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Mathematics teaching and Sign Language: a mediated relationship in deaf education

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Abstract: This research aimed to analyze the role of sign language in the process of teaching and learning mathematics by deaf students in the negotiation of meanings and construction of concepts. *Educational Design Research* was used as the research method, and the second phase of the design/construction is specifically presented here, in which interviews were conducted with Mathematics teachers, Libras translators and interpreters, parents and deaf students from state public schools in a municipality in the state of Paraná. The data was analyzed using Content Analysis. The results highlight the need for attention to be paid to the teaching of mathematics in deaf education, so that its foundations should be based on an understanding of sign language as a means of learning, valuing deaf culture and visual experiences in the classroom.

Keywords: Mediation. Brazilian Sign Language. Inclusion.

La enseñanza de las matemáticas y Lengua de Señas: una relación mediada en la educación de sordos

Resumen: Esta investigación tiene como objetivo analizar el papel de la lengua de signos en el proceso de enseñanza y aprendizaje de Matemáticas por parte de estudiantes sordos en la negociación de significados y construcción de conceptos. Como método de investigación se utilizó la Educational Design Research, se presenta especificamente aqui em la segunda fase de diseño/construcción em la que se realizaron las entrevistas. Los participantes fueron profesores de Matemáticas, traductores e intérpretes de Libras, padres y estudiantes sordos de escuelas públicas estatales de un municipio del estado de Paraná. Los datos se analizaron mediante Análisis de Contenido. Como resultado, se destaca la necesidad de prestar atención a la enseñanza de la Matemática en la educación de personas sordas, de modo que sus fundamentos deben basarse en la comprensión de la lengua de señas como medio de aprendizaje, con la valorización de la cultura sorda y las experiencias visuales en el aula.

Palabras clave: Mediación. Lengua de Señas Brasileña. Inclusión.

Ensino de Matemática e a Língua de Sinais: uma relação mediada na educação de surdos

Resumo: Esta pesquisa teve como objetivo analisar o papel da língua de sinais no processo de ensino e aprendizagem de Matemática por estudantes surdos na negociação de significados e construção de conceitos. Como método de pesquisa, utilizou-se a *Educational Design Research*, e apresenta-se aqui especificamente a segunda fase do *design*/construção em que foram realizadas as entrevistas com professores de Matemática, tradutores e intérpretes de Libras, pais e estudantes surdos das escolas públicas estaduais de um município do estado do Paraná. Os dados foram analisados via Análise de Conteúdo. Como resultado, destaca-se a necessidade de atenção para o ensino de Matemática na educação de surdos, de modo que seus fundamentos devam se basear na compreensão da língua de sinais como meio para a aprendizagem, com a valorização da cultura surda e das experiências visuais em sala de aula.

Palavras-chave: Mediação. Língua Brasileira de Sinais. Inclusão.

1 Introduction[1]

There is a growing interest in studies on deaf education. Research (Lacerda, Santos & Caetano, 2013; Madalena, Correa & Spinillo, 2020; Souza & Góes, 2017) has converged on the inclusion of these students in a school environment that includes the teaching and learning process with respect for sign language as the first language for communication and understanding classes, and valuing deaf culture.

Over the years, the education of people with disabilities, global development disorders, high abilities and giftedness has undergone transformations; one of the biggest concerns today is the inclusion of these students in the school environment. In Brazil, the wording of the National Education Guidelines and Bases Law [LDB] 9.394/96 defines that Special Education will preferably be offered in the regular education network, with the support of specialized assistance to meet the specific needs of the students (Brasil, 1996). Decree 5.296/2004, which regulates the accessibility law in Brazil, deals with the guarantee of services for people with hearing disabilities in Brazilian Sign Language [Libras] (Brasil, 2004).

According to Lacerda (2006), the proposals put forward in the legal documents have not yet been put into practice in the classroom: there is a lack of physical resources, accessible materials and teacher training. A lot of time has passed since the author's diagnosis, but most of the problems remain without progress towards a solution. On the other hand, there is now greater access and recognition of the importance of Libras in the classroom, whether in the bilingual modality or from the perspective of school inclusion.

The Brazilian Law for the Inclusion of People with Disabilities (2015), which aims to ensure and promote the rights of people with disabilities, states that education must be guaranteed at all levels in an inclusive educational system. The document refers to bilingual education in Libras, in special schools, bilingual classes and inclusive schools, as well as the provision of Libras teaching, training and provision of Libras Translators and Interpreters [TILS] (Brasil, 2015).

