

We hypothesized that the lack of effective coordination between teachers and the TILS, coupled with training gaps and the absence of established bilingual practices, constituted a primary barrier to inclusive physics learning for deaf students. Consequently, the coordinated interaction among the teacher, TILS, and deaf student takes center stage, serving as the primary means of knowledge mediation in mainstream schools.

Consequently, this study aimed to analyze the dynamics of the teacher-TILS-deaf student triad in physics classes, identifying barriers, potentialities, and strategies that may contribute to constructing effectively inclusive pedagogical practices. Using a bibliographic SoA methodological approach, we mapped and systematically analyzed Brazilian academic output (theses and dissertations) from 2010 to 2024 to identify the main trends, gaps, and possibilities regarding the interaction of this triad in physics classes.

To ensure clarity and a coherent approach to the data, the article is organized as follows: Section II discusses the premises and challenges of bilingual education for the deaf; Section III addresses the roles and responsibilities of the Sign Language Translator and Interpreter (TILS) in the school setting; Section IV examines the obstacles and needs of inclusive physics education; Section V details the methodological approaches and analytical framework structuring this SoA; and the conclusion summarizes the impacts of the relationships within this triad on the physics teaching-learning process.

II. Bilingual Education for the Deaf

Bilingual education recognizes deafness not as a disability to be corrected, but as a linguistic and cultural difference. In this approach, Brazilian Sign Language (Libras) is considered the first language (L1), or the deaf individual's mother tongue, which mediates their interaction with the world and constructs thought. Written Portuguese is understood as a second language (L2) acquired through formal educational processes rather than a mother tongue (Quadros, 2006; Skliar, 1998).

The bilingual approach values deaf identity, visual culture, and the centrality of Libras in the teaching and learning process. Unlike the oralist perspective, which historically sought to teach speech as the sole path to inclusion, bilingualism respects the Deaf person's mother tongue and guarantees the right to learn through it. This shift represented a departure from the dominant clinical ideology and challenged oralization narratives by prioritizing sign language and Deaf culture, as Skliar (1998, p. 1-2) advocated. Quadros (2006) argued that a bilingual school must have deaf teachers and hearing teachers proficient in Libras, an adapted curriculum, accessible teaching materials, and interpreters when necessary, especially in mainstream education.

Brazil legally recognized Libras as a means of communication and expression through Law No. 10,436/2002, regulated by Decree No. 5,626/2005, which established guidelines for teaching Libras and Portuguese as a second language for deaf individuals. Notable provisions included the mandatory teaching of Libras in teacher training programs and the presence of interpreters in educational institutions (Brasil, 2005).

More recently, Decree No. 10,502/2020, which established the new National Special Education Policy, sparked debates on inclusion. In response, Decree No. 11,340/2023 reinforced bilingual education by establishing guidelines for creating bilingual schools and classes at all educational levels (Brasil, 2023).

In subjects such as physics, bilingual education becomes even more relevant because it involves abstract concepts, technical vocabulary, and experimental practices. Teaching in Libras extends beyond translation; it involves understanding a visual epistemology shaped by specific cultural and linguistic experiences (Strobel, 2008).

Despite legislative and institutional advances, effectively implementing bilingual education faces significant challenges, including a shortage of deaf teachers, inadequate Libras training for hearing teachers, a lack of accessible teaching materials, and attitudinal barriers. Creating and strengthening bilingual schools, alongside investments in teacher training and specific public policies, are fundamental to consolidating this model and ensuring effective learning. As Skliar (1998, p. 1) noted, the absence or limitation of these specific political-educational projects has been a primary cause of the limitations in everyday pedagogical practice.

Until bilingual education is fully implemented, the TILS plays a central role as a mediator between the teacher's language (spoken Portuguese) and the deaf student's language (Libras). Learning depends on collaboration among the teacher, the TILS, and the student.

III. The Sign Language Translator and Interpreter

The Sign Language Translator and Interpreter (TILS) is a key professional facilitating communication between deaf and hearing individuals, especially in schools where most teachers do not master Libras (Botan, 2012). According to the Ministry of Education (MEC),

> *The interpreter is fully engaged in the communicative interaction [...] processes the information provided in the source language and makes lexical, structural, semantic, and pragmatic choices in the target language that should approximate as closely as possible the information provided in the source language* (MEC, 2004, p. 27).

Their role extends beyond literal translation to interpreting technical concepts, making appropriate lexical choices, and conveying meanings while respecting the visual epistemology of the Deaf community. Effective coordination between the teacher and the TILS is central to inclusive learning, enabling the student to actively participate and feel included.

Professional recognition of the interpreter emerged with Law No. 10,436/2002, which officially recognized Libras as a legal means of communication, and Decree No. 5,626/2005, which regulated the teaching of the language in teacher training programs (Brasil, 2002, 2005).

Despite mandatory Libras instruction, the presence of proficient interpreters remains limited, highlighting the importance of the TILS in overcoming the primary linguistic barrier. Initially operating in informal settings, the TILS assumed a structured role in school mediation, taking responsibility for ensuring linguistic accessibility and content comprehension (Gonçalves; Festa, 2013; Lacerda, 2010).

The TILS does not replace the teacher; each professional has a distinct classroom role, and both must collaborate. The TILS mediates communication between spoken Portuguese and

Libras, providing the deaf student with effective curriculum access. Lacerda (2010) observed that confusion and role reversal often occurred between the teacher and the TILS, leading to professional burnout and compromising both interpretation quality and effective inclusion.

The TILS translates not only words but also concepts and logical relationships, thereby facilitating learning. They must adhere to ethical principles of confidentiality, impartiality, and fidelity to the conveyed information (Brasil, 2004). Ethical practice is essential to ensure that mediation interferes with neither the content nor the deaf student's autonomy. Despite legal advances, the mere presence of a TILS does not guarantee effective inclusion. The main challenges regarding this profession include a shortage of Libras-proficient interpreters; limited initial training for both the TILS and hearing teachers working with deaf students; a lack of accessible and adapted teaching materials, especially for science and physics content; and attitudinal barriers stemming from a lack of understanding of the interpreter's school role (Mota, 2023; Picanço, 2022; Santos, 2023; Silveira, 2023).

Therefore, the TILS is the link enabling effective interaction within the triad. Their role mediates language, facilitates content comprehension, and respects the deaf student's linguistic identity.

IV. Inclusive Physics Education

Inclusive learning seeks to ensure that all students, regardless of their physical, sensory, cognitive, or cultural conditions, have full curriculum access and actively participate in school activities (UNESCO, 2009). Unlike welfare-oriented or segregating models, inclusion recognizes diversity and does not view it as an obstacle.

In deaf education, inclusive physics education (e.g., learning in general) involves understanding and respecting the student's linguistic and cultural identity, valuing Libras as a first language, and promoting pedagogical practices sensitive to their needs (Skliar, 1998; Strobel, 2008).

Physics education presents particular inclusion challenges due to conceptual abstraction (Picanço, 2022), technical vocabulary, and the need to interpret symbols that lack specific signs in Libras (Santos, 2023). Consequently, teaching physics requires not only content transmission but also epistemological mediation, enabling students to understand relationships and phenomena visually and concretely (Silveira, 2023).

Research has indicated that without appropriate strategies, deaf students do not participate effectively in the learning process; they are merely physically present rather than genuinely included (Quadros; Karnopp, 2004). This reinforces the importance of inclusive pedagogical practices that incorporate the adaptation of language and technical vocabulary into Libras, the use of visual aids, diagrams, and hands-on experiments, and collaborative planning between teachers and the TILS to ensure full content comprehension.

V. Methodological Approaches

This research was classified as qualitative because it involved collecting descriptive data, focused more on the research process than on the final results, and required the researcher to be directly immersed in the studied context (Lüdke; André, 1986). Furthermore, it constituted bibliographic research, which provides direct contact with the investigated field through the analysis of relevant academic literature (Prodanov; Freitas, 2013). We analyzed Brazilian theses and dissertations, allowing for detailed engagement with the subject matter.

The research employed the SoA approach, which is appropriate for studies based on previously published literature. We adopted the stages systematized by Santos and Morosini (2021), organizing the execution into three phases: I- Annotated Bibliography, II- Systematized Bibliography, and III- Categorized Bibliography, as illustrated in Figure 1. Santos and Morosini (2021) also suggested a fourth phase, the Propositional Bibliography, which expanded the purpose of the SoA beyond descriptive mapping.

