



## Teaching Cartography to Blind People: Methodological and Technological Transformations and Perspectives

### *O Ensino de Cartografia para Pessoas Cegas: Transformações Metodológicas, Tecnológicas e Perspectivas*

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**Abstract:** In this review article it is presented the art state of Tactile Cartography based on its advances and challenges. First, it shows the historical profile at the international and national levels, with an emphasis on publications dating from the 20th and 21st centuries. Afterwards, it discusses on the theoretical and methodological contribution that indicates the propensity to deal with the themes of Geography and Cartography in Education based on research that has theories of Piaget or Vygotsky as its main basis. As research challenges to be faced, there is the standardization of the Tactile Cartographic language, tactile maps production and printing consensus, but mainly, the map teaching methodology for blind students. The final discussions, which guide the contributions indication, are based on experiences with blind students and show the importance of the blind child cartographic initiation from the initiation to drawing, even in the preschool phase, with languages mediation and surrounding environment exploration using their own body as a reference.

**Keywords:** Spatial representation. Tactile map. Drawing.

**Resumo:** Neste artigo de revisão apresenta-se o estado da arte da Cartografia Tátil a partir de seus avanços e desafios. Primeiro, mostra-se o recorte histórico em nível internacional e nacional com ênfase nas publicações datadas dos séculos XX e XXI. Depois, discute-se sobre o aporte teórico e metodológico que indica a propensão de se tratar os temas Geografia e Cartografia na Educação a partir de investigações que têm como base principal as teorias de Piaget ou Vigotski. Como desafios de pesquisas a serem enfrentados, elencam-se a padronização da linguagem Cartográfica Tátil, consenso na produção e impressão de mapas táteis, mas, principalmente, a metodologia para o ensino do mapa para alunos cegos. As discussões finais, que direcionam a indicação das contribuições, são pautadas em experiências com alunos cegos e mostram a importância da iniciação cartográfica da criança cega a partir da sua iniciação ao desenho, ainda na fase pré-escolar, com a mediação de linguagens e exploração do ambiente próximo, tendo como referencial seu próprio corpo.

**Palavras-chave:** Representação espacial. Mapa tátil. Desenho.

## 1 INTRODUCTION

This review article returns to the past and intends to present the first steps of the Tactile Cartography studies through documents consultation which illustrate each era thinking, whose cut refers to the 20th and 21st centuries at international and national levels. Likewise, theoretical and methodological mobilized references supports teaching practices carried out by Brazilian and foreign researchers with blind students. It is not an intention of the authors to exhaust the topic or the references, but through their research experience in the area share some practices that, in their simplicity, show how enriching it can be for a teacher to work with blind children and young people in inclusive classes.

Such experiences, by placing the student at the center of didactic mediation, highlight their skills and their ability to unravel the world. In this sense, the teacher is not the one who stays in front, nor behind the

student, but at his side, touching his hands, sometimes placing himself as a professor, at other times as a learner, seeking to see perception and learning things that our active visual channel often hides, distorts and superficializes.

In this context, at first, the international theoretical framework is presented and, later, the national one – the Brazilian one in this case - which contributed to the strengthening and dissemination of Tactile Cartography. Then, we briefly discuss Piaget and Vygotsky theories, due to the importance of their investigations contributions in Education and School Cartography in a special way. Finally, reflections on experiences in the area of initiation to the design and representation of space by the blind are shared, as well as the multisensory nature present in the acquisition of concepts that points to this area of Cartography future challenges.

## **2 TRACES OF TACTILE CARTOGRAPHY THROUGH HISTORY**

With the aim of contextualize the strengthening of Tactile Cartography as a line of research, the historical outline of international and, later, national initiatives that contributed to its strengthening and dissemination is presented in first plan. The delimitation includes a literature review from authors who investigated symbology, design, production of tactile maps prepared for teaching, orientation and mobility, techniques, materials and craft procedures, and technology for the production of cartographic documents, teaching practices, and teachers continuing education. The aim is to present the range of publications analyzed by the authors over two decades of research on the subject, with the certainty of the impossibility of a dialogue with all the already analyzed authors or investigation of the theme.

### **2.1 International initiatives**

There is no record of who created and how the first tactile map was built, but there are indications that before 1830 the production of tactile maps was a result of individual initiatives or restricted to certain blind students. The maps were built through orders or prepared by the blind people themselves, such as the one built with pieces of glass and silk threads by the blind Germanic Weisenberg (McGINNITY; SEYMOUR-FORD; ANDRIES, 2004; GROSVENOR; MACNAB, 2013).

Samuel Gridley Howe was responsible for a milestone in the production and printing of cartographic documents with textual information when, in 1837, asked Stephen Preston Ruggles to create a tactile globe whose circumference measures 53 inches (134 cm) in diameter, in whose construction approximately 700 pieces of wood were used (McGINNITY; SEYMOUR-FORD; ANDRIES, 2004). Howe described the globe as beautiful, durable, and the most perfect of its kind in the world. However, a century later, Clara L. Pratt considered that the representations size and detail on the globe were not suitable for exploration by touch (PRATT, 1937).

Ruggles, to fulfill the orders of Howe, built lots of tactile maps in carved wood (McGINNITY; SEYMOUR-FORD; ANDRIES, 2004). The high costs of wooden maps have made them restricted to few blind students (PRATT, 1937). In 1837, Howe published the Atlas of the United State Printed for the Use of the Blind (McGINNITY; SEYMOUR-FORD; ANDRIES, 2004; GROSVENOR; MACNAB, 2013). The Atlas was elaborated by Samuel P. Ruggles with symbology and textual information in latin alphabet in high relief according to the method developed by philanthropist Valentin Haüy that was called linear and consisted of the high-relief printing of texts in the Latin alphabet from the inversion of that time print plates page and allowed reading, but not writing. Despite this it was a breakthrough in teaching to blind students (ROCHA, 1992). Records indicate that such Atlas was the first cartographic material for blind students with significant print run (50 printed copies) (RICHARDS, 1977).

It is possible that the Atlas is the first book-shaped tactile cartographic document to represent the largest number of places and provide better representations quality and information to empower blind people. The geographic textual content covered information about all the different countries of the globe, similarly to those found in school geography books at the time, for students who saw. Until that time, to blind students, the Geography teaching adopted method was the reading aloud of texts by the teacher, as well as the verbal

description of places and countries. Blind student rarely had the opportunity to explore tactile maps with autonomy. The Atlas was used in other institutions for blind students located outside the boundaries of the school where Howe used to work (PRATT, 1937).

Another important name in elaboration and printing of tactile maps history is Martin Kunz (1847-1923), who was the director of the *Illzach bei Mühlhausen Institute for the Blind* and, at the time, exerted immense influence in the market of photo production and embossed maps. The products were distributed and used in institutes for blind people throughout Europe, Australia and North America (McGINNITY; SEYMOUR-FORD; ANDRIES, 2004; GROSVENOR; MACNAB, 2013).

In 1937, Clara Louise Pratt publishes the book *Practical Geography for the blind*<sup>1</sup> with indications of materials and procedures for the construction of tactile didactic material for the teaching of Geography. This book is an important milestone in the initiatives that contributed to the teacher and blind students building tactile maps in the school environment, consistent with their financial realities. The author indicates plasticine as the base material for the tactile maps construction because it has low cost, is easy to model and accessible to teachers, despite having little durability (PRATT, 1937).

In 1933 Cutsforth published the book *The blind in school and society: a psychological study* in which questions the education of blind people based on the education of people who see. The author criticizes the excessive use of verbal description (verbalism) based on vision (visuocentrism) in blind children education, generating discrepancies between their perceptions and experiences of the world and what is taught to them. The author was blind, studied in schools and lived with the society written about. Despite having graduated clinical psychologist, the content of his book was not considered scientific, but of self-expression opinion resulting in its destruction in 1943. However, the importance of the work was later recognized and, in 1951, the *American Foundation for the Blind* reedited the book (CHEVIGNY, 1969). The translation into Portuguese and printing in Brazil were carried out by the *National Campaign for the Education of the Blind* in 1969. The book (1969) is a reference on topics related to blindness in current research.

The criticism made by Cutsforth (1969) are not ignored by everyone. One example is the cartographer John Clinton Sherman who began a research with tactile maps in 1950 and published it in the article *Maps the Blind Can See*, published in the *Journal of Geography* in 1954. Sherman focused on research on the design, production of maps and their use, submitting its products for quality evaluation by blind users (BUTTENFIELD, 2013). Wingert (1997) reports that a group of undergraduates, under guidance of Sherman developed tactile maps with diversified and low-cost materials, such as fabrics, sandpaper, peas, noodles, and then presented them to blind students to assess their effectiveness in orientation and mobility in the represented spaces. The author also reports interest of Sherman in understanding how blind people are located and oriented in spaces to improve the quality of cartographic products.

In 1960, J. Alfred Leonard expressed concerns about the mobility of blind people, but only in 1963 indicates to consider tactile maps as support resources. From that year on, the researcher became a reference in Great Britain (WIEDEL; GROVES, 1969).

