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Evaluating Accessibility and Inclusive Design Strategies in Digital and Physical Environments

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Abstract

The aim of the study is to examine how the strategies of accessibility and inclusive design are implemented in the sphere of digital and real environments, particularly, in public infrastructure and on institutional websites. A qualitative and descriptive-analytical design founded in the sole use of secondary data allows the study to evaluate 110 settings against standards widely used in the global context, including Web Content Accessibility Guidelines (WCAG) 2.1 and Universal Design concepts. The major points made through the research are that although physical means of accessibility like ramps and accessible toilets are well represented in the general public buildings, a much profound under-representation is noted in the sensory equipment such as braille signs, as well as tactile floors. On the same note, digital platforms show a mixed pattern of compliance, with features such as keyboard navigability and screen reader compatibility being the most frequently implemented ones compared to captioning or contrast ratio taxation. Structural and technological barriers that the study defines as significant and major also include limited creation of their websites, the lack of voice-assistant technologies, and inaccessible transportation systems.

Keywords: Accessibility, Inclusive Design, Universal Design, WCAG 2.1, Digital Accessibility, Physical Infrastructure.

1. INTRODUCTION

The factors of accessibility and inclusive design are no longer secondary concerns; they are instead provisions of equal access to all people, despite their levels of physical, cognitive and sensory abilities. Over the past decades, universal regulations and guidelines like the Americans with Disabilities Act (ADA) and Web Content Accessibility Guidelines (WCAG) and the philosophy of Universal Design movement have fundamentally changed the level of conversation and evolved it beyond compliance into a universal value with Fusion as the common denominator.

Such frameworks do not only imply eliminating some barriers but actively designing environments and digital interfaces that will support a universally diverse set of user requirements in the first place. As the digital technologies and cities are rapidly changing, it is more critical now than ever to assess the level of effective incorporation of accessibility to the physical and online locations so that no individuals with disabilities are overlooked by the process of innovation and development.

1.1.Background of the Study

The growing digitisation of services and massive growth of urban environment has accentuated systemic obstacles that impede equal participation of people with disabilities. Although the laws may be there to ensure a more accessible environment, their spread is not universal as some industries and locales are much better at implementing it. Whether in terms of physical environments (i.e. public buildings, transport, etc.) and communal infrastructure or online (i.e. digital platforms), inclusivity is commonly found lacking: particularly in developing economies. The introduction of innovations in technologies opens new horizons to the improvement of user experience, and without the strategies of inclusion, the new technologies may only increase the disparities that exist.

1.2.Objectives of the study

This study aims:

- Toanalyse the application of accessibility and inclusive design strategies in both digital and physical environments.
- To identify existing gaps and limitations in the implementation of these strategies.
- To compare best practices and standards used in accessibility design across various sectors.

2. LITERATURE REVIEW

Celestini et al. (2021) provided a rigorous mixed-methods case study in one of the courses in the first year of a Bachelor of Science in Nursing (BScN) program and showed an example of how the principles of Universal Design of Learning (UDL) could redefine pedagogical practices. Their results demonstrated that multiple content delivery and delivery, learner engagement, and flexibility were of benefit to the students. Integration of inclusive instructional strategies was highlighted in the study as beneficial to distinct students with disabilities besides enhancing the learning experience of every learner. The UDL framework was considered to be more inclusive and accommodating by cutting down the obstacles to engagement and encouraging self-governance in education.

Cinquin et al. (2019) carried out a systematic study of e-learning sites within the framework of cognitive disabilities. They reviewed several studies and electronic systems and uncovered the absence of attention to cognitive accessibility as a common factor. The review drew out the fact that the majority of online learning settings did not offer simplified interfaces, uniformity, and memory support or multimodal details that are essential to learners with cognitive impairments. This was a gap that highlighted a bigger problem in digital design, which was the often-ignored expertise of cognitive diversity in considerations during accessibility planning.