ETAPAS	DEFINIÇÕES
1. Bibliografia Anotada	Identificação e seleção, a partir da pesquisa por descritores, dos materiais que farão parte do corpus de análise.
2. Bibliografia Sistematizada	Leitura flutuante dos resumos dos trabalhos para a seleção e o aprofundamento das pesquisas, a fim de elencar os que farão parte da análise e escrita do estado do conhecimento.
3. Bibliografia Categorizada	Reorganização do material selecionado, ou seja, do corpus de análise e reagrupamento destes em categorias temáticas.
4. Bibliografia Propositiva	Organização e apresentação de, a partir da análise realizada, proposições presentes nas publicações e propostas emergentes a partir da análise.

Fig. 1 - Steps for *conducting the State of the Art. Source: Santos and Morosini (2020, p. 127)*

Stage I

In the initial phase of the research, we searched for and selected the documents that would constitute the analytical corpus based on previously defined descriptors. We established two main sets of descriptors: *"Physics Education"* and *"deaf students,"* and *"Physics Teacher"* and *"deaf students."* We conducted the searches in the CAPES Thesis and Dissertation Catalog and the Brazilian Digital Library of Theses and Dissertations (BDTD), initially covering the period from 2010 to 2021, which corresponded to the analysis conducted during the master's research[2]. To broaden the scope of the investigation and include more recent works, we subsequently extended the search to cover the period from 2022 to 2024.

[2] Thesis access link: https://repositorio.ufsc.br/handle/123456789/254393.

In the initial search using the defined descriptors, we first consulted the BDTD. Using the descriptor *"Physics Education and Deaf Students,"* we found 69 publications. After analyzing the titles, we selected 27 works, comprising 6 theses and 21 dissertations. When searching for the second descriptor, *"Physics Teacher and Deaf Students,"* on the same platform, we found 55 publications. After analyzing the titles, we selected 18 works (3 theses and 15 dissertations). However, we had already included 15 of these works in the analysis of the first descriptor. Thus, for the second descriptor in the BDTD, we retained 3 publications (1 thesis and 2 dissertations). In total, using both descriptors, we selected 30 studies by title on this platform.

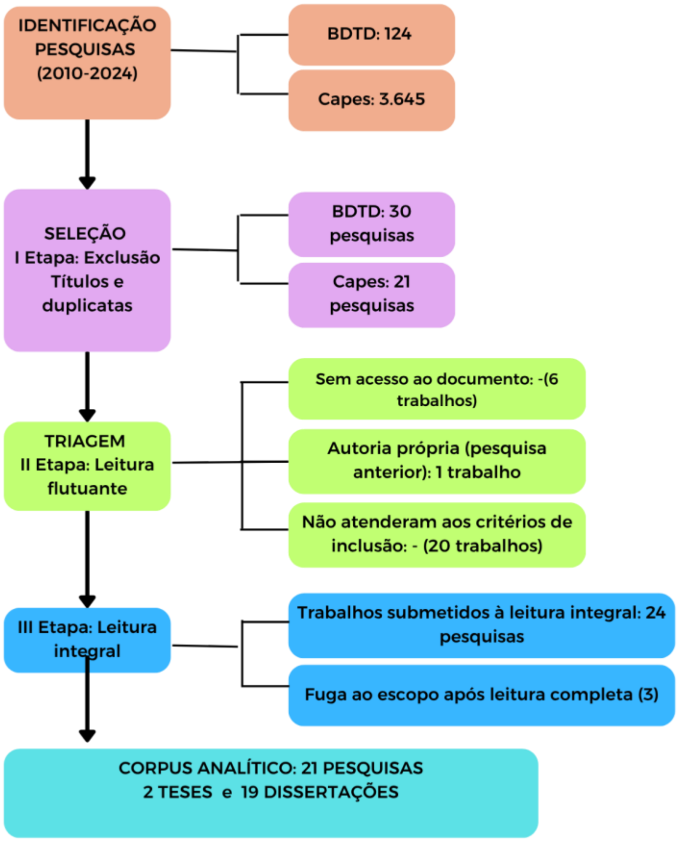
In the CAPES Thesis and Dissertation Catalog, we found a higher number of works, which required us to apply filters such as Exact and Earth Sciences and Physics. We found a total of 2,651 titles; after removing duplicate works already identified on the first platform, we selected 13 dissertations and 1 thesis. For the second descriptor, we found 994 titles, and after analysis, we selected 7 works (2 theses and 5 dissertations). In total, we chose 21 studies on this platform using both descriptors.

Ultimately, in the first stage of the EC, covering the years 2010 to 2024, we found 30 studies in the BDTD and 21 studies in the CAPES catalog, totaling 51 studies. Figure 2 presents the inclusion and exclusion flow of the analyzed studies within each stage of the analysis methodology.

Stage II

After selecting the titles, we read the abstracts in detail to refine the *corpus*. During this stage, we could not access six studies due to dissemination restrictions and therefore excluded them from the analysis. Additionally, one of the identified studies was an author's own dissertation, which served as the basis for our research, titled "Um estado do conhecimento sobre o eu docente no processo de ensino de física para estudantes surdos: o que dizem as pesquisas brasileiras?" (Schumacker, 2023); we also excluded this work from our *corpus*.

The inclusion criteria prioritized studies related to physics that involved physics teachers, TILS, and deaf students, excluding those that addressed inclusion without a specific focus on this group. Following this analysis, we excluded 20 studies for failing to meet the criteria and three studies after a full reading because they did not fit within the scope, despite their abstracts indicating they fell under our theme. The studies we excluded after a full reading were Tavares's (2014) study on the evaluation of interfaces for the deaf, which did not address deafness directly; Santos (2015), which addressed bilingual learning through software without a focus on physics education; and Guedes (2019), whose focus was the relationship between deaf students and educational interpreters, not specifically involving physics education. The final sample consisted of 21 works: 2 theses and 19 dissertations. Table 1 provides the data from the studies comprising our corpus, as well as the access links. For the qualitative analysis of the documents, we used the Atlas.ti software, which enables the processing of texts, audio,



images, and videos. In this study, we restricted the analysis to textual documents.

Fig. 2 – Stages of study inclusion/exclusion. Source: Authors (2026)

Table 1 – Analysis Corpus.

Document No.	Information about the Studies, including the access link
D1	GASPARIN, C. **As percepções dos intérpretes de libras sobre a influência dos seus conceitos de física na sua prática profissional**. 2019. 140 f. Dissertação (Mestrado), Universidade Federal da Fronteira Sul, Chapecó, 2019. Disponível em: https://rd.uffs.edu.br/handle/prefix/3327. Acesso em: 01 abr. 2026.
D2	MARTINS, D. R. **Educação em Ciências e Educação de Surdos:** vivenciando possibilidades em aulas de Física. 2017. 116 f. Dissertação (Mestrado) - Docência em Educação em Ciências e Matemáticas - Mestrado Profissional, do Instituto de Educação Matemática e Científica, Universidade Federal da Fronteira Sul, Belém, 2017.

	Disponível em: hhttps://repositorio.ufpa.br/items/720ea31a-976e-4ee8-9e39-387815a89872. Acesso em: 01 abr. 2026.
D3	BOTAN, E. **Ensino de física para surdos**: três estudos de casos da implementação de uma ferramenta didática para o ensino de cinemática. 2012. 177 F. Dissertação (Mestrado) -Programa de Pós-Graduação em Ensino de Ciências Naturais, Universidade Federal de Mato Grosso, Cuiabá, 2012. Disponível em: https://Repositorio.Ufsc.Br/Handle/123456789/190822. Acesso em: 01 abr. 2026.
D4	VIVIAN, E. C. p. **Ensino-aprendizagem de astronomia na cultura surda:** um olhar de uma física educadora bilíngue. 2018. 390 F. Dissertação (Mestrado) - Programa de Pós - Graduação em Educação Matemática e Ensino de Física, Universidade Federal de Santa Maria, Santa Maria, 2018. Disponível em: https://repositorio.ufsm.br/handle/1/15575. Acesso em: 01 abr. 2026.
D5	MOTA, V. M.T. **Sujeitos surdos e suas identidades**: perspectivas inclusivas no ensino de física. 2023. 108 f. Dissertação (Mestrado em Ensino de Ciências da Natureza) – Programa de Pós-Graduação em Ensino de Ciências da Natureza, Instituto de Química, Universidade Federal Fluminense, Niterói, 2023. Disponível em: https://app.uff.br/riuff/handle/1/31541. Acesso em: 01 abr. 2026.
D6	SILVA, J. F. C. O **Ensino de Física com as mãos**: Libras, bilinguismo e inclusão. 2013. 220 f. Dissertação (Mestrado) - Ensino de Física, Universidade de São Paulo - Instituto de Física, São Paulo, 2013. Disponível em: https://doi.org/10.11606/d.81.2013.tde-08032013-091813. Acesso em: 01 abr. 2026.
D7	PICANÇO, L. T. **O Ensino de óptica geométrica por meio dos problemas de visão e as lentes corretoras**: uma unidade de ensino no contexto da educação inclusiva para surdos. 2015. 63 F. Dissertação (Mestrado) - Mestrado Nacional Profissional em Ensino de Física - Instituto Federal de Educação, Ciência e Tecnologia do Amazonas Universidade Federal do Amazonas, Manaus, 2015. Disponível em: http://repositorio.ifam.edu.br/jspui/handle/4321/439. Acesso em: 01 abr. 2026.
D8	OLIVEIRA, V. R. O **Ensino do som como conteúdo de física para alunos surdos**: um desafio a ser enfrentado. 2017. 145 F. Dissertação (Mestrado) - Programa de Pós-Graduação em Educação Nível de Mestrado, Universidade Estadual do Oeste do Paraná, Centro de Educação, Comunicação e Artes/Ceca, Cascavel, 2017. Disponível em: http://tede.unioeste.br/handle/tede/3415. Acesso em: 01 abr. 2026.
D9	FERREIRA, A. B. **O processo de escolarização de crianças surdas no Ensino Fundamental**: Um olhar para o ensino de ciências articulado aos fundamentos da astronomia. 2015. 125 f. Dissertação (Mestrado em Educação) - Pós-graduação em Educação para a Ciência, Universidade Estadual Paulista, Faculdade de Ciência, Bauru, 2015. Disponível em: http://hdl.handle.net/11449/134137. Acesso em: 01 abr. 2026.

