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Augmented Accessibility: Review of Digital Tools and AR Solutions for Disabled Library Users

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ABSTRACT

The present research delves into the role of digital technology in general, with special emphasis on Augmented Reality (AR), to make disabled people's access to library services more friendly, their information accessibility and learning outcomes better. First off, the study sets the groundwork for its conversation by pinpointing the main difficulties and obstacles that impair the access of users with disabilities to the library services, whether they are physical or digital. Then, a review of the current assistive devices is made in terms of their ability to meet the needs of diverse users, followed by an exploration of the AR-based solutions' potential in areas such as assistance to navigation, information retrieval, and the promotion of self-directed learning. The assessment of user experiences, satisfaction, and acceptance of both the digital and AR-based tools is performed in order to comprehend the factors that contribute to usability, the perceived benefits and limitations. Moreover, the study discusses policy, ethical and inclusivity aspects related to the implementation of these technologies, as well as the role of libraries and institutional capacity. The analysis of the engagement, autonomy, and educational outcomes reaped by users from the use of digital tools will also be part of the procedure. A framework is eventually put forward, which is based on the results, for the smoothing out of AR-based assistive technologies to be efficiently integrated into the libraries. The present research not only offers practical suggestions for the technical integration of transition but also presents a case for the establishment of a template for the creation of user-friendly and inclusive libraries, through the involvement of the disabled and the facilitation of their independent learning experiences with the help of opening up their new accessibilities and information skills.

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KEYWORDS: Assistive technology; Augmented Reality; Inclusive libraries; Accessibility; Disabled users; User experience; Digital transformation; Information services**.**

INTRODUCTION

The libraries have always been the main tools in helping people get access to information, learning, and social participation. A different story is that the severely disabled may still find it very difficult to avail of library services due to the accessibility barriers that also exist in physical and digital environments. Even though policies have become more and more inclusive, the roll-out of accessible technologies has been inconsistent, and a considerable

number of disabled users are still having a lot of trouble with navigation, resource retrieval, and engaging with learning materials independently. As a result of the fast-changing digital world, libraries have decided to rely on assistive technologies that are from the most common screen readers, speech recognition tools to the most modern AI-based recommendation systems to overcome this gap. But still, a lot of the conventional tools prove to be still insufficient when it comes to solving problems associated with dynamic, multi-sensory, and spatial accessibility.

DIGITAL ACCESSIBILITY

Digital accessibility in libraries refers to designing library web sites, discovery systems, digital repositories, and on-site digital services so people with a wide range of disabilities can perceive, navigate, and interact with them. Accessibility in libraries increasingly aligns with international and technical standards (for example WCAG), which provide practical guidance for making web content, applications, and digital resources usable by people with visual, auditory, cognitive, and motor impairments. Adopting these standards is both a legal/ethical imperative and a usability improvement for all patrons [27].

Web design, content presentation, navigation, and interaction are the main aspects of accessibility in the digital libraries context. Accessibility's ultimate aim is to eliminate all barriers and ensure everyone has the same access to information and resources, no matter what their abilities are. The digital transformation of libraries opens up a whole new world of opportunities but at the same time requires a lot of attention to digital accessibility to make sure that all people, especially the disabled ones, get equal access to those resources. This means conforming to worldwide rules and regulations as well as government policies and being committed to the principles of universal design [17].

ASSISTIVE TECHNOLOGIES IN LIBRARY CONTEXTS

The World Health Organization (WHO) defines assistive technologies (ATs) as any items, software, equipment, or product systems that are specially designed to keep, raise, or improve the functional skills of persons with disabilities. In the case of libraries, ATs pertain mainly to hardware and software devices that assist disabled people, especially the visually impaired (PwVI), in accessing computers and other information technologies. These technologies are of great importance because they give access to resources and services of public libraries without distinction to the PwVI group and thus are responsible for the overcoming of a barrier concerning historical information access. ATs implemented by PwVI in libraries include: reading machines, video conferencing tools, internet-connected computers, screen readers, Braille writing equipment, Braille translation software, Braille embossers, scanners, and closed-circuit televisions (CCTVs). ATs have made a remarkable shift in the way services are provided in public libraries, allowing people with visual impairment to choose and be independent in accessing such resources as e-books, email, and the internet [28].