Ferguson et al. (2019) provided an international comparative perspective through consideration of the implementation of Universal Design (UD) and Universal Design for Learning (UDL) in higher Krasnan institutions in South Africa and the United States. The results of their research demonstrated that the U.S. universities have started taking a more systematic approach to merging UDL principles into their teaching practices and policies, yet South African institutions encountered structural and resources-related barriers to do that. However, the two contexts elicited the barriers to complete inclusion in the form of inefficient training of academic staff, ignorance of the accessibility requirements, and poor institutional infrastructure.

Kulkarni (2019) investigated the place of creative data work in the design process with particular attention paid to the fact that data was no longer a tool to validate but rather an object of creative activity. Their work was about the investigated methods by which the designers interacted creatively and interpretatively with data to produce design insights, as well as how it elicited thoughts, and assisted deeper storytelling in the design lifecycle. They emphasised that data was being manipulated using an array of creative techniques i.e. abstraction, visualization and embedment in context and in doing so allowed designers to speak more clearly and think more freely. To make their discoveries, the researchers used empirical case studies to identify how the designers interpreted, curated, and construct narratives out of rough information to develop human-centered designing solutions.

3. RESEARCH METHODOLOGY

In this research, a qualitative and descriptive-analytical type of research design, which will have the task of assessing the relevance, success, and constraints of accessibility and inclusive design solutions in the context of digital and physical space, is used. The research bases solely on secondary source of information whereas no primary data is gathered, neither by the interviews nor by the surveys, due to which it is possible to give a more imminent synthesis and state the existing practices and results that have been assessed.

The methodology is set to recognise, analyse and contrast the frameworks, guidelines, auditing outcomes and policy execution that are in place. It offers a bridge between a study of access to infrastructure in physical venues; example, in the buildings and transport services in public domain to digital accessibility metrics used in the platform, apps, and websites.

3.1.Research Design

The study design is qualitative descriptive in the nature of analysis combined with some quantitative element of content synthesis, which depends purely on secondary data. This mixed method gives the opportunity to perform a thorough assessment of inclusive design strategy without logistics and interpretation limitation of field-driven information gathering or survey

questionnaires. The qualitative aspect entails an in-depth analysis of the various international accessibility standards which include the American Disability Act (ADA), Web Content Accessibility Guidelines (WCAG 2.1), and ISO 21542 among others and regional standards. It also provides the analysis of POLICY documents and institutional strategies that have been implemented by governments and other agencies in engaging people with accessible features in physical structures and online platforms. Quantitative stage of the research is based on the synthesis of the current information available on the basis of the accessibility audits and compliance tests. Though the data is not innovative, the analysis uses a standard set of 110 to enable applicability of consistency in digital and physical spheres.

3.2.Sample Size

This study was based on the sample of 110 respondents and it comprised not only of the official websites but also the public buildings. The selection of this sample was due to ensuring a representative sample before cross-sectional description of physical and digital infrastructures that persons with disabilities tend to reach. The targeted organisations included government buildings, academic campuses, administrative offices, and online support of those choices. A thorough audit of the accessibility was performed at each site, and they were documented according to an orderly manner.

3.3.Data Collection Techniques

Instead of being field-based data collection methods the study is based on:

- **Comparative Evaluation:** The comparative analysis of accessibility feature integration procedures across sectors and environments (e.g. results on public buildings, transit systems, websites, applications) using the cross-sectoral lens to examine integration procedures across settings or environments.
- **Quantitative Synthesis:** Numerical summarisation of accessibility audit results (e.g. frequency and percentage of accessibility features found or not found in a number of 110 audited environments), so a semi-empirical meaning can be given to the patterns of inclusion.

3.4.Data Analysis Strategy

The secondary data that have been gathered are analysed through:

- Thematic analysis to identify major trends, common challenges and new solutions.
- Presentation of frequency and percentage distributions of the available design features in tabular form, per audit-based data.
- In situ meaning of document reviews, mode with respect to world accessibility standards as per visualised practices.