Wiedel and Groves (1969) researched the linear scale, size, simplification in drawing, Braille information, orientation, reproduction of maps and procedures for the blind to understand the maps. The researchers discussed the advantages and disadvantages of each procedure and the used material. In addition, they highlighted the almost lack of publications before 1958, considering the unpublished article written by Heath (1958) as an important contribution to alleviate the gap. This article addresses some aspects of surface discrimination from distinct textures in the maps, which were later reviewed by Nolan and Morris (1963) bringing new contributions to symbologies (WIEDEL; GROVES, 1969).

In 1972, Wiedel and Groves published an article in which they point out that there are many people dedicating themselves to the production of tactile maps, but there is a lack of studies on how blind people can benefit from these maps. Most researchers are geographers and cartographers whose focuses of investigation are on design, symbols and reproduction of tactile maps.


In the following years of the 20th century, international publications confirm the statements of Wiedel

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<sup>1</sup> The book was digitalized in 2019 by Internet Archive and free available in <http://archive.org/details/practicalgeprgra0000clar/model/lup>

and Groves (1972) on the research themes. The publication analysis shows important advances in research on design and symbology for tactile maps with a view to orientation and mobility. Examples of the advances in design indications of the size of tactile maps, not exceeding 50 x 50 cm, considering that the scope of the touch is smaller than that of the vision, heading position and symbol of the north, always at the top of the paper, use of touch pleasant textures, among others. In terms of symbology there is proof that a grouping of lines or points is easily recognized by touch, as well as the fact that very small or very close symbols hinder their recognition by touch and the advantage of exploiting the proportionality of the size of symbols, considered as errors in a conventional map, which can be suitable on a tactile map etc. (NOLAN; MORRIS, 1971; JAMES, 1982; TATHAM, 1993; COULSON, 1991; PIKE; BLADES; SPENCER, 1992; PERKINS, 2002). However, in such studies, there are no discussions about the map teaching, about how blind people have been benefited from its use in everyday activities, in the school environment and in the exploration of urban places. Figure 1 illustrates the symbology proposed by Wiedel and Groves (1972).

Figure 1 - Symbology to tactile maps for orientation and mobility.

Wiedel and Groves (1972) proposed symbols for mobility maps		
Symbols for building tactile plans		Map symbols for a city section (Block, neighborhood, among others)
Area limit	.....	Area limit
Wide paved area		Wide paved area
Sidewalk	-----	Sidewalk
Wall or barrier	—————	Road limit or sidewalk lack
Part of a barrier (wall	- - - - -	Division between two buildings
Light post or column	○	Tree of light post
Block	□	Block
Entrance	▲	Entrance
Stairs	Step  --- step	Stairs
Escalator	---	Escalator

Source: Ventorini (2007, p. 77 -78).

In 1992, Polly K. Edman<sup>2</sup> published the book *Tactile Graphics* with methodological procedures suggestions for the construction of tactile didactic material and for its application in school activities. The book aims to help teachers in the production of tactile sets for blind students and has more than 500 pages that are composed of procedures to mediate concepts about representations, symbols, etc., including reflections on the importance of blind children learning to draw (EDMAN, 1992). The author investigated for more than 30 years the production of tactile didactic material and the book contributed to reduce the lack of publications aimed at

<sup>2</sup> The book was digitalized by *Internet Archive* with *America Printing House for the Blind* funding in 2019 and free available in <http://archive.org/details/tactilegraphicspoll/mode/up>

teaching graphic representations and reading maps by blind people (CARMO, 2010). Significant advances in studies on the relationship of blind people with space and the ability of children to use maps are found in the publications of Ungar (1988, 1996, 2000), Huerta, Ochaíta and Espinosa (1993), Espinosa et al. (1998) among other authors. They investigated how blind people, through out their spatial experiences, can be benefited from tactile maps. Initially, research in psychology followed the comparative trend, comparatised the results of blind children with children they saw. However, in-depth research in the area of Blindness Psychology rescues the concerns published by Cutsforth in 1933 about the education of blind people based on the education of people who see, and brings important contributions to the understanding of the blind subject from himself (VENTORINI, 2009, 2014).

The research covered topics such as motor and cognitive development, symbolic and communicative development, spatial organization and elaboration of representations, among others. The motor and cognitive developments of people with blindness were investigated by Warren (1994), Dias (1995), Forns, Leonhardt and Calderón (2000), Santin and Simmons (2000), Leonhardt and Santacana (2007) who concluded that delays occur due to lack of experience and not because of blindness. Delays typically occur at phases where the child needs to be stimulated to stretch the body members to touch and/or grab objects, crawl, and walk.

The symbolic and communicative developments in the blind child were investigated by Ochaíta (1984), Ungar (1988, 1996), Ciria (1993), Jiménez (1994), Warren (1994), Dias (1995), Andrade (1999), Frutos (2000), Forns, Leonhardt and Calderón (2000), Gallego (2000) Santin and Simmons (2000), Alvarez-Ballesterro (2003), Ochaíta and Espinosa (2004), Leonhardt and Santacana (2007), among others, also considering that delays occur due to lack of stimulation and appreciation of the visual channel.

The theoretical research basis is articulated, at the beginning, from assumption made by Piaget, later migrating to Vygotsky theory for attributing extreme importance to language and sociocultural relations. To deepen this theme, the publications of Fraiberg (1971, 1977), Gottesman (1973), Warren (1984, 1994), Huertas, Asensio and Simón (1988), Fernández, Ochaíta and Rosa, (1988), Alderete et al are indicated. Al. (1988), Rosa Ochaíta (1988), Ochaíta and Rosa (1988), Santin and Simmons (2000), Rosa and Ochaíta (1993), Blanco and Rubio (1993), Dias (1995), Soler (1999) and Ochaíta and Espinosa (2004).

Between the end of the 20th century and the beginning of the 21st century several investigations evaluate the quality of tactile cartographic symbols and their designs and print qualities were determined by each specific culture and technology (PERKINS, 2002). Technological advances have improved tactile map impressions and sound information insertions. Examples of these early advances are *Nomad Mentor*, *Talking Tactile Tablet* (TTT), *Blind Audio Tactile Mapping System* (BATS) and *SVG Mapping*. The products are composed of maps and tactile graphics, tablet and software. A map or chart is placed on the digitalizing board and calibrated from the software installed on a computer. After calibration, the user inserts information in the calibrated points and, when exploring these points, sound information is emitted (figure 2). The disadvantage of these products is the high cost and the difficulty of maps calibration by general public (VENTORINI, 2012).

Figure 2 - Example of a Tactile map with sound features.

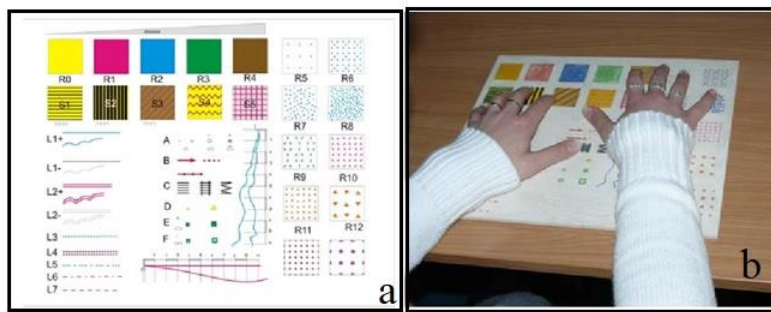


Source: Hamid et al., 2016 (p. 157).

The technology for three-dimensional printing (3D) was a new option that emerged in recent years, thus allowing the diversification of tactile maps, but also presenting itself as a challenge for researchers, who started investigations on types of symbols, sizes suitable for printing (figure 3), production time, ease of recognition through touch, among others (VOŽENÍLEK; VONDRÁKOVÁ; 2014; ORTÍ; CAZORL; MACIA; BRITTEL, 2015; BRITTEL; LOBBEN; LAWRENCE, 2018). 3D printing technology was also used on maps

with sound features by researchers such as Voženílek et. (2009) and Voženílek and Vondráková (2014).

Figure 3 - (a) Symbology developed for 3D printing and (b) blind person assessment.



Source: Voženílek and Vondráková (2014, p. 196 and 198).

In the communicational technology area researchers face the challenge of developing mobile navigation resources for people with visual impairment. At the University of Mauritius, the Android application called *Mobile Vision* was developed for blind people to use preloaded maps and voice information from landmarks along the user-selected route (KHEDO; BHUGUL; TEM, 2020). In 2019 the company Google released the app with voice guide for Google Maps. Such an application has been continuously updated and aims to assist blind people in their displacements. The route is narrated and if the person leaves the planned route, the feature sends an alert and the person, by voice command, can reprogram it. The release was for Android and IOS, in English and Japanese, in the United States of America and Japan, respectively. The goal is to make the application available in other languages (SUGIYAMA, 2019). Another example is *Eye-D* app that allows the user, in their path, to take a picture of an object and the application narrates the image, transmitting to users information about obstacles or types of establishments. So, for example, when taking a picture of the sidewalk the app will identify and inform the user if there are trees or holes in the path. Similarly, if there are commercial establishments in the image (bank, pharmacies, stores, etc.) the application will indicate to the user. In this study, no results were found to discuss the benefits and limitations of this technology.

This brief international historical review on Tactile Cartography, using as sources outstanding works on the theme, intended to contextualize the reader in this area of Cartography to understand how the methodological evolution and production of tactile materials for the inclusion of blind people in the cartographic representation and in the reading of maps took place.