PHYSICAL SPACE ACCESSIBILITY ISSUES IN LIBRARIES

Library buildings have multiple accessibility issues in their physical spaces, including book stacks, desks, computer workstations, classrooms, study rooms, bathrooms, lounges, cafes, and makerspaces. Every one of these physical spaces needs to be altered so that everyone can use them. In 2005, the International Federation of Library Associations (IFLA) created a checklist to help identify primary concerns libraries face in making their physical spaces accessible and to propose solutions. Physical infrastructure barriers in libraries affect not only the interiors of

the buildings but also the extended external access to the libraries. These issues involve costs, complex planning, and external administrative approvals, underscoring the difficulty of achieving complete physical accessibility on the premises [2].

INFORMATION RESOURCE ACCESS

WIPO states that, internationally, less than 10 % of the world's publications are available in accessible formats, despite over 250 million people being visually impaired, indicating a need for access to those works [1]. Some of the challenges related to accessibility faced by libraries include underfunding that limits the ability to perform necessary updates and acquire newer assistive technologies, underdeveloped infrastructures without barrier-free access and appropriate wayfinding, and the continued use of outdated assistive technologies, which certainly undermines the purpose of accessibility. Libraries still have inadequate access to assistive tools, as they lack access to sufficient quantities of materials in formats such as Braille print, large print, and audio, which creates a disability access inequity. The lack of adequate policy instruments and overarching institutional policies also damages the willingness to address the needs of people with disabilities more adequately. The lack of trained library personnel makes it even harder to address accessibility issues, as insufficient staff training in assistive devices and software keeps support for disabled users low. This situation is made worse by the lack of volunteers to record audio and assist users, especially those who are blind or have low vision. On top of that, the lack of skilled personnel among untrained workers continues to negatively impact the quality of service and user experience. Accessibility issues in libraries are made worse by the lack of qualified personnel, as untrained staffs constitute a barrier to assisting disabled persons. This is made even more difficult by the low level of volunteer participation in such support activities as audio recording and assistance to the visually impaired. Also, untrained employees who do not have the necessary skills to serve blind users remain a hindrance to improving the quality of service and the user experience [3]. Among the significant challenges are formats that are difficult to access, unusable websites, overly complex processes, and insufficient explanations, which together hinder the use of library resources by people with disabilities [4].

DIGITAL ACCESSIBILITY CHALLENGES

Digital accessibility constitutes an important aspect that cuts across the entire process of libraries' services. The availability of digital content and services to all users is very similar to the legal requirement to provide universal access to library tools and services, including the old reading order, clear headings, contrasting colours, zoom, and keyboard navigation. All libraries must adhere to the WCAG standards regardless of where or what the platform or resource they offer is. If the interfaces are not user-friendly, they will limit user access, especially for actions such as searching, clicking, or making requests. Furthermore, getting access to content not only increases the user experience but also ensures equal access for all librarians [4]. The dilemma of digital accessibility in libraries arises from ever-changing technology and design standards, which make compliance difficult. This situation is compounded by ongoing accessibility issues in web and PDF formats, as well as internal problems stemming from resource scarcity and staff lack of awareness or training. Overcoming these obstacles will require continuous effort, funding, and education [2]. There is a frequent misunderstanding that if something is digitised, it is automatically accessible. However, this is not the case in every situation, since not every student with a disability can take advantage of the resources offered in the same format. This issue raises a significant concern for libraries: the equal rights of all users to access information [5]. The remote access to digital resources has turned out to be of great

significance, especially for users with physical disabilities who can get the materials in home setups that are suitable for them; however, these resources usually do not have the appropriate accessibility features for the proper functioning of screen readers, keyboard navigation, and different assistive technologies [6].