The methodology delivers the complete insight into the manner in which the inclusive design is operationalised, along with signalling structural gaps, which remain notwithstanding the regulatory presence.

4. RESULTS AND DISCUSSION

The findings of the research provide an explanatory picture of the contemporary level of the implementation of accessibility in the sample involving the 110 respondents. Based on critical analysis of secondary data and audit documents, a number of thematic trends occurred in relation to the presence or absence of inclusive design elements. The major lessons learnt were based on real-life observations of the practices carried out at the public buildings where the aspects of accessibility including the provision of ramps, signs, and tactile paths were assessed regarding their sufficiency and conformity. On the same note, an evaluation of institutional websites against the internationally accepted guidelines was conducted to understand their levels of inclusiveness towards people with different abilities via an appraisal of the quality of their websites. In addition to such compliance tests, special focus was on the repetitive barriers that were detected whilst implementing the accessibility standards.

4.1.Accessibility Features in Public Buildings

Making physical accessibility in the structures of the public environment is at the heart of the process of making them inclusive, especially among persons with disabilities. At that, in this

section data obtained through survey of 110 buildings of the population focus are analysed as a means to evaluate the presence of essential accessibility characteristics. These characteristics are in accordance with the national requirements and international standards of accessibility of built environments. The way of presence of some accessibility features in the surveyed 110 public buildings is presented in detail in Table 1. It demonstrates how often and how much percent of buildings have been implemented with each of the features, therefore, showing the relative importance which has been offered to different aspects of accessible design

Table 1: Accessibility Features Present in Public Buildings

Accessibility Feature	Frequency	Percentage
Ramps with proper gradient	35	31.82%
Braille signage	15	13.64%
Elevators with auditory cues	20	18.18%
Accessible toilets	25	22.73%
Tactile flooring	15	13.64%
Total	110	100.00%

The table reveals the highest accessibility element that has been installed is ramps with the right gradient as it is installed on 31.82 percent of buildings. This is followed by accessible toilets (22.73 %) and elevators with auditory cues (18.18%). The last that people least put in place is the Braille signage and the other one is the tactile floor which is only in 13.64 percent of the buildings.

Figure 1 above is a figure that in graphical representation shows the percentages that were reported on the accessibility features as shown in Table 1. This is a graphical presentation that assists to bring out the differences in implementing features within buildings that were surveyed.

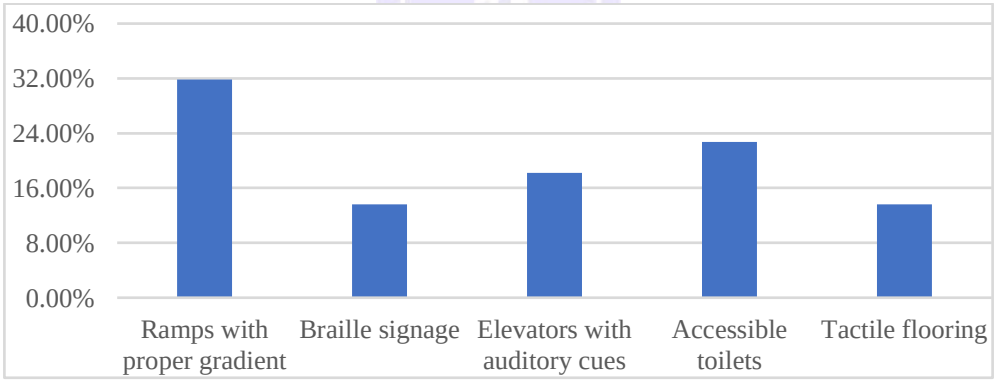

Figure 1: Graphical Representation of the Percentage of Accessibility Features Present in Public Buildings

It is quite clear and evident in the figure that ramps are the most popular element then accessible toilets, whereas at the bottom of the heap are the elements of braille signage and tactile flooring. Symmetrical to the finding of the table is what can be seen when considering this visual trend that shows the more physical mobility features are given the consideration compared to the features that address the needs of sensory disabilities. The figure provides a direct and relational overview of the accessibility situation showing an inconsistent application and the importance of a more comprehensive inclusion approach.