The teaching of mathematics involves important issues for the development of deaf people; mathematical language, with all its theorems and demonstrations, needs to be linked to

[1] This paper is an excerpt from a doctoral thesis entitled “Mediation in the teaching of mathematics in deaf education: a study in the cultural-historical approach”, defended in the Postgraduate Program in Science and Technology Teaching at UTFPR, written by the first author, supervised by the second author and co-supervised by the third author.

an effective learning proposal for these students. In this sense, studies (Barbosa, 2013; Peixoto, 2015) indicate that sign language underpins the mediation and understanding of math concepts, in order to contribute to students' cognitive development.

According to Radford (2016), Mathematics Education, from the perspective of Historical-Cultural Theory, is understood as a political, social, cultural and historical issue, since it derives from the critical analysis by the subjects of the situation in which they find themselves, in a reflexive and ethical movement. The author refers to the construction of knowledge as a mediated process, and that the classroom should be a space for debate and the development of responsibility, solidarity and critical reflection. Given this context, this research focuses on the appropriation of school knowledge by deaf students in the classroom, and the following research problem is included in this section: What is the role of sign language in the teaching and learning process of mathematics by deaf students in the negotiation of meanings and construction of concepts?

2 The relationship between Mathematical Language and Sign Language

Language teaching for deaf children is based on the child's ability to perceive and understand the visual aspects of language, which is made up of a combination of different images and movements that form the word (Vygotski, 1997). Santana, Muniz and Peixoto (2018) state that education for the deaf needs to consider their specificities and offer quality teaching, observing the culture and educational approaches geared towards their characteristics.

According to Vygotski (1997, p.187), “The cultural development of deaf children is the fundamental sphere in which there is a system of possibilities for overcoming the paths that are blocked”. In other words, cultural development for deaf people expands the forms of communication and the use of sign language mediates this process. Making use of and sharing sign language inside and outside school provides an environment conducive to the acquisition of this language by deaf students (Coutinho, 2015). In this sense, Romário & Doziart (2018) point out the importance of exchanges between deaf peers in schools as a way of expanding opportunities for appropriating deaf identity and culture.

Peixoto (2015) cites the school failure of deaf students and attributes this to the lack of social relations established inside and outside the school, which results in the need to establish exchanges with the external environment. Coutinho (2015, p. 234) adds: “When assessing the failure of deaf education, the key to understanding it is always the linguistic issue, especially the lack of proficiency in Libras of hearing teachers”. In this direction, two points need to be considered: the teaching of mathematics to the deaf and the learning of mathematics by deaf students, since in both the convergence is in understanding the use of sign language in the classroom as fundamental.

The relationship between sign language and mathematics in the learning process of deaf students stands out. Communication in sign language and the level of proficiency, as well as the acquisition of the language at an early stage of the child's development, influence the learning of mathematics, as can be seen in the results of the Hrastinski and Wilbur (2016) research. In this regard, Madalena *et al.* (2020) explain that the performance of deaf students in numerical recitation tasks is related to the age at which they had their first contact with Libras, being more favorable to those who had early language acquisition (developed before the age of four). Karnopp, Pokorski & Zanini (2019) state that schools were and are essential for the dissemination and strengthening of sign language.

Number counting with the help of fingers can be understood as a communication tool by deaf students, just as embodied language through visual-manual experiences can interfere

with the performance of their mathematical skills (Hochman, Cohen, Ben-Shachar & Henik, 2020). The authors explain that the use of datiology in some tasks inhibits numeracy during the development of activities.

In this teaching and learning process, it is also essential to expand the linguistic vocabulary of deaf students, specifically in mathematics, as the lack of a broad understanding of entries and concepts is detrimental to their development (Costa, 2019). The author explains that deaf people are often taught in a fragmented way, which consequently impairs their acquisition of the Portuguese language and does not favor increased knowledge of the vocabulary and terminology necessary for learning. Expanding vocabulary in Libras and developing visuality in Mathematics are factors to be further developed in the education of the deaf (Sales, 2013).

Mathematical language does not yet have all the signs it needs to be translated into sign language. In this way, signs are created in the classroom, as can be seen in the work of Sales, Penteado and Moura (2015). As the authors point out, the negotiation of signs between students, teachers and TILS is crucial for the collective construction and sharing of knowledge in the classroom, expanding mathematical vocabulary.

Vygotski (2000) states that deaf people also communicate through gestures and require all visual information to guide their attention to words. The schemes produced by deaf students articulate signs and gestures; gestures in particular have broken with the function of communication and are also used as a cognitive action by students in the development of mathematical tasks (Peixoto, 2015).

