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Process of construction of the guiding dimensions for interactive school projects: the basis in the spatial perception of students with visual impairments

Abstract

The theme of this article is the Spatial Perception, investigated from the perspective of school projects focused on students with visual impairment of Elementary School, whose studies started in the Master course, culminating in the conclusion of a Doctoral Thesis of one of the authors. The objective is to demonstrate part of the process of construction of the Guide System of Interactive Projects, essentially the structuring of the guiding dimensions of one of its basic structuring elements, Spatial Perception. Focused on its purposes, the research was carried out, under a systemic process, in three steps: Conceptualization, Structuring and Legitimation, guided by Interaction Design and application of research techniques, such as Content Analysis and Concept Analysis. The Guiding Dimensions, based on multisensory perception are aligned with the proposal of Interactive School Projects, which have as a product, the physical space treated as an Artifact System. The research notes the importance of Spatial Interaction in school projects, proposing results that favor readers interested in the subject and phenomenon addressed. It contemplates the researchers and professionals involved in the planning of school physical spaces, observing the SP as a guideline for school projects that seek to benefit School Inclusion, as well as those who wish to use the theoretical and methodological guidance of this research to address other contexts.

Keywords

Spatial perception. Spatial interaction. Students with visual impairments. Interactive projects. School inclusion.

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PROCESSO DE CONSTRUÇÃO DAS DIMENSÕES NORTEADORAS PARA PROJETOS INTERATIVOS ESCOLARES: A FUNDAMENTAÇÃO NA PERCEPÇÃO ESPACIAL DE ALUNOS COM RESTRIÇÕES VISUAIS

Resumo

O tema deste artigo consiste na percepção espacial, investigada sob a ótica dos projetos escolares focados em alunos com restrições visuais do Ensino Fundamental. Também pretende demonstrar parte do processo de construção do sistema norteador de projetos interativos, essencialmente, a estruturação das dimensões norteadoras de um dos seus elementos constituintes basilares, a *percepção espacial*. A pesquisa foi concretizada em três etapas: Conceitualização, Estruturação e Legitimação, orientadas pelo *design* de interação (DI) e aplicação de técnicas de pesquisas tais como a análise de conteúdo e análise do conceito. As dimensões norteadoras, fundamentadas na percepção multissensorial estão alinhadas à proposta dos projetos interativos escolares, os quais possuem como produto, o espaço físico tratado como sistema de artefatos. A pesquisa observa a importância da interação espacial em projetos escolares, considera os pesquisadores e os profissionais envolvidos no planejamento dos espaços físicos escolares, observando a percepção espacial como diretriz de projetos de escolas que buscam beneficiar à Inclusão Escolar, bem como, aqueles que desejem utilizar a orientação teórica e metodológica desta pesquisa para abordar outros contextos.

Palavras-chave

Percepção espacial. Interação espacial. Alunos com restrições visuais. Projetos interativos. Inclusão escolar.

Introduction

This article shows part of the results and the trajectory of the research carried out in the master's and doctorate courses of one of the authors, applied at the time in the post-doctoral research underway at the Federal University of Santa Catarina (UFSC). It deals with the investigation that culminated in a theoretical and methodological basis to support interactive projects (IP) of elementary schools. This focus is justified due to the lack of spatial solutions for students with visual impairments or, when they exist, many of them do not meet the minimum required by legislation and standards or guidelines of specialists. There are still resources in projects that do not support the use, in their entirety, or suffer from a lack of characterization of their functions, due to the lack of knowledge (attitudinal barriers) on the part of educators or those responsible for schools.

This is not an exclusive reality of education, as it is widely observed in other sectors, in which this condition should act as an important design guideline, such as health services and health interest (in the case of schools). The lack of construction or the construction without foundation of "resources" that should constitute assistive technologies (AT)[1] was found in numerous visits and observations made during the conduct of this research in schools, notably for students with visual impairments (SVI) (KASPER, 2007, 2009, 2013). Often caused by the lack of knowledge of designers and the absence of design guidelines adequately grounded for designing schools, emphasizing the specificities of this service and the spatial inclusion of its students, or focused unilaterally on standards and legislation, without considering the multidimensionality of these projects.

Thus, the research evolved to consolidate the *Guide System of Interactive Projects* (Portuguese acronym: Sinpi) for SVI, treating the physical space in a systemic way, considering a set of artifacts (spatial elements), which integrate it (KASPER, 2013). Artifacts comprise communication, signaling, guidance, mobility and security resources. The AT that facilitate or encourage the autonomy of this student indicate an organization based on the needs of users and according to the demands of schools, activities originated by pedagogical practices[2], comprising compositional elements of environments and technologies that can be incorporated into them. For the constitution of the artifact system, the proposal for a high-depth investigation, demanded by the existing gaps, sought to know the core of the problems highlighted, as well as to contribute to the construction of knowledge.

In this article, an excerpt of the research is approached, having as its investigated theme, *spatial perception* (SP) and its importance in the interaction

[1] In Ordinance No. 142 (BRASIL, 2006), which establishes the Technical Assistance Committee (TAC), TA are defined as "an area of knowledge, with an interdisciplinary characteristic, encompassing products, resources, methodologies, strategies, practices and services that aim to promote functionality, related to the activity and participation of people with disabilities, disabilities or reduced mobility, aiming at their autonomy, independence, quality of life and social inclusion".

[2] In the study, in addition to the principles of Piaget and Vigotsky, pedagogical proposals adopted in Brazilian schools were investigated, such as the Waldorf and Freinet Pedagogy, the Montessori Method, the constructivist practice and the theory of multiple intelligences by Howard Gardner (NA).

of SVI with the physical space. The purpose of this article is to present the "Structuring Process of Guiding Dimensions of the SP, relevant to support Elementary School IPs for SVI", therefore, not being focused on their application, but on their construction. The dimensions consist of an important segment of each research area investigated and constituent of the Sinpi[3], which propose to guide the fulfillment of a purpose to support the performance of activities with autonomy, meeting the needs and specificities of SVI demand, being aligned to the actions for access, use, perception, understanding and appropriation of the school space by the student in question.

Its problematic considers the definitions, practical and theoretical applicability of the research, conjecturing about "how to structure Guiding Dimensions of the SP, applicable in interactive school projects for SVI in elementary education?" Due to the question asked, a theoretical framework was constructed, with research in important areas of knowledge identified in the exploration step of the research. In the case of the SP, it was necessary to research and understand several of its founding theories, including multiple specialties and approaches, such as that of psychology, neuroscience, geography, architecture, art, engineering and digital sciences.

