International Journal of Arts and Social Science www.ijassjournal.com
ISSN: 2581-7922,
Volume 4 Issue 4, July-August 2021

Mathematics for Portuguese Students with Hearing Impairment: An exploratory study of mathematical terms/concepts used in inclusive schools

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ABSTRACT : *Mathematics seems to be an academic subject hard to master by students with hearing impairment, considering there is a huge gap in the translation of mathematical terms/concepts from an oral language to a sign language when students are exposed in a bilingual education. This is the case in Portugal since 2008 with the inclusion of students in regular schools exposed to two languages. The goals of this study were to describe the academic background and professional experience of Portuguese Sign Language (PSL) Teachers and Interpreters, to discuss possible collaborative work between the latter professionals and Mathematics Teachers and how they act during classes in the absence of pre-defined gestures for some mathematical terms, and understand the terms used by teachers within math curriculum which have no direct translation for PSL. PSL. When there is no gesture to translate a mathematical term, the interpreters use dactylology and explanations by other existing gestures, leaving to students the process of designing of a code/sign to better represent it. It is necessary to foster a dynamic partnership between the different professionals working with students with hearing impairment, aiming at enriching the specific vocabulary of several subjects in order to improve the teaching-learning process.*

KEYWORDS -*Hearing Impairment, Portuguese Sign Language (PSL), Mathematics, Bilingual Education, Inclusion*

I. INTRODUCTION

The past thirty years have been marked by some advances and setbacks with regard to legislation for an inclusive education. In the case of students with hearing impairment, a law launched in 2008 enabled the transformation of some mainstream schools into inclusive schools, calling them Reference Schools for Bilingual Education for Students with Deafness, equipped with a range of additional and diversified resources to cater for the specific needs of these group of students, such as PSL Teachers, Interpreters, Speech and Language Therapists, among others, supporting them to be included with their peers (Decree-Law 3/2008, article 23rd [1)). This law stresses that educational responses must be flexible, assuming an individual and dynamic character, and presupposes a systematic assessment of the hearing-impaired student's teaching-learning process, as well as family involvement and participation. The inclusion of these students is assured since early ages by school districts holding reference kindergartens for the bilingual education for children with hearing impairment through an articulation of the educational system with the early intervention services, in order to support and inform the choices and options to their families, provide specialized technical resources available, namely PSL

teachers and speech and language therapists, as well as the early attendance of kindergarten in a group of children with hearing loss.

These reference schools adopt the bilingual education model (Cummings, 1989 [2]), which posits the existence of a common proficiency underlying all languages, arguing that cognitive/academic or literacy skills acquired in a first language could be transferred to the learning of related skills in a second language. Therefore, the main difference to the "traditional" curriculum is the teaching of PSL as first language (L1) and the Portuguese Language in its written form as a second language (L2), which means that learning of all subjects is carried out in their first language, that is, in sign language, through the presence of an Interpreter in the classroom to support these students to access the knowledge conveyed by their hearing-teachers. These students are also supported in all classes by a Special Education Teacher, trained to understand and cater their specific pedagogical and didactic needs, which role is to assist those teachers to adapt the contents and/or materials to be addressed with the students with hearing loss.

However, regarding Mathematics, the understanding of its contents by students with hearing impairment is often conditioned by linguistic differences at the most varied levels between a visuospatial language and an oral-auditory language, leading to a discrepancy, in most cases significant, between the chronological age and the level of education attended Its magnitude lies typically between two and three and a half years of delay compared to their listening peers (Swanwick, Oddy, & Roper, 2005 [3]). On the other hand, one must keep in mind that teaching mathematics to students with hearing impairment is done in a trilingual environment (national language, sign language and language of mathematics), which further challenges this process (Vitova, Zdrazilová, & Jezková, 2014 [4]). This explains why these students have enormous difficulties in the interpretation of mathematical statements and relationships (Lee & Paul, 2019 [5]).

These findings may lead one to think that the connection between mathematics and language is very strong, thus explaining why the majority of students with hearing loss face so many difficulties in learning mathematics. Others, however, emphasize that mathematics is about logic and spatial reasoning, and the only reason why these students fall behind to their hearing peers stems from the fact they end up receiving a narrower curriculum and less mathematical teaching, in comparison to the time devoted to learning to read and write (Nunes, 2004 [6]).