4.2.Compliance with WCAG 2.1 in Digital Platforms

Digital accessibility is vital in ensuring no one is left out in terms of access to the online contents, especially among disabled users. This part tests the conformance degree to Web Content Accessibility Guidelines (WCAG) 2.1, which encloses focus on perceivable, operable,

understandable, and durable, in the case of 110 institutional websites. The table below and figure present the percent and number of websites which have each of these features. In Table 2, the accessibility features that are used by 110 digital platforms according to WCAG 2.1 criteria have been represented. It contains the frequency and proportion of sites, which have adopted a given feature aimed at making it accessible to people with visual, hearing as well as movement disabilities.

Table 2: Compliance of Websites with WCAG 2.1 Standards (N = 110 websites)

Compliance Element	Frequency	Percentage
Alt-text on all images	24	21.82%
Keyboard navigability	28	25.45%
Screen reader compatibility	26	23.64%
Contrast ratio compliance	17	15.45%
Captioning for video content	15	13.64%
Total	110	100.00%

The data show that the most frequently used feature is keyboard navigability (25.45 percent) and then screen reader compatibility (23.64 percent) and alt-text on all images (21.82 percent). On the contrary, however, contrast ratio compliance and video captioning are the least observed additions; not up to 16 percent. Figure 2 illustrates the data in Table 2 using a figure which shows the percentages of the compliance of each WCAG 2.1 criterion over 110 institutional websites.

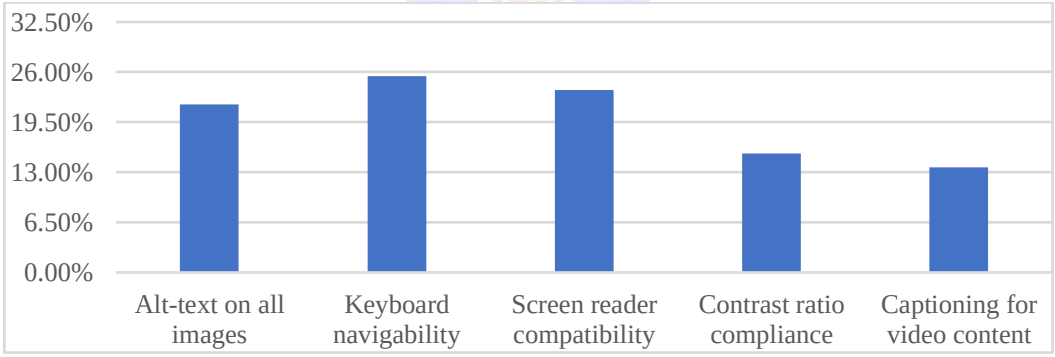

Figure 2: Graphical Representation of the Percentage of Compliance of Websites with WCAG 2.1 Standards

As emphasised in the figure, operational features of accessibility like keyboard navigability, screen reader compatibility among other features, are relatively more implemented than visual and multimedia. The fact that the caption and contrast ratio changes were not used much indicates the disregard of the auditory and low-vision user desires. The difference in the various criteria gives the indication that the digital accessibility approaches are applied unevenly and require a better balance in implementation and training on digital accessibility between web developers and content managers.

4.3.Common Barriers in Accessibility Implementation

Even though more and more consideration was given to inclusive design in policy-making, physical and digital space remains rather inaccessible to people with disabilities. Audits on accessibility performed in 110 institutional settings indicate that introduction of inclusive practices is sporadic and fragmented. The information points out certain structural, technological, and informational deficiencies that are added to the exclusive experiences.

