Design of a Tactile Map: An Assistive Product for the Visually Impaired

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Abstract Assistive Products that promote the learning of spatial mobility, route guidance and selection of destinations, can favor the independence and quality of life of blind people or with low vision. This paper presents the design process of a tactile map to assist in teaching the discipline of mobility and spatial orientation for blind and low vision people. The tactile map is an assistive product that aids in route selection and location of buildings and public spaces. Such a map has the different blocks through different textures with different reliefs. The project uses the methodology for development of assistive technologies aimed at accessibility and inclusion of people with disabilities. The design process included needs data collection with a teacher of mobility and spatial orientation discipline. Later, with the objective to meet the requirements shown in the research, the researches elaborated sketches and alternatives. After this step, the tactile map was selected as the best option due to costs and resistance through 3D printing technology. The validation of the product will occur with visual impaired users who attend the discipline of mobility in the Blind Institute, located in the state of Parana, Brazil. The product generated can assist the institute's teachers to explain the location of each building, street or public place with the help of differentiation through tactile textures.

Keyword Assistive technology · Tactile map · Blind · Low vision

1 Introduction

The basic concepts of orientation and mobility (OM) is essential to visually impaired people translocate safely and efficiently through the development of the senses, among which for specific location action commonly is used tact.

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F. Rebelo and M. Soares (eds.), *Advances in Ergonomics in Design*,
Advances in Intelligent Systems and Computing 485,
DOI 10.1007/978-3-319-41983-1_64

To move from one point to another, more than know routes, you need orientation to the destination and thus build a mental map. Teachers that work OM discipline with this group of people can use tactile maps to define reference points. These maps can be done through artisanal lr industrial methods but it is important to make the student with blindness or low vision[1] trace the path to their operation and rebuilds his/her space [2].

Assistive technology is an area of knowledge (interdisciplinary) involving the development of products, resources, methodologies, strategies, practices and services that aim to promote functionality, activity and participation of persons with disabilities or reduced mobility, in order to improve the autonomy, independence, quality of life and social inclusion [3].

Assistive technology is divided into 11 categories, which are:

- Aid for daily living;
- Augmentative communication (additional) and alternative;
- Accessibility features to the computer;
- Environmental control systems;
- Architectural designs for accessibility;
- Orthotics and prosthetics;
- Postural adaptation;
- Mobility aid;
- Aids for the blind or with low vision;
- Aid for deaf or hearing loss;
- Adaptations in vehicles.

In this research, the developed project is classified as a mobility aid. Given the above, this paper presents a space guidance system entitled of a tactile environment map around the Paraná Institute of the Blind (PIC), an aid product to teach the discipline of mobility for the blind and people with low vision.

The methodological procedure follows the steps: inspiration, ideation and implementation [3]. In this paper, first we present a literature review of tactile maps and subsequently demonstrate the design process to assistive product, from inspiration to the 3D modeling.

It also includes the principle of Universal Design which is defined as a way to transform environments, communication, dispositives, products and services so they can be utilized by people of all kinds of capacity, with the widest extension possible [4, 5].

[1]There are two types of visual impairment, caused by diseases, congenital problems, traumatisms or ocular disfunctions: blindness or low vision. Blindness is the total lost of vision, but it may have some vestige of perception of light. Low vision is when there is difficulty to see near and/or far beyond the limitation of the front and peripheral visual field, the contrast and color perception. Both of them can not be repaired with conventional ways, as glasses or eye contact [1].

2 Methodological Procediments

There are some differences to elaborate mockups or tactile maps. The first on brings the information about volumetric format in a real way, while the second option do the same, but with use of symbolic elements such as dots, lines and surfaces [6]. In both cases, the elements should be clearly represented without harming the haptic reading. In a research with 30 blind people it was noticed that tactile maps need to put in evidence the relationship between the elements, the general environment context, precision, urban characteristics, barriers and intersections [7].