Teaching mathematics bilingually, in which sign language is the first language, has been observed as a predictor of better performance for deaf students due to its visual and accessible language (Lange, C.; Lane-Outlaw; Lange, W. & Sherwood, 2013). Bilingual education is a demand of the deaf community (Lange, C. *et al*., 2013; Barojas-Gómez; Garnica & Dovala, 2017). Borges and Nogueira (2013) support Libras as a first language for deaf people, but point out that this alone is not enough, it is necessary to overcome barriers such as interaction in the classroom, visual activities, a curriculum aimed at deaf education and the initial and continuing training of teachers and TILS.

According to Sales (2013), teaching mathematics in the language spoken by deaf students provides better opportunities for them; in addition, a school where teachers and classmates share sign language is important. Interaction in sign language allows students to exchange experiences by working in groups, and communication in Libras between the deaf student and the teacher helps in the appropriation of knowledge.

In the teaching of mathematics, Libras becomes important as a mediator of knowledge, since students understand concepts, in many cases, from their everyday experiences (Pinheiro & Rosa, 2019). The Barojas-Gómez et al. (2017) study noted the need to establish a communication network between teachers to share experiences related to the teaching and learning process of deaf people. An environment in which students can interact with teachers in sign language to support learning (Sales *et al.*, 2015), as well as communication between them, favors the learning of school knowledge.

In the teaching of mathematics in deaf education, it is necessary to strengthen the relationship between teacher and student, overcoming the communication barrier, as well as the joint work between teacher and TILS in the planning of teaching activities to choose the best way to teach (Muniz, Peixoto & Magina, 2020). In this context, the study of language and the teaching of mathematics establish relevant relationships for teaching and learning, enabling

deaf students to explore various experiences in the school environment. Such experiences provided by teachers need to make use of diverse strategies that benefit students in the construction of mathematical knowledge.

3 Methodology

As a methodological approach, we opted for a design experiment based on the Educational Design Research [EDR] methodology, based on the definition of McKenney and Reeves (2012), who define research as iterative (repeated), flexible and focused on theory and practice. To this end, the design propositions were defined by their theoretical scope and the results of the exploratory research. In this section, we highlight the design proposition: Sign language as necessary in the process of teaching and learning mathematics by deaf students (Coutinho & Carvalho, 2016), since it is through sign language that exchanges take place, the negotiation of meanings (Sales et al., 2015) and the construction of concepts.

It should be noted that for data collection, the research instruments were applied with the authorization of the Free and Informed Consent Form [TCLE], the Free and Informed Assent Form [TALE] and the Consent Form for the Use of Image, Sound and Voice [TCUISV]. The study was also authorized by the Ethics Committee under Opinion number 83443418.0.0000.5547 and by the Paraná Regional Education Center [NRE].

Data was collected from 27 participants: seven math teachers, seven TILS, seven deaf students and six parents and/or guardians of deaf students. For each deaf student taking part in this study, their math teacher, the TILS accompanying them in class and their parents and/or guardians were interviewed. The interviews took place in the respective schools, with audio recordings of the teachers and TILS, with the appropriate authorizations. With the deaf students, the interviews were conducted in Libras, with the mediation of a TILS professional. Interviews were also carried out with parents and/or guardians; for these last two groups, notes were taken as research tools, with the appropriate authorizations.

The interviews were structured with a script of questions, on pre-scheduled dates and times. This stage was necessary in order to gain a better understanding of the issues that permeate the participants' math teaching and learning process. When defining the schools that would take part in this stage, those with deaf students enrolled in secondary school were selected. This level of education was chosen because there is still little research involving this audience, as observed in the literature review, which justifies the interest, as well as the availability of the group involved and the space/classroom for the study.

Data analysis used Content Analysis, characterized by Bardin (2011) as a set of communication analysis techniques involving methodological tools that can be applied to different sources of discourse. The corpus of this research consists of the transcripts of the interviews conducted with the four participant groups. In order to analyze the interviews, the participants were assigned codes to preserve their identity. The thirteen schools were given letters (A to M); math teachers, (P), preceded by ascending numbers; TILS, (I), preceded by ascending numbers; parents and/or guardians of deaf students, (R), preceded by ascending numbers; and deaf students, (A), preceded by ascending numbers. For example: P1A is teacher one at school A.