## 2.2 National initiatives

In Brazil, the available initiatives records for blind people education date from the 19th century. Through Imperial Decree No. 1.428 of September 12th, 1854, the *Imperial Institute of the Blind Boys* in Rio de Janeiro was created by Dom Pedro II of Brazil (VEIGA, 1983; VENTORINI; SILVA; ROCHA, 2015). The expansion of the physical space and the number of students attended occurred in 1890, with the inauguration of the *Benjamin Constant Institute* (IBC).

In the 19th century, at the IBC, the Teaching of Geography and History was carried out by Professor Mauro Montagna (1863-1944) who developed procedures for the construction of maps and tactile maquets to support the teaching of cartographic and geographical concepts such as orientation, spatialization, etc. (VEIGA, 1983). Montagna built a tactile map of South America with a mechanism that reproduced the water paths in rivers, simulated the flashes of active volcanoes and lit lights of different sizes to represent the different sizes of major cities (LEMO; CERQUEIRA, 2003; VENTORINI; SILVA; ROCHA, 2015).

By the end of the 1980s, the production of tactile cartographic material was scarce in the country and carried out by parents, students and teachers. The methods of production of tactile maps developed internationally were not disclosed or used in Brazilian institutions for the blind. The predominance was the artisanal construction of matrices for printing in *thermoform* machine, which allowed the serial reproduction of plastic material, as illustrated in Figure 4 (VASCONCELLOS, 1993a). For more information on the

production of tactile maps through this machine, the reading of doctoral dissertation of Vasconcellos (1993a) is indicated.

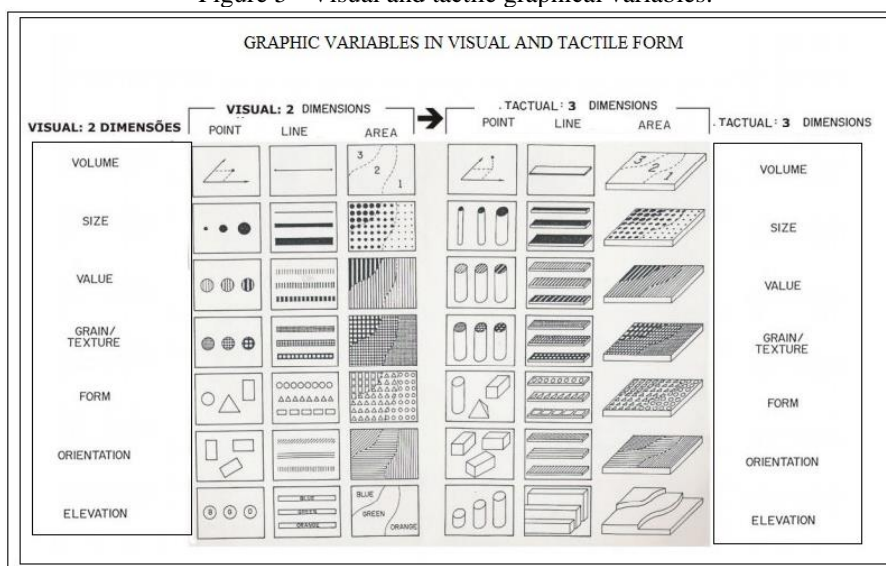
Figure 4 - Thermoform machine and tactile map.



Source: Carmo (2009 p. 73).

Almeida (2007, p. 120) points out that "[...] in Brazil, until the end of the 1980s, studies on this subject were nonexistent in geography, with few graphic resources in tactile form, mainly maps and images." The researcher Regina Almeida (Vasconcellos), with doctoral dissertation Vasconcellos (1993a), was a pioneer in the investigation of procedures to construct tactile variables based on the visual variables proposed by Jacques Bertin (figure 5). From dialogues with international authors, the author presents indications of adequate size for tactile maps, considering that the field of breadth of the hands is smaller than the field of view, amount of information not to saturate the material, type of textures and techniques for the construction of tactile maps, as well as the importance of the introduction to graphic language to blind students in the early years, among other topics (VASCONCELLOS, 1993a).

Figure 5 - Visual and tactile graphical variables.



Source: Adapted from Carmo (2009).

Through the doctoral research Vasconcellos (1993a) disseminates the materials, techniques and methods developed internationally (VASCONCELLOS, 1992, 1993a, 1993b, 1996). The state of art in this theme was carried out from surveys and visits to international centers (ALMEIDA, 2007). With the objective of bringing together researchers to discuss and disseminate Tactile Cartography in Brazil, the researcher organizes, in 1994, at the University of São Paulo – State of São Paulo (SP), in partnership with the International Cartographic Association, the IV International Symposium on Maps and Graphs for the Visually Impaired, in which 150 Brazilians and 50 international participants took part in.

From 1995 to 1997, Meneguette (1996), Meneguette and Eugênio (1997a, 1997b) and Meneguette and

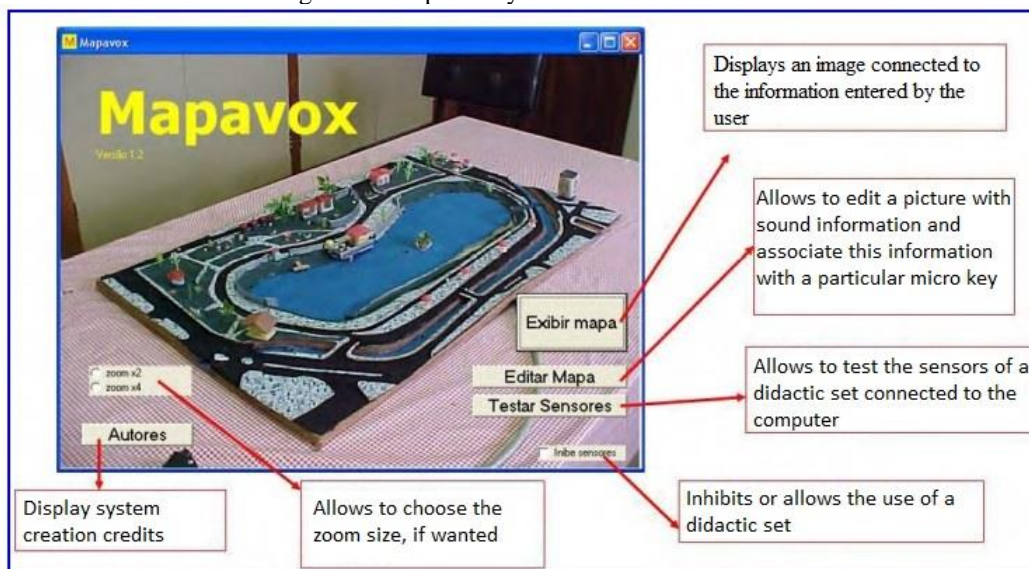
Máximo (1997) published results of their research on the teaching of Cartography to blind students in the initial grades of Elementary School from practical activities such as the construction of the body map and the exploration of elementary topological relations. The generated products were a tactile model of the classroom and tactile maps of Pontal do Paranapanema, a region located in the extreme west of the state of São Paulo - SP. Later, Fonseca (1999) defended a master thesis whose objective was to investigate the process of building spatial notions of blind students with the support of the model of the classroom and a tactile plan.

In 2000, under the coordination of Vasconcellos and in partnership with the Pedagogical Support Center for The Care of the Visually Impaired (CAP), at University of São Paulo - USP, held the Latin American Meeting on Geography Teaching for the Visually Impaired (ALMEIDA, 2007). The facts cited are important because they paved the way for other researchers to start their research trajectories.

In 2002, Sena defended, at USP, a master thesis in Geography whose objective was to investigate the practice of studying the environment for students with visual impairment (SENA, 2002). Ventorini and Freitas, in 2003, published the first results of the research whose objective was to develop and disseminate tactile models representing the lived place of blind and low-vision students who attended classes at a Special School in the municipality of Araras - SP, as well as tactile maps to support the teaching of Geography (VENTORINI; FREITAS, 2003).

The following year, advances in the use of the Tactile Model System and Mapavox are announced, which allowed the insertion of sound resources in tactile educational sets from the technology of the Dosvox program, since it enables blind people to operate computers from a voice synthesizer (figure 6). The system was the first to be developed in Brazil with accessible cost to the Brazilian public (FREITAS et al., 2004). However, the constant changes in operating systems and hardware make it impossible to use the System in public schools. More information can be obtained in Ventorini et al. (2005a, 2005b), Ventorini (2009, 2014) and Nogueira, Ventorini and Freitas (2015).

Figure 6 - Mapavox system functions.