There are preferences related to design, symbology, characteristics and cartographical elements. This assistive products should [7]:

- Offer useful information without causing confusion in users;
- Be easy to read by touch;
- Use symbols that can be easily remembered;
- Have good resistance to use and to represent streets crossroads.

It is not necessary to include superfluous details when there is no space enough and when they can be perceived by the use of white cane, such as ramps, stairs and escalators. Still, places a requirement distance between the members of at least 3 mm [6].

Table 1 *Source* [6]

Technique	Digital model	Materials that can be used	Description	Capacity to produce	Limitations
Laser cutter	2D	Acrylic sheets, cardboard and wood	Cut into layers that are superposed	Contour	Impossible to print Braille and details in high relief
Milling machine	3D	Wood and other synthetic materials	Sculpt by a mechanical arm	Topography and low relief	Impossible to print Braille and to have furrows with negative angle
Deposition of material	3D	Resin and plaster powder, melted plastic	Deposit resin droplets layer by layer	Any kind of mockup, including Braille, depending on machine´s resolution	Resolution does not allow some details
Solidification of material	3D	Liquid or in powder Resin with some light or laser	Solidify resign with laser or light	Everything with high definition and durability	High cost

Then, rapid prototyping is presented as a way to produce tactile models, according the criteria above because it can provide resistance and the possibility of incorporate high resolution textures, symbols and texts in Braille [8]. There are four main techniques: one in 2D and three in 3D [9]. The first is the laser cutter which is ideal to represent curve levels, but not to Braille and details in high relief. The second is milling machine that has an mechanic arm that sculpts the material, generally used to topographic forms and low relief. The third is the deposition material laying resin droplets for the production of any map, but the resolution may not present some details. The last one uses resin, in liquid or powder, and a laser beam to produces a material with high-definition and durability, but also much higher costs (Table 1).

The techniques application can be utilized to teach disciplines, as cartography or geography, to perceive works of art and tactile maps for mobility. For this project, we propose to use the technique Deposition of Material to meet necessities of PIC.

3 Theoretical Foundation

The product development was based on the methodology of User-Centered Design and with emphasis on Universal Design with the following steps: inspiration, ideation and implementation [3].

Initially, we intend to identify necessities of people with visual impairments. According to a professional of OM discipline from PIC, Lilian Biglia, located in Brazil, a tactile map could be easier to teach her students to learn how to get around from one point to another, beginning familiarization with the surrounding area of the institution.

Later, based on the literature review on tactile maps destinated to the visually impaired, we delimited the design methodology [3]. After the inspiration and the ideation phases, it occurred the implementation step. At first, it was made the bidimensional model in sketches. Then, we were able to generate a 3D model in Sketchup software.

After the digital modeling, we exported the archive from Sketchup to the .DAE format (3D model) that maintains the structural and volumetric properties from the generated geometry. Afterward, we readapted the geometry in MeshLab program and exported to .STL to allow 3D printing. Both of the softwares could be used for free and had free license agreement.

From the prototyping phase, it will be applied a survey (Table 2) with PIC teachers of OM discipline to check if the product meets the need that was found

Table 2 *Source* The authors

1. Do you consider that an assistive product could assist in teaching classes of OM discipline for the visually impaired in Paraná institute for the Blind? ( ) Yes ( ) No
2. What are the main difficulties faced by the visually impaired in relation to spatial orientation and location of public places and urban buildings?
3. What is the importance of using an assistive product during class mobility and spatial orientation of blind and low vision?
4. What would you like that were stated in on a tactile map?
5. If you could make use of a tactile map that would help in class mobility with visually impaired, select the features that are important include this assistive product: ( ) Blocks and streets ( ) Pictograms in relief differentiating blocks ( ) Different textures in relief differentiating blocks (each block with a different texture) ( ) Marking the sidewalks, the presence of directional floor and alert, simulating the route to the user ( ) Blocks in high relief ( ) intaglio streets ( ) Sidewalks embossed with greater gap compared to the streets ( ) Relief of pedestrian paths to traverse the streets ( ) lndicative tactile traffic lights ( ) Explanatory caption of Tactile surfaces (textures explanation of what each one refers)
6 What a height of unevenness/reliefs and low reliefs that you consider interesting to think when the design of a tactile map? Please answer based on the minimum height required for differentiation of streets/sidewaIks/buildings through the sense of touch by people with blindness or low vision