4 Results and Discussions

The school inclusion proposed in Brazilian legislation is described as an ideal scenario for achieving educational goals. However, this does not reflect what happens in school practice (Costa, 2019). In deaf education, the school becomes a space that goes beyond a curriculum,

methodologies and appropriation of curricular knowledge: the school also becomes the environment for promoting deaf culture, as Romário and Doziart (2018, p. 324) state: "With regard to the inclusive school environment, the presence of these subjects becomes even more necessary to, at least, rescue Deaf Culture, in addition to being essential for the self-knowledge of deaf children".

School is a place where deaf culture is shared for many students, who begin to use sign language in this educational space (Karnopp et al., 2019). The authors point out that many deaf children are the children of hearing parents, and the school environment is fundamental, since "[...] it may be the only space in which the exchange of cultural, philosophical and moral knowledge can take place" (Karnopp *et al*., 2019, p. 5).

We present here an excerpt from the second phase of the design/construction of the research, in which the interviews were carried out based on the design proposition Sign language as necessary in the process of teaching and learning mathematics by deaf students (Coutinho & Carvalho, 2016), because it is through sign language that exchanges take place, the negotiation of meanings (Sales *et al.*, 2015) and the construction of concepts.

As for the characteristics of the participating students, one student was in the first grade, one in the second grade and five in the third grade of secondary school. The schooling process of these students took place in more than one school, with an emphasis on mainstream schools, in the form of school inclusion.

After reading and organizing the data from the interviews, we looked at Sign Language and the teaching and learning process based on the issues surrounding language acquisition, deaf culture and the relationships established between math teachers, deaf students and TILS, as these are fundamental to the educational context. As for learning Libras, most of the deaf students started to use it as a means of mediation in the classroom environment and with the presence of the TILS only in the final stage of elementary school, which may have left gaps in their teaching and learning process.

The early acquisition of sign language is fundamental to students' development, as Madalena *et al.* (2020) argue, and it is important that deaf students have contact with sign language from an early age, as this will bring benefits for the acquisition of mathematical knowledge. In the report by the TILS (I1C), we can see the consequences of late acquisition of Libras: "*I suspect that because she learns too late, some signs or concepts I think she doesn't understand the meaning properly, she uses them in the context of the sentence, but in isolation she doesn't know what it means*" (I1C).

One of the issues surrounding the teaching and learning process of deaf students in school inclusion situations is the recognition of Libras as a first language, a means of communication and internalization of concepts, and as an official language. By recognizing this, deaf culture and elements of deaf identity are recognized.

However, the reality experienced by deaf students in practice, as can be seen in the comments of the participating students[2], is the absence of the TILS in the classroom for a period: "*It was bad, I heard little and understood little. Then I would ask the teacher to explain it again*" (A1A); '*I remember it was very difficult, nobody knew Libras, the children didn't know, the teachers didn't know, I felt lost, alone and isolated*' (A2A); '*It wasn't very good when I was a child, at the local school I didn't have an interpreter, I didn't learn anything, I just copied and did activities with the teacher*' (A1J). One student describes the moment she started

[2] The interviews with the deaf students were mediated by a TILS professional and the answers were recorded by the researcher.

learning Libras during the final grades of elementary school: "*I learned a lot of words and signs. In sixth grade I didn't know anything, neither Portuguese nor Libras, but then I started learning*" (A1C). The teaching of Libras could be offered to all students, deaf and hearing, so that they could establish channels of communication and new relationships of sharing in the classroom.

The TILS (I2A) also commented on her first contact with student A2A, still in elementary school: "*We did a lot of work, it was the first year she had an interpreter all year, she managed to do a lot, she's very intelligent, she managed to recognize words, I believe that the work of the family with the school makes all the difference*" (I2A). This statement reinforces the need for the presence of a TILS in the classroom, who helps with mathematical understanding and word recognition, and reveals the role of the school in the student's development, working together with the family.

According to Vygotski (1997), cultural forms, such as the use of sign language in communication, are necessary for the cultural development of deaf children, in order to make their higher psychological functions possible. Cultural development, through the use of psychological instruments, occurs and is possible for deaf children, even through different paths (Vygotski, 1997). It should be noted that knowledge of Libras is central to their development.

The participants said that they learned Libras at the school for the deaf, which they attend during the day, in parallel with their regular school classes. Contact with the deaf community was also attributed by the participating deaf students to living together at the deaf school; two of them mentioned that in addition to support meetings, they attended parties and events that took place at the school.