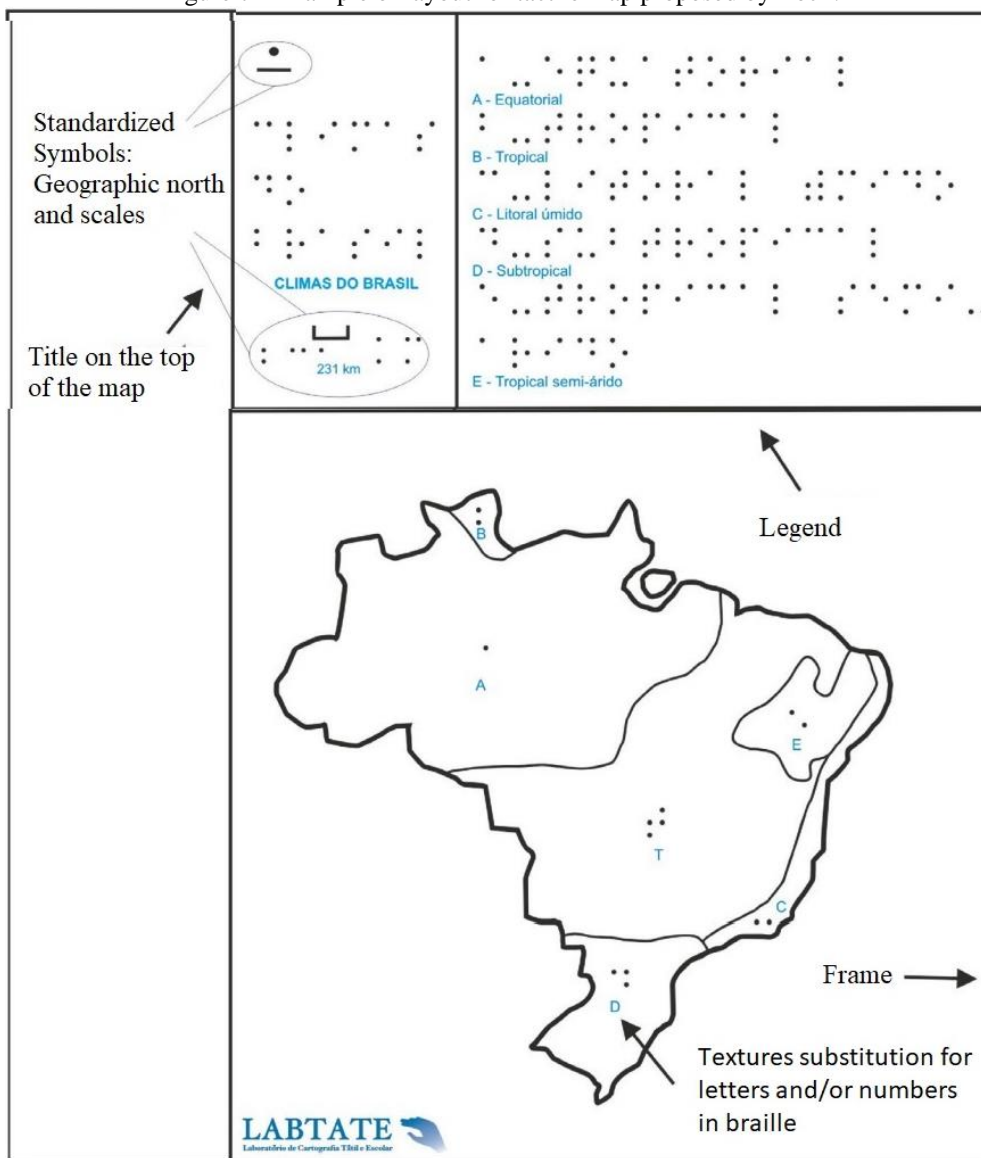


Source: Ventorini (2012, p. 39).

In 2005, at the request of the Santa Catarina Foundation of Special Education, of the State Government of Santa Catarina, Nogueira began the research trajectory on the subject and proposes patterns of symbology for some cartographic elements such as the Oceans, Tropics, Ecuador and Greenwich Meridian, among others (NOGUEIRA, 2009). Nogueira research design, layout, symbology and production for the standardization of a language for tactile maps ((Figure 7). In her research, the author considers three factors relevant in the standardization: the resources necessary for the production and acquisition (by the user) of tactile maps, the portability of the map files in digital environment, that is, with extensions compatible with the operating systems of computers and the ability of users to reproduce maps anywhere in Brazil, according to the economic reality in which it is integrated (LOCH, 2008).



Figure 7 - Example of layout for tactile map proposed by Loch.



Source: Loch (2008, p. 54).

Together with the initiatives mentioned, which contributed to the dissemination of Cartography in Brazil, there are, during the 1990s, movements at the international level in favor of the right of all to study in regular classes in Basic Education. Discussions and documents from the World Conference on Education for All, generally known as the Jomtien Conference, held in 1990 in Jomtien, Thailand, that pointed to the satisfaction of basic learning needs influenced changes in Brazilian legislation, which led to a considerable expansion of the process of entry of students with disabilities into the regular school system.

The challenge in Brazil related to the implementation of educational systems that promote teaching and learning environments for all without discrimination has not yet been overcome, but the changes in legislation that promoted the increase in enrollment of students with visual impairment in Basic Education, added to social movements to give voice to students with disabilities, stimulated researchers from all parts of Brazil to start research in the area of Inclusive Education, which was also reflected in the strengthening of Tactile Cartography.

Further in the ideals of movements in favor of equality and struggles to ensure that groups constituted by minorities have a voice and are heard, research has intensified in the approaches of the production of tactile didactic material (REGIS, 2016), using technology (VENTORINI, 2009, 2014, BARBOSA, 2018), in understanding the relation between the blind person with space from blindness itself (VENTORINI, 2009, 2014; CUSTÓDIO, 2013), in the expression of knowledge about the place lived through narratives and drawings (ALMEIDA; NOGUEIRA, 2009; VENTORINI, 2009, 2014; SILVA, 2017, VENTORINI, 2018;

VENTORINI; SILVA, 2018), in the teaching of Geography and Cartography (SENA, 2009, CHAVES, 2010; ANDRADE, 2014; JORDÃO, 2015), in the continuing training of teachers (NOGUEIRA, 2009; CARMO, 2010, 2016; BITTENCOURT, 2011; FREITAS; VENTORINI, 2011, VENTORINI; SILVA; ROCHA, 2014), in the use of 3D printer technology, (FERREIRA; SILVA, 2012, SILVA, 2017), in the production of maps and models, in the printing of symbols by means of a 3D printer (FERNANDES et al., 2016; ANDRADE; MONTEIRO, 2019), in a See Color color code system consisting of a color code elaborated based on braille (MARCHI, 2019; ARAÚJO et. al., 2020), in the symbology for tactile maps for buildings (BEM; PUPO, 2019), among other topics (figure 8).

Figure 8 - Tactile cartographic documents produced with a 3D printer (a) classroom map and mockup; (b) symbology for tactile map; (c) tactile maps for orientation and mobility.



Sources: (a) Silva (2017, p.117), (b) Fernandes et al. (2016, p. 489) and (c) Piva (2016, p.1).

The brief review of historical clippings presented indicates the strengthening of Tactile Cartography in Brazil and the diversity of themes investigated for the right to access of blind students to geographic and cartographic education. In the research trajectory of the authors, publications with Piagetian and Vygotskian theoretical and methodological assumptions were analyzed, respecting the choices of each researcher, which is why it was chosen to discuss briefly the importance of these theories in the theme under discussion.

### 3 VYGOTSKY AND PIAGET AND THEIR INFLUENCE ON SCHOOL AND TACTILE CARTOGRAPHY IN BRAZIL

To talk about Vygotsky and Piaget is to talk about the scientific method and methodological rigor that strongly influenced and have been influencing the research and didactic practices developed in Brazil, not exclusively, but mainly when the theme is Geography and Cartography in Education. There are many research papers developed based on the theories and experiences of these two international references in psychology and child education. Often, such references do not appear explicitly, do not have direct quotation, but are revealed with a more accurate look at the ways in which research has been produced in this area since the first works such as *Estudo Metodológico e Cognitivo do Mapa* [Methodological and Cognitive Study of the Map] (OLIVEIRA, 1977), thesis of free teaching of Livia de Oliveira, with strong Piagetian bases and one of the first references of School Cartography as it is recognized in contemporaneity.

Almeida and Almeida (2014, p. 890) analyzed publications of the annals of scientific events on School Cartography held in Brazil and highlighted that "[...] in the representation of space theme, psychogenetic theory of Jean Piaget is the main foundation of studies on the construction of spatial relations and for methodological proposals in the teaching of concepts such as scale, projection and location. For the authors, the predominance of piagetian contribution is the result of the wide dissemination of ideas of Jean Piaget from the Portuguese translation of some of his works in the 1970s and 1980s, as well as the discussion on space epistemology in mathematics, which allows to support research on representation of space in Cartography.

In the 1980s and 1990s, important research was developed on the teaching and learning of the map with methodological foundation piagetian supposition (PAGANELLI, 1982; PASSINI, 1994; ALMEIDA, PICARELLI; SANCHEZ, 1996; ALMEIDA; PASSINI, 1989; SIMIELLI, 1986, 1997). Although the publications do not include tactile cartography themes, they represent a basic basis for the teaching of Cartography for children who were fundamental references for professionals who developed work with blind children.

The analyses of Almeida and Almeida (2014, p. 890) of the annals of the VI Cartography Colloquium for Children and Schoolchildren and II Latinamerican Forum of Cartography for Schoolchildren, also indicate

that Lev Vygotsky and collaborators are used in more recent studies in education and with indications of opposition between the assumptions of Piaget and Vygotsky. For the authors "[...] a consequence of this is the impoverishment of discussions about spatial representation in school cartography, which has left it unmoved by the important debates of the sciences of Language, Geography and Education."