The directive guidelines offer conceptual-theoretical foundations, which can be broken down into other specific elements applicable in projects for different contexts. They provide a basis for the construction of various instruments, such as those for *post-occupation evaluation* (POE), preparation of *guides* or *conceptual maps* for specific artifacts or a system of these artifacts and support other research, in view of the lack of principles, guidelines or formally established SP design criteria, which can be used, according to the Sinpi's purposes.

Theoretical framework

A synthesis of the theoretical framework carried out for the research is presented, explaining about the state of the art and the different approaches of the SP, as well as the data on the deficiencies, mainly the visual, and the influences on the spatial interaction (SI) of SVI. Information from national and international databases was used, referenced by authors, legal and normative documents, guides, books, among others, which supported the investigation as a whole. The research process observed the existing gaps in knowledge, as well as the problems evidenced at the beginning of the research (master's degree), meeting Sinpi's objective and structural needs.

One of the findings was that the term "accessible" or "accessibility" and its implications (cited as an important need for inclusion of students with disabilities), did not include the multidimensionality of the issues involved in the SP of children and adolescents with visual impairments in school age, with the physical environment of schools. Depending on the restrictive or insufficient approaches, it was necessary to extrapolate to the minimum observed for "access", sometimes pointed out by documents and authors, or

[3] The areas surveyed, in total, for the construction of the SINPI were *Spatial Perception* (SP), *Inclusive School Architecture* (ISA) and *Usability* (U), with a focus on the SVI needs of Elementary School (SN).

required by current rules and legal bases. In addition, the mere exclusion of barriers to provide "accessibility" to the education, especially physical, for VSI, proved to be insufficient to support projects that valued the interaction of these students with the environment, including, that supported the guidelines of pedagogical practices. Important actions to "interact" proved to be indispensable and were strongly observed in the construction of the dimensions of the SP.

From this, the research was developed, considering the observations of the social model of disability (LARA, 2013; PORCIÚNCULA; BOTELHO, 2018; SCHINAZI, 2008) that perceives it (disability), as a result of the structuring (preparation) or the destructuring (unpreparedness) of society in face of it, assuming that the school physical environment can generate and accentuate situations of exclusion and, also, of inclusion. The person with disability (PWD) is considered "*who has a long-term physical, mental, intellectual or sensory impairment, which, in interaction with one or more barriers, can obstruct his/her full and effective participation in society on equal terms with other people*" (BRASIL, 2015, Art. 2). Promoting ways of including PWD in society is provided, including, in the physical environment, in the aforementioned law.

There are strategies to promote spatial inclusion, based on data on the characteristics of social demands, as noted in the *World Report on Disability* (ORGANIZAÇÃO DAS NAÇÕES UNIDAS, 2018), which reveals that there are more than one billion people with disability in the world. The incidence of physical or intellectual disabilities, in the Brazilian population, is 23.9% (45,606,048 people), with a percentage, in the range of 0 to 14 years, of 7% (IBGE, 2010). PWD visual covers the percentage of 18.60% of the total PWD in Brazil, followed by PWD hearing (5.10%), PWD motor (7%) and PWD mental (1.40%). Of the more than 6.5 million PWD visual, 6,056,654 have low vision (great and permanent difficulty in seeing) and 29 million people have some permanent difficulty in seeing, even wearing glasses or lenses, in Brazil (IBGE, 2010).

Specifically, in the area of education, Law No. 13,146 (BRASIL, 2015, Art. 2) highlights actions aimed at the inclusion of the PWD, as "*constitutes the right of people with disabilities, ensuring an inclusive educational system at all levels and lifelong learning*", which is the subject of this article. It is assumed that schools that invest in interactive environments, because they are spontaneously inclusive and, based on ergonomic principles, tend to observe requirements that strengthen the student's communication with their environments. Such commitment highlights the important role of the school in the training of individuals, for a fuller and more productive life, including the training of SVI.

Brazilian inclusive education system, numbers and legal basis

The inclusive educational system, at different levels and modalities, contemplates the improvement of educational systems focused on access, permanence, participation and learning, guaranteeing the conditions for the actions described. It is important to mention the importance of AT, as they serve students with some kind of impairment under conditions of equality with their peers (BRASIL, 2015, Art.1).

Data from the *School Census* of the National Institute of Educational Studies and Research Anísio Teixeira (Inep) (2019), between the years 2014 to 2018, prove the increase in the number of PWD enrollments by 33.2% in Brazil. In the same period there was an increase from 87.1% to 92.1%, reaching 1.2 million students enrolled in 2018, mainly in the state (96.4%) and municipal (95.5%) networks of Brazilian schools (INEP, 2019). Preliminary data from the 2010 Census sample of the Brazilian Institute of Geography and Statistics (IBGE) (2012) indicate, in Santa Catarina, 993,180 people with some visual impairment. If the number of children and adolescents with different impairments to see is verified, it is assumed that a significant number of them are out of school for some reason, pointing out, a certain lack of preparation by schools to welcome them (access and permanence).

In the case of AT, many schools have them in a restrictive manner, observing, at least, the needs of students with motor impairments in bathrooms, ramps, handrails, etc. This situation falls short of fulfilling other demands arising from sensory or cognitive impairments, so that they benefit both the teaching-learning process and the interaction with the physical environment. The amount of PWD visual indicated by the IBGE Census (2010) and one of the goals of the National Education Plan (PNE) (BRASIL, 2014) warns about the importance of physical planning in schools, as a way to expand the conditions for inclusion of students with disabilities from 4 to 17 years.

In line with the purposes of this research, the PNE (BRASIL, 2014, Item 4.14) provides guidance on the quality of the schools' physical projects, emphasizing the incentive for the participation and permanence of PWD, through AT, highlighting the proposition of "*quality indicators and evaluation and supervision policy for the functioning of public and private institutions*". They consider those that shelter students with disabilities, global developmental disorders and intellectual giftedness, welcomed in appropriate spaces and accesses of the school "*that include universal design – design of spaces, artifacts and products - with the objective of simultaneously serving all people with different anthropometric and sensory characteristics*" (INEP, 2019, p. 14). The PNE (BRASIL, 2014) represented a great advance in understanding the educational needs of the PWD, exposing the relevance of "*identifying, elaborating and organizing pedagogical resources that eliminate barriers for the full participation of students*" (BRUNO; NASCIMENTO, 2019, p. 2).