With regard to socializing with other deaf people, the participating students referred to their deaf friends, with whom they share information: "*I have many deaf friends, I don't despise deaf friends, I'm always in contact, interacting with them*" (A1J); "*I'm always in contact with friends through social networks, like Facebook [...] I have Instagram, I have several social networks and I talk a lot on the internet*" (A1H); "*I exchange experiences, I talk to deaf friends at meetings, at the bus station I meet a lot of deaf people, I have many friends. I play soccer in a deaf team*" (A1B). These excerpts reveal the importance of contact with deaf peers and the social relationships established there. Karnopp *et al*. (2019) state that it is in contact with deaf peers that deaf people identify themselves and strengthen the deaf community. It is believed that interaction between deaf and hearing people is beneficial, as it develops language and there is an opportunity to get to know a different culture.

The feeling of having more contact with the deaf community was pointed out in the speech of the father and/or guardian of one of the students: "*She doesn't have much contact, but she knows several deaf people, as she went to the deaf school she has contact with these colleagues, they grew up together, it's not a daily contact, but sometimes we meet them. When there are parties at the deaf school, we go. She likes school, she gets on well with everyone, but she likes being with the deaf more, because they speak the same language*" (R2A). And reaffirmed by another student: "*I'd like to have other deaf friends at school*" (A1B).

In the family environment, social relationships are fundamental, and it is essential that parents and/or guardians have knowledge of sign language and understand aspects of deaf culture in order to help deaf children in their development. In this sense, with regard to the deaf participants' communication at home and with their family, the parents and/or guardians reported that they have good communication; two said that the family knows Libras, and five said that someone in the family knows Libras, such as siblings, mother, grandmother or niece.

They recognized the importance of communication and some claimed to have taken courses to learn Libras, as well as accompanying their children to activities at the school for the deaf.

The statements in the interviews showed that there is still a long way to go for interaction between hearing and deaf people. However, despite the lack of interaction, the following statements show that Libras is an appropriate form of communication.

Communication through Libras has brought good results in the view of the parents and/or guardians, as the following statements reveal: "*Since she was a little girl, she has been attending the deaf school, since she was two she has interacted with Libras, with her classmates. Before that it was very difficult, then communication improved, she had her classmates at the deaf school and it was a relief, it seems that someone understood what she was feeling*" (R2A) and "*When she was little it was more difficult, now as a teenager she wants to tell us, sometimes she writes so that we can understand. When she gets home from class, she talks to her niece who understands Libras and tells her everything that happened*" (R1J).

According to Vygotski (1997), deafness only implies the lack of one of the pathways that establish relationships with the environment. In this way, deaf people are able to perform all the functions that make up human behavior, based on social compensation. This, in turn, takes place in the social relationships shared by deaf children. In this sense, Karnopp et al. (2019) affirm sign language as a marker of the deaf community and necessary in the educational context.

In this process, the school plays a fundamental role by becoming a locus of social education, seeking ways to overcome obstacles (Vygotski, 1997). In this environment, deaf people seek a model of education with the presence and appreciation of their culture and language (Karnopp et al., 2019), and the relationships established between the subjects who share this space are reflected in the teaching and learning process.

The family's relationship with the school was considered good by four parents/guardians who reported establishing a close relationship with the school; another two explained that they go to the school when necessary, whenever they are called. Three parents/guardians reported that they have more contact with the TILS, and that they contact her when necessary, although they have good communication with the school.

Deaf students' interaction with their hearing classmates is not always a natural process, with only two deaf students saying they have good communication and friends at school with whom they talk. The other five said they had little contact, interacted little and didn't have many friends at school: "*Many find it difficult to talk to me, when it comes to work I'm left alone. In the beginning I had a lot of difficulties, the teachers didn't know Libras and there were a lot of changes of interpreters*" (A2A). Borges and Nogueira (2013) explain that for deaf students to be in a classroom environment with only hearing classmates and teachers, many obstacles arise along the way, and knowledge is presented to them in a language that is not their domain. It is therefore necessary to understand this universe of factors that circumscribe educational phenomena in deaf education, such as the relationships established between teachers and students, so that ways can be found to overcome the challenges.

Among the deaf student participants, five claimed to have a good relationship with their math teacher: "I like the math teacher, I've learned a lot from the teacher (teacher's name), the teacher helps me, corrects me when I'm wrong. The teachers adapt the material for me" (A1J), but point out that communication needs to be mediated by the TILS: "*The teacher uses gestures, he talks to me, but we communicate through the interpreter. But the teacher is always willing to help me with the help of the interpreter*" (A2A); "*I have difficulty because I'm deaf and the*

teacher doesn't know Libras. But she shows it in the notebook, on the board, without the interpreter we try to communicate without Libras, because she doesn't know it" (A1H), and they add that they like the school and have a good relationship with the interpreter.