Jean Piaget was the researcher responsible for the Development or Cognitive theory who, according to Maury (1991), based on the work of Binet and Claparède, understanding conceptual thinking as opposed to the image and whose method of analysis was based on introspection, centered on the "mechanism" of thought.

Piaget (1971, 1986) developed studies of the relation between development of cognitive structures and school learning, performing tests with children exhaustively, with a great methodological rigor and dedicating not only to the correct answers, but mainly to the mistakes made by children in performing the activities selected for their experiments. During paternity, followed the motor, sensory, language and thought development of his children from the first months of life, which contributed significantly to the consolidation of his theory.

One of the contributions resulting from their experiments and of great value to the scientific community was the definition of the thoughts systems of the child, organized in 3 stages: motor intelligence, egocentric thinking and rational thinking, which allows the child to build an objective representation of things.

According to Maury (1991), for Piaget "between action and reason is the me, with the illusions of perspective due to Egocentrism" (MAURY, 1991, p. 67). And egocentrism is exactly the main focus of the author's studies.

In the case of Lev S. Vygotsky, in addition to broad-spectrum production in psychology and education, the theorist deeply studied the Works of Piaget in the search for elements of cognitive theory that could be checked, reinforcing own perspectives, leading to the consolidation of historical-cultural theory. Vygotsky (2009) attributes to Piaget pioneering in the study of language functions in children and the relationship between development of cognitive structures and school learning. Although critical of Jean Piaget's Theory of Development, studied it deeply, finding convergences and divergences that allowed the construction of a particular theory, making respectful criticisms and valuing the contributions of Piaget to child psychology studies. An example of this fact can be observed in his statement about the development of language and the child's thought, when it came to grammar and logic:

Piaget's studies have clearly shown that the child develops grammar before developing logic, and only relatively late assimilates the logical operations that correspond to the grammatical structures he has been using for a long time. (VIGOTSKI, 2009, p. 138 - Translation).

As noted in the statement of Vygotsky, the attitudes of both researchers converge in some aspects of child development, although the rupture occurs during Vygotsky experiments, which highlights the preponderance of social aspects and the word of thought construction.

In these studies, the author aimed to understand the aspects of the social genesis of the superior psychological functioning, as contrast to the Development theory of Piaget. "One cannot fail to recognize the decisive and exclusive importance of inner language processes for the development of thought," said Vygotsky (2009, p. 133). The author, although he adopted experimental activities along piaget's egocentric language studies, introduced "a series of complicating moments of the child's behavior" (VIGOTSKI, 2009, p. 53). An example is the execution of a normal task of free drawing that was conducted with complicating elements such as the absence of material such as pencils, paper, among others, which showed an increase in the coefficient of egocentric language for such activities, when compared with the Piaget coefficient and with the coefficient calculated for the same children in the activities without the complicators. The children's reactions to the difficulties and unforeseen events led them, unequivocally, to become aware of the situation and difficulties, which helped them to change strategies for the realization of the design. This and other experiments with complicating situations led the author to consider that:

It is the fact that the egocentric language of the child can not only not be an expression of egocentric thought but also to exercise a function diametrically opposed to egocentric thinking - the function of realistic thinking - and thus approach not the logic of dream and

reverie but the logic of rational and sensible action and thought (VIGOTSKI, 2009, p. 60 - Translation)

The fact that egocentric language is directly linked to realistic thinking and not to egocentric thinking is one of the examples of distancing from theories of Piaget and Vygotsky when the theme is child egocentrism. In addition to the psychological aspects and the preponderance of sociocultural influence on children development, Vygotsky also devoted himself to the studies of defectology, a term usual in the first half of the 20th century to refer to what we now call Special Education, an area of Pedagogy dedicated to studies related to people with disabilities. With regard to studies carried by Vygotsky on blindness, Nuernberg (2008) points out that:

The historical-cultural theory also allows the criticism of conceptions about blindness that conceive this condition through the subtraction of visual experience, reducing the blind person to lack of vision. From a qualitative focus on psychological development in the presence of blindness, Vygotsky understands that this condition produces the restructuring of all psychic activity, leading the superior psychological functions to assume a different role from that played in the seers. (NUERNBERG, 2008, p. 312 - Translation).

It can be seen from this statement that for educator different possibilities of understanding the ways in which the blind child conceives and understands the world are open, taking into account numerous abilities, in addition to the lack of vision. But why approach the relation between language and thought in a study related to Tactile Cartography and the teaching of cartographic and geographic concepts for people with visual impairment?

According to Lewis (2003 apud BATISTA, 2005) language is the main source of information for the blind child, considering that in many cases it replaces what is lost by lack of vision. Nuernberg (2008) reinforces this perspective by presenting an approach by Vygotsky(1983) to the cognitive development of people with visual impairment, which comprises the "social compensation process centered on the ability of language to overcome the limitations produced by the impossibility of direct access to visual experience" (NUERNBERG, 2008, p. 311).

For Vygotsky (1983) knowledge is constructed according to social relations and not the presence of one or more senses. Although it is aware that the visual channel is the predominant means for the development of concepts, which facilitates the knowledge and understanding of the world, it is understood that a blind person will be more or less able to build such knowledge according to the stimuli arising from their social relations, the use of language and their different meanings.

There is a consensus among the authors consulted that language plays a decisive role in the development of concepts by children with disabilities. It is considered that the teacher, by restraining himself in the dialogue in which he hears the student and is heard by him, can perform successful didactic mediations whatever the audience, especially visually impaired students.

However, it is understood that, although spoken language plays a decisive role, it is not exclusive. There are many experiences that in a multi-sense exploration approach, especially tactile, enable the learning and development of cognition of visually impaired students in school. Such paths can be multiple, not exclusive to one or another sensory channel, and it should be taken into account that in the educational formation of a blind child, in addition to touch, hearing, the use of the word for language development and for the necessary dialogical construction of concepts that decode a significant part of the world for an individual who does not have the visual channel should be stimulated (SOLER, 1999).

Some international researchers have experienced a methodological transformation throughout their research work on blindness, mainly due to didactic contact with visually impaired students. Extensive research by researchers at the *Universidad Autónoma de Madrid* on the viability of using Piagetian theory to understand the variables involving the absence of vision and the reasons for abandoning Piaget's theory and the formulation of the hypothesis that cognitive and motor developments of the blind are better grounded by the theory of Vygotsky, because it allows the language to be attributed to the compensating function in development, was published in the book *Aspectos cognitivos del desarrollo psicológico de los ciegos* (volume II) (ALDERETE, et. al., 1988).

David Warren also experiences the methodological transformation between Piaget and Vygotsky and, to understand it, it is necessary to analyze two books *Blindness and Early Childhood Development* (WARREN, 1984) and *Blindness and Children: an individual differences approach* (1994). In the first book, the author presents the research on the development of the blind child from its comparison with the development of children who see in comparative analysis based on the Piagetian contribution. In the second book, published ten years later, Warren reviews analysis and takes a critical position in the face of investigations on the various topics related to motor and cognitive development scans of blind children from the comparison with children they see. It is important to highlight that the criticism is not in relation to the theory of Piage, just as there is no overvaluation of the theory of Vygtsky, but corresponds to the rescue and in-depth investigation of the placements of cutsforth (1933) in his book *The blind in school and society: a psychological study*, previously mentioned, on the analysis of investigations involving blind people based on the research of people who see. The publications cited, as well as those of Fernández, Ochaíta and Rosa (1988), Alderete et al. (1988), Ochaíta and Rosa (1988), Warren (1984, 1994), Gottesman (1973), Fraiberg (1971, 1977), Santin and Simmons (2000), Huertas, Asensio and Simón (1988), Rosa and Ochaíta (1993), Blanco and Rubio (1993), Dias (1995), Soler (1999), Ochaíta and Espinosa (2004) bring extremely important analyses to understand the relation of the blind ones with space, from birth to language acquisition, spatial organization, symbolism and other activities for teaching cartographic concepts to blind students. In the publications there are discussions about functional distance and configurational organization, acquisition of information by topological relationships, symbolic game, among other important concepts that are part of the teaching of cartography for schoolchildren and tactile cartography.

In Brazil, in the area of Tactile Cartography, it is observed that the researches of Ventorini (2009, 2014), Freitas et al. (2004) and Freitas, Ventorini and Borges (2011) in the Tactile Cartography Group linked to the CEAPLA of IGCE - Unesp, Rio Claro campus, began in 2000, with different phases, participants and approaches over time. All the initial work of the group had, in its early years, a strong Piagetian component, being based on the elaboration of didactic material at the University and its experimentation with blind and low-vision students of a Special School and a Child Qualification Center. However, during the first decade of the project, living with blind students and their teachers in these spaces led to the methodological transformation that directed the authors to analyses of practices that allowed blind students to generalize spontaneous and scientific concepts and acquire awareness of their own mental processes, as highlighted by Vygostky (1989).

Regardless of the theoretical and methodological line followed in the different stages of the academic life of researchers working in School and Tactile Cartography, one should consider the results of their experiences in the construction of spatial concepts when teaching children and blind adolescents. Such results can and should serve as guidance experiences for the teacher in the classroom, making the teacher not only disseminator of such practices, but the central agent in the learning process of the blind student, through experiences in the classroom, considering the apprentice central figure of educational practice. Therefore, among the contributions and challenges presented in this article are included the reports of practices with blind students.