Despite the efforts (legal, normative, increase of researches) in this field of knowledge, the reality of schools reflects a not so favorable situation, needing to progress in the provision of technologies that accommodate the diversity of students. This condition is observed in the studies of some researchers (CALADO; ELALI, 2013; GELLER, 2005; KASPER, 2007, 2009, 2013; ABATE; KOWALTOWSKI, 2017; LUIZ, 2013) focused on the assessment, diagnosis and propositions that can be used to improve Brazilian school physical environments. It is noteworthy that such researches observe the need to progress in the design quality of schools, especially for the SVI of the Elementary School (KASPER, 2007, 2009, 2013). Even though formal schooling and attendance at this level of education is guaranteed for the PWD (BRASIL, 2014), the insufficiency or inexistence of design guidelines that meet the needs

of SVI, especially those related to SP, constitute an obstacle to the achievement of the country's educational goals, which are one of the justifications for the development of this research.

Spatial perception and repercussions on the SVI interaction

To comply with the provisions of Brazilian legal bases and the expressive demand for SVI enrolled in public elementary schools, it is important that those responsible for their planning know and understand the different ways that these students interact with the physical environment and how the SI can favor its development. The SI focuses on the successive exchange of user information with the environments, and the conditions for this are usually not even foreseen in the schools' physical projects. There are mistaken solutions that do not effectively meet the perceptual specificities of SVI and the school context, nor are they treated in a systemic way, including observing the pedagogical guidelines. In addition, it is observed that, in practice, there is a tendency to base projects, unilaterally, on the user's impairments, disregarding the possibilities of contemplating their perceptual skills in design.

Perception is one of the most complex fields of research and one of the most neglected, its studies span time and involve several domains of knowledge, contemplating problems and methodologies originating in different areas of science (LEDERMAN; KLATZKY, 2009; SCHIFFMAN, 2005; STERNBERG; STERNBERG, 2017). For the exploration of the SP, in this study, there was an intense investigation of the different aspects that comprise it, also, about the diversity of interferences resulting from visual impairments (GIBSON, 1966; HALL, 2005; HOLZCHUH FRESTEIRO, 2000; MARTÍNEZ DE ARAGÓN *et al.*, 1998; STERNBERG; STERNBERG, 2017) that can support the elements of spatial composition in school projects.

Saffer (2010) emphasizes, as relevant, the contribution of different scopes of knowledge to obtain products with the necessary and adequate final quality. The author emphasizes the involvement of multiple disciplines operating harmoniously, allowing performance in overlapping spaces, which form areas of great practical achievement, involving architecture and ergonomics, for example. Except for the ergonomic guidelines and school architecture, the SP demands investigations that observe their quality, with regard to the "*study of the behavior, performance and preferences of children in different age groups*", (VASQUEZ; PEREIRA; KUHNEN, 2018, p. 12) to design schools.

For Vasquez, Pereira and Kuhnen (2018), researchers show interest in the characteristics of school environments as a way to understand the relationship of students with the learning process. Based on what was exposed by the authors, it is assumed that designing schools without understanding the needs and skills of SVI can imply restrictive school environments, which tend to rationalize movements and dependent displacement. The limitations of the visual system can also have a decisive impact on socialization, participation in daily activities and later, adult life and access to the labor market (ALEGRE, 2001; BRASIL, 2005; CONDE, 2017).

Another issue refers to the behaviors adopted by the PWD visual in known or unknown spaces, because in their movement they receive messages from their bodies, stabilizing the "visual world", using tactile and auditory information to complement the information coming from their visual residues (ABATE; KOWALTOWSKI, 2017; GIBSON, 1966; HALL, 2005; HOLZCHUH FRESTEIRO, 2000; MARTÍNEZ DE ARAGÓN *et al*., 1998; STERNBERG; STERNBERG, 2017). Along with them, the known sounds, smells, touches are added, even if their generating sources are not being visualized or precariously visualized. People with low vision or even those with blindness (who use visual residue) commonly perform such processes (HALL, 2005). There is also an influence on the type and quality of information, which can be obtained by tactile, auditory and proprioceptive means, allowing the performance of actions or activities with dexterity and in a reduced time (MENEZES, 2007).

It is important to focus on the possibilities of processing visual information (residue), guided by active (intentional) and passive (unintentional) perception, combined with the use of the other sensory channels in a combined way. The example of information from skin pressure receptors that is coordinated and combined with another type of information, called kinesthesia (SCHIFFMAN, 2005), is cited. It is understood that the well-planned architectural work, supported by a system of spatial elements (artifacts) composing it, hat benefit the orientation and mobility, the recognition of environments and the choice of safe routes by the SVI, have a greater probability of success, as described by Cañas and Waerns (2001) and Saffer (2010). For this, a reliable design base can offer important subsidies, as there are important issues to consider. This is because elementary school students go through a process of building a repertoire of knowledge, capable of benefiting from pedagogical activities and guidelines.

In view of the complexity surrounding active and passive perception, specifically the apprehension of spatial clues by the SVI, building knowledge on this subject is essential, as the reflection of this condition points to the scarcity of reliable design guidelines with the potential to satisfy both physical and pedagogical dimensions. It is proposed to cross the barrier of projecting only based on the nature of school activities, combining the perceptual skills of SVI for Spatial Interaction. These are used in techniques, such as *orientation and mobility* (OM) and *activity of daily living* (ADL), even practiced in the school environment. Skills can be developed and benefited by the experiences provided to them, arising from multiple stimuli for the construction of a repertoire of diverse spatial concepts, acquisition of experiences and skills important for their maturation.

Spatial interaction and the artifact system

The interaction is about an event highlighted by pedagogical practices, emphasized by the theoretical framework built in the exploration step of this research, figuring implicitly and explicitly in the investigated documents. The

beneficial results of SI guide the premises of inclusive school projects, based on the guidelines of pedagogical practices, encouraging SVI communication with those involved in this process: the physical environment and people. Some actions guide interaction in the organization and in the spatial configuration, providing the conditions to "*perceive, understand, access, use and appropriate*" the surrounding environment (KASPER, 2013, p. 32). The SI, in turn, consists of the "*communication process between user-physical environment, mediated by a set of multisensory perceptible artifacts, capable of supporting the construction of the cognitive map*" and the performance of actions, previously described (KASPER, 2013, p. 32).