However, Mathematics is not simply a language but rather a way of representing the world based on abstract, formal structures, such as the notions of number and space, through specific ways of thought. Yet to master these processes is indispensable to learn and understand, in order to correctly apply them later, all the specific terms and concepts related to the central areas of mathematical knowledge. This goal seems to be very hard to accomplish for a student with hearing impairment, given the huge gap in the translation of mathematical terms/concepts from an oral language to a sign language (Umbezeiro et al., 2013 [7]), compelling Interprets to appeal to dactylology (or manual alphabet) to "spell" in sign language the nomenclature of concepts and / or procedures (Mesquita & Silva, 2009 [8]). Alternatively, the combination of existent gestures or the creation of codes previously settled between the Interpreter and students can be used as a representation of these concepts and / or procedures (Arroio, 2013 [9]). Kidd, Madsen and Lamb (1993) [10] identified five common problems faced by students with hearing impairment regarding mathematics learning: (a) words with multiple meanings, (b) specific vocabulary, (c) words with special importance in mathematics, (d) varied but related forms, and (e) specific abbreviations and symbols. According the authors, the results indicated a higher percentage of errors occurred in understanding the vocabulary.

There is a huge research gap in Portugal concerning the learning-teaching process of mathematics by students with hearing impairment. The existing studies refer mainly to learning how to read and write the written Portuguese language in the early years of schooling (Freire & César, 2007 [11]), issues related to bilingualism (Ferreira, 2005 [12]) or the role of family relationships in order to succeed in school (Ruela, 2000 [13]). Thus, it

is essential to search for studies that can contribute to gather and record a set of widely accepted signs for learning mathematics, enabling these students with hearing impairment to access knowledge (Sales, 2013 [14]).

II. METHODOLOGY

This study was carried out following a qualitative research paradigm, through a content analysis method, which allows to make replicable and valid inferences from verbal data aiming to describe or quantify a specific phenomenon (Downe-Wamboldt, 1992 [15]).

2.1.Research questions/ Objectives of the study

- describe and analyze the academic background and professional experience of LGP Teachers and Interpreters;
- understand if PSL Teachers collaborate with the Mathematics Teachers and how Interpreters act during the mathematics class, given the lack of pre-defined gestures for some mathematical terms;
- understand the terms used by teachers in mathematics with no direct translation for PSL.

2.2.Participants

Three PSL interpreters, all female, aged 26, 29 and 32 years old, participated in the study, as well as three PSL teachers, one female aged 34 and two males both aged 34 years old. Regarding PSL Interpreters, regarding the academic qualifications, all have degrees in PSL and a MSc in Translation and Interpretation; the most experienced has nine years of professional activity, followed by another with seven years and the less experienced has five years. All Teachers have a degree in PSL, and just one of them a MSc in Alternative Communication and Support Technologies. Concerning the professional experience, one of the teachers has only a few months of professional practice, while another has four and a half years and the most experienced has been working for six years.

*2.3.*Instrument to collect data

To conduct this study, an interview script (see Table 1) was developed for each group of participants (PSL Interpreters and Teachers), with questions organized by specific topics in order to collect the data (Rodríguez-Gómez, Gil-Flores& Garcia-Jiménez, 1996 [16]).

*2.4.*Data collection and analysis

Interviews were designed and recorded in audio and video and lasted between 40 to 60 minutes. The interviews of PSL Teachers were carried out in sign language, allowing a better communication and understanding of thoughts and opinions, and were translated by a guest Interpreter. The purposes of the study were explained, as well as the usefulness and opportunity of the interviews (Olabuégana, 2012 [17]), and each interviewed was asked to freely express her/his points of view (Bodgan & Biklen, 2013 [18]).

