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Inclusive Architecture: Digital Technologies, Co-design and Qualification of the Project Process

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Abstract: This article presents the scenario of programming use by architects and engineers, creating their own unique tools. The goal is to emulate and understand the phenomenon of Building Information Modeling (BIM) software customization by developing plug-ins that can explore the human-environment relationship. Demonstrate the process for building a plugin that seeks to equalize the theory of accessibility technical standards, visually impaired and architects. Use Design Science Research methodologies to guide the construction of artifacts for specific practical problems and the Collaborative Design/Co-design to understand and know the users' expertise. It is argued that the low quality of projects that include elements for the orientation of the visually impaired in Brazil is often related to an unstructured methodology in which important aspects such as the real needs of this group and the human-environment relationship are neglected.

Key words: BIM, design science research, co-design, inclusive project.

1. Introduction

The difficulty of equalizing the needs for People with Disabilities in architectural projects is a theme widely discussed in the world. At all times, researches are emerging with new experiences and methodologies to identify the most assertive way for this to happen. Bianchin and Heylighen [1] affirm that this search for social inclusion in general becomes more difficult, because when inserting ways of accessibility in projects, seeking to serve the largest number of people, it becomes impossible to meet all the human differences of one time, without listing major problems. In addition, in doing so, designers are forced to disregard needs that are of utmost importance to another specific group of people.

In Brazil, one of the factors that most influence the difficulty of assertiveness in the visually impaired elements in the projects is due to the very teaching of architecture being based above all on the supremacy of vision. Heylighen and Herssens [2] argue that this supremacy in teaching environments during the design of projects causes other sensory perceptions of the human body to be disregarded, whereas the projects bring elements that, at most, exhibit qualities of environmental, thermal comfort and acoustic. In this context, among the elements that are inserted in projects aimed at vision impaired people, the tactile floor stands out. However, even before the element was consolidated with defined standards in its home country, it was replicated and presented various problems and weaknesses, both in color standardization and in the specification of its materials. With this, several types of floors were elaborated by the most diverse countries, with innumerable and distinct standardizations, and no research has been found so far that showed total satisfaction of the users with this element.

However, although advances have been made in the study of methods that include vision impaired people in the design process, architects move from academic life to their professional careers, replicating the technical parameters contained in normative texts,

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without real notions and such parameters satisfy the accessibility to the problems that they propose. This factor occurs both because of the lack of knowledge of the experiences of these people, and because of the need and demand of the market so that the design processes are increasingly agile.

The article presents a discussion about the second factor, because the advances of the digital technologies of design allowed the architects to optimize time during the design process by means of the elaboration of algorithms, which allow the programming of plugins using software Building Information Modeling (BIM). This makes it possible for commands and actions to be customized from variables defined by the designer in the design environment.

These algorithms are procedures to address problems using a finite series of steps that follow a logical and consistent sequence [3]. Thus, algorithms are not exclusively digital and can be applied in solving any everyday task. Brígitte and Ruschel [4] highlight how it is common to observe the creation of algorithms related to quantitative, acoustic, luminous and thermal performance, but little is seen qualitative algorithms that explore the human-environment relationship.

These algorithmic strategies have become particularly important because they serve as the basis for different methodological approaches during project processes. For Ref. [5], the parametric design process is defined as the development of a model or description of a problem, where the representation is based on the relations between objects controlled by variables: the parameters.

In the research the parameters are results of the equalization between technical norms of accessibility, vision impaired people and designers. They aim at qualifying the design process when it aims to insert floors for the visually impaired, by designing a plug-in using Autodesk Revit, BIM software and Dynamo, a visual language programming software.

Eastman [6], long before the emergence of the BIM concept, was able to demonstrate the description of repetitive activities carried out throughout a design process. In his research, he described the results of an exploratory study of the various ways that would be possible to solve a bathroom layout, in which designers verbalized their sequences of design decisions. At the end of the process, the author came up with eleven manipulations that can be explained as a routine of steps to solve a specific problem.