The perceptual process has a fundamental role in the SI, implying in understanding the different ways that the user uses in communication and performance in school environments. In projects focused on interaction, the SP deals with the "*process of recognition, organization and understanding of multisensory information from the space, provided by an artifact system that compose it, aimed at supporting human 'performance'*" (KASPER, 2013, p. 261 emphasis added).

Figure 1 shows how SP can be planned in the prediction of AT and other elements of spatial composition (artifacts), considering the different human sensory channels operating in a combined way. Sinpi advises that spatial characteristics favor pedagogical dynamics, and therefore the relationship/ communication between the environment and the technologies employed (artifacts). In the research, two essential types of interactions were identified: those provided between artifact-user and between artifact-artifact, treating them in an "*artifact system*" (Figure 1).

The levels of interactions verified in Figure 01, the primary, user-artifact (interface) and the secondary, artifact (interface) -artifact (interface), provide the harmonic functioning (interferences and interdependencies) of these subsystems, a condition highlighted by Cañas and Waerns (2001) and Schinazi (2008). In the case of the primary subsystem, it considers the performance of specific tasks with the artifact (and its *interface*) or more than one artifact by the user (SVI). In the secondary subsystem, it considers the

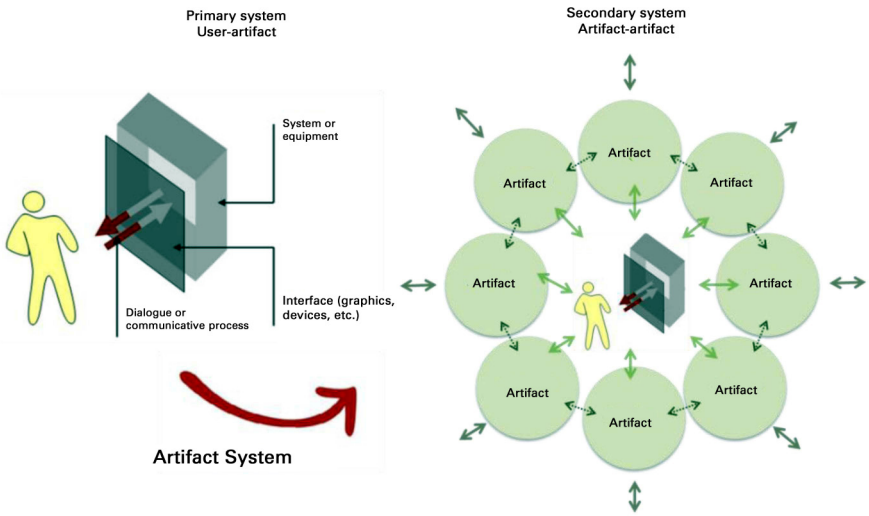

Figure 1 – The interactive school space treated as an *artifact system*
Source: Based on Kasper (2013).

harmonic functioning between the artifacts present in the physical space, so that they are designed respecting the possible interferences of each other or, their interdependencies in functionality and interference in the other level of interaction (user-artifact). The interface, as the point of contact between the user-artifact and the environment, through which the individual inserts and receives the information to perform the described actions, must present a response, in view of the visual, tactile or audible inputs, which will provide a output to the user. The output (response) must be perceptible to the SVI.

The system proposes to provide information that allows the recognition of access to accessible environments and routes, for example, using resources such as shapes, textures, contrasts and sounds, in a combined way, through the artifacts and their interfaces. The information captured by the SVI' remaining senses proposes the investigation of the levels of interaction (Figure 1) based on their perceptual characteristics, to propose strategies and elements necessary to consolidate them in the artifacts. The remaining senses of SVI with blindness and low vision, consist of immediate receptors (touch) and remote receptors (hearing, smell and visual residue) (GIBSON, 1966; HALL, 2005; HOLZCHUH FRESTEIRO, 2000; LIDWELL; HOLDEN; BUTLER, 2010; MARTÍNEZ DE ARAGÓN *et al.*, 1998; STERNBERG; STERNBERG, 2017). These senses would be used to perceive the organization or reorganization of the artifact system, in addition to the demands or possible changes in the requirements of the schools, such as the increasing number of admitted SVI and the new technologies that can be added. The possibility of "experiencing" and reliably understanding the environment allows the acquisition of experiences and the expansion of skills, favoring the coexistence and development of social and intellectual skills of students. Provided by the disposition of the artifacts, the reading of the environmental events and the spatial arrangement of the school can be accomplished by the integration of sensations, both in active and passive perception.

Methodological foundations

The process of building the dimensions of the SP is exposed, and sometimes its contribution is mentioned in the formation of the Sinpi and the relations with the other areas that constitute it [Inclusive school architecture (ISA) and Usability (U)], through of the methodological basis, to obtain the guiding elements of the project in this field of knowledge. To cover the two levels of interaction (Figure 01), the systemic approach considered the simultaneous construction of the dimensions of the three areas (ISA and U) of the Sinpi. So that the SP was aggregated, observing its relevance and its interferences in each area, according to the guidance of authors, such as Cañas and Waerns (2001), Schinazi (2008) Preece, Rogers and Sharp (2013).

The philosophical basis of this study is structuralism, which, from a systemic perspective, proposes to verify "*the relationships between the elements that make up a process in the explanation of a phenomenon*", aiming to generate scientific knowledge about the "*causes (inputs) and effects (outputs) of a given process*" (PACHECO JÚNIOR; PEREIRA; PEREIRA FILHO, 2007, p. 48). Two research

methods were adopted: the descriptive, covering the description, the record, the analysis and the interpretation of current phenomena; and the deductive, focusing on the state of the art, covering the declared theme and phenomenon (MALHOTRA, 2019; RICHARDSON, 2008). This, to obtain the dimensions of the SP, observing the construction criteria defined in this research. The qualitative nature of the investigation presents complex or specific situations as the object of verification (CERVO; BERVIAN; DA SILVA, 2007; GIL, 2008; MALHOTRA, 2019). It identifies "the presence or absence of something", presenting itself as an attempt to understand in detail the meanings and characteristics of the research phenomenon (MATTAR, 1997, p. 77), which involves the guiding dimensions of the SP, applicable in school IP for elementary school SVI. Due to its low amplitude and high depth, it is characterized as a case study, which seeks to unveil complex social phenomena inserted in a context that needs investigation (BOUGIE, 2016; KASPER, 2007; 2013; SEKARAN; YIN, 2015).