#### **4 CONTRIBUTIONS AND FUTURE CHALLENGES: LEARNING THE SPATIAL CONCEPTS AND TEACHER MEDIATION**

The theoretical trajectory presented in this article indicates that there are many future challenges in the Tactile Cartography area. In more than two centuries of research there has not yet been consensus for the standardization of symbols of their language, which could mean solving the difficulties of producing and serial printing of cartographic documents from technology for 3D printing with affordable cost to your audience, mainly for teaching the map to blind people. Mobile technology, which includes resources for the autonomous displacement of blind people, identification of objects in the pre-established path, as well as guidance on changes in routes, among other aspects, is a challenge mainly with regard to which information will be relevant to the blind person during its displacement a certain space.

In the scientific path shown by the authors, the greatest challenges were and still are those related to

the teaching of Cartography and Geography to blind students in the early years of Elementary School. From the research experience, the initiation of the teaching of concepts of spatial representation for blind students from drawings, preferably initiated in Early Childhood Education and the fundamental role that the teacher develops in the classroom, even in the face of the uncertainty of their practice, are indicated. "The development of scientific concepts at school age is, first of all, a practical issue of immense importance - perhaps even primordial - from the point of view of the tasks that the school has before it when it starts the child in the system of scientific concepts" (VIGOTSKI, 2001, p. 241).

For the discussion on the placements, experiences are presented that matches with what is believed to be contributions to the theme. It begins with the drawing, which is not natural in the congenital blind because the child makes the first scribbles by imitating the adult or another child. Thus, the act of drawing is culturally related to the act of seeing. Without seeing and unable to imitate, the blind individual can reach adulthood without observing and copying the shapes of objects. According to Duarte (2004):

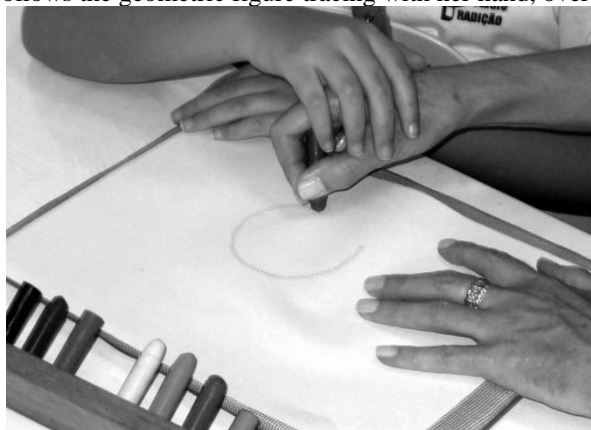
Seeing is an experience constructed by the subjects throughout their childhood as well as the learning of speech, in which the meanings of the words of the mother tongue are gradually assimilated and the vocabulary expanded. One learns to see how one learns to speak, identifying and memorizing each code, each element, associating similarity, recognizing differences, outlining meanings (DUARTE, 2004, p. 6 - Translation).

The learning of seeing, speaking, forming concepts, representing spatially occurs, therefore, in living with parents or guardians, it is transformed throughout childhood and necessarily passes through the teacher mediation. At this moment, the representation of objects through embossed drawings can be an ally in the understanding not only of geometric shapes, but also of the numerous possibilities of representation of spatial information resulting from them.

In this sense, from an early age it is possible to start tactile exploration and drawing practices with blind children, making use of simple materials such as a clipboard and a thin canvas that allows the inclusion of texture on a sheet of paper with greater weight and with the use of crayons. This material, low cost and easy elaboration, was part of initiation practices to drawing for blind people, published in Duarte (2008), Almeida and Nogueira (2009), Vantorini (2009, 2014), Juliaz and Freitas (2012), among other authors, allowing its initiation into the world of drawing and graphic and cartographic representations.

Duarte (2008) tells the experience of the initiation of a congenital blind student to the drawing of geometric figures, in this case a circle, making use of a procedure called by her as "imitação-sensório-motora" [motor-sensory-imitation] that corresponds to the conduction, by the mediator, of the student who, with his hand resting on the mediator's hand, follows the movements of tracing the design of the object (figure 09). This step is repeated so that the blind child sequentially memorizes the movement of the mediator in the elaboration of the circle until it has autonomy to draw it alone.

Figure 09 - The student follows the geometric figure tracing with her hand, over is Duarte's hand.



Source: Duarte (2008, p. 15).

The author calls the stages of Reaction - Repetition – Imitation. Reaction is the tracing performed

immediately after the experience of following the tracing made by the mediator, the Repetition corresponds, as the name says, to the repetition of the tracing after a time of the realization of the initial practice, with a pause for reflection. Imitation occurs when the tracing is not preceded by the perception of the model, conducted by the mediator, and may occur hours or days after the stages of Reaction and Repetition, requiring the child to have a record in the memory of the act of drawing and the shape drawn.

According to the author, the fact of performing the drawing with autonomy, considering it as already learned, does not rule out the possibility that, after some time, the child has difficulties to perform his tracing again, as if he had "forgotten" the construction procedure, which needs to be resumed, which makes the task slow and demanding of greater commitment. The author concludes:

[...] it is understood that this study attests to the presence of brain motor images and the possibility of drawing and memorizing drawing strokes based on the action itself, and not necessarily the image of the object [...], emphasizing that in the case of the practices in question tactile images were also made available. (DUARTE, 2008, p. 18 - Translation)

The experience of drawing based on imitation can provide the teacher with a means of initiation to the drawing of blind students, allowing their insertion in the world of representations, mainly as a preparatory stage for reading maps. But, as highlighted by Duarte (2008), the child should be based on his own action, that is, his reflexive awareness about the process of drawing. Such awareness is acquired through the process of understanding the concepts about symbolization, reduction, size relationship, among others, which requires "[...] the series of functions such as arbitrary attention, logical memory, abstraction, comparison and discrimination, and all these very complex psychological processes cannot be simply memorized, simply assimilated" (VIGOTSKI, 2001, p. 246).

The drawings of everyday places, unlike maps, represent subjectivity and are not standardized, but must contain socially known elements. The expression of knowledge through drawings expands the repertoire of the students regarding languages and can assist the teacher in the mediation of cartographic language (ALMEIDA, 2019). The preparatory reading of the map should be initiated from drawings, as is already recurrent in research on the teaching of Cartography for students who see. The problem is that, culturally, it is believed that the act of drawing is visual and this is not: the act of drawing involves imitation, not necessarily by visual observation, but by the relationship with the other.

To exemplify the statement, a research conducted by Ventorini (2012), reports how a teacher from a special school taught blind students to draw objects from their daily lives and use their drawings as forms of expression and communication with people who saw or did not.

The activities with drawing were part of the procedures adopted by the teacher in the braille literacy process of congenital blind students. In order for the students to have a signature as a personal brand, something not allowed by the Braille code, but made possible by the ink pen, the teacher taught students blind to the symbology of the letters of the Latin alphabet along with braille symbology. However, the procedure did not consist of training or repetition without meaning for the students, nor in literacy in Latin symbology, it meant using the spontaneous and scientific concepts highlighted by Vygotsky (1989)

[...] the fact that we become aware of our operations, conceiving them as a process of a certain type [...] make us able to do them. School learning induces a type of generalizing perception, thus playing a decisive role in raising the child's awareness of their own mental processes. Scientific concepts, such as their hierarchical system of interrelations, seem to constitute the means in which consciousness and mastery develop, and are later transferred to other concepts and other areas of thought. Reflexive consciousness reaches the child through the portals of scientific knowledge. (VIGOTSKI, 1989, p. 79 - translation)

Thus, first, the student had contact with the material for drawing (drawing board coated with canvas, paper and crayons) and, when feeling at the fingertips the traces performed, understood the function of the material and performed traces freely, for the pleasure of scribble (figure 10). Then, the drawing of the traces was mediated by the teacher as a school task. The teacher explained that horizontal, vertical and inclined

strokes could, if combined, represent objects such as a house and circle-shaped strokes, could represent the sun. Later, the teacher explained that the word "house" contained the letter "A" and that it could be represented by two inclined strokes and one horizontally. The letter "O", in turn, was contained in the word "sun" and that the sun could be represented by a circle being that, this same circle could represent the face of a person if symbols were inserted in it to represent eyes, mouth, nose, etc. (VENTORINI, 2014). The association between the letters and the objects represented, stimulated by the mediator, gave meaning to the learning of the Latin alphabet and allowed the construction of concepts (forms of letters, objects and their meanings) by the child's own mental processes, which is far from memorization and approaches the reflexive consciousness presented by Vygotsky (1989).

Figure 10 - Blind student drawing with clipboard covered with thin canvas and crayons.



Source: The authors (2020).

These were school tasks, however, the certainty of the teacher about students learning occurred when they generalized the concepts addressed and drew not the house or the sun requested in school tasks, but when they presented drawings of their houses whose traits represented not the shape of the real object, but emotions, social and cultural relationships, private and collective experiences narrated during and at the end of the act of drawing (VENTORINI, 2014).