SYSTEMIC AND ORGANIZATIONAL BARRIERS

Common issues faced by libraries include underdeveloped institutional frameworks, limited funding, and dispersed policies, which, when combined, make it hard for libraries to offer inclusive services that last. No collaboration in planning and no responsibility-taking mechanisms in place make it slow or inconsistent to carry out accessibility initiatives. The organisational culture too often fails to take disability inclusion into account; thus, staff training and resources are insufficient. On top of that, disabled clients are seldom consulted in decision-making, resulting in services that do not correspond to their actual needs. Such gaps in the system keep reinforcing discrimination, especially in areas with limited resources [7]. One of the significant obstacles institutions face when introducing extensive accessibility programs is the behaviour of departments working in 'silos', which results in poor communication and coordination. The departments not working together seem to be the biggest obstacle to achieving the common goals and to making the combined vision for campus accessibility active. The libraries face an in-house challenge in convincing all stakeholders to support resource accessibility, partly due to a lack of collaboration. This scenario underscores the urgent need for departments on campus to work together [5].

INVISIBLE AND MULTIPLE DISABILITIES

There are lots of people suffering from invisible disabilities, and some of them do not feel able to register as disabled, which leaves the door open for not addressing their accessibility needs [8]. Because people are living and working longer, disabilities due to ageing will be treated as a matter of when rather than if about access to digital resources for people with special needs. This will not only affect the senses, such as sight and hearing, but also cases of arthritis and dexterity loss among the elderly [6].

DIGITAL TOOLS

Assistive Technology (AT) used in libraries, such as screen readers and voice interfaces, aims to provide equal access to information, thereby improving accessibility and inclusivity for people with disabilities. The accessibility features and disability inclusivity of digital libraries are enhanced with voice activation technology and AI chatbots. Nevertheless, librarians' differing knowledge and implementation difficulties leave a gap for improvement in accessibility and inclusivity for specific disabilities. The current state of these technologies as they pertain to specific disabilities will be addressed in this response. Individuals who read aloud the text help blind people to access and surf the internet. Nevertheless, their potential advantages and functions are limited in libraries due to inadequate implementation and training [29].

Voice controls are a simple and smooth way for people with physical disabilities to communicate with the library systems. On the other hand, the use of such systems in many organizations remains quite low [30]. The role of librarians is very important here, as they screen the internet, provide support with tech use, and thus encourage the visually impaired to become independent users. Because many library resources are not easily accessible, librarians often use other techniques to help users. Thus, it is necessary for librarians to have a basic understanding of assistive

technologies and to be proactive in support. They not only help but also empower users and campaign for better access [10].

AI-enhanced chatbots and assistive technologies have greatly increased library accessibility and provided patrons with disabilities with real-time assistance in various forms, including those with no vision, hearing, or physical limitations. Besides, these technologies have brought library services closer to everyone by removing language, cultural, and geographic barriers and, at the same time, enabling flexible, personalized experiences. On the other hand, issues around data protection, the impartiality of algorithms, and morality need to be discussed and addressed to ensure responsible use of technology [11]. AI power is such that it removes hurdles through sophisticated communication tools and support for people with physical disabilities, whose only limitations are visual or auditory impairments. Smart chairs, robots, and recuperative systems are enabling users to get around and have their needs met with less physical labor, challenging them. Aiding and abetting education through AI technology has meant teaching inclusively and providing individual attention. It translates into more accurate, less dependent, and equally distributed opportunities. AI, in a nutshell, if not a full-fledged human, then at least an immediate and integral ally, if not one with disabilities, consists of an invisible pull force that drives society towards earthlings who have been unreasonably subjected to isolation and negligence [9].