before. We also intend to verify the main difficulties by the users related to the spatial learning and memorizing process, such as location of buildings, streets, public constructions. And, finally, to discover if the tactile map helps as a facilitator in OM education to visual impaired people. The idea is to enrich the prototype and adjust it until develop the final product.

With three dimensional printed version, after the Survey application (Table 3) with PIC teachers and the pilot test with students with blindness and low vision, we will enter in Validation phase of Assistive Technology.

Table 3 *Source* The authors

1. Do you consider that this tactile map would assist in teaching classes to mobility and spatiaI orientation for the visually impaired in Paraná Institute for the Blind? ( ) Yes ( ) No
2. Do you consider that the pictograms used to distinguish the most important buildings of each court favor the memorization and the location of each building? ( ) Yes ( ) No
3. Do you consider that the pictograms had a significant design that is associated with each building? ( ) Yes ( ) No
4. Do you consider that the reliefs or unevenness are suitable for tactile differentiation: blocks, buildings, streets and pictograms? ( ) Yes ( ) No
5. You would use this tactile map for mobility and spatial orientation in their day-to-day? ( ) Yes ( ) No
6. Recommend suggestions for improvement of this tactile map (if deemed necessary)

4 Results and Discussions

The necessities were gathered in two reunions with Lilian Biglia from OM discipline of OM. The PIC teacher had asked for a tactile map or mockup to serve as support material in initial classes so her students could develop the ability to move between places with autonomy and independence. In that way, it was determined the importance to elaborate a product that could represent in three dimensional format the surroundings of PIC with courts and streets differences and main buildings representation. Then, it was chosen the tactile map due to its resistance and low costs.

Based on images from Google Earth, we started to draw the tactile map in Sketch Up program (student version). The established scales were within the measure limit (20 × 10 × 5 cm) for 3D printing by deposition technique material, the Federal Technological University of Paraná.

4.1 Inspiration

The project modelling followed the requirements found [6, 7] to seek precision and clarity in the information is presentation. In this way, we used symbols that may be easy to remember, distinct and read, with simple shapes and sturdy materials. We also present streets and intersections that separates the courts.

4.2 Ideation

The drawn pictograms on each building of the courts have similarity with the widespread used in traffic signals and interfaces in Brazil. Each of the symbols were made by the authors with filled forms and few elements for easy recognition and distinction, as envisaged by NBR 2050—brazilian normative which deals with the accessibility criteria for urban spaces and signaling systems (Fig. 1).

We have highlighted buildings that could be useful in their routine, such as: PIC, supermarket, fast food establishment, hotels, restaurants, dental offices, fitness gym, pharmacy, beauty salon, school, bakery and shopping mall (Table 4).

4.3 Implementation

After the structural drawing, we exported files to Sketchup in .DAE format to preserve its properties of 3D model. Then we used it in MeshMixer to correct the surface, repair occlusions and export to .STL format to finally print it (Fig. 2).