Throughout the interview, a table with some mathematical terms is presented, which were selected after an analysis on the Curricular Goals for Mathematics of the Elementary (first to fourth grades) and Middle School (fifth and sixth grades) and a research in student manuals within these levels, and the PSL Teachers and Interpreters asked to discuss their translation. Specialized bibliographic sources were consulted, namely the Portuguese Sign Language "Gestuary"[1] (Bettencourt, 2011 [19]), the Portuguese Sign Language Dictionary (Baltazar, 2010 [20]), and an online word search platform in several sign languages, including Portuguese (*Spread the Sign*). The terms chosen were based on a number of studies that show that students with hearing

[1]A collection of gestures of the Portuguese Sign Language, which first edition dates back to 1991, that emerged as the result of a research of the dialects used at the time by the different groups of people with hearing impairment, throughout the country, and considered as the first dictionary of the Portuguese Sign Language.

impairment have difficulties in the concepts of number and fraction, among others (Tinoco, Martinho, & Cruz-Santos, 2012 [21]).

Table 1
Guiding topics for interviews with PSL Teachers and Interpreters

PSL INTERPRETERS	• Difficulties in translating terms / concepts in mathematics classes. • Procedures adopted in the absence of a direct translation between a mathematical term and a PSL gesture. • Prior planning of the translation of mathematics classes. • Prior access to materials (worksheets, manuals, etc.). • Collaborative work between colleagues to combine gestures that represent specific mathematical terms for which there is no direct translation to PSL. • Full translation of all that is said vs the possibility of losing information. • Major difficulties in teacher-student translation or student-teacher translation. • Work in partnership with the PSL Teacher, in order to bridge the existing gaps regarding the PSL that can negatively influence success in the Mathematics discipline.
PSL TEACHERS	• Analysis of texts or tasks related to Mathematics, in order to know the existing communication difficulties, and work on their translation to PSL. • Work in partnership with PSL Interpreters to understand students' vocabulary needs in the Mathematics subject. • Work with the Mathematics´ Teacher to develop a bridge between the contents of this subject and the PSL. • Exchange views with your colleagues to combine gestures that represent specific mathematical terms for which there is no direct translation for PSL.

III. RESULTS

The existence of a collaborative work between the teachers of Mathematics and teachers of PSL would allow to identify the existence of linguistic gaps that might constrain the understanding of some mathematical terms/concepts. However, all the PSL Teachers were unanimous in stating they prepare their classes only based on the PSL Curricular Program and that they do not work the specific vocabulary of other disciplines. Likewise, when questioned about a collaborative work with the Interpreters, in order to realize the vocabulary restraints faced by students with hearing impairment in learning Mathematics, Teacher "D" stated that the school he works has no Interpreters, which compromise his communication with the hearing-teachers of the school. According to him, maybe for this reason, he was not called to participate in the discussion of his students' Individual Education Plan (IEP) and therefore he chose to perform his work apart. On the other hand, Teacher "E" said that, occasionally, the Interpreters asked him about the correspondence of a gesture to a specific word, or called for his opinion about a code / gesture created by them to symbolize a word without a direct PSL translation. He

also stated he has a good relationship with hearing-teachers, helping them whatever is needed, especially analyzing some texts to be presented to the students and actively contributing in the IEP conception.

Teacher "F" stated that because she recently started to work at a newschool didn´t feel comfortable yet to interact with the hearing teachers. Regard the Interpreters, although did not work collaboratively with them, she usually met them during breaks or at school meetings.

Table 2 presents a survey of the mathematical terms / concepts, selected after a search on the Curriculum Program and Goals of the mathematics subject for the 1st and 2nd levels of Basic Education, further complemented with a review of the students' manuals. The presented selection was based on studies about the difficulties revealed by students with hearing impairments regarding the domain of the specific lexicon of this discipline (Tinoco, Martinho,& Cruz-Santos, 2012, 2018 [21, 22]; Cruz-Santos & Martinho, 2019 [23]).

Table 2. Mathematical terms/concepts pulled from the Curriculum Program and Goals of the Mathematics subject by grade levels without direct translation to Portuguese Sign Language.

