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Comparative study of ergonomic and technological criteria for universal accessibility at the Faculty of Architecture and Urbanism, Guayaquil, Ecuador

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Abstract. Accessibility focused on people with reduced mobility has been a challenge for urban design in Latin America since these considerations are only met in 25% of public spaces in cities. Universal accessibility within the study centers is even more limited since the facilities do not have inclusive designs focused on people with reduced mobility. The University of Guayaquil was chosen as a case study, specifically the facilities of the Faculty of Architecture and Urbanism due to their spatial and architectural conditions. The objective of this study proposes the architectural redesign of public and buildable spaces with ergonomic and technological criteria that improve accessibility for people with disabilities. A qualitative and quantitative approach methodology is applied, evaluating the spatial and architectural conditions through weightings applied to ergonomic and technological criteria. As a result, it is obtained that the ergonomic criterion improves the conditions of users with physical disabilities by 60% according to adaptations of size and design and that the technological and communication information systems generate a better performance around disabilities. visual and auditory generating a 90% general improvement in users. As a future line of research, it is intended to extend these criteria to the rest of the faculties of the University of Guayaquil to obtain an inclusive model of higher education.

Keywords. Universal accessibility, public spaces, inclusive design, ergonomic criteria, technological criteria

1 Introduction

At present, in educational centers nationwide, considerations regarding universal accessibility are almost nil since less than 6% of establishments do not have architectural elements such as ramps, handrails, accessible floors or adequate spatial conditions for its deployment. of people with reduced mobility (Nakamura & Ooie, 2017). The ability to study ergonomics implies obtaining important considerations around the human physiognomy to establish guidelines in architectural and spatial redesign (Colorado Pástor et al., 2020). Previous studies show that the technology applied to guide people with disabilities makes them autonomous elements within society (Stjernborg, 2019), increasing their inclusion and improving their quality of life.

The study of ergonomic and technological criteria refers to the examination and evaluation of various aspects of design and functionality that impact the user experience. Ergonomic criteria focus on the physical comfort and ease of use of a product or technology, while technological criteria assess its specifications and technical capabilities.

The objective of this type of study is to guarantee that the products or technologies are easy to use, efficient and safe to use (Hutyria et al., 2020). To do this, researchers and designers consider factors such as ergonomic design, ease of use, accessibility, safety, and general user satisfaction.

In ergonomic design, factors such as the size and shape of a product, the materials used, and the location of buttons and controls are evaluated to ensure that the user can use the product comfortably and safely (De et al., 2019).

Technology criteria, on the other hand, focus on the technical specifications of a product or technology, such as battery life, processing power, storage capacity, and connectivity options (Sun et al., 2014). The objective is to determine if the technology is suitable for its intended purpose and if it meets the needs and expectations of the target audience.

The study of ergonomic and technological criteria is important to create functional and easy-to-use products, and is essential in fields such as technology, engineering, and product design.

Materials and methods

1.1 University educational inclusion

Educational inclusion refers to the practice of providing equal educational opportunity to all students, regardless of background or ability (Wuo & Paganelli, 2022). This includes students with disabilities, students from low-income families, students from diverse cultural and linguistic backgrounds, and gifted and talented students.

The goal of educational inclusion is to ensure that all students have access to a high-quality education that meets their individual needs and enables them to reach their full potential. This may involve providing additional supports and accommodations, such as specialized instruction, assistive technology, and individualized learning plans.

Educational inclusion also emphasizes the importance of creating a supportive and welcoming school environment that values diversity and promotes social and emotional learning (Starks & Reich, 2023). This may involve providing professional development for teachers and staff, fostering parental and community involvement, and creating opportunities for students to participate in extracurricular activities and leadership programs.

Ultimately, educational inclusion is an ongoing process that requires the collaboration and commitment of all stakeholders, including educators, policy makers, parents, and students themselves. By working together to create inclusive learning environments, we can help ensure that all students have the opportunity to succeed and thrive in school and beyond.

In the context of university education, educational inclusion refers to the practice of ensuring that all students have equal access to education and can fully participate in the academic and social life of the university. This includes students from diverse backgrounds, including those with disabilities, students from low-income families, students from underrepresented groups, and international students.