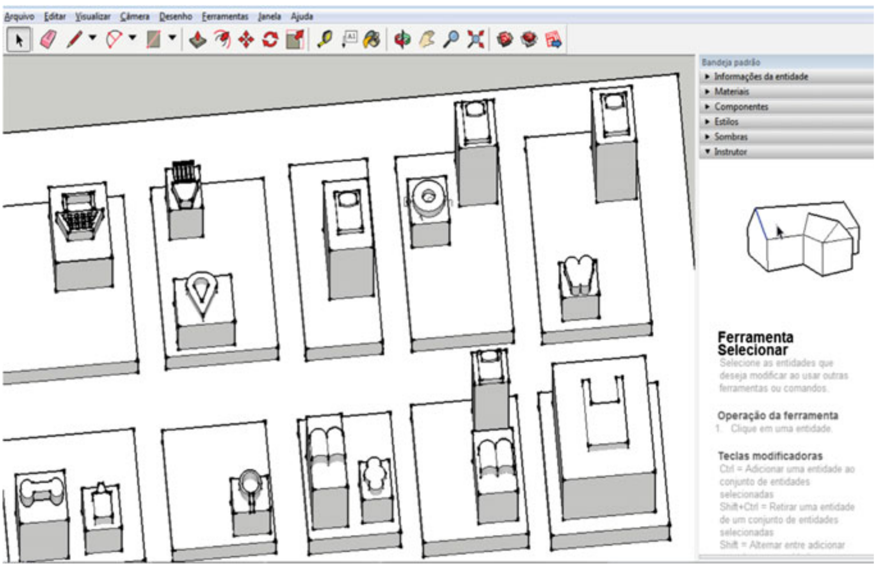

Fig. 1 *Source* The authors

Table 4 *Source* The authors

Places	Simplified pictograms
PIC	Symbol of point of arrival that is used in conventional digital maps
Supermarket	Shopping cart
Fast food establishment	French fries
Hotel	Bed
Restaurant	Plate
Dental office	Tooth
Fitness gym	Dumbbell
Pharmacy	Medicine bottle
School	Mirror
Bakery	Bread
Shopping mall	Shopping bag

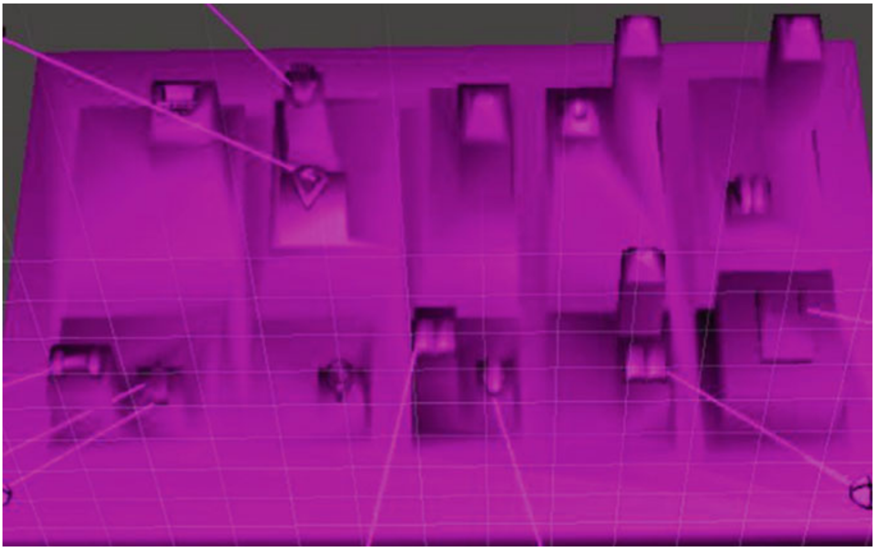

Fig. 2 *Source* The authors

5 Conclusions

This article had the objective to develop a design process of a tactile map that can be affordable, easy to prototype and resistant in its final form. The product should be utilized as a material support in OM lessons at PIC. The needs assessment identified that such assistive technology could help the didactic and pedagogical activities to develop in visual impaired students the ability to dislocate between different places. As we mentioned before, the map should be felt through the sense of touch with relevant details of PIC surroundings that are useful in the user's routine.

To meet the requirements and achieve a concept of the product, we developed a code system based on symbols that may be recognized from its reliefs through the touch by users. In that way, a group of embossed pictograms has been defined to facilitate the differentiation of buildings and facilitate its memorization.

The next stage of this research consists in apply questionnaires proposed in Tables 2 and 3 and the pilot test of the prototype to measure the utility of the product to blind and low vision students. Thus, we can analyse if the prototype can be improved and adjusted to help teachers in OM classes.

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