D10	TEIXEIRA, F. R. P. O **uso de aplicativos para deficientes auditivos**: uma alternativa para o ensino de física. 2018. 103 f. Dissertação (Mestrado) -Mestrado Profissional de Ensino de Física (MNPEF), Universidade Federal do Ceará, Fortaleza, 2018. Disponível em: http://www.repositorio.ufc.br/handle/riufc/35863. Acesso em: 01 abr. 2026.
D11	RODRIGUES, S. F. Vídeos **Bilíngues**: Ensino das Leis de Newton para Estudantes Surdos e Ouvintes. 2020. 243 f. Dissertação (Mestrado) -Ensino de Física, Universidade Federal do Rio Grande do Sul, Tramandaí, 2020. Disponível em: http://hdl.handle.net/10183/210548. Acesso em: 01 abr. 2026.
D12	DIAS, A. C.L. **Conhecendo As Deficiências Para Ensinar Física**: Uma Proposta Baseada Na **CAA.** 2018. 123 F. Dissertação (Mestrado em Educação) - Programa de Pós-Graduação de Educação em Ciências e Matemática, UFRRJ, Seropédica, 2018. Disponível em: https://tede.ufrrj.br/jspui/handle/jspui/4508. Acesso em: 01 abr. 2026.
D13	SILVEIRA, C. F. **A importância da visualidade e contextualização nos processos de ensino e aprendizagem de Física para alunos surdos: o caso dos movimentos uniforme e uniforme variado.** 2023. 145 f. Dissertação (Mestrado Profissional em Ensino de Ciências e Matemática) – Programa de Pós-Graduação em Ensino de Ciências e Matemática, Universidade Federal de Pelotas, Pelotas, 2023. Disponível em: https://guaiaca.ufpel.edu.br/handle/prefix/10018. Acesso em: 01 abr. 2026.
D14	COZENDEY, S. G. **A libras no ensino de leis de Newton em uma turma inclusiva de Ensino Médio.** 2013. 139 F. Tese (Doutorado) – Programa de Pós-Graduação em Educação Especial, Universidade Federal de São Carlos, São Carlos, 2013. Disponível em: https://repositorio.ufscar.br/handle/ufscar/2906. Acesso em: 01 abr. 2026.
D15	PICANÇO, L. T. **Construindo significados sobre o conceito de energia**: resultados de uma unidade de ensino inclusiva aplicada a estudantes surdos do ensino médio em tempos de pandemia. 2022. 267 f. Tese (Doutorado em Ensino de Ciências e Matemática) – Programa de Pós-Graduação em Ensino de Ciências e Matemática, Universidade Luterana do Brasil, Canoas, 2022. Disponível em: http://www.ppgecim.ulbra.br/teses/index.php/ppgecim/article/view/422/419. Acesso em: 01 abr. 2026.
D16	LIMA, I. S. **Desenvolvimento de manual de Física em Libras e objetos educacionais aplicados ao som**: Uma proposta de aprendizagem metodológica para os alunos com Deficiência Auditiva. 2018. 101 F. Dissertação (Mestrado) - Programa de Pós-Graduação da Universidade Federal do Sul e Sudeste do Pará, Unifesspa, Marabá, 2018. Disponível em:

	https://www.oasisbr.ibict.br/vufind/Record/BRCRIS_687b776a161a84d7207c7d23c79e52f1. Acesso em: 01 abr. 2026.
D17	LIMA, M. D. C. **Ensino de Cinemática para a comunidade surda.** 2015. Dissertação (Mestrado) - Mestrado Nacional Profissional em Ensino de Física, Universidade Federal de Rondônia, Ji-Paraná, Ro, 2015. Disponível em: https://sucupira.capes.gov.br/sucupira/public/consultas/coleta/trabalhoConclusao/viewTrabalhoConclusao.jsf?popup=true&id_trabalho=3599407. Acesso em: 01 abr. 2026.
D18	HEIDEMANN, M. K. **F-Libras: Aplicativo móvel como instrumento didático tecnológico no ensino de conceitos de física em libras para estudantes surdos e ouvintes que ingressam no Ensino Médio.** 2021. 178 f. Dissertação (Mestrado) - Programa de Pós-Graduação em Ensino de Ciências e Matemática, Universidade do Estado de Mato Grosso, Barra do Bugres, 2021. Disponível em: https://portal.unemat.br/media/files/MARCIELE_KEYLA_HEIDMANN.pdf Acesso em: 01 abr. 2026.
D19	OLIVEIRA, E. J. M. O **Ensino de física para estudantes surdos.** 2019. 123 F. Dissertação (Mestrado) - Mestrado Nacional Profissional em Ensino de Física, Universidade Federal do Rio Grande do Norte, Natal, 2019. Disponível em: https://repositorio.ufrn.br/handle/123456789/27520. Acesso em: 01 abr. 2026.
D20	GARCIA, Q. D. C. B. **"Física Libras"**: Um aplicativo como proposta para o ensino do vocabulário de calorimetria para alunos surdos. 2019. 114 F. Dissertação (Mestrado) - Mestrado Profissional de Ensino de Física, Fundação Universidade Federal de Rondônia, Porto Velho, 2019. Disponível em: https://sucupira.capes.gov.br/sucupira/public/consultas/coleta/trabalhoConclusao/viewTrabalhoConclusao.jsf?popup=true&id_trabalho=10901165. Acesso em: 01 abr. 2026.
D21	SANTOS, R. N. **A língua brasileira de sinais no ensino de Física para surdos**: tecnologias assistivas como suporte educacional. 2023. 99 f. Dissertação (Mestrado em Educação) – Universidade Federal de Sergipe, São Cristóvão, 2023. Disponível em: https://ri.ufs.br/jspui/handle/riufs/18693. Acesso em: 01 abr. 2026.

Source: Research data (2024).

Stage III

In the categorization stage, we read the selected documents in their entirety, organizing the works into analytical categories according to the methodology of Santos and Morosini (2021). The study considered two analytical categories: I- The Relationship Between the Teaching Triad, TILS, and Deaf Students in Physics Classes and Its Implications for the Teaching-Learning Process; and II- Teacher Training and Practice in Pedagogical Work with Deaf Students and the Didactic-Methodological Strategies Evidenced.

This study focused on issues related to the first category: The Relationship Between the Teaching Triad, TILS, and Deaf Students in Physics Classes and Its Implications for the Teaching-Learning Process. To organize the discussions, four subcategories were adopted: Challenges in Language Mediation; Pedagogical Challenges in Physics Instruction; Challenges in Deaf Students' Learning in Physics Classes; and the Relationship Between TILS and Physics Teachers.

Regarding the second category (Teacher Training and Practice in Pedagogical Work with Deaf Students and the Didactic-Methodological Strategies Evidenced) Schumacker and Leonel (2025) identified and mapped the didactic-methodological strategies employed by teachers lacking fluency in Brazilian Sign Language (Libras) when teaching physics to deaf students. The research highlighted the importance of promoting inclusive physics education, given the growing number of students with disabilities entering the school system. In addition, we observed that teachers continued to adopt visual strategies, such as images, videos, bilingual video lessons, Fotolibras, board games, experiments, and computational resources, including simulators, games, and applications (Schumacker; Leonel, 2025).