Educational inclusion at universities involves providing accommodations and support for students with disabilities, such as accessible buildings and technology, alternative formats for course materials, and individualized academic and career advising. It also involves creating a welcoming and inclusive campus environment that values diversity and promotes equity and

social justice (Borge, 2023). This may involve promoting diversity and inclusion through academic programs, student organizations, and community outreach efforts.

Universities can also promote educational inclusion by providing financial assistance and other forms of support to students from low-income families and underrepresented groups. This can include scholarships, grants, and tutoring programs designed to help students succeed academically and socially.

Additionally, universities can foster educational inclusion by providing opportunities for international students to study and participate in campus life. This may include language and cultural support services, international student organizations, and study abroad programs.

In general, educational inclusion in universities is essential to ensure that all students have the opportunity to succeed academically and personally, and to promote a more equitable and just society (Nakamura & Ooie, 2017).

In recent years in Latin America, as an ideal case, the UNAM of Mexico has developed inclusive policies within university education that propose strategies for the ideal and autonomous process of students, proposing support systems, more comfortable spaces, and specialized service areas.

1.2 Ergonomic criteria

Ergonomic criteria are important to ensure universal accessibility because they help ensure that people of all abilities and disabilities can use products, environments, and technologies safely, comfortably, and effectively (Yablonskii, 2020). Universal accessibility requires considering the diverse needs of users, including their physical, sensory, and cognitive abilities, as well as their personal preferences and cultural background.

The following are some important ergonomic criteria to consider when designing for universal accessibility:

Usability: Products and environments must be designed so that they can be used easily and efficiently by people with a wide range of abilities and disabilities. This includes considering factors such as the size and layout of controls and interfaces, the use of clear and concise language, and the provision of appropriate feedback.

Comfort: Products and environments must be designed so that they do not cause discomfort or injury to users, regardless of their abilities or disabilities (De et al., 2019). This includes considering factors such as the size and shape of the products, the layout of controls and interfaces, and the use of appropriate materials and finishes.

Reach and Accessibility: Products and environments must be designed to be within reach and accessible to people with a wide range of abilities and disabilities. This includes considering factors such as the height and position of controls and interfaces, the use of alternative input methods (such as voice or touch), and the provision of appropriate feedback.

Visual accessibility: Products and environments must be designed so that they can be used by people with visual disabilities, including those with low vision or color blindness (Huerta, 2007). This includes considering factors such as the use of high contrast colours, clear and simple visual designs, and the provision of alternative input methods.

Hearing accessibility: Products and environments must be designed so that they can be used by people who are hearing impaired, including people who are deaf or hard of hearing. This includes considering factors such as the use of clear and easy-to-understand audio signals, the provision of subtitles or transcripts, and the use of alternative input methods.

The consideration of ergonomic criteria facilitates the deployment of the architectural and spatial design centered on people and each of the physiognomic and sensory characteristics.

1.3 Technological criteria

Universal accessibility in technology criteria refers to the design and creation of products and services that can be used by people with a wide range of abilities and disabilities (Yüce et al., 2013), including those with visual, hearing, mobility, and cognitive disabilities. To achieve universal accessibility, there are several technological criteria that must be considered, including:

Perceivable: Information and user interface must be presented in such a way that users can perceive it through sight, hearing, or touch. This may include the use of alt text descriptions for images, captions for videos, and high-contrast color schemes.

Operable: The user interface through an alternative input device or an application.

Understandable: Information and user interface should be easily understandable and navigable by users, even those who may have cognitive or language issues.

Robust: The technology must be compatible with a wide range of assistive technologies, such as screen readers, and must be able to adapt to the changing needs of users over time.

Compatible: The technology must be compatible with a wide range of devices, operating systems, and browsers, so that users can access it.

2 Methodology

A qualitative and quantitative approach methodology is applied, evaluating the spatial and architectural conditions through weightings applied to ergonomic and technological criteria. Among the ergonomic criteria, there are weightings derived from 1 to 10 applying usability, comfort, reach, and visual and auditory accessibility established as initial parameters that define physical accessibility. As technological criteria they will be qualitatively evaluated by a selected group of the sample of users with disabilities chosen by probabilistic sampling under what is perceptible, operable, understandable, robust, and compatible. For the tabulation of results, bar and scatter graphs will be used to determine the comparison with proposals established under ergonomic criteria. The results of ergonomic criteria will verify their usefulness as complementary elements to spatial and architectural conditioning.