Deafblind people use various assistive technologies simultaneously. There are hearing aids and amplification systems for those who have lost their sense of hearing. Talking devices, white canes, braille, and magnifying glasses help visually impaired people. Additionally, the use of tablets, videophones, and Bluetooth braille displays—the tech from the mainstream—reduces communication and navigation barriers. These tools certainly help deafblind people live an independent, accessible life [12].

Augmented reality (AR) and virtual reality (VR), among others, are emerging technologies with significant potential for people with low vision when delivered via head-mounted displays (HMDs). These modern technological tools can be very useful for creating inclusive environments in libraries when the specific visual needs of the users are taken into consideration. By incorporating the use of digital content in a creative way [13]. Additionally, the use of computer vision technology makes it easier for the visually impaired to navigate and recognize objects more quickly than before. These are the kinds of things that have brought about a significant change in how AI and the digital devices commonly found in libraries are used [14].

To sum up, the impact of digital assistive technology in libraries is supported by evidence, but further testing and refinement are still needed to better support people with different types of disabilities in their unique situations. For example, user training can be prioritized, the design of assistive tools can be improved, and an inclusive library culture can be developed, thereby greatly increasing accessibility and inclusivity for people with disabilities.

AR-BASED SOLUTIONS

The use of AI-assisted tools and technologies is leading to a reformulation of keepers' access to the library, granting greater freedom and improving services for disabled users. Nevertheless, the successful implementation of these technologies in libraries depends on addressing primary concerns, such as how to keep data private, ensure data

security, maintain system reliability, and provide effective training for staff and users alike. The libraries that stay updated with AI and its technologies as they unfold will not only be able to protect their position as inclusive and trusted sources of knowledge but also, in doing so, follow the strictest ethical practices and provide robust support systems [16].

Academic libraries can significantly improve their information services by implementing modified work practices that are information-centric. These practices involve searching, compiling, mixing, framing, sharing, or reusing information, and learning from it ([15].

The transition from traditional libraries to digital libraries brings a lot of advantages but at the same time it creates a problem of access for Divyangjan people with disabilities who might have visual, hearing, motor or cognitive difficulties. So, librarians should be very active in finding out and removing such barriers in the digital world that prevent the disabled from accessing information. That is why there are international measures such as WCAG developed by W3C which helps developers in making web content that is inclusive and easy to use. Digital accessibility implies having a good design for users with special needs, being very clear in how the content is presented, making navigation very simple, and having very friendly interactions. Ability of everyone to receive information should be incorporated in all aspects of the library service from start to end [17].

Thorough enumeration of the conventional Assistive Technologies (AT) used in libraries is, however, mainly limited to past or traditional tools such as screen readers, Braille embossers, adaptive keyboards, and mobility aids. Apart from locating such facilities, particularly those serving the hearing-impaired and the locomotor-impaired, who have been the worst affected, and the unreasonably complicated practice of buying AT devices without consulting users, it has nothing to do with the new technologies that are changing global accessibility standards. Moreover, it does not take into account Augmented Reality (AR) solutions, which include navigation assistance, object recognition, and interactive learning overlays, thereby missing the opportunity to explore inventive, future-oriented methods. As a result, the assessment yields a good starting point but does not provide the vital penetration of the future trends that the dual nature of accessibility in the present electronic and physical library settings requires [18].

ASSESS USER EXPERIENCES AND ACCEPTANCE

The usability of augmented reality (AR) systems is one of the most important factors in determining disabled users' satisfaction with the library service. When the device's usability is very low, the technology intended to assist people with disabilities becomes ineffective, thereby greatly affecting their quality of life and independence [19]. On the other hand, properly crafted AR interfaces that may include gaming-like features or a high level of interaction can enhance cognitive skills and make the entire teaching process more fun and varied [20].Visually impaired learners can greatly benefit from a user-friendly VR platform that gives them access to library premises that were once inaccessible to them. Although VR and AR are two separate techniques, the concepts of accessibility and user-centered design in VR for people with disabilities can be readily transferred to AR applications, underscoring the need for custom solutions. For example, a VR application developed for Thai visually impaired university students demonstrated that user-centered design can be an extremely effective and powerful approach to enhancing accessibility, thereby making the students' orientation experience more positive [19].