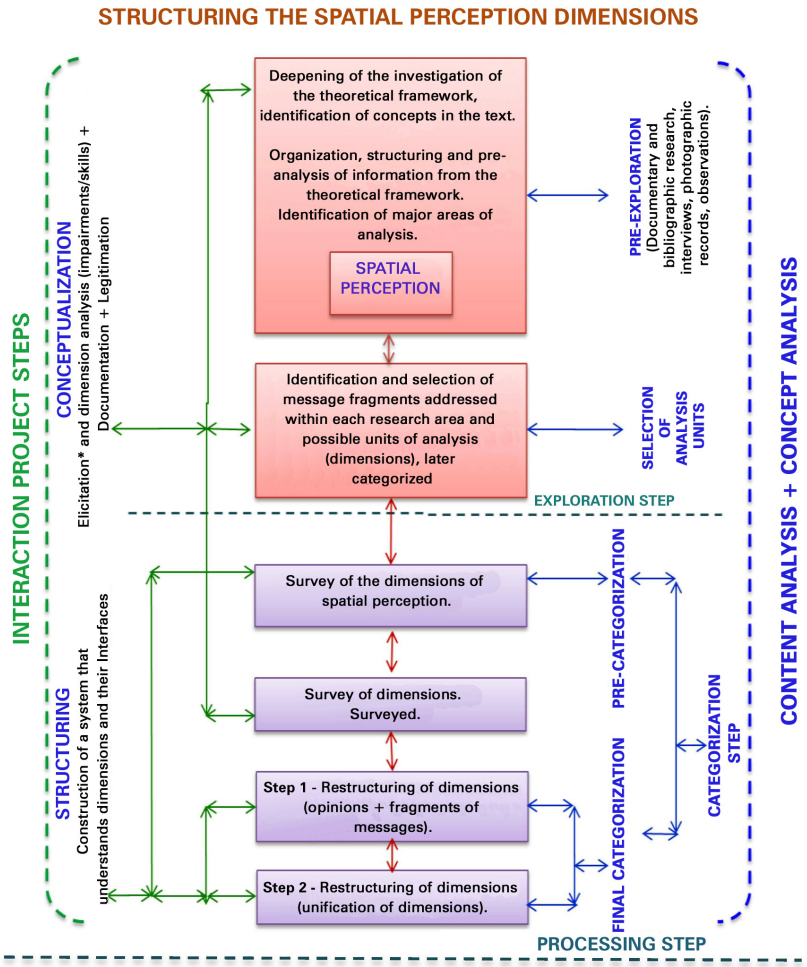

Figure 2 – Scheme of the methodological design of the research
Source: Adapted from Kasper (2013, p. 36).

Research techniques such as documentary and bibliographic research in secondary sources were used. The investigation stands out from the founding theories and approaches of Perception and SP, including the absence of principles, guidelines or design criteria, formally established in this area, which can be used according to the purposes of the Sinpi and, consequently, the dimensions of the SP. For the survey of the most representative guiding dimensions of the SP, the content analysis guidelines were mainly followed (Figure 2), which consists of a set of research and communication analysis techniques, which uses systematic procedures, aiming at the description of the content messages and indicators (qualitative or quantitative) (CAMPOS, 2004; BARDIN, 2010; SILVA; FOSSÁ, 2013). It is guided by the production of inferences about the content of the messages, an action equivalent to the reasoning that induces the observer to draw conclusions; a logical operation in which a proposition is admitted in the face of an existing link with other propositions already accepted as

legitimate (BARDIN, 2010; CAMPOS, 2004; CAMPOS; TURATO, 2009; SILVA; GOBBI; SIMÃO, 2005).

There were also visits, observations, photographic records and filming, according to the authors (MALHOTRA, 2019; PACHECO JÚNIOR, PEREIRA, PEREIRA FILHO, 2007) in elementary schools and institutions located in the city of Florianópolis (Santa Catarina), for SVI attendance. During the research development process shown in figure 2, several original concepts were built by the rigorous application of the research techniques, mainly, the concept analysis (WILSON, 2001) and the content analysis (BARDIN 2010), under the guidance of the two, of the four steps proposed by the *interaction design* (ID Figure 2 shows the methodological scheme of the research:

Following the premises of the ID, interactive projects support people's daily activities, their orientations are based on projects of physical spaces that support the significant exchanges between user-space (PREECE; ROGERS; SHARP, 2013). Of the four steps proposed for the development of the ID, the first two steps (Figure 2) were addressed in the research and comprise identifying needs and "*establishing requirements*"; "*creating design alternatives*" that fulfill these requirements (PREECE; ROGERS; SHARP, 2013, p. 15). Conceptualization" and "Structuring" were renamed, respectively, as a way of making content analysis compatible, although maintaining the ID proposals for such steps, as seen in Figure 2. The last two steps proposed by Preece, Rogers and Sharp (2013), presentation of the interactive version or the prototype and the evaluation of the built prototype, were not addressed in the study, maintaining the reliability of the research proposal: build a theoretical framework for interactive projects that will serve as a basis for research that addresses the other steps. "Conceptualization" and "Structuring" were treated in a systemic and transdisciplinary way, differently from this area of knowledge (ID).

The construction of knowledge was privileged, avoiding to adopt rigorous steps for the application of the techniques, a condition observed by Campos (2004), emphasizing a triangulation: the construction of knowledge was privileged, avoiding to adopt rigorous steps for the application of the techniques, a condition observed by Campos (2004), emphasizing a triangulation the SP. Thus, the cycle (Figure 2) was concluded by information from the experts' opinions, both from the legitimation of the dimensions (assessed in the pre-categorization), and from the Sinpi (Figure 2).

The scheme in figure 2 details this process, demonstrating the obtaining of information regarding the explicit and implicit dimensions of the theoretical framework, the formulation and reformulation of the terms and concepts of the dimensions of the SP, through the combined application of the main research techniques (ID, content and concept analysis). We tried to maintain the definition of dimensions faithfully in its initial construction process (Figures 2 and 4). The methodological design scheme presented in Figure 2 presents the fulfillment, mainly, of the two steps of the ID (Conceptualization and Structuring) in line with the combined application of the research techniques

(content analysis: pre-exploration; selection of analysis and categorization units), highlighting two main steps:

– *Exploration step*: conceptualization step (ID), and Pre-Exploration and Selection of Analysis Units (content analysis) steps and the identification of the three areas of approach (SP and other areas) of the SINPI.