BASIC EDUCATION					
FIRST CYCLE				SECOND CYCLE	
Grade 1	Grade 2		Grade 3	Grade 4	Grade 5	Grade 6
subtração	número natural	losango	contagem progressiva / regressiva	vértice de um ângulo	simplificação de frações	crivo de Eratóstenes
subtrativo	sentido aditivo [1]	poliedro / não poliedro	dividendo, divisor, quociente e resto	ângulo convexos / côncavos	frações irredutíveis	subtração e soma algébrica
aditivo	sentido combinatório[1]	aresta	classe / ordem dos números	medidas exprimíveis em números inteiros	critérios de divisibilidade	reta tangente (a uma circunferência)
diferença	Fator[1]	face	arredondamento	ângulos nulos	algoritmo de Euclides	apótema de um polígono
retilíneo	Produto[1]	sólido geométrico	divisível	ângulos rasos	ângulos complementares / suplementares	prismas obliquos / regulares
plano (objeto)	quádruplo, quíntuplo, sêxtuplo, (...)	atributo geométrico / não geométrico	número racional	polígonos regulares	ângulos correspondentes	geatrizes e superfície de um cilindro / cone
vértice	dividendo, divisor, quociente (divisão exata	sistema métrico	decomposição de um número racional	planos paralelos	semirretas inversamente paralelas	poliedros convexos
paralelepípedo	terça parte, quarta parte, (...)	medidas não convencionais (área, volume, massa, etc.)	algoritmo	paralelepípedo retângulo	ângulos alternos (internos e externos)	relação de Euler
figuras equidecomponíveis	partilha equitativa	imersão	fração própria / imprópria	prismas retos	triângulo obtusângulo	isometria / invariância
figuras equivalentes	agrupamento	recipiente	fração decimal	pavimentações do plano	ângulos opostos / adjacentes	mediatriz / bissetriz
diagrama de Venn	semirretas	interseção de conjuntos	dízima (finita / periódica)		grau (medida de amplitude em minutos e segundos)	reflexão axial
	polígonos	diagrama de Carroll	quartos de volta		transferidor	potência de base racional não negativa
	linhas poligonais		superfície esférica		inverso de números racionais positivos	variáveis quantitativa / qualitativa
	triângulo isóceles		conversões (sistema métrico)		linguagem natural / simbólica	população
	triângulo equilátero		diagrama de caule-e-folhas		referencial cartesiano, ortogonal e monométrico	unidade estatística
	triângulo escaleno		moda		eixos da abcissa e da ordenada	
	quadrilátero					

1 associado à multiplicação;

Focusing from now on the Interpreters, all stated they have already faced difficulties translating some mathematical terms. When there were no gestures to translate some mathematical term / concept, the term was spelled through dactylology and later explained by other gestures or concepts and then the students designed an informal gesture/sing that in their opinion could better represent it.

Regarding the issue of some information conveyed by the Mathematics Teacher might get lost during the translation process, Interpreter "A" stated that this is inevitable and transversal to all disciplines, although she considers that it is possible to translate the essential information conveyed. However, Interpreter "B" stated that, on many occasions, she asked the Mathematics Teacher to reformulate an explanation of a term/concept, in order the students may have access to information.

The translation of a message between teacher-student and student-teacher was classified by the Interpreters as very hard. The Interpreter "C" said this difficulty is quite often associated to lack of awareness hearing-teachers usually reveal towards the specific education needs of a student with hearing impairment. However, she recognized that this also depends on the proficiency level of the student in sign language and, consequently, on her/his ability to understand the translation performed by the Interpreter.

In what concerns preparing the contents to be translated during the classes, the three Interpreters referred that they make an effort to learn in advance the contents that are to be taught in classes, resorting either to the manuals, worksheets or directly questioning the teachers before and after each class.

IV. DISCUSSION

The learning of mathematics entails the transmission of knowledge through communication, which can be oral for most students or signed for those who have some hearing impairment. The present study aimed at finding out if and how Portuguese Sign Language' Teachers and Interpreters articulate themselves to easy the access by students with hearing impairment to the mathematics curriculum and realize which terms whose lack of direct translation to PSL might represent an obstacle to the development of mathematical literacy. However, evidence suggests the difficulties experienced by these students on this subject do not result from sensory deprivation, but from communication problems this deprivation causes (Nunes & Moreno, 2002 [24]). Such difficulties were observed by Tinoco, Martinho and Cruz-Santos (2018) [22] among 6th grade students with hearing impairment, who revealed struggling when were asked to interpret mathematical statements. According to the authors of this study, the main constraint/barrier to learning was related to their understanding of specific terms, as well as vocabulary that take different meaning in different contexts, which entails a complex linguistic challenge to students with hearing loss.