3 Results

The probabilistic sampling of users was taken based on a sample of the student population with disabilities, having a total of 3679 students, from which a simple random probabilistic sample was taken determined by the students of the Faculty of Architecture and Urbanism, Faculty of Administration and Civil Engineering as the closest faculties, obtaining a total sample of 386 students with various types of disabilities.

3.1 Weighting of ergonomic criteria

The study considers parameters from 1 to 10, with 1 being the lowest value in the table as not contributing to the improvement of spatial and architectural conditions and 10 as a contributing value. For the assessment, the conditions between the years 2000 and 2013 will be evaluated, as a point of university renewal and the current conditions of the architectural spaces.

Usability as a reference to the size and design of architectural elements such as ramps, stairs, and furniture (seats). The result is that the size and design of the furniture is below the range of average satisfaction, while the ramps and stairs around its design do not meet the needs of the users.

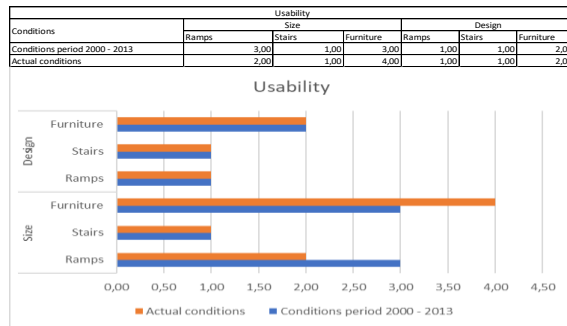


Fig. 1. Ergonomic usability analysis.

Comfort as a reference to the amount of discomfort and injuries from architectural elements such as ramps, stairs, and furniture (seats). A directly inverse weighting is considered since the greater the number of discomforts and injuries, the lower their rating will be therefore, the following weightings will be used:

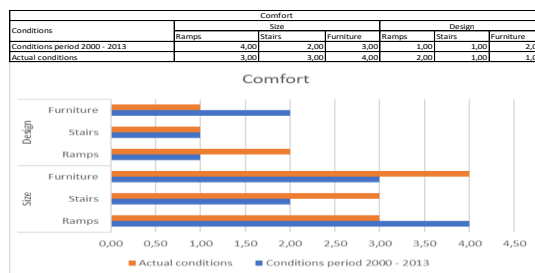


Fig. 2. Ergonomic comfort analysis.

The scope as a reference to the height of architectural elements such as ramps, stairs, and furniture (seats) will have the following weighting:

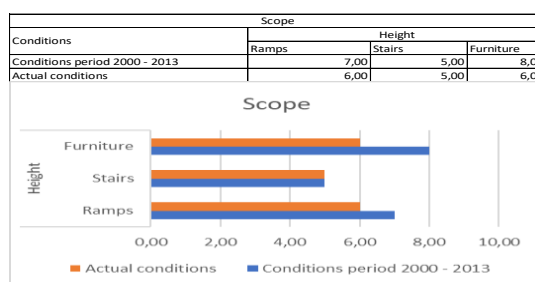


Fig. 3. Ergonomic comfort analysis.

The accessibility made up of two types of disabilities around the visual and auditory accessibility of architectural elements such as ramps, stairs, and furniture (seats) will have the following weighting:

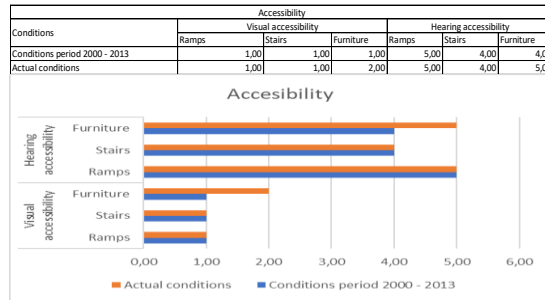


Fig. 4. Ergonomic comfort analysis.