– *Processing step*: structuring step (ID) of the Guiding Dimensions and Categorization (content analysis), legitimizing the Dimensions.

In the Conceptualization of the Exploration Step (Figure 2), the application of the content analysis technique was observed according to Cervo, Bervian and Da Silva (2007), Campos and Turato (2009) and Bardin (2010), referring to the pre-exploration of the surveyed content. In this step, the reading of all the researched material followed, without the commitment to systematization, but aiming to apprehend the guiding ideas of the SP and its meanings. Inferences, analysis and interpretation of the characteristics of the messages were made, anchoring them to their references (authors, rules, guides, etc.). The analysis of the concepts of Wilson (2001) and Campos (2004) was applied to elect the terms that define the dimensions, aligning them to the historical and social context of insertion of research. The pre-exploration of the content and the construction of the knowledge proposed by the triangulation already informed, guided the adoption of differentiated steps (fragmentation) for the Categorization of dimensions (Figures 2 and 3), adjusting to Campos' recommendations (2004), and to apply the steps of space ID (PREECE; ROGERS; SHARP, 2013; REBELO, 2004).

Still, in the Conceptualization, Selection of Analysis Units step (Figure 2), the information was organized, adjusting the terms to their definitions (concepts) or categories, without a predetermination of the possible dimensions to emerge (SILVA, GOBBI, SIMÃO, 2005). The text excerpts with the dimensions were clearly shown, trying to organize them, in line with the proposal to build the Sinpi. The limitation of up to 22 dimensions, accepted by the specialists (pre-categorization step) verified those with the potential to represent, faithfully and synthetically, the SP knowledge (SILVA; GOBBI; SIMÃO, 2005), and some guidelines for this selection were chosen (and judged by experts), emphasizing:

– Observe the relationship of interdependence, or even, of interaction between the important elements to ensure the functionality of the artifact system (and the levels of interaction shown in figure 1).

– Survey the relationships and interdependence more aligned to the research objectives, that is, to the SVI' specificities for interaction with the school context;

– Consider the systemic construction of the theoretical framework, evidencing already in the survey of dimensions, the relationships and interdependencies between them, due to their connections and due to the similarity of the semantic content and contexts of the defining terms;

– Consider those most relevant from the point of view of the theoretical framework researched within the areas analyzed to build the Sinpi.

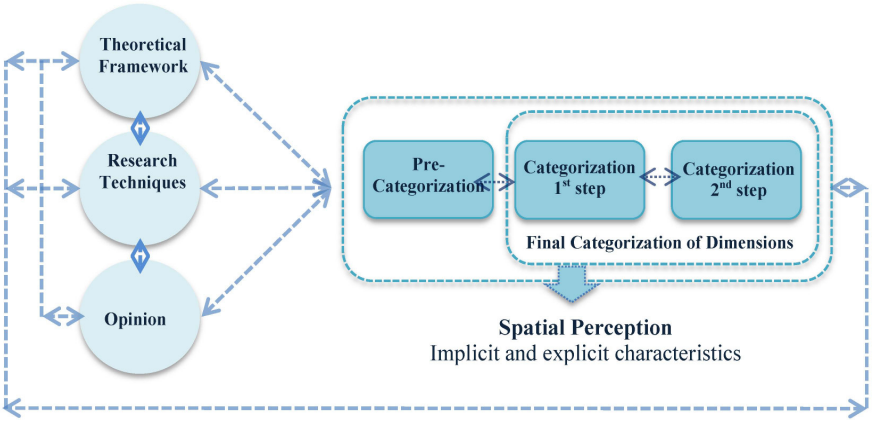

Figure 3 – Systemic approach to categorize the dimensions of spatial perception.
Source: Prepared by the author (2020).

This was followed by the preparation of summary tables of the contents to assist in the ordering and visualization of information from the theoretical framework, including relating them to their authors. An example of these was the table that represented one of the founding theories of the SP, *Gestalt*, which organized first the excerpts of the contents and the fragments of messages, from which the first dimensions were extracted (Organization, *Prägnanz* (Simplicity), Experience, Systemic View, Meaning and clearly explained. The dimensions implicit in the message fragments were analyzed in the other areas (ISA and U), despite having been addressed with greater emphasis on the final categorization (first and second step) (Figures 2 and 3), under the guidance of the experts' opinions.

The election of the units of analysis covered the deep appreciation of the message fragments, considering them in view of the described selection criteria, maintaining the reliability, relevance, validity and significance of the knowledge related to the SP for further categorization (Figure 3).

Figure 3 shows, from the triangulation already described (*Theoretical Framework*, application of *Research Techniques* and the guidelines of the experts' *Opinions*), the complete categorization process of dimensions: pre-categorization and final categorization. Initially, it demonstrates the pre-categorization of the dimensions and concepts evidenced in the system's input, in the literature by its authors. After that, the final categorization covered two steps, in which the Conceptualization and Structuring of the System overlap (Figure 2), with the characterized dimensions emerging, considering the degree of intimacy or proximity between them.

In the pre-categorization of the dimensions of the SP, the concepts and terms contained in the theoretical framework were extracted, as cited by their authors, considering the frequency in the content (quantitative), the interpretation of the information and the understanding of their characteristics or of their whole. The number of dimensions sought to provide, to the conceptual-theoretical basis, the support and structure necessary to carry out the following steps of the Sinpi's research and construction, and a set capable of meeting the expectations of the specialists working in the areas addressed.

The pre-categorized SP dimensions were documented and presented to the specialists, with the respective meanings referenced, in addition to a

justification about their approach, and explanation of their relations with other Dimensions (of ISA and U), constituting the: *'Affordance'; Learning; Attention; Categorization; Cognition; Environmental Cognition; behavior; Diversity; Stimuli; Experience; Skill; Intelligence; Language; Cognitive map (construction of); Memory; Guidance; Perception;* Simplicity*; Problem solving; Meanings; Wayfinding*. After the analysis of the dimensions of the SP by two specialists, opinions were prepared, based on criteria set out in the Legitimation Script, of which some considerations are outlined in the Results and Discussion of Research item. The process of legitimizing the Guide System of Interactive Projects was carried out in two steps, in which we sought to obtain the opinion of experts about its structure in these two distinct moments. The first step of legitimation (addressed in this article, in relation to the SP) occurred in the Conceptualization of the project, in relation to the Guiding Dimensions of the SP, ISA and U, categorized (Step1), by four specialists, to proceed to Step 2 of Categorization (Figure 2). The second step of legitimation covered the Sinpi, being carried out by a specialist with knowledge of the three areas, not being addressed in this article.