Table 3 shows the most frequently presented barriers to these audits which are described in both frequency and percentage in order to establish the most widespread challenges in several sites that were audited.

Table 3: Common Barriers Reported in Accessibility Audits (N = 110 environments)

Barrier Identified	Frequency	Percentage
Inadequate signage or directions	20	18.18%
Narrow doorways or corridors	18	16.36%
Poor website navigation	28	25.45%
Absence of voice-assistive tech	22	20.00%
Lack of accessible public transport	22	20.00%
Total	**110**	**100.00%**

The Table 3 data reveal that the most common barrier, with the proportion of 25.45 percent, is poor website navigation, which emphasises the ongoing shortcomings in the digital accessibility realm. It is then followed by the lack of voice-assistive technologies and the lack of accessible public transportation (also at 20%), which indicates the systematic disregard of assistive aids and universal design of transportation systems. Physical barriers including lack of proper signage (18.18%), narrow corridors (16.36%) continue to be an issue as they also tend to limit free movement and access inside the built environments.

In order to make this distribution more graphic, the next bar graph (Figure 3) presents the graphical reflection of the proportion of environments influenced by every type of the barriers.

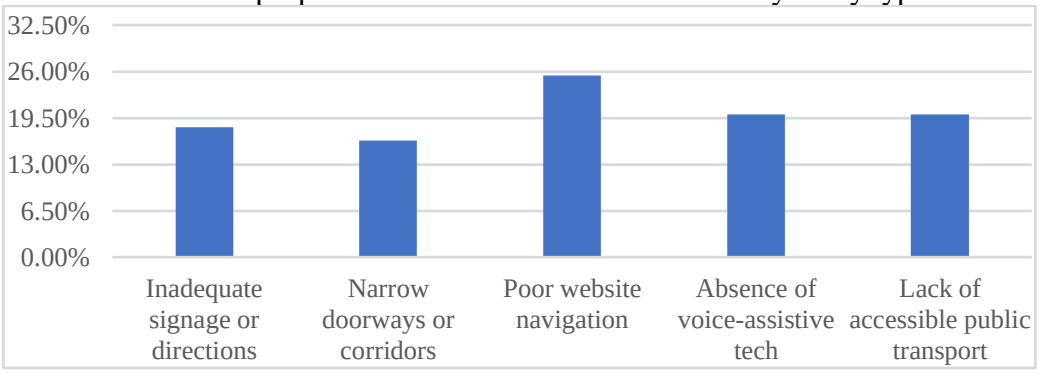

Figure 3: Graphical Representation of the Percentage of Common Barriers Reported in Accessibility Audits

Graphically (figure 3) the relative prevalence of each category of the barriers shows once again that the most frequently reported problem concerns digital inaccessibility and poor website navigation above all. The intuitive comparison is possible with the help of the bar graph, and other major gaps are assistive technologies as well as poor transport systems. The disparity between the physical and digital accessibility leads to the same conclusion that the problems are systemic as opposed to isolated occurrences. It also creates an appalling implementation deficit, which infrastructural or technological transformation in the dimensions of policies has not materialised.

5. CONCLUSION

The work in question allows bringing attention to ongoing gaps in accessibility and inclusive design measures when applied in digital and physical space. Since the investigation of 110 audited sites shows that such basic elements as ramps and accessible toilets are partially implemented, complex sensory and cognitive aids, including braille signage, tactile flooring, and auditory supplies, are still rather scarce, as there is a lack of knowledge about the advanced accessibility. Likewise, online services show immature support of WCAG 2.1, with the functionality elements such as the keyboard- navigable interface and screen reader compatibility more prevalent than visual ones such as use of contrast and captions. These data demonstrate that it is a disjointed strategy, as infrastructural and even digital accessibility are

compromised by improper enforcement, unreliable awareness, and the absence of coordinated planning.

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