The manipulations resemble the functions that a plug-in is able to perform by describing algorithms that mean the reading of a logical system divisible into several subsystems by the recognition of patterns from activities performed by designers, even if unconsciously, during the stages of a project [7].

Eastman [6], however, reports that only one machine would be able to patiently perform the recursive simulations of the protocols generated from the rules that were established. Thus, what the author explains in his work resembles what is happening in the new revolution of contemporary architecture that seeks, through the formulation of algorithms, to program the repetitive activities in a project process that can be established through a set of rules. One of the most important points of the author's work, which is extremely relevant to the research to be presented, is that by verbally programming the preferences of architects during a design process, it is possible that, if translated into logical routines, preferences of people can also be programmed.

Therefore, the objective of the article is to discuss the use of Design Science Research and Co-design strategies to optimize project support tools when it is focused on projects aimed at including the visually impaired. In this way, it will be demonstrated the importance of the development of building codes related to the inclusive architecture so that user preferences can be allied to normative parameters and can be used through a digital design tool. The research seeks to demonstrate the importance of exploring the combination of algorithm design and BIM platform as a way to qualify the inclusive design process in architecture.

2. Methodology

During a design process, the tasks performed by architects are sequentially based on identifying problems, generating solutions in parts and integrating them into the whole. However, when problem identification and decision-making are elements of accessibility, especially for the visually impaired, architects rely much more on normative texts than on people's preferences.

Therefore, for the parameters used for the programming of the plug-ins to contain the preferences of the visually impaired, the research makes use of the Collaborative Project, or Co-design, that centralizes the decision making of the design process in the user. Affirming a methodology that seeks to understand and learn from the user, his/her expertise regarding the theme addressed in a particular project and context. According to Ref. [8], this participation of users in the design of projects allows in-depth discussions about the different existing needs. By using Co-design it is possible to promote a common project language so that users and project professionals can understand and express themselves [9]. According to the users' daily activities, project possibilities are defined and, in this way, constant changes are made between architects and users for the progress of the project.

In this way, the infographic (Fig. 1) seeks to demonstrate, briefly, the intention of the research to use the Co-design as a set of collaborative methodologies that seek to centralize the visually impaired people in the design process so that their preferences are extracted from normative parameters in relation to the tactile floor. It also demonstrates that using the strategy of Design Science Research, according to Ref. [10], is aimed at the creation of artifacts as a way to operationalize prescriptions for specific problems, it will be possible to propose a design tool. This tool will be elaborated by the equalization of all the variables of the research: the technical norms, the preferences of the visually impaired people, the tactile floor and architects.

3. Preliminary Results

3.1 Equalization in Theory

The first step in equalizing research was an in-depth study of legislation addressing the rights of the visually impaired in the built space. Thus, through research of legislative references the evolution of the guarantee of the right of accessibility in Brazil was studied. This was important because it provided a consistent theoretical basis to analyze the situation that the regulations currently seek to promote