Regarding the academic qualifications of PSL Teachers and Interpreters, although both groups have a similar academic level, the latter also have a Master's degree, which is currently necessary to access most qualified employments in Portugal. For PSL Teachers, the law that firstly introduced bilingual education for students with hearing impairment (Decree-Law 3/2008 [1]), subsequently was replaced by the current legal framework (Decree-Law 54/2018 [25]), which privileged PSL to be taught by an adult with hearing impairment (point 16 of article 23rd). Although a master's degree in education was not required until 2008, it is currently mandatory for all teachers under the Bologna Process[2]. For this reason, until then PSL was taught by Technicians[3]. However, the Decree-Law 16/2018 [26], which recognizes the right of these professionals to integrate the teaching career,

[2] process of standardization of academic degrees in the European Union, aiming to facilitate the mobility and employability of graduated students, through a reorganization of higher education in three study levels, which maintain the previous designations - graduation (3 years) or a master's degree (2 years) and PhD (3/5 years).

[3] this term is used as a reference to the non-teaching professionals working in schools, such as Psychologists, Speech-Language Therapists, Occupational Therapists, Portuguese Sign Language Interpreters, Social Workers, etc.

stipulated that until the end of the school year 2018/2019 they had to complete an in-service professionalization course (Official Notice 7424/2018 [27]).

Interpreters expressed concern with respect to the accomplishment of communication goals in a class of hearing-impaired student, outlining the difficulties arising from the lack of appropriate gestures for many curricular contents. Borges and Nogueira (2013) [28] observed the lack of signs/gesture to represent many words in an inclusive 9th grade Math class (with deaf and hearing students together), and witnessed the need for a previous arrangement between the students and Interpreter. However, often signs/gestures had to be created in the simultaneous translation context, which led the Interpreter to use dactylology as a simplified way to convey the term/concept addressed. Borges and Nogueira also observed that sometimes the Interpreter could not follow the teacher's speaking pace, resulting in some translation cuts. Moreover, the Interpreter in Math class often struggled to find the best spot in the room to be seen by the students while still following the teacher.

Concerning the collaborative work with Mathematics Teachers, the Interpreters stated they sought to interact with them, unlike the PSL Teachers, who reported that this proximity was not so evident because they did not see each other frequently. They share, however, their willingness to collaborate with the mathematics colleagues if requested to do so. Meanwhile, the collaborative occurrences reported by the Interpreters did not seem to be systematic or organized, which might hamper the students' learning process. Gonçalves (2018) [29] studied whether Teachers of students with hearing impairment understood the presence of an Interpreter as an added-value element to the education process and, therefore, if they saw them as partners. His findings highlight the importance these professionals may have for student´s learning, not only on the translation of contents conveyed in classes, but also as the communication bridge between teacher and students and the ablest person to support them within the school community. Considering all these aspects, most of teachers inquired acknowledge the Interpreter as a fundamental element in the teaching-learning process of students with hearing impairment. They also recognize the Interpreter as an effective member of the multidisciplinary educational team, with whom they are expected to develop collaborative work. The author adds that in order to accomplish this goal, it is necessary that both Teacher and Interpreter know the students well enough. This requires consulting their Individual Educational Plans, which record students' personal data, as well as teaching and assessment methodologies adopted, therefore allowing them to discuss which pedagogical responses better address their needs.