The implementation of Augmented Reality (AR) and digital accessibility tools within library settings necessitates a thorough examination of institutional policies, ethical considerations, and inclusivity issues. Effective digital accessibility policies are vital for promoting diversity and providing clear institutional roadmaps [21]. Libraries are increasingly adopting AR, AI, and blockchain to enhance user experiences, streamline operations, and personalize learning [22], [23]. The use of augmented reality (AR) in libraries has very much a positive side, nevertheless, the current mobile AR solutions are generally not context-aware, thus showing more advanced methods are needed [25], [24]. AR can consolidate the differences between the physical and digital library experiences, but the absence of AR in libraries is a serious matter and its use in libraries needs to be backed up by policies [26].

LIBRARIANS' ROLES AND SKILLS

It is absolutely necessary to communicate directly with students with disabilities so that their needs, complaints, and dissatisfaction are understood. It is recommended that formal feedback channels be established, that town hall meetings be held, and that patrons who are involved in the development of library resources be actively sought. To increase awareness of the available AT, libraries should also expand their outreach efforts through helplines, chat services, online tutorials, and informative signage. The training on empathy and accessibility at academic libraries implies that library staff will be able to use both their technical and interpersonal skills for effectively helping the patrons with disabilities. The training would cover cultural and psychological aspects for the purpose of building empathy, dealing with discomfort or insensitivity, and encouraging respectful interaction. The training would also highlight the librarians' moral and ethical duties of being fair, inclusive, and serving with high quality. By making accessibility the core principle of information service design rather than just an add-on, libraries can turn into places where assistive technologies are not only provided but also actively used in a meaningful way. A comprehensive training strategy, in its turn, will not only support the staff's competence and ethical awareness but also their ability to innovate continuously, so that dignified and effective service to disabled users is always guaranteed [15].

With libraries going digital more and more, the need to cater to the accessibility demands of various user groups becomes a necessity in making sure that everyone has equal opportunity to access info and literacy. Providing access for Divyangjan is not only an issue of social equity but also a legal and moral necessity, since the availability of information is a primary source for education, work, and social integration [17].

DEVELOPMENTS AND INITIATIVES

In the past few years, there have been some remarkable advancements and measures taken to make the digital world accessible. For example, the World Wide Web Consortium (W3C) has created guidelines such as the Web Content Accessibility Guidelines (WCAG) to set the criteria for web content that can be accessed by everyone. All around the world, governments and public institutions have been passing laws and implementing policies to not only advocate for but also safeguarding the rights of disabled individuals in the digital world. The latter includes for instance, making provision for the purchase of accessible ICT. All these initiatives are a clear sign of the increasing acknowledgment of digital accessibility as a basic human right [17].

CONCLUSION

Disabled library users still face serious obstacles in receiving library services, even though the digital transformation is taking place and accessibility standards are becoming more recognized. The provision of traditional assistive technologies is crucial, but these technologies still work in a disconnected manner, lacking integration, scalability, and user-centric design. On the other hand, the new tech, especially AR, has the potential to support better by providing real-time, context-specific, and multi-sensory means of communication and interaction. Still, the hype about the technological promise outweighs the reality of practical application.

The current state of affairs is characterized by libraries overcoming accessibility issues by adopting a mix of technological innovation, inclusive design, policy structures, staff training, and robust infrastructure. AR technology has the potential to rethink how libraries are viewed in terms of accessibility, user experience, and inclusivity as learning environments. Future studies ought to focus on user-centered evaluation, collaboration design with the disabled communities, and thorough testing of usability and learning outcomes. The issues of privacy, ethical considerations, cost, and feasibility should also be of concern to ensure fair distribution.

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