Stage IV

This section addresses the difficulties and barriers to physics education for deaf students. We examined the challenges faced by teachers, TILS, and the deaf students themselves, alongside structural and linguistic barriers, and explored potential pathways toward inclusive physics classes.

1. Challenges in Language Mediation

When discussing the challenges inherent in linguistic mediation between spoken Portuguese and Libras, we encountered barriers related to TILS interpretation and translation, deaf students' proficiency in both their native language and Portuguese, and the specific vocabulary required for physics.

1.1 Difficulties with TILS in Translation and Interpretation

When analyzing the triad's role in the teaching-learning process for deaf students, certain barriers frequently emerged. Our analyses identified studies indicating that part of the responsibility for deaf students' academic failures lies with the TILS (D1; D16). We disagreed with this perspective; as previously mentioned, this professional is only one of the parties involved in the process. Furthermore, it is necessary to understand the context and the structural support available to these individuals.

One of the most frequent difficulties regarding TILS, as noted in several studies (D1; D4; D5; D8;D13;D15), was the lack of specific mastery of Libras within physics. This stems from the discipline's high level of abstraction and "the absence of scientific signs in Libras, forcing the use of finger spelling for technical terms" (D5, p. 25).

The primary obstacle involved semiotic processes at the symbolic level, specifically the lack of translation for scientific concepts and formulas into sign languages, particularly Libras (D15, p. 37).

The Libras translator/interpreter encountered difficulties conveying certain concepts and explaining physics formulas through signs, as some concepts and phenomena lack literal interpretations (D21, p. 6).

The vocabulary barrier in Libras was one of the most frequently cited issues in the analyzed studies; however, it remains difficult to resolve. As noted in D15 (p. 37): "The regionalism of Libras, which makes the adoption of signs for concepts difficult to resolve, requiring creation and consensus within the Deaf community."

Regarding the signs and vocabulary used by TILS, a common perception existed that these professionals must master all areas of knowledge to adequately interpret and translate. However, many TILS lacked specific training in disciplines such as physics, mathematics, or chemistry, which naturally limited their conceptual mastery in these fields. Consequently, collaborative work between the TILS and the instructor became essential to clarify doubts and avoid potential conceptual misunderstandings when mediating knowledge, as evidenced below:

In lecture-style classes, it is a fact that the interpreter strives to follow and interpret the teacher's explanation; however, difficulties regarding the subject matter were observed, and it appears that there may be a lack of dialogue between the teacher and the interpreter in the planning and development of classroom activities (D3, p. 72).

The expectation that TILS must master all content stems from a misunderstanding of their classroom role. Many teachers, unfamiliar with Libras, Deaf culture, and the capabilities of deaf students, did not understand the TILS's function, as illustrated in D3 (p. 72): "At times, the interpreter takes on the role of a teacher, explaining and correcting exercises. In these circumstances, we might wonder how Pedro feels in an 'inclusive' classroom where interaction with the teacher seems nonexistent."

This lack of understanding ultimately hindered the inclusion of deaf students, as communication became restricted to the TILS and the deaf student, excluding hearing educators and peers. Our research identified the following excerpts supporting this argument:

[...] the presence of the interpreter is essential; but at the same time, in some cases, it has also become a barrier to scientific learning (D4, p. 89).

Without the interpreter's presence, teaching will be based almost exclusively on oral communication, shifting the responsibility to the deaf student to adapt to the environment (D2, p. 53).

[...] the fact that there is an interpreter in the classroom does not mean that the educational content will be effectively conveyed to the deaf, even if they are proficient in sign language (D2, p. 55).

[...] there are no interpreters. [...] Without an interpreter, students leave the school just as they entered it (D3, p. 12).

Focusing on School E2, the physics teaching processes for deaf students at this school were based on the idea that the presence of an interpreter alone was sufficient for students to learn any subject (D6, p. 124).

Other difficulties identified in D1 included the simultaneous nature of the teacher's speech and board writing, the physical positioning of the TILS relative to the student, and freedom of movement. These issues could be resolved through discussion and consensus between the teacher and the TILS, thereby improving collaborative efforts to support deaf students' learning. As previously mentioned, the lack of signs in Libras and limited vocabulary presented significant challenges, especially in the natural sciences, where specific terms remain scarce. This absence of signs often led to imprecise translations of physics concepts, as TILS had to make lexical choices to contextualize the content within Deaf culture. However, selecting synonymous words sometimes caused conceptual misunderstandings. We highlight several excerpts related to these difficulties below:

The *interpreter's lack of knowledge regarding the appropriate sign to use in this situation* (D1, p. 19).

The Libras translator/interpreter encounters difficulties in conveying certain concepts *and explaining formulas from the field of physics through signs, given that some concepts and phenomena do not have literal interpretations* (D21, pp.6-7).

Misinterpretations (D1, p. 51).

Rewriting of the *discourse* (D1, p. 52).

When the Libras translator/interpreter is not fluent in Sign Language, the original statement may be distorted or even rendered meaningless in Libras, resulting in students having limited access to the taught content (D8, p. 114).

Among the authors discussing the importance of Libras in physics, Almeida (2013), while investigating the role of the interpreter in physics classes, concluded that the teacher's speech differs from the translation provided by the interpreter, and these differences are related to the interpreter's limited vocabulary in Libras and the absence of certain signs in Libras (D2, p. 51).

She believes that the current difficulty with physics lies in interpreting the concepts for the deaf student, since, according to her, there are many similar words and signs that she does not yet know, and in certain situations she uses signs that sometimes do not correspond to the physical concepts (D3, p. 120).

Although the interpreter said she understood how to solve the exercise, her expression of doubt suggested to us that she still had difficulty visualizing the forces and understanding the dynamics of how each one interacted with the person in the elevator. Perhaps this explanation did not help in conveying all of this to the deaf student (D3, p. 64-65).

It is clear that although the deaf student was present and physically "participating" in the activity, the interviewee was unable to follow along and convey most of the information provided by the PFB (D9, p. 90).

Statements such as these clarify the struggle of deaf communities advocating for bilingual education over inclusive education. "Inclusive education, for the most part, allows all students to interact with one another, but it has not guaranteed our learning, the learning of the deaf" (Carta aberta..., 2012). Therefore, we emphasize the defense of bilingualism:

The defense of bilingualism involves understanding sign language and its significance for the deaf. In addition to serving as a form of communication that acts as a prerequisite for other subjects such as Portuguese and mathematics. Thus, sign language represents the empowerment of the deaf, as it allows them to be heard and represented (Nunes et al., 2015, p. 542).

This touches upon a long-standing debate within deaf communities regarding educational proposals, which was not the primary focus of this study. However, to overcome barriers in the teaching-learning process, teachers and TILS ideally should plan and develop lessons collaboratively.

Essential conditions must be met by these professionals. For instance, teachers should provide lesson plans in advance so that interpreters are not caught off guard by unknown or nonexistent signs; this allows interpreters to identify and address difficulties with physics concepts prior to class. Furthermore, there was a "need for interpreters to prepare before working in the classroom with the deaf student, so that they can choose the best interpretation strategy" (D1, p. 110).

If barriers persisted even with the presence of a TILS, whose role is to mediate interactions among the deaf student, their peers, and teachers, imagining a classroom without them was even more difficult. Despite their importance, a shortage of TILS in education remained, as demonstrated by the following excerpts:

Communication in an inclusive school without an interpreter and with a deaf student is very limited (D6, p. 108).

Lack of translators/interpreters (D8, p. 56).

Student 06 – When the interpreter is absent, it's as if I weren't in the classroom (LIBRAS) (D16, p. 43).

The data reveal that, in high school, these students did not always have an interpreter for physics classes. Because of this, most report that they always had difficulty learning physics concepts through Portuguese-language texts that were hard to understand (D17, p. 48).

When discussing difficulties in the teaching-learning process, it is necessary to address the perceptions some TILS and teachers held regarding deaf students' potential:

Often, when the teacher wrote certain content on the blackboard, the deaf student would immediately try to start copying it, but the teacher would ask him to stop, as she was about to conduct another activity (D9, p. 79).

[...] we can observe the distress and venting of indignation regarding the attitude of classroom teachers in the face of their ignorance of their own roles and of the capabilities and potential of the deaf individual, in the statement "sometimes, they even think [...] that deaf people don't think, right, and they want us to think for them, answer for them, and speak for them." And I1 adds: [...] because they don't know the interpreter's role, [...] And that hinders their work and ours, and it also hinders our student (D18, p. 60).