Another issue concerns the loss of information reported by the Interpreters during the translation of mathematics lessons, which according to Kurz (2003) [30] results from lack of training to interpret specific mathematics contents, sometimes leading to a literal translation (word by word) rather than a conceptual interpretation, with appropriate grammatical structure. The author adds the difficulty sometimes experienced by Interpreters in following the Mathematics Teacher speech, leading to omit important concepts or keywords for understanding the whole content addressed. For the entire process to work, collaboration between the stakeholders in the learning process (Interpreters and Teachers) is essential, as highlighted by Umbezeiro et al. (2013) [7]. The need for ongoing training, as well as the Interpreter participation in lesson planning becomes crucial for a better understanding of mathematical paradigms underlying concepts / terms that would frame translation in a broader perspective (Tabak, 2014) [31]. Cruz-Santos and Martinho (2019) [23] added that the previous sharing of a lesson plan could allow the Interpreters to anticipate the mathematical terms and thus timely search the existence of formal gestures or, in their absence, sketch an explanatory gesture that, based on the students' proficiency level in sign language, will enable them to attain the objectives settled for the lesson. Lacerda (2013) [32] and Albres (2015) [33] point out the importance of planning with the sign language Interpreter, as well as the dialogue among the class teachers and the interpreter about the development of each student with hearing impairment. This sort of attitude was observed by Silva and Oliveira (2016) [34], who analyzed the work of a Libras (Brazilian Sign Language) interpreter in a 7th grade classroom, having found out how he prepared himself for the interpretation, taking advantage of some breaks between classes for planning. One of his methods was a notebook collecting notes from class experiences, guidelines occasionally given by teachers, and printed and virtual dictionaries.

However, the mere presence of an Interpreter does not guarantee that a student with hearing impairment will understand everything conveyed by the teacher. Actually, he has to divide attention to both the Teacher's speech, gestures and / or writings, and the Interpreter's translation. This often leads to a loss of information, sometimes relevant to understand the content taught. The time difference, sometimes of just mere seconds, between the attention given to the Teacher and the Interpreter can limit, or even prevent, an active participation in discussions / debates within the classroom (Stinson & Foster, 2000 [35]).

The lack of gestures suitable to translating relevant mathematical terms/concepts is known to hamper and/or delay the access to mathematical knowledge. This fact is sometimes devalued, since students with hearing impairment usually have success on formula application, which, however, does not correspond to the development of proper mathematical reasoning. In fact, traditional teaching of mathematics often emphasizes the memorization of formulas, rules and/or theorems, undervaluing conceptual understanding (Umbezeiro et al., 2013) [7]. Seeking to understand the mathematical learning process within a 5th grade hearing impaired student taught by a hearing teacher not proficient in sign language, Viana and Barreto (2014) [36] found teaching was restricted to algorithms, even when images were used as auxiliary tools. The authors concluded the minimum skills a teacher must hold to teach mathematics to students with hearing impairment goes way beyond the academic degree, but requires as well the ability to resort to strategies and a set of materials to build up insight and convey the essence of the concepts/terms addressed. Often this is not the case as many Mathematics Teachers lack specific pedagogical skills for an effective and inclusive teaching, and tend to standardize their intervention, wrongly expecting that all students will learn in the same way and at the same pace. According to Ferreira (2005) [12], specialized training is not an obligation of a Mathematics Teacher, but rather an opportunity to change / expand / review his knowledge, seeking to improve learning skills and, consequently, pedagogical practices. In the case of hearing-impaired students, it is essential for a hearing-teacher to respect their culture and language, through which they build a system of significant meaning in a visual-spatial structure that potentially enable them to "talk" about specific contents in any area of knowledge (Miranda & Miranda, 2011 [37]).