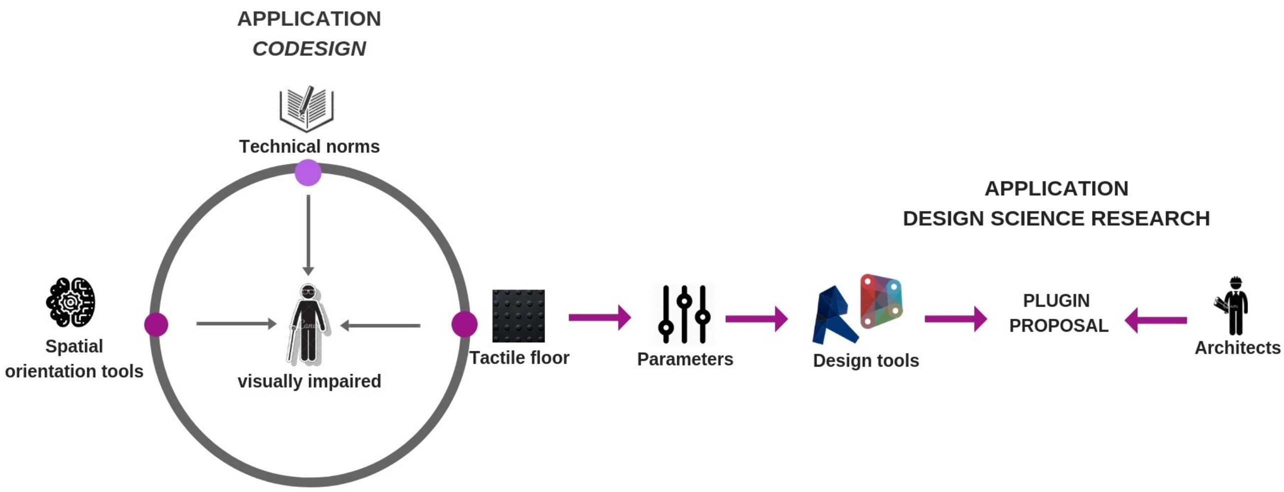

Fig. 1 Methodological process used by the research.

accessibility in spaces for the visually impaired, as a consequence, the most analyzed norms were those that mention the tactile floor, in particular the Brazilian technical standard NBR 16537 [11].

Subsequently, by deepening knowledge about the origin of the tactile floor, its use as an element of spatial orientation for the visually impaired and its effectiveness for the purpose for which it is proposed in the projects, some issues began to become prominent. At the beginning of the research interest in the study of elements of spatial orientation for the visually impaired, besides Brazil, soon was configured by the United States due to the fact that the country is the cradle of the term “barriers free design”, which gave rise to the concept of Universal Design, a concept known as a design concept that seeks to include people holistically and not a project that is designed to cover special needs.

Then, it was begun by the initial research that the country used the tactile floor of alert only in some specific points and did not use directional tactile floor, as it happens in several places of the world, like Brazil. This being the element of greater popularization as a way of inclusion of the visually impaired in the constructed spaces, we questioned the reasons why this element is little explored by the country for later identification of which would then be the elements used for the orientation of these people. Added to that as a result of exploratory studies of other types of spatial orientation tools also identified that the country has the main programs of orientation and mobility for visual world disabled and is home to research universities such as the Massachusetts Institute of Technology, which have specific laboratories to study and understand the spatial orientation processes of blind people [12, 13].

With these questions, we began the survey of specific data to understand how the accessibility of built spaces happened in the United States and Brazil, so that one could characterize the reasons why these differences are configured and, identify parameters that can add knowledge in the elaboration of the plugin. The answers to all the questions are found in Schwartz’s research [14], which states that changing the country’s perspective so that people with disabilities cease to be segregated from society and that the country gains a position as a world model for the theme were supported by socioeconomic explanations. It also explains that the large number of income assistance programs and other forms of direct assistance for persons with disabilities, including support for rent payments, consisted of a transfer of wealth aimed at compensating these people for the presence of some kind of which generated great costs for the government.

O’Leary et al. [15] argue that this economic or cost-benefit argument has been more strongly reflected in the various professional rehabilitation programs adopted for people with disabilities in the United States. Most of the legislations that introduce them, establishing the right to employment and access to all sectors of society, were approved with the aim of improving individuals’ ability to generate economic activity and higher personal income for themselves. All these efforts were directed both at increasing the workforce in the country and at curtailing income-aid programs.

Thus, with this incentive for people with disabilities to actively participate in society, O’Leary et al. [15] demonstrated that different national defense organizations of the visually impaired in the United States had conflicting views on the need to use the floor tactile. The National Federation for the Blind in contrast to the American Council of the Blind and the American Foundation for the Blind was not in favor of the use of tactile floors because they claimed that these surfaces being widely used would lead the visually impaired not to persevere in their learning orientation and mobility.