The weightings show that the ergonomic criteria satisfy less than the average number of respondents, obtaining as non-contributors to the ramps and stairs regarding usability, comfort and accessibility and having a variant in favor in terms of the scope of these architectural elements. The furniture system (seats) used is in the average results since its weightings remain between 4 and 5 according to each of the ergonomic criteria.

3.2 Weighting of technological criteria

The weighting of the results is established by sample groups, establishing types of disability, such as physical, visual, and auditory. The groups are made up of 10 students each and how is their evaluation of parameters such as perceptible, operable, understandable, robust, and compatible of information and communication technology systems.

The scatter plot contemplates three perspectives: existing functional, existing non-functional and non-existent non-functional. Of the total of 30 respondents, only 6 of them perceive that the technological criteria expressed in the technological and communication systems used are functional, characterizing the existing signage and location schemes within the faculty; the rest of the respondents (24) perceive that they are not functional and in cases there are not enough systems to obtain better autonomy.

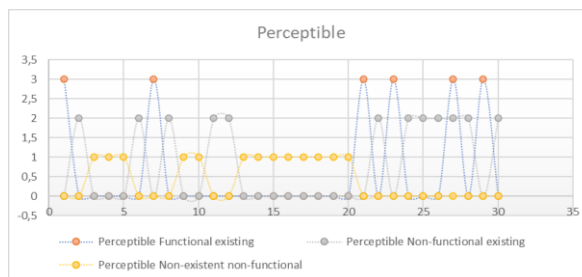


Fig. 5. Technological perceptible analysis.

Currently there are no applications within the local higher education institutions that improve the autonomy of the users, which does not make them operable, for this reason the category of own is framed with the current applications that the respondents use as Google Talk and SpeakLiz, obtaining a specific result of 9 users who use these applications.

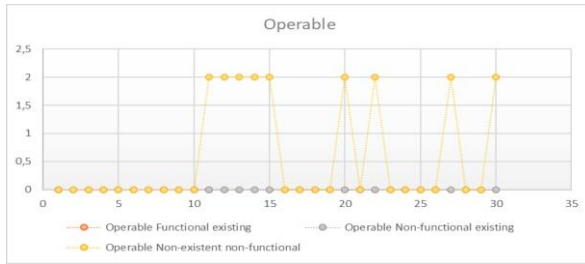


Fig. 6. Technological perceptible analysis.

Two applications used by 30% of users such as Google Talk and Speaklizz were evaluated. The 2 applications were demonstrated to the users plus the integration of Esacesible, for which variable results were obtained in terms of the comprehensibility of the applications, raising their general understanding to 50%.

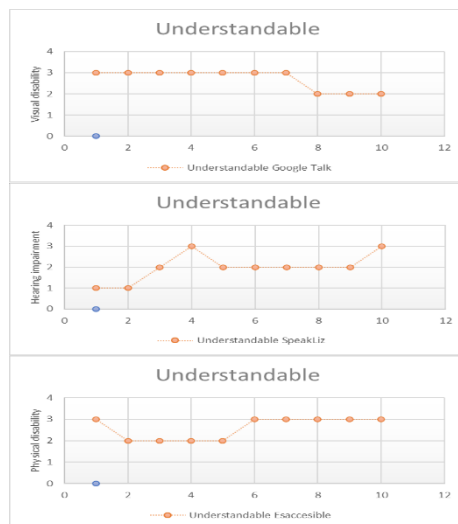


Fig. 7. Technological understandable analysis.

Among the applications evaluated, 70% of users perceive that they are adaptable to their long-term needs and are convenient to improve their autonomy.

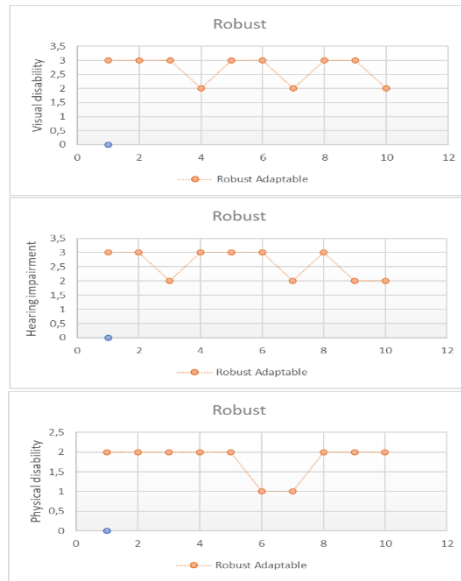


Fig. 8. Technological robust analysis.