Deaf students often did not receive equal opportunities, content, or activities inside and outside the classroom. In some cases, even the professionals involved in their education lacked awareness of the students' limitations and potential. This lack of clarity regarding Deaf culture and identity ultimately disadvantaged the students.

These mediation difficulties, frequently reported in the analyzed studies, aligned with Lacerda's (2006) description of the educational interpreter's complex role, emphasizing that translation is not a mechanical process but an activity requiring a deep understanding of the content. When the data indicated flaws in this mediation, the urgency of joint planning became apparent, corroborating the thesis that the TILS cannot bear sole responsibility for pedagogical accessibility.

1.2 Difficulties in Portuguese and Libras

The previously identified difficulties all converged on a single issue: communication barriers. To address communication specifically, we analyzed the two languages involved in this process: Libras (L1, the mother tongue) and Portuguese (L2, the second language).

As noted in D4 (p. 20), “the students in question, in addition to being in the process of learning written Portuguese and receiving instruction in Libras, do not fluently master either Libras or the Portuguese language.” Many difficulties in assimilating content stemmed from a lack of proficiency in Portuguese; students struggled with interpretation, reading, and comprehension, particularly when reading problem statements, as evidenced in the excerpts below:

We attribute the students' difficulties in dialogue and the barriers to understanding abstract concepts and/or phenomena to three main conditions: the students' lack of linguistic proficiency, few spontaneous concepts, and a scarcity and/or lack of knowledge of specific signs for discursive and argumentative structuring (D4, p. 155).

During the implementation of the teaching materials, we observed that the students exhibited linguistic deficiencies in both Libras and Portuguese, with the latter being more pronounced (D3, p. 127).

Even though they were fluent in Libras, the students did not master written Portuguese and faced barriers because they could not follow the teacher and interpreter simultaneously (D4, pp.89-90).

The issue of the Portuguese language is a barrier for them, as it is not the native language of deaf students (D20, pp. 74–75).

Teacher B: These students are unable to access science content; they first need to learn to read and write, which is why I prioritize Portuguese, and at most, I work on Math, but it's still difficult for this class (D9, p. 75).

What this situation reveals is that perhaps Pedro's difficulty in understanding the interrogative form highlights a lack of linguistic skills and competencies, a lexical and grammatical deficiency, which is also observed in the students' reading and writing (D3, p. 82).

While reading, we observed that Lúcia followed the sentence with her finger and pronounced some sounds. At one point during the reading, Lúcia laughed, but did not lose focus; she continued reading the text. I discussed the situation with the interpreter Marta, who said that Lúcia did this when she read. We asked if she believed Lúcia understood what she was reading, and in response she said: “nothing... I don't think so... they don't know Portuguese” (D3, p. 97).

[...] *during the administration of the questionnaire to identify prior knowledge, it became apparent that the students had difficulty answering it in Portuguese. This difficulty arose because the students' native language is Libras* (D11, p. 21).

In addition to difficulties with writing, the students had trouble reading and interpreting the questions, which led to a change in strategy (D11, p. 21).

The difficulties with mathematics and text comprehension, elements that can be considered among the foundational skills for studying physics, point to a need to adopt differentiated strategies for presenting and discussing physics content with this student (D14, p. 55).

Another difficulty regarding the Portuguese language related to textbooks, as indicated by excerpts from D19 and D13:

[...] *the use of the textbook, which is written in Portuguese, limits these students' comprehension* (D19, p. 38).

[...] *textbooks contain explanatory texts and lengthy conceptual* explanations *(in Portuguese), which makes comprehension difficult for deaf students who use written Portuguese as a second language (L2)* (D13, p. 16).

In other words, textbooks did not facilitate deaf students' reading and comprehension; furthermore, they were designed for and referenced only the daily lives of hearing individuals. In physics education, problem statements should be formulated more clearly and objectively to facilitate reading and interpretation.

Language barriers were not limited to Portuguese; they also extended to Libras. As noted, "the professional encounters students who, often, do not know their own language" and "if the student does not fully know their mother tongue, the interpreter's translation will make no sense" (D4, p. 70). The excerpts below corroborated this difficulty:

Student João, due to limited exposure to Libras in the school environment, was not fluent in Libras and therefore used the sign language created at home; consequently, he lacked proficiency in reading and writing (D2, p. 81).

[..] learning Libras, since until previous years she had only been exposed to oral communication (D3, p. 43).

Communication difficulties through Sign Language are presented as the main factor for the learning gap among the deaf (D17, p. 16).

This inclusion process, however, proves contradictory when we consider the acquisition of written Portuguese as a second language, since the deaf student does not yet possess satisfactory communication skills, as they have not yet acquired their natural language, Libras, to be able to learn a second language (D8, p. 55).

Thus, the difficulties in the teaching-learning process for deaf students represented foundational challenges in basic education that hindered their progression across all subjects.

Ultimately, this lack of communication compromised inclusion, the teaching-learning process, and the overall education of these students.

The linguistic barriers and the challenge of bilingualism evident in *the corpus* resonated with Skliar's (1998) critiques of hearing-centeredness[3]. According to the author, imposing the structure of Portuguese onto Libras reveals an outdated conception of deafness, viewing it as a condition to be corrected. The analyzed studies indicated that when Libras was not recognized as L1, physics instruction remained based on a translation logic that frequently marginalized the deaf student.

1.3 Difficulties with Specific Signs for Physics

Previous sections demonstrated that several difficulties encountered by TILS relate to signs and vocabulary in Libras. "Often, the translator/interpreter, in the absence of a sign for a particular concept, uses analogies to try to explain it" (D8, p. 76). The present section demonstrates how specific substitutions of words and signs in physics instruction led to the conceptual errors observed in this study:

> *When the interpreter explained the board's content to Pedro, we observed that she used the sign for weight to describe the concept of mass, although these are physical quantities of different natures* (D1, p. 53).

> *Many words specific to physics vocabulary do not exist in Libras* (D2, p. 52).

> *One assessment question included the term "energy," prompting both students to ask the interpreter about its sign and meaning. During this interaction, Polly used the sign for "electricity" and pointed to the classroom's ceiling light. We subsequently explained that the energy referenced in the mechanics question was of a different nature, relating to the displacement of bodies subjected to a force rather than to electricity or magnetism* (D3, p. 77).

> *The signs for Earth, World, Planet, and Universe in Libras are similar across the consulted dictionaries* (D4, p. 129).

> *The absence of certain signs, or the interpreter's lack of knowledge regarding them, caused insecurity among students. When interpreters informed deaf students that no corresponding sign existed, it generated negative feelings toward their own language* (D6, p. 133).

> *Deaf students frequently asked about confusing physics concepts, such as speed and acceleration. The interpreter's mere use of a sign did not facilitate learning, prompting teachers and*

[3] Skliar (1998, p. 15) introduced the term "hearingism" as: "... a set of representations held by hearing people, based on which the deaf person is compelled to view and describe themselves as if they were hearing."

interpreters to ask the deaf students for patience. Teachers addressed the students' questions but asked them to wait during the lesson explanation so a new sign could be created (D6, p. 136).

Libras lacks signs for all the words used in Portuguese statements. This reality hindered the flow of classes in certain subjects (especially those requiring specific signs, such as high school physics). In the absence of a Libras sign, interpreters had to use fingerspelling, which made the class monotonous and exhausting for both the interpreter and the students reading it (D14, p. 23).

Regarding terms specific to physics instruction, not only were signs missing for many concepts, but some existing signs with Portuguese equivalents differed in meaning from the actual physical concepts (D14, p. 23).

The words "rest" and "reference," even when fingerspelled by the interpreter, remained unknown to the deaf students; thus, it was unreasonable to expect these students to understand the text when they did not know the contextual meanings of the involved words (D17, p. 70).

Among the difficulties related to signs and vocabulary, we observed the use of fingerspelling for equation variables without accompanying discussion or contextualization for the deaf student. While understanding equations is already challenging for hearing students, presenting an equation's derivation without explaining its meaning to a deaf student exacerbates this difficulty, as noted in D1. A similar issue appeared in D3:

Another point observed is that during the interpretation of Newton's second law, the interpreter did not discuss what each letter represented in the formula F=m.a; she merely signed the formula. We also noted that the sentences made no mention of the phenomenon involved or the problem the teacher solved with the students. [...] In the explanation of Hooke's law, Polly also signed the word "deformation" and the formula, but did not say what each letter represented (D3, p. 55).