These divergences between countries in both the trainings used for these people to effectively participate in society as well as the different public policy incentives have led the United States to have several spatial orientation elements and tools that make the tactile floor of little alert used and directional, never been used by the country. All the differences found, as well as the features and elements that are used by the country that serve the function of guiding the visually impaired in the constructed spaces are being taken into account for the elaboration of the plugin and will be inserted in the programming, even if in the form of texts, so that the architect possesses greater plurivalence of knowledge at the moment of inserting the tactile floor in the project.

3.2 Equalization in Practice

Another determining factor in the search for equalization is the methodological strategies used to effectively approximate the visually impaired so that, in practice, one can understand how these individuals relate to a given environment. The chosen method was the Accompanied Walk (Fig. 2), which seeks to learn the user's expertise from concrete situations experienced by them, evaluating their difficulties and facilities to use the spaces appropriately. These strategies allow the researcher to identify elements that are not included in technical norms, such as determining their preferences for locomotion, which are the main beacons that are used by them, and whether the tactile floor actually contributes to these displacements. It was important for the research to clarify the concepts of spatial orientation and perception about the processes of understanding orientation and mobility of the visually impaired in the space constructed as a whole.

3.3 Plugin Programming

With the results already obtained from the previous equalizations the plugin will focus on the common element between the technical norms studied, Brazil and the United States, which will be the tactile floor alert. This choice was also chosen because, due to the preliminary results obtained with the practical equalization strategies presented previously, it is already assumed that the directional floor does not have a contribution in the participants' displacements since, even when identified, it is disregarded and replaced by other elements beacons.

The first step in defining the plugin's activities was to specify what their general features would be. Thus, through the "sort project view elements" feature (Fig. 3), Autodesk Revit will select all families that are required to search for parameters as prescribed by NBR 16537 [11]. The main design groupings necessary for the insertion of the tactile floor will be those composed by the door family; family of elevators and lifting platforms; family of stairs, ramps, including their steps; family of stairs or mats, family of equipment for use, service or service; and finally, families of suspended elements that should be classified as any type of element within the project that has a height between 0.30 and 2.10 meters. At this point, the tool must already scan to detect beacons in the design, such as vertical surfaces that could already serve as a guide. These are the key elements for verification.

The most effective strategy was to start by the routine that intersected the geometries (Fig. 4) necessary to remove the width parameters of the element category

Fig. 2 Application of the co-design by means of the accompanied walk methodology.