Legitimation followed the guidelines of Cross, Borgatti, Parker (2001), related to the ability to relate respected sources to support decisions, to increase the credibility of proposals for possible design solutions. The Guiding Dimensions of the SP were presented to two specialists following the representativeness criteria described by Rajendran (2006): having a high degree of objectivity and rationality; have good performance in their area of operation and; having time available to participate in the research, considering the effort required to do so. Support material for Legitimation was presented: Legitimation Script and documentation of the set of Guiding Dimensions surveyed (concept, reference and justification about the importance of its application in interactive school projects). The Legitimation Script sought to guide the elaboration of the experts' opinion based on criteria that supported the judgment, the acceptance and the declaration of the legitimacy of the SP dimensions, by two specialists, were elected based on Cross, Borgatti and Parker (2001) and Medeiros (2012). They consider the relevance and originality; credibility; transferability (viability to practical application and interpretive representation); methodological, theoretical, technical, constructive consistency and contextual representation, formalizing the basis for the Opinions.

In the first step of the final categorization, after the experts' evaluation, other dimensions that were implicit in fragments of messages were added to the set of pre-categorized dimensions, with the guidance of the legitimizers. These were not clearly defined and conceptualized in the literature, as well as their defining terms, later confirming other *Interfaces* with the other investigated areas (ISA and U) of the Sinpi. The adoption of non-a priori (pre-defined) categories sought not to limit or interfere with the possibility of the emergence of new dimensions that are not very evident (implicit), or the possible connections between them (BARDIN, 2010; CAMPOS, 2004). This last fact, mainly due to the systemic nature of the research, otherwise, it could compromise the desired results.

The second step sought to reformulate the dimensions more expressively, confirming some *interfaces* between the three areas surveyed, the SP with the ISA and U. Considering that the SP, unlike the others, did not have any type of principle, guideline or design criteria formulated explicitly, there was greater intensity in its restructuring, even because, most of these did not reflect the specificities of the school context and the SVI. In this last step, reflection and intuition based on observations, interviews and experience, sought to establish relationships with the real context, making a connection of ideas, transforming the limits of specific and general semantic structures, according to Campos (2004); Silva, Gobbi and Simão (2005); Campos and Turato (2009); and Bardin (2010). This condition made it possible, at times, to transcend the explicit message, visualizing, albeit in a primary way, clues and evidence that were not yet very evident. This process deepened during the development of the research, sometimes requiring the review of steps of the process (Figure 3). Other information were surveyed when necessary and some experts were consulted to clarify specific problems.

Mainly, in the final categorization, the analysis of the concept (WILSON, 2001), helped in the conceptualization of the implicit dimensions and restructuring of those that did not effectively serve the construction of the Sinpi. Wilson (2001, p. 2) warns that the technique does not have precise and well-defined norms constituting "general practical knowledge, widely applicable", which guided questions that started, not only from the concept itself, but from the context and the scope of the SP. When considering that there is no "correct answer for all circumstances", it is important to explain in which category the term will be treated in the research, ratifying "the possible and effective uses of words" in the context of insertion, examining their true meaning (WILSON, 2001, p. 2).

Research results and discussion

In this item, considerations about the results obtained in this study are outlined, emphasizing the Categorization of the guiding dimensions of the SP, which are exposed in Figure 4. For their approach, the complete process is eventually mentioned (Figure 2, p. 13). Figure 4 shows the Guiding Dimensions in their final Categorization, after the inclusion of the experts' guidelines, presenting the defining term and the elaborated concept of each categorized dimension. The Dimensions of the SP and their interconnections with the ISA and U were reevaluated, preserving the specificities of SVI and the school context and, depending on their use and application, requiring from researchers "*an intense movement in relation to the analyzed material and supporting theories*", without "*losing sight of meeting the research objectives*", as directed by CAMPOS (2004, p. 614). When applying the Concept Analysis, each area occupied by the concept was highlighted, observing a mapping by approximation, although the boundaries between them are blurred; also, respecting the relevant associations in the areas of ISA and U.

The defining term and the concept of the guiding dimensions of the SP (Figure 4) were reconfigured after reading expert opinions. It was considered

Figure 4 – Guiding Dimensions of Spatial Perception categorized.
Source: Prepared by the author (2020), based on Kasper (2013).

that the joint and integrated application to the other areas tends to increase the possibilities of more complete results in design terms. This is because the multi- and transdisciplinary basis, based on the set of pedagogical activities and spatial characteristics, was considered capable of achieving positive design impacts (also investigated). Also considered relevant is the possibility of meeting the perceptual requirements in the operation and design of artifacts for SVI and the understanding of a set of these, so that responses can be obtained in a systemic manner similar to the capture (multisensory) of environmental clues. Other conclusions of the experts are described, regarding the set of Guiding Dimensions of the SP:

– The three supports were duly declared, on which the guiding dimensions of the SP are based: space as a place for carrying out activities from the point of view of the SP and spatial exploration by the student, along with the spatial arrangement, including the equipment (artifacts) usable by the SVI.

– Recognized as comprehensive and capable of giving rise to other specific elements applicable in different designs, in addition to the school designs: those of health and health interest, cultural spaces and other buildings for public use, mainly.

– They can be deployed to meet particular situations, providing a basis for the construction of guides or conceptual maps for specific artifacts or their system.

– The application of research techniques for structuring the set of guiding dimensions is considered coherent, as well as the admissibility of fusion or elimination in a manner guided by specialists.

– Recognized, as important, the instrument (Sinpi) to promote the SI, as well as the representativeness of the SP and its Guiding Dimensions in the construct for the support of pedagogical activities (by the SVI) in different types of school spatial conceptions.

– Allow the recognition of the relevance of the SI in interactive projects focused on the SVI, subject to adjustments for applicability in other public or complex projects, such as hospitals, airports, malls.

The methodological reliability and consistency, recognized by the legitimizers, proposed to offer integrated concepts and guidelines, elucidating what the artifact system should do, how it should behave and how it should look, considering the implementation context, in perceptual terms for the SVI. In turn, the impacts related (desirable consequences, or not) to the use of the product (interactive physical spaces of the school, such as artifact system) can be added to the elements of the system's input (Figure 3), feedback and, if necessary, integrated with design constraints, such as deadlines, legislation and financial reserves.