The excerpt from D3 highlights the difficulties associated with equations, which accompany students throughout their physics education. Without proper explanation, contextualization, and the construction of meaning for each variable, equations fail to fulfill their pedagogical role, ultimately increasing students' difficulty and disinterest in studying physics.

The lack of technical symbols for physics concepts, as noted in the analyzed studies, reinforced the need to expand and document the lexicon in specialized contexts, aligning with previous discussions by Quadros (2004). Although the creation of improvised or "homemade" signs in the classroom addressed immediate needs, it often led to conceptual inaccuracies. This highlights that didactic adaptation in the natural sciences still lacks a consolidated lexicon consistent with the visual-spatial nature of Libras.

2. Pedagogical Challenges in Physics Education

A primary difficulty encountered in teaching practice was the minimal course load allocated to the physics discipline, as identified in D1. This constraint hindered instructional planning by limiting the time available to prepare appropriate lessons tailored to the specific needs of the class. Furthermore, restricted class time impeded information exchange between the teacher and the TILS, reducing the time available to discuss, reflect upon, and plan suitable teaching strategies for individual deaf students.

Teachers are frequently overburdened with excessive teaching loads, leaving little time to plan, innovate, or move beyond traditional instructional methods. This systemic issue further complicated the design of inclusive lessons, as illustrated in D15:

> *The reality in schools, especially public ones, is that physics teachers lack the motivation to teach, since in the vast majority of cases, the teacher does not have time to design a lesson tailored to deaf students that makes teaching more engaging* (D15, p. 14).

Another factor identified in this study was the lack of knowledge some teachers demonstrated regarding Libras, the Deaf community, and the identity of Deaf students. As highlighted in D4, this knowledge gap caused a breakdown in the teacher-student relationship, which manifested in how Deaf students were integrated into the classroom. Frequently, these students did not feel a sense of belonging in the school environment, resulting in a “lack of direct communication between teacher and student” (D5, p. 74).

This rupture, typically driven by communication barriers, led to the exclusion of deaf students within the classroom and interfered with their teaching-learning process. Consequently, students found classes boring and overloaded with content. They also perceived that teachers avoided communicating with them due to an unwillingness to learn or use Libras. Although some teachers attempted to communicate using gestures when they did not know Libras, classroom communication predominantly occurred only between the teacher and the TILS. The following excerpts from deaf students illustrate these perceptions:

> *Student 01 – Teachers have too much content (LIBRAS)* (D16, p. 43).
>
> *Student 05 – Classes are boring; they don’t involve me (LIBRAS)* (D16, p. 43).
>
> *Student 01 – Bad, doesn’t know LIBRAS and doesn’t want to learn (LIBRAS)* (D16, p. 44).
>
> Student *02 – There’s no communication (LIBRAS)* (D16, p. 44).
>
> Student *03 – Sometimes, he uses gestures (LIBRAS)* (D16, p. 44).

In addition to *the ongoing difficulty of finding qualified physics professionals, those who taught the subject often lacked training in special education, even though their initial training curricula included* Libras (D18, p. 37).

Another critical issue was the lack of clarity in teachers' speech, which hindered the teaching-learning process for deaf students, whose primary linguistic structure differs from that of Portuguese. Consequently, teachers must be clear and objective in their explanations and instructions. Many teachers expressed a desire to include and communicate with their deaf students but did not know how to initiate this process, as seen in the following excerpts:

[...] I would like to have a closer relationship with them, but I don't know how to communicate with them. Perhaps with more direct communication, I could convey the content more clearly (P5) (D8, p. 91).

At school, we never receive any information on how to support these students. The only information comes from the interpreters, who have more contact with them, but we teachers try to teach as best as we can (P2) (D8, p. 91-92).

Study D1 asserted that not all teachers accepted inclusion; many believed the regular classroom was not the appropriate environment for deaf students. This perspective largely stemmed from a misunderstanding of deafness, Deaf culture, and the capabilities of deaf individuals, perpetuating the misconception that students with hearing loss cannot keep pace with hearing students.

A teacher-related difficulty noted in D6 was the challenge of accurately assessing deaf students. In many cases, the assessment methods were inappropriate. Deaf students face significant challenges with Portuguese because Libras utilizes a different linguistic structure, creating difficulties in writing, reading, interpretation, and particularly in understanding written instructions. Consequently, assessment methods for deaf students must be reevaluated. The following excerpts highlight these difficulties:

The majority of students (80%) indicate that they are not assessed with their disability in mind; the same activities are performed by both (D16, p. 46).

In the interview with the teacher, he estimates that the student only absorbs between 30% and 50%, which is below the 70% passing grade; yet, despite this assessment, he does not implement a plan that addresses the student's actual needs. The interpreter, however, states that the student's learning can reach up to 80% (D16, p. 57).

Deaf students end up not receiving the same content as hearing students; this is not inclusion (D2, p. 53).

[…] we noticed that Pedro's assessment did not have the same structure as the others' (D3, p. 50).

I did not assess these students' participation in the same way as hearing students' because of their particular needs. I tried to assess them through group activities so as not to disadvantage them. During the assessment, for questions addressing this content, I helped them formulate their answers, explaining each concept again (P2) (D8, p. 91).

Despite these difficulties, the literature revealed several strategies for the effective assessment of deaf students, notably written assessments in Libras administered with TILS assistance. Effective assessments utilized clearer, more objective, and shorter prompts to facilitate reading and interpretation. Additionally, oral assessments proved useful when the teacher posed questions in Portuguese and the TILS translated them into Libras for the student.

The difficulties teachers faced in inclusive classrooms partially stemmed from a lack of training in inclusive education and the specific teaching-learning processes required for deaf individuals. Undergraduate programs typically provided only basic exposure to Libras and inclusive education practices; thus:

We believe that teacher training to work with students with Special Educational Needs remains one of the major obstacles to dealing with inclusive contexts, where difference must be taught and respected. In this sense, most teachers are still not prepared to teach deaf people (D6, p. 119).

I had two years of teaching experience at that point, and I had never been prepared *by the institution where I earned my full teaching degree in Physics to serve the special education population* (D7, p. 1).

These training deficits led to further complications: as emphasized by D8 and D10, many teachers felt unprepared to work within inclusive settings, plan appropriate lessons, assess students, or establish effective communication with deaf individuals. This insecurity was compounded by a lack of teaching materials and specific pedagogical strategies for teaching physics to this population:

Lack of teaching materials in Brazilian Sign Language (D15, p. 108).

Lack of pedagogical strategies among mainstream classroom teachers for working with deaf students (D5, p. 31).

Because Libras is a visual-spatial language, visual aids significantly assisted deaf students in the teaching-learning process, as highlighted in D8. Consequently, educators must be deliberate when selecting images and videos. At a minimum, classroom videos should be subtitled and preferably brief, allowing for repeated viewing if necessary. These details are critical, as poor instructional choices often led to conceptual confusion. For example, presenting an image solely for its visual appeal was insufficient; the visual aid needed to resonate with the student's context, remain clear and objective, and maintain a strong connection to the target concept.

My biggest concern, perhaps not a difficulty, was preparing this lesson to meet the needs of this group of students. Since I have been working with deaf students for some time, I try to be mindful of content that may be more difficult for them to understand. So, I looked for a methodology that was more visual. "The interpreter helped me think of more visual material, since using the software alone would not meet my objective" (P5) (D8, p. 91).

Regarding resources, studies also noted a "lack of knowledge promotion through the use of Assistive Technologies" (D21, p. 83). Because deaf students rely predominantly on visual cues, blackboard usage presented another potential difficulty. As noted in D6, the blackboard must be organized systematically, following a logical, clear, and objective sequence supported by diagrams and drawings. Furthermore, D4 indicated that teachers' simultaneous use of speech and blackboard writing hindered the learning process, as it forced students to split their attention between the teacher's visual examples and the TILS's translation.

Physics instruction relies heavily on mathematical concepts; however, this mathematical emphasis proved to be a significant difficulty for both deaf and hearing students, as noted in D1 and D8:

I worry about whether I'm making myself understood, so I ask the interpreter if I'm being clear and if the deaf student is understanding, because in Physics there are many concepts that are very abstract, and these students sometimes have difficulty with abstraction (D8, p. 91).

Another challenge in teaching practice was a lack of interest in monitoring the progress and difficulties of deaf students. For instance, in D3, the TILS reported keeping a record of a deaf student's progress, but the teacher never inquired about it. In the same study, the TILS stated:

Polly said that there was a teacher who told her he did not feel comfortable with Pedro's presence in the classroom (D3, p. 120).