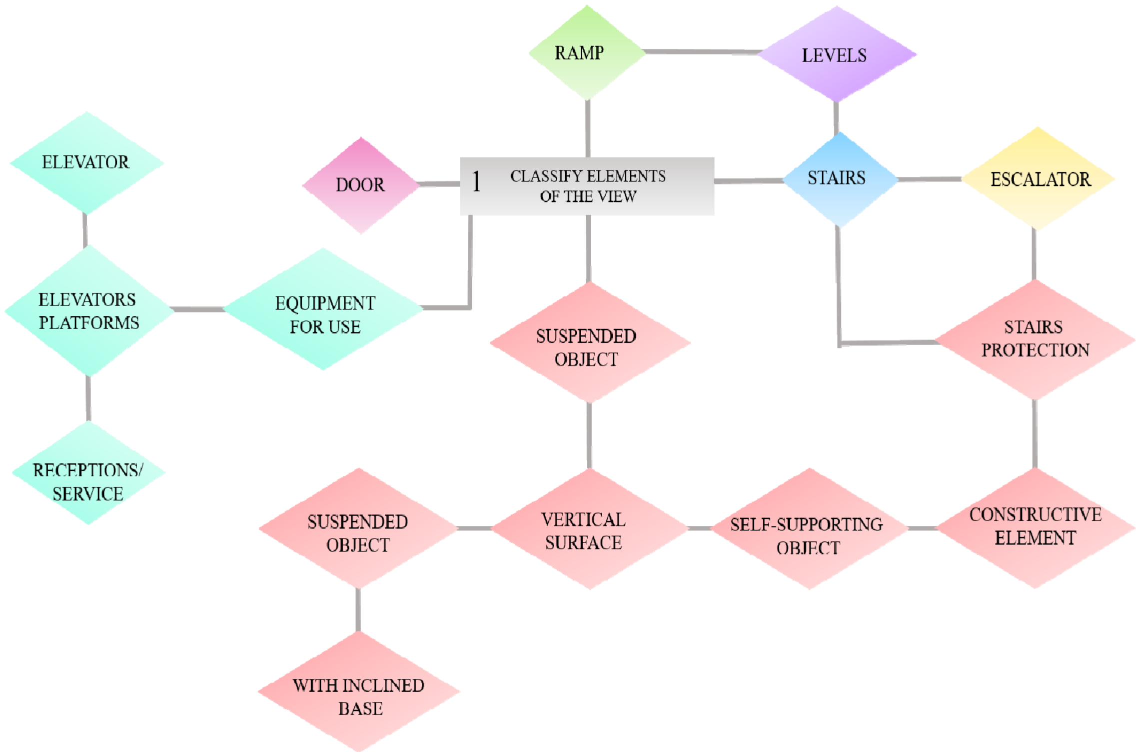

Fig. 3 **Functionality that sorts the elements of families in the project view.**

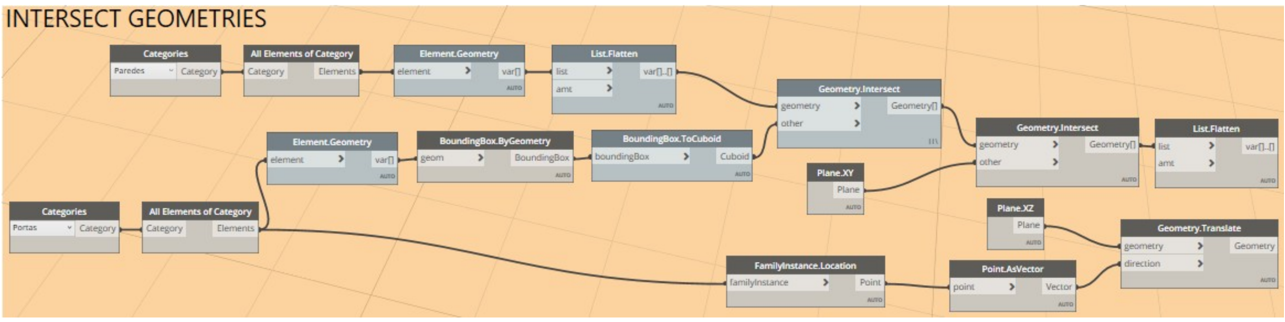

Fig. 4 **First routine to intersect geometries.**

selected by previous functionality (doors, stairs, ramps and elevators, etc.). Due to the routine being performed with varied scenarios for each element category, the article presented will demonstrate the execution of the routines used to insert family of tactile floor alert into a door. The routine starts by creating two planes (x, z) from the selected base reference geometries. The base references for the doors, for example, will be the category of elements that contemplate the walls, because only from this intersection it is possible to identify the parameter of width, necessary for delimiting the points per vector, resulting from geometry translate, which uses vectors to translate geometry. For lifts the same reasoning is followed, however, because stairs and ramps are not necessarily inserted in the design environment related to the wall, the most appropriate strategy will be the intersection of the element categories themselves with the reference floor.