The teaching of mathematics has undergone through many adaptations and even transformations, mainly regarding its methodology, a fact that is quite evident from the array of resources and gadgets/devices available nowadays in classrooms, such as manipulative teaching materials, visual representations and digital environments. Several studies report positively on this sort of resources which seem to allow students with hearing impairment to gain access to a visual method of acquisition of mathematical knowledge aided by sign language (Fernandes & Healy, 2016 [38]; Kipper, Oliveira & Thoma, 2015 [39]; Rocha, 2014 (40]). Technological advances have contributed to the standardization and diffusion of symbols representing mathematical concepts / terms, as is the case, for example, of the *Signing Math Dictionary* (Vesel & Robillard, 2013 [41]), a paid access application, available only for IOS devices, with more than a thousand entries, to assist North American hearing-impaired students from the fourth to the eighth grades in the acquisition of the vocabulary required to master the different contents covered in the classes. A similar project in the United States is the *Texas Math Sign Language Dictionary* (n.d.) [42], an open-source online webpage created as a resource for parents and professionals supporting deaf and hard-of-hearing children in a variety of educational settings, identifying signs that most accurately represented academic terms and the creation of short, student-friendly explanations for them. On the European continent, some deaf communities have access to tools to develop a better understanding of mathematical terms / concepts. One example is the *British Sign Language Glossary for Mathematics* (O'Neill et al. 2015 [43]), a project started at the Scottish Sensory Center that aims to create, define, catalog and develop signs for school/college contents for people with hearing impairment. The majority of signs on this site have the citation form of the sign and a definition in BSL. The definition is translated below into written English. Often there are also diagrams and graphics. For some groups of signs, there are lab videos or clips showing explanations or demonstrations where the technical signs are used in a real-life context, similarly to sample sentences seen in some printed dictionaries. These definitions are useful to at least three groups: students with hearing impairment, so that they can learn independently; teachers and interpreters who

may need to prepare an explanation to be given in class; and to parents who are themselves deaf and may want to explain homework to their hearing child or their child with hearing impairment. To address the lack of signs to express mathematical concepts, a group of French teachers' expert in SL and mathematics have created *Sign'Maths*, an online interactive dictionary for mathematics addressed to students with hearing impairment, offering definitions of concepts introduced in high school and college (Nadal & Collet, 2017 [44]). Preliminary results show that hearing impaired users appreciate the extensive use of French Sign Language in the interface, despite the presence of written text, for example indications in French to support navigation, which could be replaced by a most helpful search-by-word tool. Finally, participants appreciate the use of graphics to complement SL and written information. A similar tool is available for the Portuguese context - *PSL Academy*[45]-, a website funded by the Altice Foundation (former Portugal Telecom Foundation) and supported by the Jacob Rodrigues Pereira Education and Development Center, dedicated to the teaching of children with hearing impairment and young people since 1834. The videos are available in bilingual format (Portuguese and in PSL), and contents address the curricula of four subjects of basic education (History, Mathematics, Chemistry and Visual and Technological Education). This project also documents new gestures (neologisms) proposed for school concepts. The project allows a qualitative leap in communication and proximity to the hearing-impaired community, as well as an enhanced dissemination of sign language. Mathematical concepts are recorded for grade 7th (131 gestures) and 8th (48 gestures).

The child with hearing impairment, like any other children, has the same need for a mathematical environment that allows her to participate in plays and symbolic situations, using their mother language, the PSL. This explains the relevance of practices based on research (Vargas, 2011 [46]), to build a school community, thought of as a place shared by different persons in which communication would be satisfactory for all, and a global learning process conducted in the natural language of each one. Therefore, decisions should be taken by professionals who work with these students to plan and design the curriculum and adapt practices to the requirements, characteristics and interests of each student (Freire & César, 2007 [11]), valuing bilingual and bicultural education (Gonçalves, 2005 [47]), inside and outside the school.

V. CONCLUSION

This study highlights the important role of partnership, collaboration and articulation between different educational agents that work with students with hearing impairment, especially concerning the learning of mathematical terms and / or concepts. It seems necessary to foster this research dynamics, making it more consistent and systematic, in order to improve the teaching / learning process. Although this study was framed in the Portuguese context, whose Sign Language is still more limited than the corresponding language in other countries, its results offer an interesting contribution to a most relevant discussion.

This study serves as a starting point for further research. In particular, it would be relevant to enlarge the analysis to other reference schools for students with hearing impairment, in order to understand the presence of differences or similarities related to the practices adopted by PSL teachers and Interpreters in the absence of gestures representing relevant mathematical concepts / terms. In addition, we consider appropriated to analyze how Mathematics Teachers deal with this issue, whether they are aware of the methodological implications inherent to the specific needs of students with hearing impairment, and how they think they could best suit their pedagogical practices to these students in order to include them in schools and ensure rights for inclusive education.

VI. Acknowledgements

This work is funded by CIEd – Research Centre on Education, Institute of Education, University of Minho, projects UIDB/01661/2020 and UIDP/01661/2020, through national funds of FCT/MCTES-PT.

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