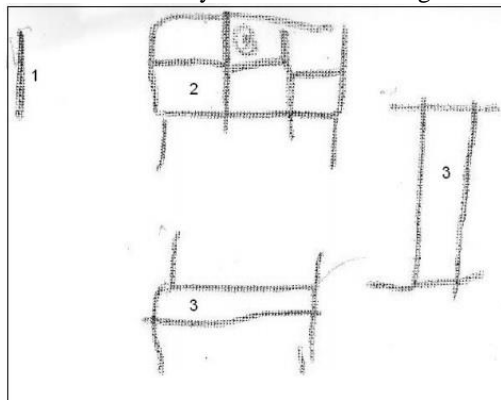
From these observations, Ventrini (2009) asked the students to express their spatial knowledge through drawings of places in their daily lives. In the analysis of the drawings, the researcher finds concepts of spatial representation such as: location of objects, harmony in the distance of objects, reduction and respect of the size relationship, use of symbols to represent large objects, bounces, among others. Moreover, for the researcher, the similarity or not of the forms of objects with the real loses its importance when it is found that the students were aware of their mental processes during the narratives of the drawings, which expressed logic, feelings, knowledge about space and social relations, beyond the aesthetic forms of what was represented (VENTORINI, 2009).

The dialogue with Ventrini (2012) indicates how blind students generalized the concepts of representation, mediated, first, by the teacher in drawing activities and, later, by the researcher in cartographic activities to represent environments of their daily life, such as a room (figure 11) and a square they frequented with friends and family. The students go through the rudimentary process of systematization through scientific concepts and then use them in their daily lives (VIGOTSKY, 1989). It is observed, in the reports of Ventrini (2012), that blind students draw spontaneously and, for Almeida (2019),

In everyday life, children draw spontaneously, using this language to express their ideas and give vent to the imagination. The drawing has a mediating function in the processes of understanding reality and expression of thought, usually accompanied by the word (spoken or written), which complements or modifies it. We remind you that imitations of writing juxtaposed to drawings produced by children are common. In school, however, the drawing aims to aim at acquiring concepts, such as a passing resource for more complex languages such as writing (tasks are common in which children must draw something from an experience, a walk, for example, to then write a text) (ALMEIDA, 2019, p. 07 - Translation).



Figure 11 - Bedroom representation elaborated by a blind student. Legend: 1- door, 2- wardrobe, 3 bunk bed.

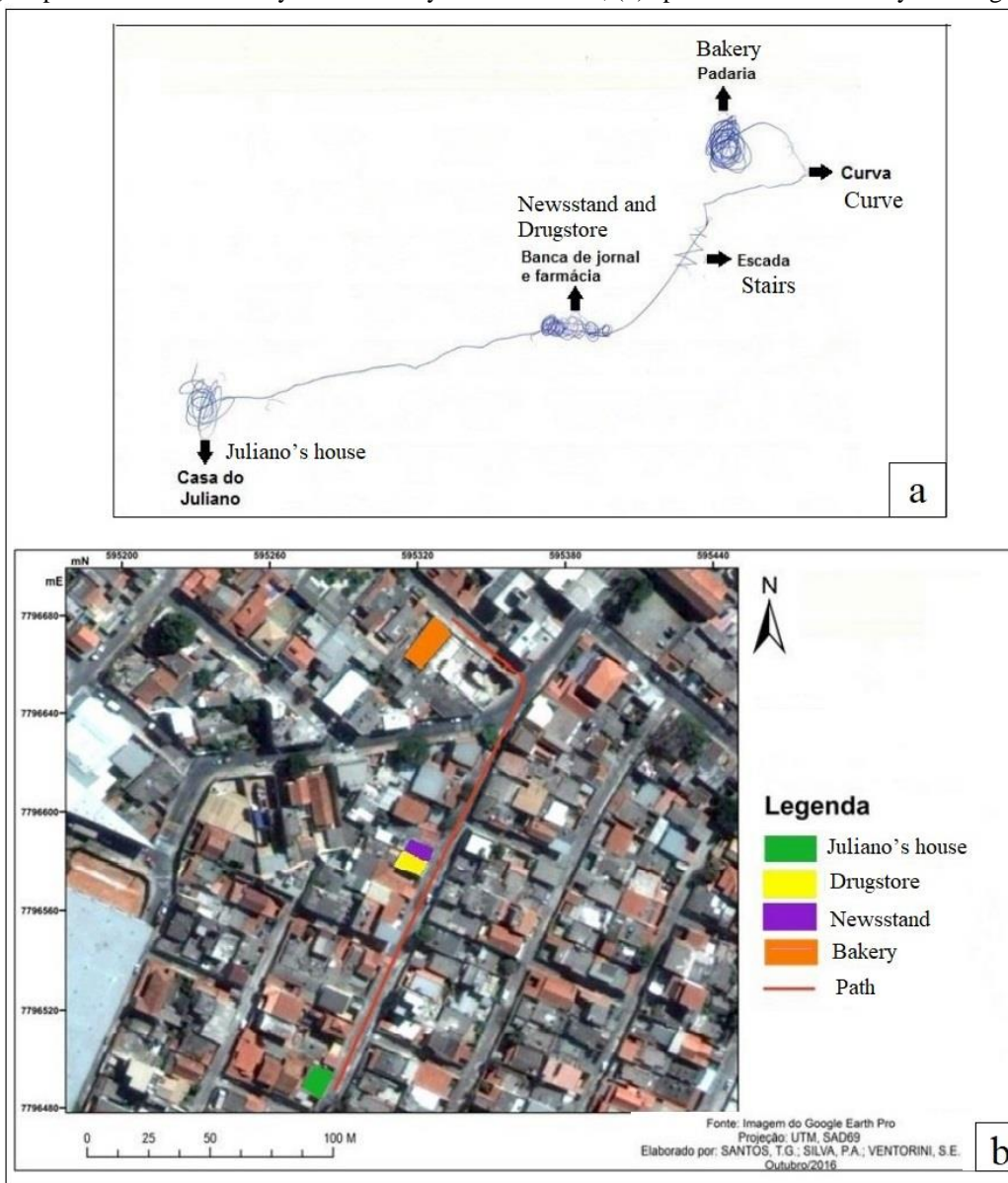


Source: Ventorini (2012, p.115).

It is important to highlight that even without having gone through the learning process of drawing, maturity, school, social and, mainly, the daily experience of social and cultural relationships, which give private and collective importance to places, allow blind people to express their spatial knowledge through representations. As an illustrative example of the statement, reported by Silva (2017) develops a research with blind students, aged between 11 and 13 years, who did not perform drawing activities in the school environment, is presented. During the data collection, the researcher found that the students reported in detail the route of their homes to places frequented by them (route from their homes to the bakeries where they bought goodies). Silva (2017, p. 93) mentally questions whether the "[...] are students able to represent such paths through drawings?" and then expose their question to the students and they answer that they are capable.

Silva (2017) takes advantage of the insight of the moment and chooses to provide students with the right to express their spatial knowledge through drawings. Blind students represent the paths from their daily experiences that involve social relationships, feelings of belonging to the place, sensory experiences, memories, etc. In the representations there are spatial concepts such as functional distance (actual distance traveled), spatial organization, topological relationships (such as neighborhood and location), symbology and narrated legend. From the representations of the students, Silva (2017) specializes the routes in Google Earth. Figure 12 illustrates one of the students representations as well as their spatialization in the satellite image.

Figure 12 - a) Representarion of the way elaborated by a blind student, (b) spatialization of the way in Google Earth.



Source: Silva (2017, p. 132).

The shape of the objects is not similar to the real one. There is in the students lack of graphic memory, however, for the researcher,

[...] as for the normovisual child, drawing can aid in the cognitive development of the blind child and it can be seen as a representation of what she perceives and feels. Therefore, the shapes of the drawings are irrelevant, what matters are the meanings of the representations and their coherence with the real. (SILVA, 2017, p. 152 - Translation).

In the teaching of Cartography and Geography for schoolchildren who see the design of paths is considered of paramount importance for the child to start learning the map by involving knowledge about the place, concepts of representation and time-space relation (ALMEIDA, 2019). It is worth noting that,

Drawings made spontaneously, in daily life, mediate processes of understanding reality and expression of thought, giving vent to human creative activity. They may be accompanied by another language, such as the word, without, however, confusing themselves with it. [...] Looking at the drawings as mediators in the process of knowledge production means, then, seeing in the drawings of paths relationships that go beyond answering questions such as "where is such a place?" or "in such a place what is there?" (which can also be answered with maps), but see how they appear, according to the interpretation of the person who drew them,

presenting traces of their imagination, with elements outlined by it and selected from their cultural context (ALMEIDA, 2019, p. 11 - Translation).

In the cited examples, listening to the students allowed the researchers to analyze that thought and language may reflect the reality that the sensorio-motor system cannot attribute to the act of drawing (representing forms) (VIGOTSKI, 1989). In the enunciation of the other, the researchers understood their own questions about the ability to teach and learn from all those involved in the process.

Another significant example of working with congenital blind children and their relationship with the construction of abstract concepts for those who do not have visual experience is presented by Moraes (2005), in the accompaniment of a play conducted at the *Benjamin Constant Institute*, in Rio de Janeiro - RJ: the challenge presented to a blind student to roleplay a ballet dancer. For the author, "the scenic space creates a field of learning that encompasses several fundamental points in the cognitive development of the blind child: orientation and locomotion, interpersonal relationships, the orientation of the body in space, etc." (MORAES, 2005, p. 5).