The objective of dimensions for interactive products sought to focus, mainly, on external or structural characteristics to support different forms of

communication and experimentation in the school physical space. It suggests systemic application, seeking the balanced use of areas of knowledge relevant to school IP; it raises theoretical and practical application for the development of interactive products, so that their structuring elements are planned in harmony, respecting their connections, the perceptual needs of SVI and the guidelines of the pedagogical proposals. This approach can guide new designs or restructure existing systems, as long as the orientations of each interface formed by the triad SP, ISA and U, components of the Sinpi are preserved, thus planning changes to preserve the spatial interaction solutions already implemented. Thus, the resources of the school spatial arrangement, of the spatial characteristics are safeguarded, considering, for example, volumes and proportions, landmarks, supports for wayfinding, affordances, colors and contrasts, sounds, rhythms, perceived by the SVI's remaining senses.

This fact allows us to monitor the evolution and changes in project needs, such as those arising from new student demands, the addition or change of technologies and pedagogical needs. In the case of the Sinpi, there was no concern to link it to specific pedagogical proposals, but to guide it in favor of spatial interaction. Bearing in mind that it is defended by most pedagogical practices, it is assumed that the structuring of the Sinpi's guiding elements favors them, allowing to assign to the space marks and meanings specific to such practices. The planning and preservation of these elements are important, as the users' way of perceiving can influence their interaction with physical environments. The actions produced by the individual can cause a transformation in space, and in the same way, space can produce a transformation in the individual, broadening, in general, all forms of learning at school. The impacts of the configuration and design of school environments and their influence on student-space relationships can assist in the choice of project guiding elements.

The interaction can be planned, however, due to the complexity of the Sinpi structure, it is recommended that, in its application, researchers or designers have some knowledge about the specificities that surround the visual impairment and the school context. The domain of meanings and connections between dimensions and their Interfaces with guidelines generated by other domains of knowledge that are equally important to meet the nature of each project are highlighted. This condition is verified when complex areas are addressed, such as SP and its connections with other areas of similar magnitude, such as Inclusive School Architecture and Usability, addressed in this article. For the results in projects or research to be qualitatively and quantitatively adequate to achieve the desired project impacts, the appropriation and investigations necessary for the use of the Sinpi are recommended.

Conclusions

In view of the results obtained by the research carried out between the years 2007 to 2013, one of the weighted questions refers to the disarticulation of professionals from different areas to work on a common and essential objective, widely addressed and emphasized by most pedagogical proposals, the interaction. Because of this gap, it has evolved to investigate subsidies that can guide interactive projects, built from a user-centered approach (SVI) and in the school context. The clues provided by the artifacts (and interfaces) of the built environment complement the environmental clues, coming from multiple sensations provided by the presence of people, phenomena of nature, such as wind and heat stroke, in addition to different sounds such as those produced by birds, for example. The two conditions must be considered, to ensure the functioning of the projected artifact system, and serve as support for classes, such as orientation and SVI mobility, within the school space.

Projects focused on these interactions tend to avoid physical spaces that do not match the specifics of the user, without considering the existing environment or its resources (artifacts) designed in isolation, without planning the important connections. The physical space treated as an artifact system (and its interfaces) allows the student to interact with it, making these elements serve as a bridge for this process. The artifact must be planned with an adequate configuration (design) and material, aiming at the performance with autonomy and safety of SVI.

The planning of spatial interaction proposes the joint work of this system (formal properties, organization in space, interdependent relationships, communication and signaling technologies, ATs), and the conscious planning of the changes (reforms) needed in space over time. This, so that the planned interaction (and the necessary resources), initially, based on the skills and needs, perceptible and usable by a diversity of students, do not fail to perform their function within the school.

Given this possibility, this research sought the restructuring of concepts, aided by the application of research techniques, which allowed to evidence relevant connections, confirming unique elements consolidated by such links, to be applied in projects. The final product offers, through these elements, a structure that optimizes the work of professionals and researchers interested in school inclusion, especially those involved with projects focused on these users.

Focused on Spatial Interaction, the dimensions of the SP contribute to the school inclusion of SVI, proposing more democratic schools, endowed with environments that, if coherently planned, allow minimizing restrictions and even transcending them when they allow students to experience them. They benefit from the work of varied stimuli recognized as important for the development of SVI, demystifying the fact that the disability necessarily establishes obstacles to the achievements and academic success of these

students. At the same time, they seek to adjust situations that induce insufficient experiences, which restrict participation and interaction with environments and people, reflecting negatively on the adult stage of these students. As they are comprehensive, the dimensions of the SP allow to act in a transdisciplinary way to other areas, supporting design guidelines with different purposes, but which recognize the SP as a founding element to be observed, as demonstrated in the construction of the Sinpi.

The (qualitative or quantitative) characteristics proposed by the guiding dimensions represent the differentiating properties, inherent or attributed to the product, in this case, the architectural work. Designers can benefit from knowledge about the SP and ergonomic guidelines to instigate appropriation and user experience with visual impairments, in the face of physical space. This emphasis is not very deep in the theories that underlie SP, mainly, considering the influence of the remaining senses, in the Spatial Interaction process. The SP Dimensions act in the transformation of design guiding elements, usually used or those determined by the legislation, into elements focused on interaction, showing in this, a guiding element of the architectural work, already in the construction of the school's needs program.

Finally, the aim of this research suggests that the designers' attention is turned to other elements with functions that can facilitate the experience in and of space by the SVI, and facilitate children and adolescents to learn and create from the interactions. It warns and highlights some latent aspects of architecture and/or design, sometimes declined by designers, which can be evidenced by the variety of artifacts, which can compose and materialize spaces in a way relevant to the SVI. In this sense, the dimensions of the SP and its interfaces with other areas tend to rescue and enhance the real functions of these elements, instigating discussions about them.

It highlights the multisensory perception, proposing school spaces that favor the experiences, learning and physical, intellectual and social development of SVI and, why not, of the other students. It is believed that the results of this research may contribute to the preparation of interactive physical spaces of the school that contribute to the SVI education and inclusion process, enabling or rehabilitating them to enjoy the space in different ways. Although the issues addressed here are mainly aimed at application in physical projects, they tend to permeate this function, because the experiences provided by the spatial quality achieved may benefit them beyond their experience at school, supporting a dignified and promising future.

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