The second routine (Fig. 5), however, seeks from the results of the points elaborated by the previous routine, inserting a reference line between them for the placement of the tactile floor family. This routine will be the one that will contain the parameters resulting from the practical equalizations with the visually impaired people, defining the family distance

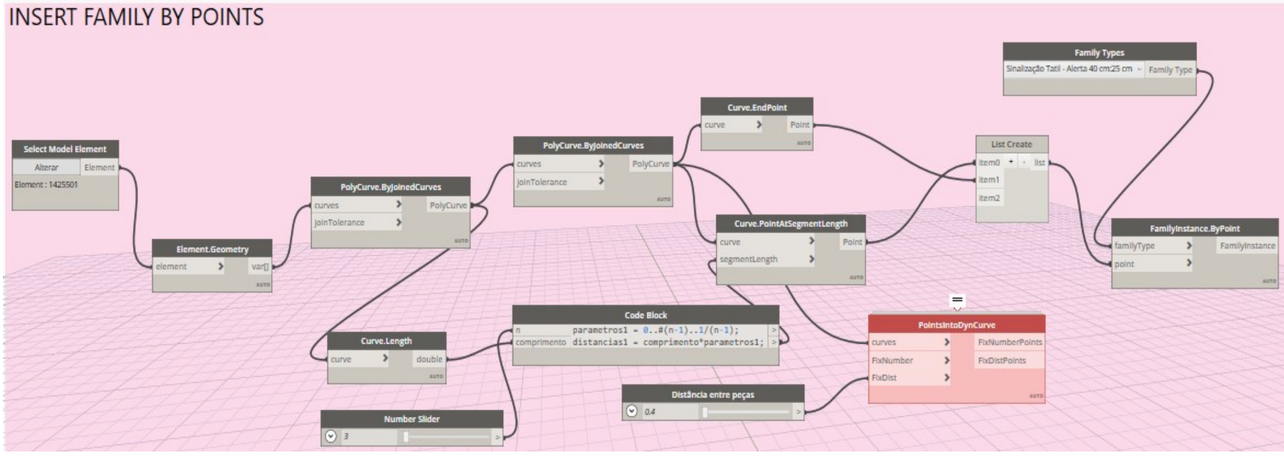

Fig. 5 Second routine to enter family by points.

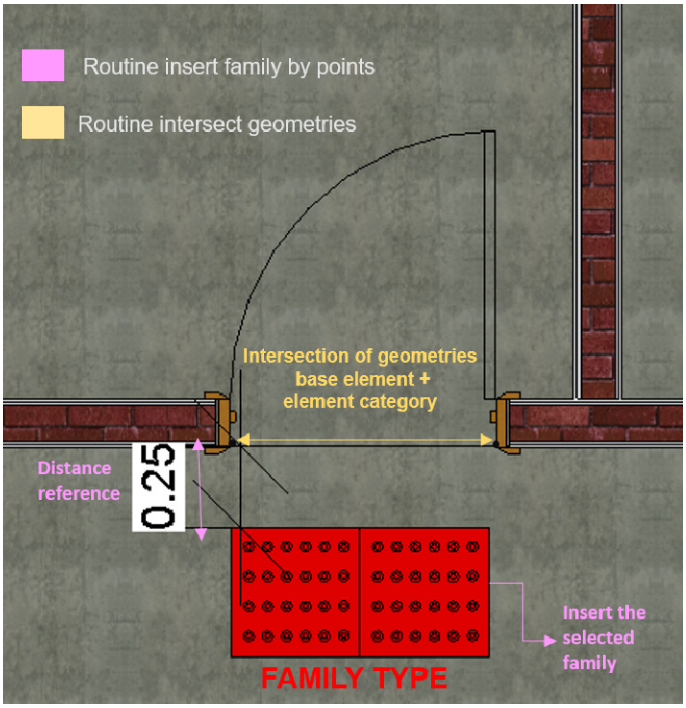

Fig. 6 Example of functionality by selecting the port category element.

in relation to the element, family characteristics, number of pieces and the distance between them. Due to the results of the accompanying tours, it is shown that the floor, although NBR 16537 [11] defines that it must have a piece width that is between 0.25 and 0.60 cm and that, consequently, it is up to the designer to define, the part of the tactile floor family that will be inserted by the plugin should be 40 cm wide, as it is the common denominator defined by the research participants as the ideal one.