Through this theatrical activity, the question was how to have the lightness of the dancer in her interpretation, something of very immediate understanding for those who have the visual channel and have already observed a ballet performance, however, complex for a congenital blind girl who has never seen or lived such an experience. Although there were several attempts to use the word to explain how she was a dancer in action, as well as the presentation of her clothes and accessories, the blind student did not understand the concept of lightness in the dancer's dance (MORAES, 2005).

According to Vygotsky (2009, p. 237) "the formation of concepts always arises in the process of solving some problem that arises for the adolescent's thinking. Only as a result of the solution of this problem arises the concept". According to Moraes (2005) two activities provided an understanding of the concept of lightness of the dancer by the blind student. The first corresponded to the exploration of a large gas balloon that contained rice inside, which allowed the student and her colleagues to stage, reproduce and explore the wide and smooth movements of the dancer. The sound provided by the movement of rice in the gas balloon sought to give sound to the continuous and smooth movements of the dance, so its choice instead of the rattles usually adopted, for example, in the soccer ball used by the blind.

The second activity corresponded to the use of a large sheet that was supported by the coordinators at the top, with the arms stretched out, on which the balloon was placed. The student and her colleagues were invited to pick up the balloon by touching the stretched tissue, being positioned under said tissue. According to the author, "at the end of these experiences the blind girl concluded: 'the ball is light and the ballerina is also light' and then said, 'my body can be light like this ball'" (MORAES, 2005, p. 10).

Simple objects introduced in the collective game created for the understanding of abstract concepts such as lightness, continuity, smoothness, in the "being a dancer" allowed the blind student to incorporate, in her interpretation, the lightness of ballet movements. The moment of the enunciation of "being a dancer" is important because according to Vygotsky (2001, p. 250) "[...] when the child is aware, for the first time, of the meaning of a new word, the process of developing the concepts does not end but is just beginning."

Another work that converges to the aspects that relate the bodywork and language in the formation of concepts was developed by Juliaz and Freitas (2012) and illustrates significant aspects of the participation of blind students in didactic activities, whose skills related to graphic representation, reading and interpretation of tactile maps were little or nothing developed - a common characteristic when dealing with such an audience. As a rule, only a small portion of blind students are initiated into drawing and dominate the interpretation of cartographic representations. This is most often due to the simple fact that they did not learn, in the first school years, to exercise such skills. The authors also highlight as factors that contribute to this reality the absence of specific materials in regular schools, as well as in the centers of qualification and reception of these individuals. According to the authors:

All activities resulted in graphic representations of the students themselves, in view of the importance of making the student active and builder of their knowledge, and the need to know the perception of the cartographic representations used and the students' previous knowledge about the content addressed (JULIAZ; FREITAS, 2012, s/p - Translation).

In this reported experience, the authors adopted as a mediator instrument of learning multisensory didactics to amplify the perception of the blind student, allowing several meanings to participate in the exploration of the theme addressed in the didactic activity. Through the students' design, their perceptions and memories about the theme "Brazil and Africa", it was possible for them to create records in free drawing, in which each one exposes his understanding of the relations between the history of colonization of Brazil, slavery, the formative cultural elements of the Brazilian people expressed in soccer, capoeira and so many other aspects of our society. In addition to touch and words, the drawing, in this case, was completed and completed the sound recordings that included thematic capoeira songs, in addition to audiovisual projections that, in the case of the blind student, were narrated while the film was designed for students with low vision (JULIAZ; FREITAS, 2012).

Still in the scope of the theme "Brazil and Africa", another very symbolic experience of the work developed by Paula Juliaz (2010), now at the Special School (EE) of Araras in SP, corresponded to a question posed by blind students when exploring the tactile maps that illustrated the slave trade from African countries to Brazil. The students could not, through representation, understand the real distance between the American and African continent. The mediator explained that Brazil is about 8,000 kilometers from Africa. But how much does that correspond to? It's far, but how far? The debate continued until it was decided to give concretely to that distance. A mathematics exercise, which would have, at first, a fun practice: measuring the height of each of the participants. After that, a simple division of the approximate distance between Brazil and Africa by the height of each. In the illustrative example: "If my height is 1.65cm, then to understand the distance between such localities would take 4,848,845 objects of my size, aligned in a straight line, crossing the Atlantic Ocean, to cover such a distance." Thus, the game of discovering how many millions of each would be needed to leave Brazil and get to Africa transformed an abstract value into a real, tangible measure, centered on the own body of each participant of the activity. Figure 13 illustrates some of the tactile maps created by Juliaz (2010).

Figure 13 - Tactile maps to support the "Brazil and Africa" theme approach.



Source: Juliaz (2010, p. 75, 76, 77).

Many other examples of experiences of people who have experienced teaching to blind people can be presented. In essence, there are the basic aspects that these experiences bring: listening to the other, understanding their understanding of the theme and seeking to materialize it in the form of graphic drawings or representations, restraining on multisensory didactics whenever possible, including sounds, videos and measurement practices, having as reference the body itself or objects and paths of mastery of the disabled person. By combining all these possibilities, the student can immerse himself in the theme, reflect and, mainly, perform the mental constructions necessary for learning to effectively occur.

The reports of activities involving the themes of drawing paths, learning of the Latin alphabet and association with objects, the lightness of the dancer and the relations between Brazil and Africa show how the teacher can face his challenges, based on understanding how his perception of the world is given beyond visuocentrism, which guides not only the didactic training of the one who mediates access to knowledge, but also the way he plans his class, selects the didactic material and explores the examples that illustrate the contents. In view of the insights and problematizations experienced with blind students, researcher and teacher should seek to listen to the students and try to understand their narratives in the contexts experienced. The focus should be on the ability of the student and not on the absence of vision.

In this sense, given the clipping of the constitutive aspects of Tactile Cartography that this article

illustrates, it is considered that the cartographic initiation of the blind child should be guided by its initiation to the drawing even in the preschool moment, with the constant mediation of the use of the word in association with the intense exploration of the near by environment, having as reference its body. It is essential to highlight that the term "drawing" should be understood as the expression of perceptions of ways of organizing their representations about geographic space. Each individual has his own and these should not be analyzed based on the concepts of conventional cartography. Cartographic science should contribute to the blind person having access to information and experiences that expand their spatial knowledge, beyond their daily location (HUERTAS; ESPERANZA; ESPINOZA, 1993). In turn, the terminology "experience" refers to two categories: "[...] direct experience (generalization of sensory data) and indirect experience (abstraction) [...]" that are determinant in the understanding of maps" (VENTORINI, 2007, p. 142).

Thus, direct experience is given light, preparatory practice for indirect experience that translates into the domain of signs and meanings that will allow the development of abstract concepts required in the reading and construction of cartographic representations, as is the case of the map.

It is expected that this review article will contribute to the dissemination of historical paths of Tactile Cartography, its theoretical bases and its tactile and multisensory products. The study indicates that such products, although predominantly "handmade" and lacking in standardization, have gradually appropriated the technologies available today. It is believed that the selected examples with emphasis on the experiences of practices in teaching blind people in the initiation to drawing and cartography can encourage teachers to act as mediators attentive to the students needs, emphasizing their skills and not their limitations.

For future research, three challenging questions are proposed:

a) How to standardize the tactile graphic language? Researchers who work in the field for the standardization of types and sizes of symbols, colors (to serve people with low vision) and textures in tactile teaching materials have long been a long-standing target. Some initiatives took place, but always with a local or regional feature, without full community support. It is considered a great future challenge for researchers, teachers and people with disabilities to come together to face this issue, giving guidelines for a standardization of the tactile graphic language, which will be a gain for the whole society, not only for people with visual disabilities.

b) How to develop teaching practices based on the skills of each student and not on their disability? It is considered that this is one of the main challenges for teachers and tutors who coordinate educational activities with people with disabilities, which can be achieved through a change in the way of approaching the teaching of these individuals. In order to be successful in this challenge, it is not considered pertinent to overestimate or despise the medical diagnosis, but to respect individual differences, highlighting the skills that characterize each person, whether they are disabled or not.

c) Is it possible to develop mobile technology that allows not only the autonomous movement of blind people, but online navigation through places, as is done by those who see? This will be an important step towards the full inclusion of visually impaired people in accessing online navigation, allowing individuals greater freedom not only in planning their displacement in space, but also in terms of their knowledge of the world, expanding the limits of their space exploration in a virtual environment. However, some technological innovations must occur in the automatic devices for narrating routes and describing the landscape so that it is possible to achieve this challenge.

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## Author contributions

Silvia Elena Ventorini organized and wrote the literature review on the History of Tactile Cartography and Maria Isabel Castreghini de Freitas organized and wrote the literature review on Vygotsky. Both authors jointly wrote didactic experiences, contributions and future challenges and reviewed the manuscript.

## Interest conflicts

The authors declare that there is no conflict of interest.

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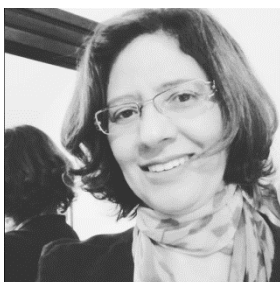
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