The students' comments are reminiscent of Lacerda *et al*. (2013) who argue that teachers need to recognize the specificities of deaf people and establish a close relationship with the TILS in order to expand learning possibilities. In the teaching of mathematics, Sales *et al*. (2015) found that the interaction between teacher, interpreter and deaf students made it possible to negotiate signs to expand the vocabulary of the content covered. The role of the teacher and the TILS becomes fundamental in deaf education to work together and share knowledge. It can be inferred that the situations mentioned in the literature are similar to those encountered by the participants in this research.

The math teachers who took part in the study said that they did not speak sign language and that their mediation with deaf students took place through the TILS. As for classroom organization in the triad of teacher, deaf student and TILS, one teacher revealed that they pass on the content to the TILS beforehand and combine the activities; two reported that they try to explain calmly, aimed at deaf students; and three mentioned helping students by answering questions; and one said they adapt the activities for the deaf student.

The role assigned to TILS in the classroom deserves attention, as it is necessary to understand that the teacher is responsible for the process of teaching and learning mathematical concepts. The teachers' reports show that in many situations they explain the content to the TILS, and the TILS has the task of re-explaining it to the student. "*When there are doubts, there usually are, today for example, I worked with them, there was a doubt, the interpreter always comes along, she comes to my desk, I let them do the activity, they ask questions, she also comes, the interpreter comes along, but I end up explaining much more to the interpreter than to the student (student's name)*" (P2A); "*With regard to the content, the content is the same given to the whole class, the teacher interpreter, when the teacher interpreter has a question, the teacher asks me and I try to explain it together to the teacher and the student*" (P1M).

In the relationship established in the classroom, the TILS begins to play a role that goes beyond interpreting the teacher's explanation into Libras, in some cases needing to first understand the content and then explain it to the student, as in the following teachers' reports: "*And when she doesn't understand, I explain it to her, because sometimes it's more complicated content, because the interpreter has to know everything, a little bit of each and she transmits it to him. Then we ask him if he has understood, when he says 'more or less', we go over it again, explain it again*" (P1H); '*Actually, we always do it with the interpreter, if she doesn't come, in the case of math I show him with my finger, I sit next to him and show him with my finger and try to show him what he has to do, but it's quite complicated working with him*' (P1B). In light of these reports, it is clear that there is a difficulty in communication and a lack of clarity about the role of the TILS in the teaching and learning process of deaf students.

This scenario points to the lack of discussion in the school environment about the issues surrounding deaf education. At a time when school inclusion is increasingly taking place in educational spaces, Borges and Nogueira (2013) cite the lack of knowledge of many teachers regarding the cultural aspects of the deaf, an essential factor that brings many benefits to the development of these studies.

The TILS pointed out that there is no planning time with the math teachers because they work full time in the classroom, and they consider this to be a gap that needs to be rethought: "*I even commented on this with the other teachers, that sometimes it's missing, even so that we can agree on a better strategy, suddenly many teachers have doubts 'look I don't know how I'm*

going to work on this', so there's a lack of time to sit down together" (I1H). Thus, as long as there is no interaction between TILS and teachers, there will be a gap in the learning process, since the exchange of information and joint planning between math teachers and TILS make it possible to recognize gaps and enhance the development of strategies for teaching and learning math to deaf students.

Translating and interpreting Libras/Portuguese language is not a simple process, given the diversity of situations involving curricular subjects in the primary school classroom. In this respect, four TILS who took part in the study said that they had difficulties interpreting mathematics content due to the students' lack of understanding and the lack of signs: "*Yes. Up to a certain point I do, because there is a lack of signs for certain subjects [...] But for example, sine, cosine, tangent, etc. But, for example, sine, cosine, tangent, there are no specific signs for that" (I2A); "Sometimes I do, like now that they're learning this log function thing, everything is in typescript, because there are no signs*" (I1J); "*There are some words that we don't know, there are some that don't have signs and the student also has the same difficulty as others who aren't deaf, they don't know the multiplication table, so that's where the difficulty lies*" (I1B), "*There's a lack of signs for the content, for specific words"* (I1C).

The work of TILS is favored when teachers use visual aids to explain content, as this provides resources for more effective interpretation (Lacerda *et al*., 2013). When the signs for certain content are missing, TILS say they resort to datiology, a fact explained by Lacerda et al. (2013, p. 197) as a time-consuming action: "[...] *if the student has no knowledge of the term, it will be of no use, as the concept is not developed from typing alone*".