The routine resulted in the identification of the points from the intersection of the geometries required for the specific element category (ports) so that the insertion of the family type, with parameters of width and dimensions, is specified by the plugin according to the preference of the disabled visual effects. These preferences will be at a reference distance of the guideline also preferable by them and with the possibility of adjustments for other situations like stairs, ramps and elevators (Fig. 6).

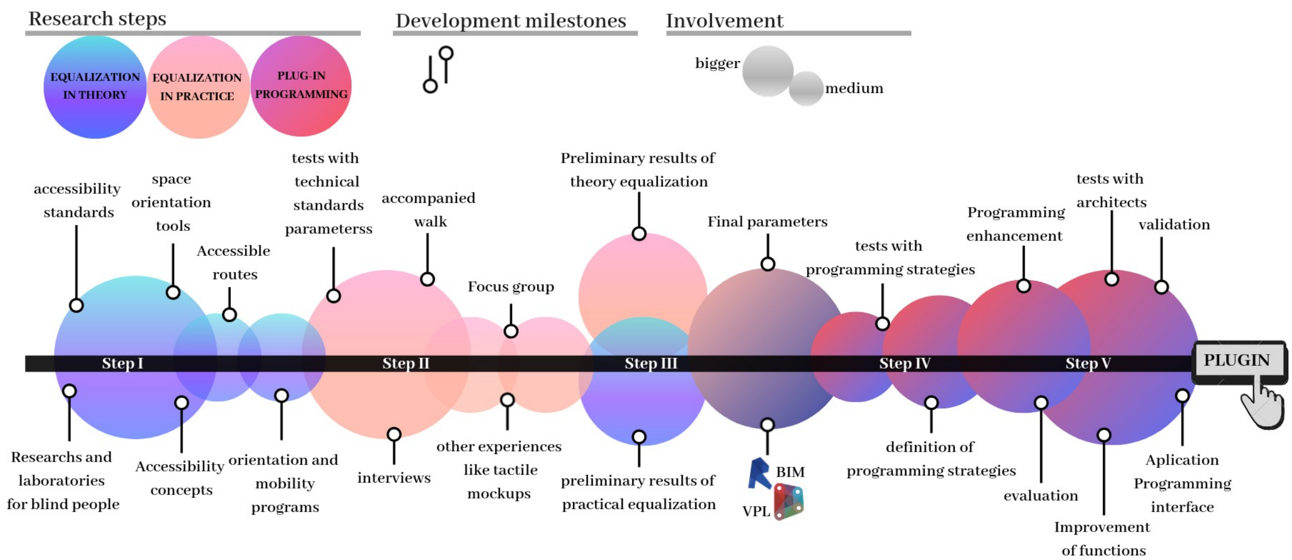

Fig. 7 Stages of research.

3.4 Future Stages

The research, as demonstrated in the course of this article, has already defined programming strategies and will continue to stage V (Fig. 7). This step will consist of programming improvements, application testing to verify its use by designers and the realization of the plugins interface.

4. Conclusions

The low quality of projects that include elements for the guidance of visually impaired people in Brazil is often related to an unstructured methodology in which important aspects such as the real needs of this group and the human-environment relationship are neglected by others. Therefore, to identify parameters applicable to programming that are capable of exploring new solutions in designing projects that focus on the human-environment relationship, using BIM tools can be a way, while optimizing time during the process project by reducing repetitive manual activities, it becomes possible to insert elements that go beyond what is described by the Brazilian accessibility norms.

In addition, it is also expected that the research will demonstrate an efficient way to search for the inclusion of the visually impaired in the design process, based on the methodology of the collaborative project/Co-design allied to the methodological strategy of Design Science Research.

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