Compatibility with other applications intended for users with disabilities is 66%, being the ones with the least amount of compatible with applications at the national level, being Speaklizz and Esaccsible.

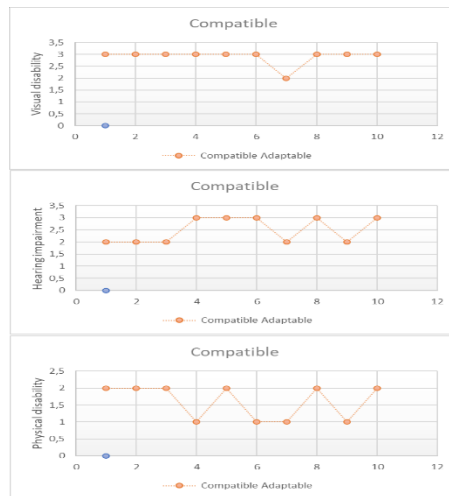


Fig. 9. Technological compatibility analysis.

3.3 Universal accessibility proposal

The universal accessibility proposal is based on the needs of those surveyed both in the qualitative and quantitative evaluation of results. The redesign of spaces based on usability will be raised according to the size and design of ramps and stairs and improve formal aspects of the furniture (seats). Through this redesign, safety parameters will be established to reduce the number of injuries that are the lowest in the comfort parameter.

The design of the proposal must attend users with visual disabilities since the respondents that make up this type of sample do not have elements in terms of ergonomic criteria that help their guidance and autonomy.

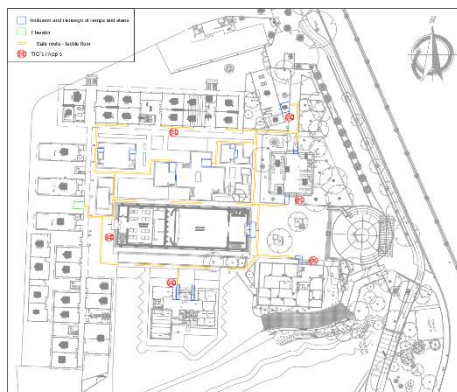


Fig. 10. Ergonomic proposal.

As technological criteria, technology and communication systems are not perceptible, that is, they are not easily located within the physical environment, so it is proposed to establish the diffusion of technological elements in the environment of the Faculty of Architecture and Urbanism. that support deficient visual, auditory, and physical capacities with the use of tactile flooring, signage, auditory and access guide elements; these elements being raised within the communication system. Regarding the technological systems, an interconnection is established between the applications Google Talk, SpeakLiz and Esaccesible, what is formulated is to establish a single application that shares these three functions in order to better integrate users and that their spatial physical journey is autonomous and allow the interaction of the platform with other applications of international diffusion.



Fig. 11. Technological proposal.

4 Discussion and conclusions

Ergonomics applied to the accessibility system is determined as the predominant criterion in the development of autonomy for users with physical disabilities, while technological criteria contribute to the development of users with visual and hearing disabilities, presenting a complementarity of results around the spatial and architectural analysis based on technological complements to improve the conditions of access, mobility, and study within higher education educational centers.

It is obtained that the proposal improves the individual parameters of the ergonomic criteria by 60% according to adaptations of size and design, which reduces the risk of injuries and improves access to the classrooms. Visual and auditory accessibility only had an increase of 15% since the conditioning of the space is limited by the current conditions of each building.

Technological information and communication systems generate better performance around visual and hearing disabilities, generating a 90% general improvement in users, which claims

that technological adaptations contribute better to these two strata of the sample than through the interaction of the 3 applications analyzed (Google Talk, SpeakLiz and Esaccessible) contribute to the performance of mobility in users with physical disabilities of up to 60%. The proposal gives the general sample of users autonomy, control and security in their process of accessing study spaces and their ability to understand architectural elements of ergonomic and technological access.

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