Another resource cited by TILS, in situations where they don't know the sign for certain mathematical terms, is digital technology, such as translation apps: "*So when a sign is missing, for example, I end up using the app, there are some apps like Hand Talk and others that help in this regard, there's also a signboard from the education department itself that they've made available. So, these are the tools I use when a sign is missing, and sometimes when there's no time to do it, you end up saying 'look, at this moment let's agree, this is the sign'. I tell him that this isn't the signal, but for the moment we'll use this one, and then I research it and show him the correct signal*". Negotiating signs is an alternative in the classroom, as previous research has shown.

The TILS add that the ideal would be for the content to be passed on beforehand, as mentioned by three participants, so that they can look up the terms, but unfortunately this doesn't happen. Communication takes place simultaneously: "*In fact, we don't have anything in advance, the lessons happen as normal, we go into the classroom, the teacher starts the lesson and we start interpreting that content on the spot and you interpret what you can, what you can't, then you research it on the run or do datiology, you do something like that*" (I1B). As a result, the student often misses out on part of the content, since if the sign is missing, they have to resort to the glossary or typing to continue interpreting.

Faced with this situation, it is argued that the initial and continuing training of mathematics teachers and also TILS is a perspective for deaf education to be reflected on. Progress is still needed to make inclusive education a reality, including the training of professionals (Pinheiro *et al*., 2019). Barojas-Gómez *et al.* (2017) emphasize the importance of communication between teacher and student, with recognition of sign language as crucial in this relationship and necessary in the classroom.

The participating mathematics teachers have postgraduate degrees; four have one or more specializations and three have master's degrees in areas related to mathematics education. Only two teachers reported having attended a basic Libras course, but because they didn't

practice, they had forgotten the concepts and signs. It is important for mathematics degree courses to provide more discussion and training for students, combining theory with practice. This would enable future teachers to better understand and plan didactic-pedagogical actions when faced with school inclusion.

The initial training of mathematics teachers should include deaf education, so that they can understand the particularities of these students and of sign language as a visual-spatial modality and, based on this, propose new classroom practices (Santana *et al.*, 2018).

The participating teachers reported that the school system doesn't offer any courses on teaching mathematics in deaf education, not even in the larger context of mathematics in inclusive education: "*Actually, inclusion is only mentioned a lot in pedagogical meetings, but nothing specific, just that it has to be included, that it's part of it, I don't know what, that we have to work in a different way, but not how to do it. We don't know how to do it, they explain a lot that we have to do it, not how to do it*" (P1B). Manrique (2016) points out that the teachers said they had no training or experience in teaching mathematics in the context of special education. In this sense, Manrique (2016) discusses the continuing education of mathematics teachers from the perspective of school inclusion and points out that training meetings encourage joint reflection, sharing of experiences, the use of diagnostics in the face of difficulties encountered and the creation of a collaborative group.

A teacher commented on her work with the Institutional Program for Teaching Initiation Scholarships [Pibid] and that at that time she took part in many workshops and strategies on the subject of school inclusion. In view of this, we can see the emergence of teacher training, whether in initial training, with the expansion of discussions, or in continuing training, in collaborative projects that could take place in partnerships with Higher Education Institutions, as indicated by Sales (2013), the importance of bringing school and university closer together for the benefit of deaf education.

The participating teachers mentioned that they would like to have further training, as their statements reveal: "*So the ideal would be for all of us regular teachers to have training, but not basic training, really in-depth training, to work with deaf students or special students in general*" (P1M); "*I think, we, I'm very old, it's difficult, I would have to have instruction on how I'm going to teach this content, I know the theory, but the practice for them, how I can work with it. I'd need training, or even a book, with content and what you can do, with topics, how you can show it*" (PIH).

Or the teacher claims to have annual training courses offered by the network, which focus on very broad themes: "[...] *so many training courses that we have, in the ten years that I've been here, so there are twice a year, pedagogical week and training and this type of work is very little, it's almost nothing, so if we could really do a training course, a course like that, so that you could work. They're very loose courses, there should be something more practical, more objective, for all the teachers, because then surely this interaction with this student who needs it, this special student, you could be much closer to them*" (P2A). One of the participating teachers suggests broadening the strategies for working with certain contents "*Actually, I would need to know how to work with them, what materials I could use with them, because we actually know a lot of material, but it's all very laborious and we don't have the resources for it, so we have, for example, second year, we have some geometric solids that we use. But most subjects don't*" (P1B), and two participating teachers expressed a desire to study Libras to improve their communication with deaf students.