Within the classroom, there was a general lack of awareness regarding diversity and a poor understanding of inclusion. This study documented instances where teachers used inappropriate terminology to refer to Libras, the TILS, and the deaf students. For example, educators occasionally used the invalid term "deaf-mute," despite the fact that deaf individuals are not mute:

[...] the use of inappropriate terminology such as: "deaf and mute and Libras teacher," "make gestures and open my mouth wide to articulate the vocabulary," "I don't know what these gestures mean," "specialized person and companion" (D18, p. 55-56).

In D20, a physics teacher described his greatest difficulty as follows: "The difficulty lies in conveying the information (physical concepts) to the (deaf) students, given the significant communication challenge (Libras)" (p. 74). Evidently, many teachers felt unsupported, unprepared, and uncomfortable teaching physics to deaf students, primarily due to communication barriers. This lack of communication was perceived not only by the teachers but also by the deaf students, their peers, the TILS, their families, and the broader school community.

The lack of pedagogical coordination between the physics teacher and the TILS emerged as a central theme in the corpus. This situation contrasted with Strobel's (2008) framework for bilingual education, which argues that inclusion is not limited to the presence of an interpreter but requires the teacher to take active responsibility for the deaf student's education. Furthermore, the absence of visual methodologies demonstrated that physics instruction still relied predominantly on oral communication and written text, disregarding the visual nature inherent to Deaf culture (Strobel, 2008).

3. Challenges in Deaf Students' Learning in Physics Classes

The learning challenges faced by deaf students must be contextualized within the broader pedagogical difficulties previously discussed. The following excerpts reinforce these challenges and highlight additional issues related to perceptions of physics education and student inclusion:

[...] lack of social acceptance of the deaf student in the educational environment (D1, p. 92).

[...] resistance to the inclusion of deaf students (D1, p. 111).

There are still teachers who perceive the presence and educational needs of these students as disruptive to their classroom routine (D1, p. 111).

[...] schools strive, within their means, to include students. Due to a lack of infrastructure, they end up excluding them (D3, p. 12).

[...] there are no interpreters. (...) Without an interpreter, students leave the school just as they entered it (D3, p. 12).

[...] a breakdown in the relationship between teacher and student (D4, p. 88).

[...] the construction of scientific knowledge and the learning of deaf students, in non-bilingual family and school environments, are hindered when they live in oralist environments with little dialogic sign interaction (D4, p. 157).

[...] From these considerations, it follows that each deaf student will require different teaching strategies, since a student who lacks a deaf identity and has not learned Libras is unlikely to learn through it; and a deaf student whom the family views as disabled will face even greater learning difficulties (D6, p. 80).

The student often sits in the corner of the classroom and shows no interest in the teachers' lessons, except for those who seek to learn their language (D6, p. 108).

[...] there is no eye contact between the deaf student and the teacher (D6, p. 108).

At the end of the year, the mother approached the school because her son no longer wanted to attend; he claimed it was too difficult since he wasn't understanding anything. The student refused to take the second-quarter assessments and walked out of one of the exams in tears. This incident deeply moved the teachers (D6, p. 110).

It was observed that the fact that the student always performs activities different from the others contributes to his refusal to accept the content proposed by the teacher; it is evident that the student feels stifled and wishes to be on equal footing with the other students (D9, p. 79).

In this sense, it was observed that the deaf student is at a disadvantage compared to hearing children. They do not receive the full academic content, and it is also impossible to be certain of their understanding of what the teacher says, since, when the teacher asks students to perform an activity or attempts to explain certain content, the interpreter conveys the information in an extremely simplified manner or in a way that is entirely different from the teacher's instructions (D9, p. 79).

Assess the student as a whole in the teaching process (D10, p. 83).

In many cases, the students' socioeconomic situation is highly relevant, since many of them need to work to contribute to the family income and, in many cases, end up dropping out of school (D12, p. 37).

As demonstrated in the cited excerpts, deaf students were frequently excluded from the educational process despite being physically present in the classroom. The perceptions of the deaf individuals revealed a lack of communication with peers and teachers, resulting in classes that felt tedious and overloaded with content. Furthermore, students felt that teachers neither knew Libras nor desired to communicate with them, and that academic evaluations were administered incorrectly. The following excerpts illustrate these points:

Student 02 – None of my classmates speak LIBRAS (LIBRAS) (D16, p. 43).

Student 03 – I'm the only one who interprets in class (LIBRAS) (D16, p. 43).

Student 04 – Students are afraid to speak; they start talking, then stop (LIBRAS.) (D16, p. 43).

Student 05 – Classes are boring; I'm not engaged (LIBRAS) (D16, p. 43).

Student 06 – When the interpreter is absent, it's as if I weren't in the classroom (LIBRAS) (D16, p. 43).

Student 01 – Bad, doesn't know LIBRAS and doesn't want to learn (LIBRAS) (D16, p. 44).

Student 02 – There's no communication (LIBRAS) (D16, p. 43).

Student 03 – Sometimes someone nearby makes a gesture (LIBRAS) (D16, p. 44).

Student 04 – Few people want to communicate (LIBRAS) (D16, p. 44).

Student 06 – It would be easier if some people knew LIBRAS (LIBRAS) (D16, p. 44).

Student 02 – No, they don't like the deaf (LIBRAS) (D16, p. 47).

Student 04 – No, the student thinks the interpreter does (LIBRAS) (D16, p. 47).

Student 06 – No, they need to learn to think like the hearing. If they went a whole day without hearing, they would know (LIBRAS) (D16, p. 47).

The majority of students (80%) indicate that they are not evaluated with their disability in mind; the same activities are performed by both (D16, p. 46).

One of the teachers emphasized that the large number of students in the classroom makes it difficult to give special attention to deaf students (D19, p. 49).

According to these interpreters, some students are already accustomed to being promoted to the next grade and end up not wanting to learn the language of the deaf community; however, the majority of them are eager to learn the new language and to try harder in school. Some have mastered Libras through interaction with the deaf community itself (D19, p. 52).

Another factor contributing to deaf students' lack of interest in physics classes was classroom overcrowding, which hindered the individualized attention and guidance required for specific student needs, as noted in D6 and D19. Furthermore, pointing to structural ableism, some deaf students had become accustomed to automatic grade promotion without academic effort. As highlighted in the literature, "The assessment of these students still occurs through the 'pedagogical five,' or that is, what teachers refer to as the 'inclusion five'" (D6, p. 119).

Finally, the learning obstacles identified in this study indicated that deaf students often assumed a passive role as spectators rather than acting as active subjects of knowledge. As Lacerda (2006) pointed out, when information arrives in a fragmented or delayed manner, the cognitive process can be compromised. This reinforces the need for pedagogical strategies that extend beyond mere translation to actively incorporate linguistic and cultural specificities.

4. Relationship Between TILS and Physics Teachers

This analysis sought to understand the perspectives of the two professionals involved in teaching deaf students and how they perceived one another. The findings revealed teachers and TILS who maintained a good relationship, exchanged information, and respected each other's work, alongside professionals who felt intimidated, uncomfortable, and apprehensive toward one another.

Maintaining a respectful relationship between teachers and TILS is essential. An analysis of the coded data regarding the lack of interaction between these professionals revealed the following perspectives:

In general, I notice that teachers are very distrustful. Maybe because of the deaf person... sometimes they think they won't be able to convey the information, even though much of it is difficult, but I notice there's no teacher-interpreter interaction, which would be fundamental, such as providing advance material or, I don't know, a preliminary explanation to the interpreter so they can convey the information a bit more accurately. I think that's the biggest difficulty; teacher-interpreter interaction is very limited (D6, p. 132).

[...] ignores me, is afraid, and feels threatened (I1, interview conducted on 11/01/2020) (D18, p. 57).

[...] as if I were supervising their work (I2, interview conducted on 11/01/2020) (D18, p. 57).

[...] they pretended we didn't exist and are afraid (I5, interview conducted on 11/01/2020) (D18, p. 57).

[...] there isn't that total trust (I6, interview conducted on 11/01/2020) (D18, p. 57).

[...] the teacher's concern is to work together with the interpreter, reviewing their lesson plan with the interpreter and being available to answer the interpreter's questions (D1, p. 53).

[*...] the professionals' attitude toward one another* (D1, p. 110).

[...*] not all teachers are aware of this, nor do they understand the roles of the individuals in the classroom* (D1, p. 110).

[...] freedom for the interpreter to act and position themselves in the classroom (D1, p. 113).

*[...] lack of prior information about what will be covered in physics classes so that the interpreter can plan ahead (*D1, p. 115).

[...] She told us that at first she did not want to be an interpreter, as she observed constant conflicts between teachers and interpreters arising from a lack of understanding of each professional's responsibilities in the classroom. On the one hand, teachers felt intimidated by the presence of another professional in the classroom; on the other, the responsibility for teaching the content ended up falling to the interpreter (D3, p. 119).