In order to achieve quality education for all students, it is essential that teachers are included in discussions, in the reorganization of the curriculum and teaching materials, and that

Specialized Educational Assistance [AEE] takes place effectively (Borges & Nogueira, 2013). Initial training should be complemented throughout their careers by continuing training courses offered by the state education network, which should address issues of school inclusion, since this is an urgent issue in the classroom.

With regard to the training of the participating TILS, four have a degree in Pedagogy, one has a degree in Chemistry, one has a degree in Sociology and one has a degree in Letters/Libras; all have a specialization in Libras or in Special Education with an emphasis on Libras and five have more than one specialization course. None of them has a degree in Mathematics. In this respect, Borges and Nogueira (2013) state that the interpreter's training does not cover all the areas they will be interpreting in a single day, i.e. the diversity of topics discussed in a morning class. This leads to situations in which miscommunication, combined with the lack of mathematical signs for translating a lot of content, has consequences that interfere with the understanding of concepts.

With regard to the TILS' continuing education, only one mentioned having taken a course on mathematics. They also complained about the lack of opportunities to exchange experiences with TILS from other schools, training spaces and improve their knowledge. It can thus be seen that the gaps in the relationships between teachers, deaf students and TILS need to be overcome and collaborative work with the appropriate training to make this happen is necessary for this process.

Teaching and learning in a school environment promote the development of human capacities and bring about qualitative changes in individuals. In this scenario, the teacher must establish relationships between students and mathematical knowledge. In the analysis of the interviews conducted, it is possible to highlight converging points, which are in line with the literature, i.e. the need to pay attention to the teaching of mathematics in deaf education, so that its foundations are based on understanding sign language as a means for learning, valuing deaf culture and visual experiences in the classroom.

5 Final Considerations

Deaf education from the perspective of an inclusive school requires pedagogical practices that consider visual experiences, sign language and deaf identities, going beyond the interpreter and deaf student relationship, in order to value culture (Romário & Doziart, 2018). It is at school, in interaction with others, that children develop a series of skills, expand their linguistic knowledge, establish affective and emotional relationships and experience the rules of coexistence in society (Lacerda, 2006).

Thus, in response to the research problem, "*analyzing the role of sign language in the teaching and learning process of Mathematics by deaf students in the negotiation of meanings and construction of concepts*", Libras was observed as necessary to guarantee a bilingual education. In deaf education, the teaching of mathematics expands students' vocabulary through the development of mathematical language and the study of written mathematical texts from a bilingual perspective (Silva, P., 2016).

According to Muniz *et al*. (2020), when teachers adopt a primarily expository and oral approach in the classroom, without using materials, drawings or resolutions on the blackboard, they are contributing to the exclusion of deaf students. The authors add that teacher training should take these issues into account, present and discuss linguistic differences and the possibilities for teaching mathematics, provide opportunities to learn about differences and establish relationships with Special Education.

Interaction and communication in the classroom are aspects of the mediated relationship; communication needs to overcome language barriers, so that even in the presence of the TILS, the teacher understands the deaf student's difficulties and ways of overcoming them, fulfilling their role in the educational process. The inclusion of deaf students in schools is the result of concrete actions from public policies and the school community in collaboration with the family, because only integrated work with material, financial and human resources can bring about the necessary changes towards quality education.

Sign language as a mediator in relationships in the school environment is recognized by the participants in this study as essential, however communication obstacles are present, since knowledge of Libras is often limited to the deaf student and the TILS. With regard to mathematics teachers, they recognized that understanding sign language would help in the process of teaching and learning the contents of this area.

The bilingual environment is a path advocated by the deaf community for the development of the teaching and learning process because it privileges the use of sign language, recognizes and values deaf culture and establishes interactions with the community. In contrast, deaf education from the perspective of school inclusion, which is the reality of most studies, urgently needs to overcome barriers and become an inclusive school. For this to happen, all students need to study in the same physical space, their differences need to be taken into account and they need to be able to appropriate scientific knowledge.

The limitations of this study include the different realities of the participating deaf students in terms of their form of communication, their schooling process and their school performance, and it is not possible to generalize. We understand that the research interface between deaf education and mathematics teaching is still being developed and that it needs new research that focuses its efforts on the mediation relationships between the triad of teacher, student and TILS. And also in the creation and development of materials and research environments accessible to deaf students in the initial and continuing training of math teachers and TILS, reflecting an opportunity for future research.

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