In addition to encountering difficulties regarding lesson planning, Polly mentioned that there was no collaboration with the teachers, whether in the development of activity plans or in monitoring the work carried out with Pedro during after-school sessions (D3, p. 119).

Documents D1 and D3 contained statements from TILS who used physical education classes to clarify doubts with the physics teacher, as well as TILS who used after-school hours to verify the accuracy of their translations and interpretations. This search for solutions extended beyond classroom and planning time in an effort to collaborate: "the teacher's proximity expands the possibilities for collaborative work, creating an opening for discussions about possible adaptations, and the exchange of information and ideas for better classroom work" (D18, p. 42).

Beyond the relationship between teachers and TILS, the research revealed how these professionals perceived each other's work. Document D1 highlighted the teacher's attitude toward the presence of the deaf student and the TILS in the classroom. Some teachers still felt uncomfortable with the presence of TILS and perceived the needs of deaf students as a disruption to classroom routines. Furthermore, regarding teacher perceptions, the data indicated that:

Some believe that the classroom is not the right place for them to study and that the students should return to the special school from which they came. Other teachers doubt their intellectual abilities and do not like working with deaf students in the classroom (D6, p. 133).

Conversely, other teachers felt reassured by the presence of TILS: "The presence of TILS serves as a source of reassurance for the teacher who teaches physics, given the acknowledged difficulty of working with students with hearing impairments" (D18, p. 53).

Not all professionals were skeptical of inclusion. As noted in D6, "Another group of teachers already believes that deaf students are equal to hearing students, with the same learning challenges but different language difficulties" (p. 133). Furthermore:

The teacher must take care to teach without excluding the student, to assess without undermining what the student already knows, and, above all, to respect what the student says; respecting prior conceptions even if they are naive and lack much scientific logical foundation. In all schools, teachers must keep an open mind to address the lack of school infrastructure, or the production of teaching materials unsuitable for deaf students, as well as the shortage of human resources, structural support, and visual materials. [...] It is essential to always look students in the eyes, as perceiving others through eye contact transcends the barriers of spoken language and builds trust to foster learning and interaction between students and teachers (D6, p. 131).

Regarding eye contact, D6 indicated that arranging the classroom in a "U" shape facilitated visual contact, thereby enabling greater interaction.

Document D2 included the following statement from a teacher: "When I have a student with Special Educational Needs (SEN) in the classroom, I select the most meaningful content for the class, prioritizing and exploring conceptual issues further" (D2, p. 62). Similarly, D4 noted, "The teacher must be concerned with transforming the content into something the student can always understand" (p. 106). These statements reflected a perception that didactic adaptation was necessary. However, didactic adaptation did not mean depriving the student of knowledge; rather, it involved finding alternative methods to ensure comprehension.

The coded data in D2 also highlighted that some teachers did not understand what the TILS conveyed to the student, creating a sense of insecurity. Additionally, a teacher's account in D2 stated, "when I realized it, I was already teaching just for them; at other times, I forgot about them and taught only for the hearing students" (p. 20). In other words, the presence of the deaf student was sometimes forgotten and went unnoticed in the classroom, as highlighted in D3:

[...] we kind of pretend that… that inclusion happened… that they learned… that they passed… but in reality, that's very vague, isn't it… I don't think we manage to achieve even fifty percent of what was intended (p. 117).

As noted earlier regarding difficulties, the lack of time to prepare and plan inclusive lessons was a challenge faced by both TILS and teachers. Consequently, teachers often did what was within their power, as illustrated below:

Even during recess, I would stay with the deaf students to answer their questions, point out pictures in the textbook, look at their notebooks, explain the homework assignment in Brazilian Sign Language, and so on." Zuffi et al. (2011, p. 6) noted that "teachers sought out on their own ways to communicate with the deaf and promote their learning, through personal effort, which shows how little the Brazilian educational system still offers in terms of teacher training in this regard (D2, p. 65).

At School E1, even without an interpreter in the classroom, the physics teacher would meet on weekends with an interpreter from the church to translate some lessons from the São Paulo State

Curriculum found in the student's notebook. In an attempt to translate the workbook's content into Brazilian Sign Language (Libras), the interpretation was recorded with a camera, and the material was brought to the student to watch during class via a laptop. These were the only lessons he paid attention to (D6, p. 123).

Regarding the perceptions of TILS, D3 included the following statement from an interpreter: "teachers are not ready for the inclusion initiative, mainly because they lack training and, with regard to the deaf, because they do not know sign language" (p. 124). Document D3 also contained a statement by a TILS indicating "the need for Libras courses for the general public, and specializations for interpreters and teachers to improve their knowledge of Libras" (p. 125).

Regarding the difficulty teachers faced in understanding the role of the TILS, an excerpt from D4 showed that the TILS often ended up performing didactic adaptation to assist deaf students: "[...] where it is first necessary for the TILS to 'create teaching materials and perform didactic transposition; first to teach this student the meaning of the sign, and subsequently the physical definitions and concepts associated with the new linguistic sign'" (p. 88). Although this exceeded the formal role of the TILS, the authors considered it necessary for the deaf students' teaching and learning. Similarly, a code found in D6 noted: "at times, the interpreter had to go to the blackboard to draw some diagrams. Interpretation combined with drawing for the deaf student facilitated the understanding of some more abstract physics content and concepts" (p. 136). Another excerpt supported this idea:

Some of them take on the role of a teacher, designing extra activities, sharing their opinions and understanding of the taught content, and providing examples not mentioned by the teacher, all in an effort to help the deaf student understand (D8, p. 98).

These examples of the codes regarding the perceptions of professionals working in Deaf education demonstrated that maintaining good relationships, communication, and planning among the parties involved in the teaching-learning process was challenging. If one part of the teacher-TILS-deaf student triad failed to function properly, the other parts were adversely affected. Continuous, collaborative work was therefore essential.

In summary, the studies analyzed between 2010 and 2024 indicated that, despite advances in access, maintaining educational quality still faced attitudinal and linguistic barriers. These challenges aligned with the perspectives of Quadros (2004) and Strobel (2008), who highlighted that bilingual education was realized only when Deaf culture and linguistic specificity ceased to be treated as add-ons and instead occupied a central place in teaching practice.

VI. Conclusions

The corpus analysis revealed that the presence of deaf students in physics classes brought to light a set of challenges spanning language mediation, pedagogical practice, and learning conditions. The data showed that, although there were positive experiences of collaboration between teachers and TILS, the educational scenario remained marked by communication barriers, a lack of knowledge about Libras and Deaf culture, insufficient planning time, and structural limitations in schools.

The teacher-TILS-deaf student triad constituted the central axis of the teaching-learning process, but its effectiveness depended directly on the interaction among those involved. When breakdowns occurred in this relationship, whether due to the absence of joint planning, a lack of teacher preparation, or uncertainty regarding the roles of each professional, the deaf student's learning was compromised. Conversely, when there was dialogue, mutual respect, and a search for inclusive strategies such as those mapped by the authors (2025), the reports indicated greater engagement among deaf students and progress in content comprehension.

Assessment was another critical aspect. The data showed that, in most cases, assessments did not account for the linguistic and cultural specificities of deaf students, resulting in exclusionary practices. However, alternative approaches, such as more visual and clear assessments supported by TILS, demonstrated possible ways to make the assessment process fairer and more coherent.

These findings reinforced the need to rethink initial and continuing teacher education to effectively include discussions on Deaf education and Libras. Inclusion cannot be restricted to the physical presence of students in the classroom; it must ensure real conditions for learning, participation, and belonging.

Thus, this research highlighted that overcoming these challenges depended not only on the individual efforts of teachers or TILS but on a broader educational policy that valued linguistic diversity, ensured better working conditions, and strengthened cooperation among all stakeholders. Regarding classroom practices, building an inclusive physics education required a reorientation of pedagogical practices, emphasizing visuality and the effective coordination of the teacher-TILS-deaf student triad. It was essential for teachers to adopt strategies prioritizing communicational clarity and visual accessibility, such as the logical and non-simultaneous organization of the blackboard, and to avoid practices that hindered the TILS's mediation, such as speaking with their backs to the class. Reorganizing the physical space into a "U" shape also presented an effective alternative to enhance visual contact among all participants.

Lastly, the coordination of this triad needed to extend to the development of more visual, objective, and concrete assessments, requiring teachers to employ clear pedagogical discourse sensitive to the specificities of Libras. Building an inclusive physics education requires both institutional commitment and the openness of professionals to learn and teach from an inclusive perspective.

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